PDHonline Course C928 (15 PDH)

Channel Tunnel: The French Connection

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2020

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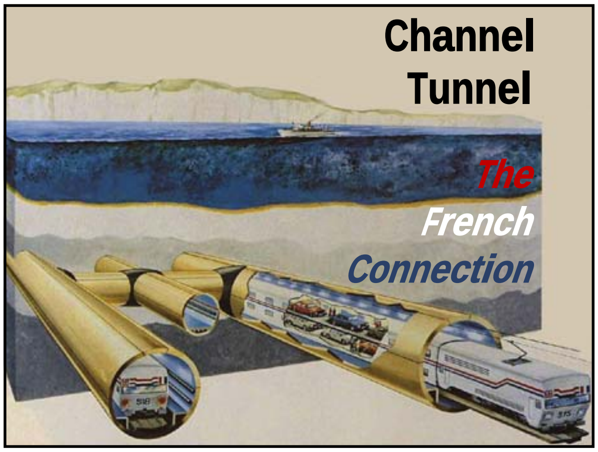

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Splendid Isolation

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Follow the Hippopotamus

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"THERE have not been wanting men who held that, in some respects, our forefathers were better off than ourselves, notwithstanding all the triumphs of modern science and civilisation. In one particular, at least, the primitive inhabitants of Western Europe are to be envied. The men who waged war with the ancient British lion, the cave bear, or the hairy mammoth, had no need to cross the sea if they wished to extend their hunting-grounds far to the east. Similarly, the old inhabitant of central France could as easily, if he so chose, follow the hippopotamus in his migrations to the Thames. For, in those old times - as there is good reason for believing - a band of Chalk extended across what is now the Straits of Dover, and the area now known as the British Isles was united to the continent of Europe…"

RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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During the *Pleistocene Age*, the *North Sea* was a giant lake, closed-off at its northern edge by merged ice sheets from Britain and Scandinavia, and at its southern edge by the *Weald-Artois* ridge. This lake was fed by both the *Thames* and the *Rhine River/s*. That, combined with melting ice, eventually burst the Weald-Artois barrier, sending the lake's water surging into the Channel.

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BREXIT v1.0

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"Scientists have found evidence of how ancient Britain separated from Europe in what they are dubbing 'Brexit 1.0' - a flooding event that happened in two stages thousands of years ago. In research published in the journal Nature Communications on Tuesday, the scientists said they now have proof that the opening of the Dover Strait in the English Channel, severing the land between Britain and France, occurred in two episodes - an initial lake spill over, followed by catastrophic flooding…"
businessinsider.com, **April 5, 2017**

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"…'The breaching of this land bridge between Dover and Calais was undeniably one of the most important events in British history, helping to shape our island nation's identity,' said Sanjeev Gupta, a professor at Imperial College London who co-led the work. 'When the ice age ended and sea levels rose, flooding the valley floor for good, Britain lost its physical connection to the mainland,' he said. 'This is Brexit 1.0 - the Brexit nobody voted for'…"
businessinsider.com, **April 5, 2017**
Above: caption: "An illustration of what the land bridge connecting Britain to Europe may have looked like before the formation of the Dover Strait"

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"…The first pieces of the puzzle came some 10 years ago, when researchers found geophysical evidence of giant valleys on the seafloor in the central part of English Channel. They believed these valley networks were evidence of a megaflood gouging out the land, probably caused by a breach in a chalk rock ridge joining Britain to France. In the new study, new geophysical data collected by colleagues in Belgium and France has been combined with seafloor data from Britain showing evidence of huge holes and a valley system located on the seafloor. This helped the team establish how the chalk ridge was breached. The ridge acted like a huge dam and behind it was a proglacial lake, the researchers explained. The lake overflowed in giant waterfalls, eroding the rock escarpment, weakening it and eventually causing it to fail and release huge volumes of water onto the valley floor below…"
businessinsider.com, **April 5, 2017**

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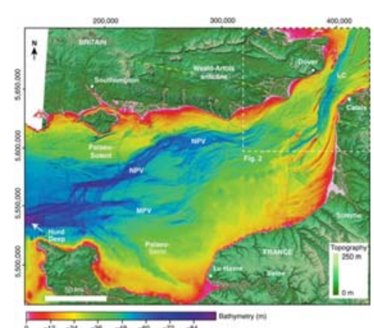

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"…'We still don't know for sure why the proglacial lake spilt over,' said Jenny Collier, a co-author of the study from Imperial's department of earth science and engineering. 'Perhaps part of the ice sheet broke off, collapsing into the lake, causing a surge that carved a path for the water to cascade off the chalk ridge. Maybe an earth tremor . . . further weakened the ridge and caused it to collapse, releasing the mega-flood that we have found evidence for in our studies'…"
businessinsider.com, April 5, 2017

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"…Either way, the scientists said, if it was not for a set of chance geological circumstances, Britain may have remained connected to mainland Europe, jutting out into the sea like Denmark…"
businessinsider.com, April 5, 2017

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"…How long ago it may be since this old 'bridge' was broken we cannot know. Probably no Englishman will regret that the bridge was broken, and few will wish it wholly restored. But, certainly, most of those who have occasion to cross the Channel will wish that we could again have the personal convenience of continuous land communication, without the political disadvantages which such communication would involve…"
RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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A Firmly Rooted Conviction

16

"Ever since the commencement of the present century there has been evinced a very firmly rooted conviction that there ought to be a line of communication established between England and the Continent of Europe other than that afforded by the passage of steamships between shore and shore…"
The Engineer, March 1876
RE: excerpt from an article entitled: "The Channel Railway." Being an island nation, Great Britain's relationship with continental Europe was one of mistrust and caution - from the days of the _Spanish Armada_ to the _Napoleonic Wars_ to the threat of invasion posed by _Nazi Germany_ in the early days of WWII. Despite this ever-present tension, plans to connect Britain with France - via the _Straits of Dover,_ have been around since the beginning of the 19th century.

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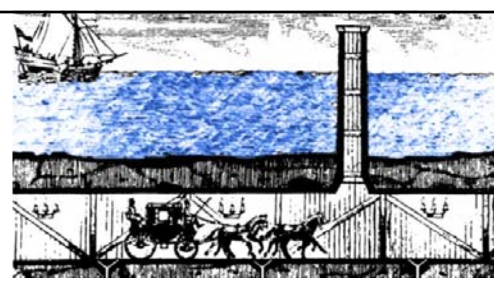

"…The first proposition to unite England and France was made in 1802, by Monsieur Mathieu, whose plans were laid before the First Napoleon, then First Consul, and were afterwards exhibited at the Luxembourg and public galleries in Paris. They have, however, long since been lost, and with them the proposed method of carrying out the work…"
The Engineer, March 1876
<u>Above</u>: caption: "Sketch of the first idea for a cross-channel tunnel between England and France - conceived in 1802 - showing the design, complete with chimneys to the surface for oxygen"

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Lessening the Inconveniences

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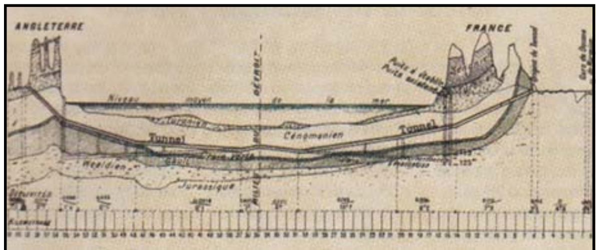

"…Modern civil engineering has resolved to attack this problem. Some of the proposals for accomplishing it we will presently examine. The plans which have been advanced for lessening the inconveniences of the Channel passage have taken various shapes. It would be impossible, within the limits of a short article, to go over them all; we will therefore confine our attention to those schemes which propose to solve the difficulty by constructing a submarine tunnel. Proposals not falling under this head are various enough. Embankments, bridges, and tubes, in one form or other, have been proposed; but the scheme which seems to have found most favour, with engineers and with the public, is that of a tunnel…"

RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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Father of the Tunnel

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"…The idea of constructing a tunnel between England and France seems to have originated with a French engineer, M. Mathieu. About the year 1800 he drew up plans, which were for a while exhibited in Paris, but which have long since been lost. In 1853 Mr. W. Austin devoted some attention to this subject, and published his plans in 1856, proposing to construct a tunnel from Boulogne to Cape Grisnez. Nearly the same line was chosen by M. Thome de Gramond, who, in 1857, published an elaborate work on the subject. Since that time the 'Channel Tunnel,' in one form or other, has been pretty constantly before the public…"

RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874." Known today as the "Father of the Tunnel", *Monsiuer Thome de Gamond* devoted more than forty years to researching a tunnel under the *Straits of Dover.* Through-out the course of his work de Gamond made over 1,500 experimental borings in France and England to examine the strata, as well as carrying out three dives to the bottom of the channel to examine the contents of its bed.

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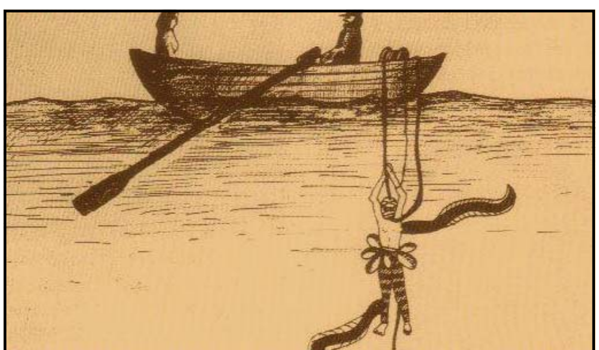

Above: caption: "Thome de Gammond plunging beneath the Channel." On the last of his Channel dives, de Gammond was seriously injured when he was attacked by giant eels. Although de Gamond lived long enough to see his idea for a tunnel adopted, he died in February 1876, just when real progress towards the realization of a tunnel beneath the Channel was being made.

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"…Mr. W. Low had also devoted much attention to this question, and he concluded that the only mode of making a tunnel would be by taking it through the Lower Chalk. With this proposal M. de Gramond subsequently agreed, and he has now abandoned his original scheme in favour of that of the English engineers…"

RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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The Inside Story

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Among the great technical projects of the future, the construction of a tunnel under the English Channel figures as one of the most probable. In fact, it appears so easy that one may even ask why it has not been done. In answer to that question, this inside story will be of interest.
Mechanics and Handicraft, **September 1936**
RE: introduction to an article entitled: "A Tunnel Across the English Channel?"

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The Proposed Channel Tunnel

The "silver streak" of sea which separates us from the Continent has been the source of much trouble and cogitation in the scientific world for many years, and many plans for overcoming the difficulty, and avoiding that bane of the traveler, *mal de mer,* have been suggested from time to time. Besides all kinds of dietetic rules and medicinal prescriptions, and the various modifications of steam vessels, of which the twin-ship *Castalia* and the *Bessemer* swinging-saloon are the latest examples, the idea has long been cherished that Father Neptune might be cheated by other means, and the necessity of a sea voyage altogether dispensed with. One proposal was the erection of a huge and lofty viaduct, another the sinking of metallic watertight tubes which should rest upon the sea bottom; and so late as 1839, M. Thome de Gamond broached the idea of constructing a gigantic breakwater or isthmus of stonework with three navigable channels, bridged over at such a height as to allow of the passage of the largest ships. It was, however, objected to this plan that it would greatly impede the marine traffic, alter the time of high water in some parts of the German Ocean, and would cost about thirty-four millions...
RE: excerpt from a March 27, 1875 article appearing in *The Graphic.* At the time, the *North Sea* was a/k/a as the "German Ocean."

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…In 1851 M. Gamond again reverted to the tunnel scheme, which soon afterwards received the approval of Brunel, Locke, and Robert Stephenson, and the subsequent boring made by Sir J. Hawkshaw, in conjunction with the late Mr. Brassey and Mr. G. Wythes, having confirmed the theory of the geologists that an uninterrupted bed of chalk would be found available throughout the whole of the proposed route, it has now at last been resolved to make an attempt to connect the shores of this country with those of France by means of a submarine railway tunnel. Two companies have been formed, one French and the other English, and the sanction of the Governments of both countries having been obtained, it is proposed to commence experimental borings at once on either side of the Channel. In each case a shaft will be sunk on the coast about 150 yards deep, and from thence an ordinary mining drifting will be driven under the sea for a distance of about half-a-mile. If these experiments succeed, the construction of the tunnel itself will then be immediately undertaken, and unless any unforeseen difficulties are encountered will be completed in about two years, at a cost of about £10,000,000…

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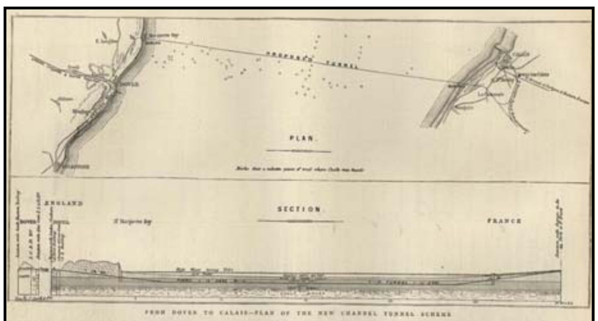

…The proposed route, as will be seen from our sketch, commences at Dover, and running eastward along the coast for about four miles, turns southward beneath the sea at St. Margaret's Bay, and is continued across to a point on the French coast about midway between Calais and Sandgatte, and so onwards until it joins the great railway systems of France at St. Tricat…

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Caption: "From Dover to Calais – Plan of the New Channel Tunnel Scheme"

…The gradients at the shore ends of the tunnel will be 1 in 80, but beneath the water only 1 in 2,640, the lowest point being in the centre of the Straits. The entire length of the tunnel will be 31 miles, and it will be cut at such a depth that at no point will less than 200 feet of solid strata intervene between its roof and the bottom of the sea. A new tunneling machine, the invention of Mr. J.D. Brunton, is to be used both in the experimental borings and in the construction of the tunnel itself. It is worked by compressed air, and while cutting away the rock, also supplies air to the workmen. The scheme is supported by some of the greatest scientific men of the day, among others Sir J. Hawkshaw, Mr. Brunlees, MM. Talabot, Michel Chevalier, and Thome de Gamond, and there is every reason to believe that in a few years the long talked of and long wished for Channel Tunnel will be *un fait accompli*. There are, of course, a number of impracticable people who still shake their heads and say that, even should the tunnel be completed, the passengers will either be choked for lack of air or drowned by a sudden irruption of the ocean, but we think that these secondary difficulties may safely be left to the enterprise and genius of those who have undertaken the great work. To the question of questions – Will it pay? – we think there can be but one answer, for who amongst us having to journey to the Continent would not rather pass half an hour beneath the water in a comfortable saloon carriage, and reach the end of our journey in ordinary health, than brave the dangers of a stormy passage on the surface and land half-dead from the effects of *mal de mer?*

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The English Channel Tunnel

The English Channel Tunnel Company was formed in 1872, at least it was incorporated on the 15th of January in that year. The object of the company is the construction of an underground tunnel beneath the Straits of Dover between England and France. The first important act of the company was the deposit of a bill, of very modest proportions, the preamble of which recites, "that whereas it is expedient, for the proposed carrying out of preliminary experimental operations in connection with the objects aforesaid, the company should be empowered to purchase and take certain lands, houses, and buildings at the foot of the cliff in St. Margaret's Bay, in the parish of St. Margaret-at-Cliffe, in the county of Kent, lying between Ness Point and Coney Burrow Point, and including the beach and foreshore abutting on such lands." The company asked to be empowered by Parliament to purchase the said land compulsorily if necessary. The piece of land thus asked for is of very moderate dimensions, and is to be used for the purpose of putting down trial borings. If these are successful, a shaft is to be sunk and heading driven; as to the further steps to be taken, they remain to be settled…

RE: excerpt from an article appearing in *Scientific American Supplement, No. 8.,* February 19, 1876

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…This bill was deposited long since, but no very energetic action appears to have been taken to get it passed for some time. On the 22d of last March, letters were addressed by the Lords of the Treasury to Mr. Kennedy, Captain Tyler, and Mr. Watson stating that it appeared to be very desirable that before any powers were conferred on the company an understanding should be arrived at, not only with the company itself, but also and primarily with the French Government, on these points, which are of international importance, such, for instance, as the question of the limits of jurisdiction of each country within the tunnel, and the question of closing or otherwise neutralizing it in time of war, or apprehended war. It was accordingly suggested that a small joint commission should be appointed by the two Governments to settle these questions. The French Government deputed MM. Kleitz, Droeling and De Lapparent, while the English Government selected Mr. Kennedy, Captain Tyler, and Mr. Watson to act on their behalf. Apparently without waiting for any definite expression of opinion on the part of the commission, the Board of Trade recommended, on the 1st of July, 1875, that the bill of the Channel Tunnel Company might be allowed to proceed through Parliament without further opposition, provided the company would accept certain clauses limiting the time during which they might retain possession of the land at St. Margaret's Bay, in case the works were not proceeded with. These amendments were accepted, and the bill received the royal assent on the 2d of August, 1875…

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…The English Government from first to last have dealt very cautiously with the whole question, and while they will offer no opposition, they demand in return that they shall be asked by the company for no pecuniary assistance in any shape or way. The French Government, on the contrary, have taken up the scheme warmly, and on the 2d of August 1875, a concession was granted to MM. Michel Chevalier, Fernand Raoul Duval, and Alexandre Lavalley, president and members of a society registered on the 9th of February, 1875, said society having for its object the construction of a tunnel and railway under the Straits of Dover. As the matter stands at present, then, we have two distinct companies – one French and one English – working harmoniously, it is to be presumed, with a common object in view. All this possesses very little engineering interest, but it is well that our readers should understand the precise nature of the agencies now at work…

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…The Blue-book supplies no information whatever as to the steps that have been taken by the companies, and we confess that we have been unable to ascertain that any works are in progress, except the taking of soundings by the French company; possibly in spring some energy will be displayed. The Blue-book does, however, furnish a good deal of information as to the route of the tunnel. St. Margaret's Bay lies a short distance to the north of the South Foreland, and a railway will have to be made from this point, in order to place the tunnel in communication with Dover…

RE: the "Blue-book" referred to was actually entitled "Correspondence with reference to the proposed Construction of a Channel Tunnel, presented to both Houses of Parliament by command of Her Majesty, 1882. Printed at the War Office." It consisted of 368 pages containing correspondence, reports of committees, evidence and opinions of military authorities, prefaced by a summary of eight pages. This summary gave a brief historical account of the proceedings in connection with the Channel Tunnel scheme broken down as follows:

- **First Period - 1867 to 1870**
- **Second Period - 1871 to 1876**
- **Third Period – 1880 to 1882**

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…On the French side the tunnel would terminate about half way between Calais and the village of Sangatte, the route being almost parallel with that of the telegraph cable between Dover and Calais. By a short line the tunnel would be united to the Chemin de fer du Nord, and thus, we may almost say, with the whole railway system of France. The route is very nearly the shortest that could be taken. The total length would be about 48 kilos., or say about 29¾ miles, but the portion of the tunnel under the bed of the Channel would occupy only about 22 miles, the remainder being required to connect surface lines with the tunnel at each end. The depth of the floor of the tunnel below high-water mark is 127.185 metres, or a little over 416 ft. in round numbers. The tunnel is to rise from each end toward the middle at the rate of 0.37 metre per kilometer, and deep sumps are to be made at the bottom of the shafts into which the drainage will flow, and from which it will be pumped. It is assumed that the success or failure of the scheme will depend on whether the grey chalk, through which the tunnel must be driven, is or is not free from faults or fissures, which may admit water from above. But from this conclusion, thus stated, we dissent. If it be intended to convey the impression that the presence of water in great quantities would prevent the formation of a tunnel under any conditions, then the statement is probably erroneous…

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…We have very little doubt that if time and money enough were available, Sir J. Hawkshaw and Mr. Brunlees, the engineers of the undertaking, would contrive under any circumstances to pierce the bottom of the Channel, and leave behind them as they went walls of iron or brick which would defy the sea In this connection, we give two illustrations of the plan for the Channel tunnel, designed by the well-known French engineer, Thome de Gamond. He proposes to erect five air shafts along the line of the tunnel, to be surmounted by great lighthouses. Three of the shafts rise above the surface of the water as shown. The central shaft is also to be provided with a harbor of refuge or dock, for the shelter of tempest-tossed vessels. The central shaft and dock will also be used as a railway passenger-station, for the railway, where passengers arriving and departing by coastwise steamers may leave or take the cars, the shaft being provided with lifts or elevators for that purpose.

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Geologizing

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"SIR JOSEPH PRESTWICH was, at the time of his death, the oldest of British geologists. While his scientific honors were numerous, the formal recognition by his Government of the value of his work, much of which had redounded greatly to the material advantage of England was tardy. It came to him in the form of a complimentary knighthood only on the New Year's day before his death in the following June, when he was not able, on account of feeble health, to accept it in person from her Majesty. Till 1872 Dr. Prestwich curiously combined the two occupations of wine merchant and geologist. His business took him frequently to France, and while there he sought and improved the opportunities he found to make geological studies of the districts he visited; and it is told of him that his friends used to like to go geologizing with him on the other side of the Channel, 'as his walks generally ended in the pleasant chateau of some vine-grower'…"

Popular Science, **December 1897**

RE: excerpt from an article entitled: "Sketch of Joseph Prestwich"

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"…Joseph Prestwich was born in Clapham, England, March 12, 1812, and died in Shoreham, Kent, June 23, 1896. He was taught at London and Paris…He began publishing scientific papers in 1835, when he was about twenty-three years old, his first, on the Ichthyolites of Gamrie, Banffshire, Scotland, having been printed in the Transactions of the Geological Society of that year, and some of his earlier papers on the Coalbrookdale Coal Field being of the same period. Other papers followed in the Quarterly Journal of the Geographical Society on Structure and Organic Remains of the Tertiary Beds of the London and Hampshire Basin, in which many now fully accepted facts of geological sequence and relations were first established. In these researches he paid special attention to the lithological changes of the strata and to the fossils. In consideration of this earlier work he was awarded the Wollaston medal by the Geological Society. Having acquired some familiarity with the geology of France by his former residence as a student and his frequent business there, Mr. Prestwich, in the course of the studies which resulted in the rearrangement of the Tertiary formations, carried his explorations across the Channel to the corresponding formations of France and Belgium, for the purpose of determining the correlation of the strata…"

Popular Science, **December 1897**

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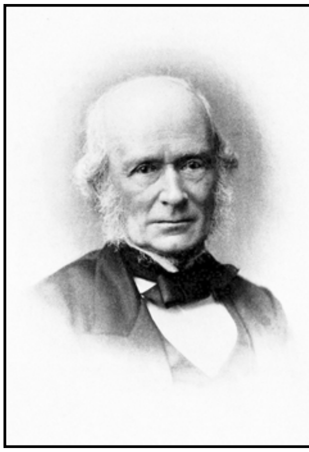

"…As Dr. Prestwich grew older he paid more and more attention to economic geology, and finally became one of the most eminent authorities in that branch…Dr. Prestwich retired from business in 1872, and in 1874 became professor of geology at Oxford. He continued his researches with his accustomed activity, and enriched the literature of geology from year to year with numerous valuable and original contributions, in the form of papers and addresses to learned societies, in connection with which his name constantly appears, and of books which are indispensable to the thorough student of the science…"

Popular Science, **December 1897**

Left: caption: "Sir Joseph Prestwich

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"…An important practical application of Dr. Prestwich's investigations of the geology of the English Channel, not anticipated when they were begun, was illustrated in his report on the subject to the Institution of Civil Engineers, presented in December, 1874. This report was described by 'Nature' as being a most excellent example of the indispensability of thorough scientific research as a basis for the useful arts, and of the way in which the highest practical results unwittingly follow from such investigations - made in abstract inquiry, the only end of which was thorough knowledge of the subject in all its scientific aspects and relations. This study of the strata underlying the Channel - an almost perfect example of close and careful reasoning on physical facts - was now brought forward to enlighten the projectors of a tunnel between England and France as to the nature of the material on which they would have to work; but Dr. Prestwich had distinctly stated that the various formations were considered 'irrespective of their relative merits in any other than a geological point of view.' His plan had been to discuss carefully all the strata underlying the Channel, from the London clay down to the Paleozoic series, and deduce his conclusions as to the fitness of each formation for being pierced by a tunnel. The investigations on which the paper was founded were mostly undertaken from no practical point of view and before a Channel tunnel was thought of…"

Popular Science, **December 1897**

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"…'Nature,' reviewing Professor Prestwich's book on geology in 1886, characterized him as the acknowledged master of British geology, of whom it might be safely affirmed that no living geologist had contributed in a greater degree to the advance of science by his important original researches…Professor Prestwich retired from the professorship at Oxford in 1888, and spent the rest of his life at his country home in Shoreham, working till almost his last day with undiminished activity."

Popular Science, **December 1897**

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The Business of the Engineer

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"In the course of the debate which followed the reading of a paper on the proposed tunnel between England and France, at the Bristol meeting of the British Association, Sir John Hawkshaw made a speech, in which he expressed his perfect confidence in the ultimate success of that great undertaking. 'The question arises,' said he, 'as to the risk in tunneling through the chalk. Of course we cannot measure that risk with any certainty, but we are constantly in the habit of undertaking engineering work which sometimes involves an unknown amount of risk, and it becomes the business of the engineer to encounter these risks'…"
***Popular Science*, February 1876**
RE: excerpt from an article entitled: "Hawkshaw on the Channel Tunnel"

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"…To Sir J. Hawkshaw (the President Elect of the British Association) is due the credit of fully working out and developing the plan of carrying a tunnel through the Chalk. At his request Mr. E.C.H. Lay, in 1864-5, made a detailed geological examination of the coasts, and constructed maps and sections of the strata. Sir J. Hawkshaw, with others, subsequently employed a steamer to take soundings in the Channel along or near to the line of the proposed tunnel, and he also made deep borings through the Chalk on each coast. The results of all these investigations are accessible, and we therefore possess a good deal of information bearing upon the question. The vertical sections (figs. 1 and 2 of Plate CXIV) show the complete successions of strata near each shore, and some attempt has here been made to indicate the characters of the various beds…"
RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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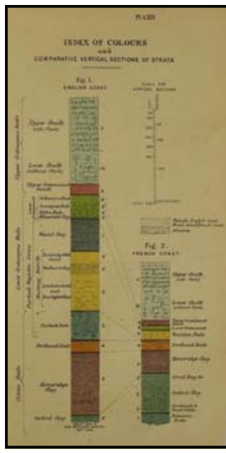

"…Horizontal shading indicates clay or shale, and consequently impervious beds; dots indicate sand, or pervious beds; vertical lines indicate limestones or calcareous beds, which are not usually very pervious in the mass of the beds, but only by reason of the joints or fissures which traverse them. The greatest thickness of the various beds is also shown in figs. 1 and 2; it often happens that the thickness of a bed varies in different places; this is shown in the longitudinal sections (figs. 3 to 6)…"
RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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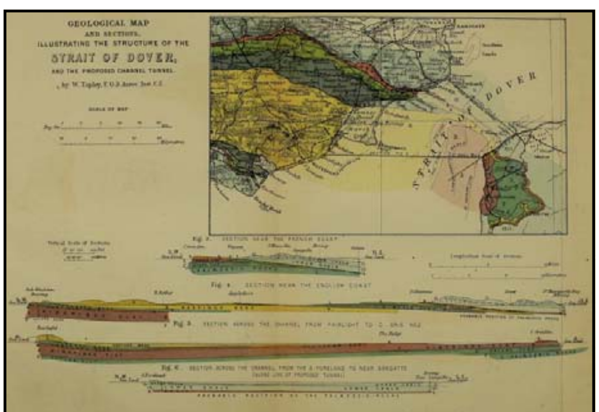

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"…The continuity of a bed on the surface is shown in the map; the continuity below ground, which is of more importance, is shown in the sections. The map and sections, therefore, contain, as well as can be expressed on so small a scale, all the more important geological data which we at present possess for testing any proposed line of tunnel. But it may be necessary to state that the information here given is of very unequal value. The outcrops on the surface are sufficiently exact; the lines of the Chalk, Gault, and Lower Greensand beneath the Channel are probably tolerably near the truth; but the Wealden and Oolitic lines beneath the Channel are wholly conjectural. The evidence upon these points is excessively meagre, and future researches may show that the actual outcrops between Dungeness and C. Grisnez are very different from those here sketched. With the sections the case is different, and I have little doubt that the general geological structure along the various lines is very much as is there shown…"
RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874."

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"…'Prof. Hebert seems to expect that the chalk, although it may be continuous, as we have ascertained it to be, all across the channel, may have such fissures in it that, in constructing the tunnel at the depth we propose to go, it is possible we may cut through the chalk into the green sand. Suppose that were so, it would not deter me from encountering this work'…"
Popular Science, **February 1876**
RE: excerpt from an article entitled: "Hawkshaw on the Channel Tunnel"

49

"…'A great mistake is often made with reference to the percolation of water. Water, though it passes through sand, passes with very slow velocity. I have had to make deep excavations in sand fifty or sixty feet below the level of the sea, and though water comes rather rapidly at first, until it has drawn away a portion of the water which is in the sand adjacent to your work, yet, after that, it comes with extreme slowness. Therefore, I am not afraid of percolation of water in that sense'…"
Popular Science, **February 1876**
RE: excerpt from an article entitled: "Hawkshaw on the Channel Tunnel"

50

"…'With regard to the percolation of water through the solid chalk, that is of no consequence; water passes so slowly through chalk, that it might continue to pass, and nobody would care about it. Of course there is a thing that might occur which would be serious. If you could imagine a clear, open fissure from the bottom of the sea to the tunnel, where water could pass, there is no doubt, with that enormous pressure, it would pass with very great velocity, and would be a very troublesome thing to encounter'…"
Popular Science, **February 1876**
RE: excerpt from an article entitled: "Hawkshaw on the Channel Tunnel"

51

"…'I do not myself believe in there being any such fissure. That is almost the only difficulty which, I think, would hinder this tunnel. I do not mean to say that would stop it, but it is possible, if we met with a thing like that, we should have to have recourse to something else, which I have not yet devised, because I do not expect it.'"
Popular Science, **February 1876**
RE: excerpt from an article entitled: "Hawkshaw on the Channel Tunnel"

52

Path of Least Resistance

53

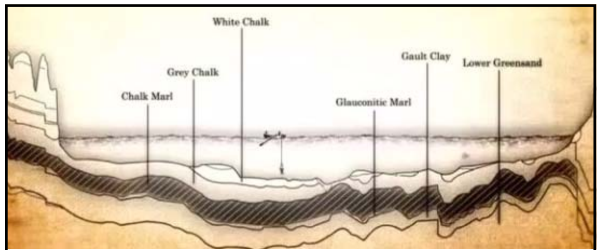
"…For several years it seems to have been generally conceded that the plan with which the names of Sir J. Hawkshaw and Mr. Brunlees are associated - that of taking a tunnel through the Chalk - is the most feasible, and comparatively little attention has been paid to other propositions…"
RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874." ***Sir John Hawkshaw*** **and** ***Sir James Brunlees*****, founders of the original** ***Channel Tunnel Company*** **(1872), proposed a 31-mile-long tunnel between** ***St. Margaret's Bay*** **to a point on the French coast roughly midway between Calais and Sangatte. This alignment was chosen to take the tunnel entirely through the lower chalk, assumed at the time to be homogenous.**

54

"…For the execution of the work, as far as mechanical aid is concerned, there need be no apprehension, there now being ample means in the way of tunnelling machinery, and ample experience in its extensive use. The tunnel will be a single one of circular or of the ordinary tunnel section, the chalk boring being 36 ft. in diameter at the arch springing, and when lined with brickwork in cement it will have an interior diameter of 30 ft…"

The Engineer, **March 1876**

55



"…Briefly reviewing the salient points of our discussion, we remark that, all things considered, the Lower Chalk offers the best chance of constructing a tunnel under the Channel. It is thick, persistent, and, in itself, is practically impervious. It is moreover easily worked, and a tunnel taken through this formation would be shorter than any other. These are points of the greatest importance, and they are sufficient reasons for selecting the Lower Chalk for the work…"

RE: excerpt from: "The Channel Tunnel, by W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England. The Popular Science Review, Vol. XIII, 1874." 56

<u>Above</u>: caption: "Geological Analysis"

<u>Part 2</u>

A Century of Distrust

57

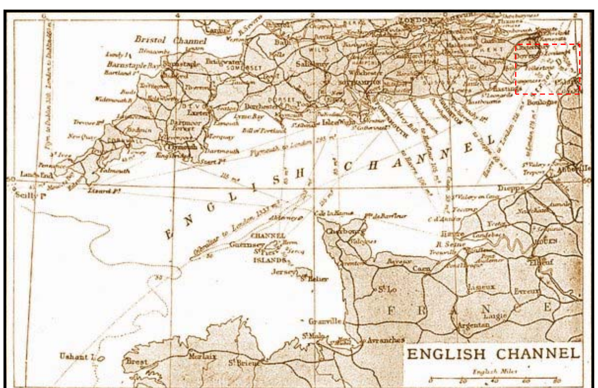
Within Gunshot

58

"DOVER, England, is within gunshot of Calais, France. The German 42-centimeters could drop a shell across the 22 miles of water that intervene. The floor of the Straits of Dover is white chalk, underlaid by a stratum of chalk and clay. Beneath, to a depth of 208 feet, lies a ledge of gray chalk, very solid, of the same general character as that quarried in France for use in making cement. This substance is easy to bore, is self-sustaining, and is practically water-tight…"

Illustrated World, **April 1917**

RE: excerpt from an article entitled: "Tubing the English Channel." By 1906, French engineers had confirmed the report of English engineers regarding the gray chalk through which the channel tunnel would be bored as impermeable to water and deep enough for all tunneling purposes. 59



<u>Above</u>: caption: "Map of English Channel, 1906 60

"…Had it not been for the groundless fears of the suspicious British long ago, this is the course a tube would undoubtedly have taken to join the island to the mainland. Many a time must the minister of munitions, the board controlling transport, and the generals in the field have cursed the spirit that had given England her 'splendid isolation'…"
Illustrated World, **April 1917**

61

62

"A German having been asked lately by an Englishman why it was that his countrymen went on yearly drilling hundreds of thousands of men, who might be so much more usefully and profitably employed, replied: 'You English, with your great wet ditch round you, know nothing of the horrors of invasion; we are well acquainted with them, and having no natural line of defence, like the seas which encompass your shores to protect us from attack, we infinitely prefer submitting even to the tyranny of our military system, to the immeasurable burden of universal service in the army, rather than run the risk of finding an army overrunning our country, and having to undergo the sorrow, the pain, and the public and private humiliation which that would mean; of two evils we choose that which is a flea-bite compared to the killing poison of the cobra.' He went on to say that we English did not understand or appreciate how much we owed to our 'silver streak.'"
Lt. Gen. G.J. Wolseley, **December 1881**

63

"…But for that spirit, a continuous stream of trains and railway carriages, as unbroken as the now famous stream of motor trucks that maintained Verdun in munitions and men, when General Petain for so many weeks resisted the German onslaught, would have borne its tens of thousands of men and its hundreds of thousands of tons of supplies to the Western front; hundreds of vessels would have been released for oversea service, and, best of all, an overwhelming German naval victory would not have meant starvation for England, nor quick dissolution of the armies on the Somme through inability to furnish further men and supplies. England has paid high, and may pay more dearly still for a century of superstitious distrust…"
Illustrated World, **April 1917**

64

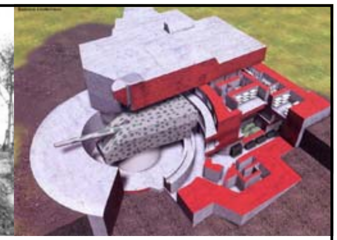
Unternehmen Seelowe

65

"All preparations are to be made to provide strong frontal and flank artillery protection for the transportation and landing of troops in case of a possible crossing from the coastal strip Calais - Cape Gris Nez – Boulogne"
Field Marshall Wilhelm Keitel **(left), Chief of the *Oberkommando der Wehrmacht* (a/k/a "OKW" - Supreme Command of thr German Armed Forces)**
RE: after the fall of France, Calais and vicinity came under the control of an enemy of Great Britain for the first time since the end of the *Napoleonic Wars.* On May 21, 1940, Hitler discussed the possibility of invasion with *Grand Admiral Erich Raeder* and on June 25th, surprised OKW, by ordering preparation for an invasion of the British Isles, which were ready by early July. The plans called for large caliber coastal guns to cover the invasion Force.

66

67



"Strong forces of coastal artillery must command and protect the forward coastal area"

Adolph Hitler, **Chancellor of Germany**

RE: Hitler issued "Fuhrer Directive 16" on July 16, 1940 for "Unternehmen Seelowe" (*Operation Sea Lion*); the invasion of the British Isles. *Organisation Todt* commenced work on the coastal gun emplacements on July 22, 1940. The largest battery included three 40.6 cm SK C/34 (16-inch) guns located between *Pas-de-Calais* and *Cap Blanc Nez*. All gun emplacements would be under the control of the *Kreigsmarine* (German Navy).

68

This battery was begun in June 1941 and completed in 1942. The Germans chose bunker type S-262 for this battery because the RAF would regularly bombard the area. The three bunkers had head cover and the guns (in casements) had only a 120-degree field-of-fire The battery was named after the captain of the Battleship *Bismarck* which was sunk by the *Royal Navy* previous to the completion of the battery. *Batterie Lindemann* was the only *Adolf Guns* battery that was engaged in action during WWII. The guns were fired constantly across the *English Channel* at the Dover area (the British responded with counter-fire). The battery area had been subject to a massive bombardment by the Allies before the D-Day invasion of Normandy on June 6, 1944 (as a diversion to make the Germans believe it would take place at the *Pas de Calais*). The Germans had long believed this to be true, thus the whole area from Calais to Boulogne was heavily fortified with strong coastal defense batteries (Batterie Lindemann had the largest guns). The battery was captured by Canadian forces and destroyed in September 1944.

69

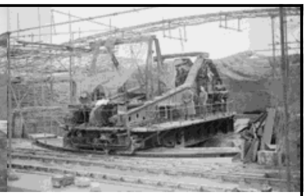
Hellfire Corner

70

On August 12, 1940, shelling from Batterie Lindemann's 16-inch guns commenced, killing a man and woman in Dover. Following this attack, shelling became a frequent occurrence, coming out of nowhere and causing instant death and/or injury. As a result, a special shelling siren was introduced in October 1940. On the evening of Saturday, September 6, 1942, about one-hundred shells were fired at Dover and an armor piecing-type hit Pioneer Road, damaging nearby properties. Loud speakers came into operation on Dover's streets in early October 1942 to warn of imminent danger. Shelling was almost a daily occurrence and on the evening of Thursday, December 10, 1942, one of the many shells was an air-burst-type. This exploded over *Priory Station* and another shell hit 79 Folkestone Road where a *Home Guard* Sergeant-Major was killed. In March 1943, there were reports of mysterious explosions coming from the French coast which led to speculation that a new type of weapon was being introduced. Fear quickly mounted that Dover would be its first target.

71

72

Britain's immediate response to the German invasion threat was to fortify the high ground on either side of the *Port of Dover* with dug-in large caliber guns. The only British cross-Channel guns already in place were "Winnie" (named after *Winston Churchill*) and later (in 1940) "Pooh" (named after the children's storybook character). They were spare BL 14-inch Mk VII (35.6 cm) guns taken from the stock of guns for the Battleship *HMS King George V*.

Left: caption: "'Winnie,' a 14-inch gun at St. Margaret's at Cliff near Dover, March 1941"
Right: caption: "'Pooh' in March 1941"

73

On the night of June 28, 1943, a German convoy was spotted traversing the *Dover Strait* prompting the British 14-inch batteries to open fire. *Batterie Lindemann* retaliated and many shells hit Dover. One shell hit Dover's General Post Office, killing three members of the *Home Guard*. Due to the extensive damage caused by the shelling, Dover was without telephone service for three weeks. This retaliatory action by the Germans of firing on the town was a deliberate ploy in the hope that locals would complain about the British long-range guns attacking the enemy's shipping passing through the *Strait of Dover,* thus making the town a target.

Left: caption: "Post Office, Priory Street, shelled on 28 June 1943 killing Walter Garrett, George Kerry and John Parfitt"

74

In the weeks preceding the D-Day invasion the Germans stepped-up their attacks on Dover, wreaking death and destruction. During the invasion, *Batterie Lindemann* was in full operation, increasing as the allied armies worked their way along the French coast from Normandy (including the launching of flying bombs), shelling Dover, East Kent and Channel shipping. The last flying bomb was launched from Calais on Sept. 1, 1944, but the shelling from the German batteries continued to increase; it was as if the Germans wanted to get rid of all their ammunition before being overrun. Day-after-day, night-after-night, the shelling continued, giving the small town the dubious nickname "Hellfire Corner."

75

Shelling of the town continued and on Tuesday, September 26, 1944, the German bombardment was especially savage - lasting from just after midday until the late afternoon. Over forty-five shells fell on the town and, although many buildings were hit, there were only four casualties. The shelling then stopped and the "All Clear" was sounded. Two hours later, the sirens sounded again and a solitary shell came in at 7:16 pm. This shell hit *Hubbard's Umbrella Shop* on Castle Street, destroying the shop and adjacent premises. Then, four years of a living hell was over and *Batterie Lindemann* fell silent. In the last twenty-six days (from September 1, 1944), five-hundred buildings had been completely destroyed and 1,500 had been seriously damaged.

76

77

Of Moles and Men

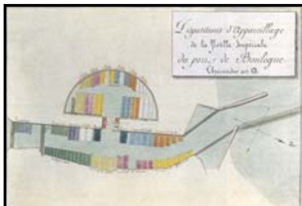
78

"AS long ago as 1802, the mining engineer, Mathieu, approached Napoleon, then First Consul of the French Republic, with the project of building a tunnel beneath the Channel to connect the continent with England. Napoleon at once recognized the enormous possibilities of the scheme and forwarded the plan to Fox, the Foreign Secretary of England. Fox was not opposed to the plan but, before anything could be done about it, war was declared between the nations…"
Mechanics and Handicraft, **September 1936**

79

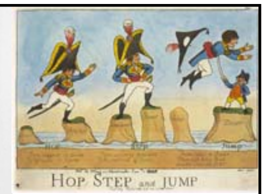
"…As far back as 1802, a French engineer of quick, practical mind and far-seeing imagination, proposed to Napoleon, baffled in his conquest of the world by the Straits of Dover, that his armies enter England not as men, over the water, but as moles, from underground. For a few hours the great leader toyed with the idea, then realizing its impracticability, he dismissed the suggestion and diverted his energies into a great campaign against his enemy, Austria, instead…"
Illustrated World, **April 1917**
FR: the first French "Army of England" gathered on the Channel coast in 1798 (a French attempt to invade had occurred in 1796). However, an invasion of England was sidelined by Napoleon's concentration on his campaign/s in Egypt and against Austria. In 1802, the *Peace of Amiens* shelved plans for a cross-channel invasion. Soon after the outbreak of war in 1803 (and building on planning under France's *Ancien Régime* in 1744, 1759 and 1779), preparations began again in earnest. From 1803 to 1805, a new army of 200K men (a/k/a "Armée des côtes de l'Océan" (Army of the Ocean Coasts) and/or the "Armée d'Angleterre" (Army of England), was gathered and trained at camps at Boulogne, Bruges and Montreuil. A large "National Flotilla" of invasion barges was built in Channel ports along the coasts of France and the Netherlands. For his planned subsidiary invasion of Ireland, in 1803 Napoleon had formed an "Irish Legion" (to form an indigenous part of his 20K-man "Corps d'Irelande"). In 1805, invasion plans were called-off (*<u>before</u>* the *Battle of Trafalgar,* not *<u>after</u>*, as is commonly believed).

80



<u>Above</u>: caption: "Inspecting the Troops at Boulogne, 15 August 1804"
<u>Upper Left</u>: caption: "Disposition of the French flotilla"
<u>Lower Left</u>: caption: "Caricature mocking the fragile landing rafts"

81

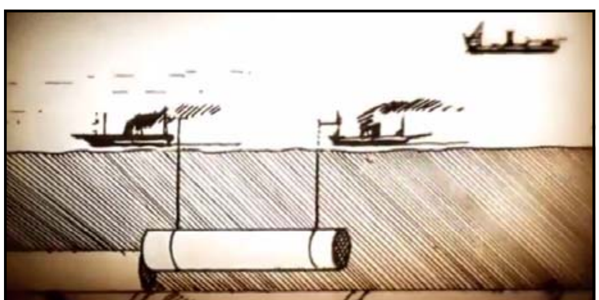


<u>Above</u>: caption: "John Bull vanquishing Napoleon"
<u>Left</u>: caption: "John Bull, a national personification of England, holds the head of Napoleon Bonaparte after a conjectured French invasion, 1803"

82

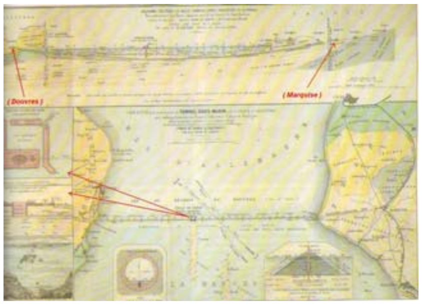
Over or Under

83



"…Thirty-five years later, another French engineer, Thome de Gamond, resurrected the scheme. This time there was a definite plan for the construction of the gigantic tube. De Gamond planned the construction of a tunnel embodying a series of iron tubes, placed end to end, and running through several concrete islands planted in the Channel. In addition he had a diagram, showing how fresh air could be supplied constantly to the tube by pumping stations…"
Mechanics and Handicraft, **September 1936**
<u>Above</u>: caption: "Thome de Gamond's presetting method"

84



Caption: "The Plans of Thomé de Gamond"

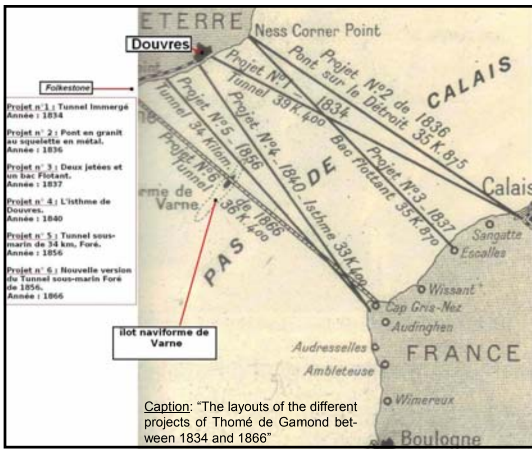
85

"…The years went by and then the restless French mind in the person of Thome de Gamond, also an engineer, proposed in 1834, that a great tube of sheet iron be sunk to the bottom of the sea, as a highway for men on horseback, and men in wagons, between the two countries. As alternatives he offered a bridge to cost $80,000,000 - doubtless a chimera - and the more practical idea of two riprap jetties, each five miles long, with ferry boats operating between, and a continuous causeway, broken for sea commerce, by three drawbridges…"

***Illustrated World,* April 1917**

Above (top-to-bottom): caption: "Draft 1834 'Tunnel resting on the sea floor' / Draft 1836 'Bridge on the Strait' / Project of 1837 'Floating tank between two dikes' / Project of 1840 'Isthmus of Dover connecting the Two Territories'"

86

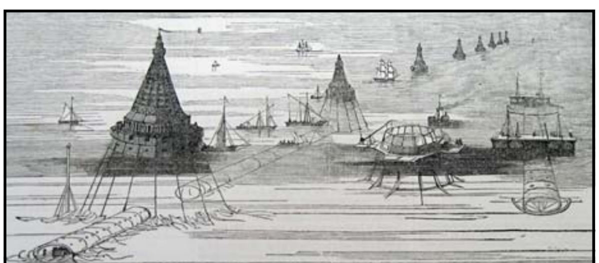


Caption: "The layouts of the different projects of Thomé de Gamond between 1834 and 1866"

87

Consummating the Union

88

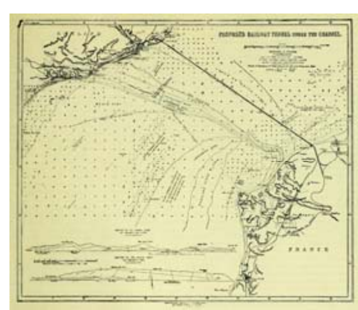


The Submarine Railway

The communication between England and France, which is daily becoming a more and more important object, has just received a most valuable acquisition in the laying of the submarine Electric Telegraph. To consummate the international union, however, means of conveyance between the opposite shores, so as to avoid the perils and uncertainties of passage by sea, remain to be provided. M. Horeau's project consists in crossing the English Channel, twenty-one miles in extent, by means of a tube tunnel, made of iron, lined and prepared for that purpose; and which, besides the path for the surveyors, contains two lines for trains. The slope would admit of a motion sufficiently powerful to enable the carriages to cross without a steam engine. These tunnels would not prevent navigation: lighthouses might be erected at the entrances; also between the lighthouses of France and England. The probable cost would be about £87,400,000.

89

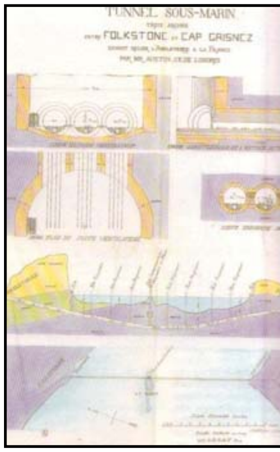
Above: illustrated newspaper article ca. 1851 concerning proposed Channel Tunnel



90

The Real Solution

91



"…Lastly, in 1856, the tunnel scheme was eagerly advanced by him as the real solution of quickening traffic between the two nations. The invention of the steam locomotive stimulated interest in the value of the idea…"

Illustrated World, **April 1917**

Left: in April 1855, engineer *William Austin* proposed a scheme composed of three contiguous tunnels, each with a pair of railway tracks. The first tunnel would be for express trains, the second for regular service and the third for freight. To consolidate the walls of his bored tunnel (and to save time), he suggested replacing the bricks with blocks of agglomerated concrete.

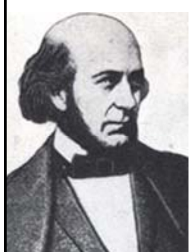
92

"…Later in the century de Gamond succeeded in interesting the French emperor, Napoleon III - always the first to endorse a fantastic and nebulous idea - in the plan. De Gamond was referred to Queen Victoria and, during the 1867 Paris World Exhibition, the undertaking was introduced to the public…"

Mechanics and Handicraft, **September 1936**

Above: caption: "Official bird's-eye view of Exposition Universelle of 1867"

93



"…Here de Gamond joined the British engineer William Lowe, who had also been perfecting plans for a Channel tunnel. Within a short time their plans, besides receiving the approval of Emperor Napoleon, were adopted by an international committee, which then set out to obtain governmental funds with which to build an experimental drift. The French Ministry of Public Works reported favorably on the scheme, but the Franco-Prussian War in 1870 temporarily terminated such plans…"

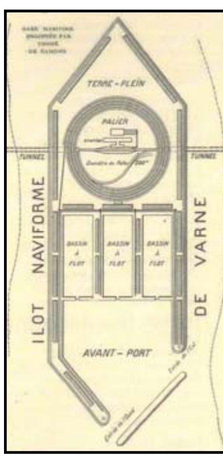
Mechanics and Handicraft, **September 1936**

Left: caption: "Thome de Gamond, who fought for an English Channel tunnel in 1867"

94

Hurry Up and Wait

95



"…Ten more years went by. Then in 1866 de Gamond offered an artificial island in mid-channel, with a shaft for entrance to the tube at that point. Experts pointed out the vulnerability of the island if attacked by a hostile fleet, and de Gamond then omitted this feature from his plan. By 1869 interest in the idea had so waxed that a joint Anglo-French committee was appointed seriously to consider the plan and to make a detailed report on its findings…"

Illustrated World, **April 1917**

Left: caption: "The ventilation islands have been abandoned in favor of an extension of the one built above the bank of Varne. becomes a real port, with wharves and piers. A huge well in the center of the island, with a spiral ramp, allows trains to access the open air."

96

Economies-of-Scale

97

"…Efficiency experts were not altogether unknown in those days, for it was estimated that if $40,000,000 were spent to put through the project, a revenue of $10,000 would be derived over operating expenses. This, in a day when $3,000,000 per mile is expended by a railway in straightening its line and when more than this sum is appropriated for the construction of a railway station, does not seem like a huge figure…"
Illustrated World, **April 1917**

98

"…The advantages of a tunnel beneath the Channel are obvious. By such means uninterrupted contact between Britain and the Continent could be maintained. Goods would no longer have to be taken from French trains, placed on boats and again unloaded upon reaching a port in England. Much strategic importance, also, has been placed upon such a Channel tunnel…"
Mechanics and Handicraft, **September 1936**
Above: caption: "Dover Harbour Entrance, ca. 1836"

99

Harbour of Refuge

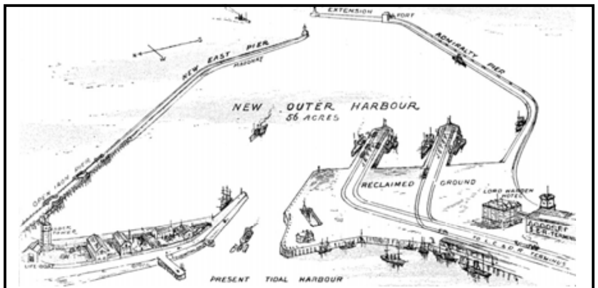
100

"Dover, situated to a distance of only four miles and a half from the Goodwin Sands, and standing out favourably to protect the navigation of the narrow seas is naturally the situation for a squadron of ships of war. Its value in a military point of view is undoubted; but the construction of a harbour of refuge, there is, in our opinion, indispensable, to give Dover that efficiency as a naval station which is necessary to provide for the security of this part of the coast and the protection of trade.' The report finished by saying that there should be an 'Immediate commencement of the construction of a great National Harbour at Dover.'"
RE: *Commission of Inquiry* report, November 13, 1846
RE: it was through the *English Channel* that much of the commercial traffic into and out of Great Britain passed. In the days of sailing ships, this depended entirely on the wind and weather and therefore, a "harbor of refuge" was needed for ships to seek shelter during storms. By the 1830s, Britain had about 24,500 ships employing 250K men.

101

On August 7, 1844, a Commission looking into the need for more "Harbours of Refuge" published its report recommending that Dover should be a combined *Harbour of Refuge* and naval base. It was recommended that the harbor should be formed by a curved breakwater enclosing an area of 500 acres. The cost was estimated to be £1.5 million and it would take 15-years to construct. In France, the reaction was one of outrage as they perceived the proposal to be a military threat and immediately began planning similar works along the French side of the Channel. After delays, in 1847 approval was given for four large harbours of refuge at Holyhead, Portland, Alderney and Dover. It was estimated that the works would cost, in total, £2,250,000.
Left: caption: "Harbour of Refuge proposal 1844 from Rawlinson Sanitary Map of 1846"

102



Caption: "New Harbour at Dover. There will be a new pier, starting from an open iron viaduct. 1260 ft. long, forming an agreeable marine promenade, which will be approached from the esplanade near the Granville Clock-tower. This involves the removal and rebuilding of the clock-tower. The solid pier, at the end of the iron viaduct, will be of concrete blocks faced with granite, equal in height to the Admiralty Pier, and 1500 ft. in length; its direction at first will be south-easterly, but its outer portion will curve to the south-south-west, approaching the end of the Admiralty Pier, to which an extension of 580 ft. will be added. This will leave an opening, 430 ft. wide, for the entrance to the harbour. The space of water thus enclosed will be fifty-six acres, after deducting the reclamation of five acres in front of the Lord Warden Hotel, with the construction there of two jetties, each 400 ft. long and 100 ft. wide, and of landing-stages for steam-boat passengers at low tide, at a covered station of the London, Chatham, and Dover and South-Eastern Railways. The existing tidal harbour will remain, for the present.
(*Illustrated London News,* July 22,1893)

103

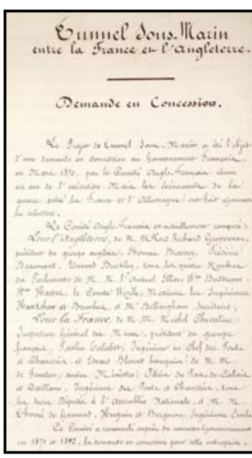
Above: caption: "Dover Harbour, late 19th century"

104

105

Shore-to-Shore

106


Tunnel Sous-Marin
entre la France et l'Angleterre.
Demande en Concession.

"…Neither were the projectors of the enterprise scared by the cost. In both nations, companies were organized by law. It was agreed that the British corporation was to complete its half while the French were similarly engaged upon the Continental side. The outlook for the project looked bright. Six hundred thousand dollars actually was spent in boring a tunnel from either shore.…"
***Illustrated World*, April 1917**
Left: caption: "Handwritten text entitled: 'Submarine tunnel between France and England. Application in Concession.'" (1870)

107


"…On the English side, all did not go so smoothly. Permission was obtained to begin work near St. Margaret's Bay, east of Dover. The British company then passed through a series of receiverships until, in 1881, it was controlled by the South Eastern Railway company. Preliminary borings were then begun, which demonstrated the practicality of the plan. In all, three trial tunnel shafts were built…"
***Mechanics and Handicraft*, September 1936**
Left: caption: "Shakespeare Cliff, Dover, England"
Right: caption: "A photograph of the Shakespeare Cliff near Dover, today. From this point, in the year 1882, a tunnel to France was started."

108

The first proposal for a railway between Dover and London was made in May 1834. On June 21, 1836, a *Parliamentary Act* was passed incorporating the *South Eastern & Dover Railway,* which soon became the *<u>Sou</u>th <u>E</u>astern <u>R</u>ailway* (SER). The new company would construct the line from London to Dover. By the end of June 1843, the line had reached the outskirts of Folkestone. The route between Folkestone and Dover took the line between the cliffs and the sea, presenting several engineering challenges. One of the major obstacles was *Round Down Cliff* (it was dynamited). Four tunnels would be required:

- ***Martello Tunnel* (530 yards – at the western end);**
- ***Abbot's Cliff Tunnel* (1 mile 182 yards);**
- ***Shakespeare Cliff Tunnel* (1,392 yards);**
- ***Arch Cliff Tunnel* (50 yards – opened in 1927 – at the eastern end, near Dover).**

On Jan. 27, 1844, the SER finally reached Dover and on February 7th, train service began with six trains per day in each direction. The SER bought Folkestone Harbor and turned it into their port-of-choice for cross-channel ferries.

109


DOWN TRAINS FROM LONDON.

8 a.m. 1st and 2nd class.	9 30 a.m. 1st, 2d, and 3rd class.	11 30 a.m. 1st and 2d class.	1 30 p.m. 1st, 2d, and 3rd class.	4 p.m. 1st and 2nd class.	5 30 p.m. 1st, 2d, and 3rd class.	7 30 p.m. 1st, 2d, and 3rd class to Tunbridge.

DOWN SUNDAY TRAINS.

9 30 a.m. 1st 2nd, and 3rd class.	1 30 p.m. 1st, 2nd, and 3rd class.	5 p.m. 1st, 2nd, and 3rd class.

UP TRAINS FROM DOVER.

7 40 a.m. 1st, 2d, and 3d class from Maidstone.	6 45 a.m. 1st, 2d, and 3d class.	9 a.m. 1st and 2d class	11 a.m 1st, 2d, and 3d class.	1 p.m. 1st and 2d class.	3 p.m. 1st, 2d, and 3d class.	6 15 p.m. 1st and 2d class

UP SUNDAY TRAINS.

9 30 a.m. 1st, 2d, and 3d class.	12 30 p.m. 1st, 2d, and 3d class.	4 30 p.m. 1st, 2d, and 3d class.

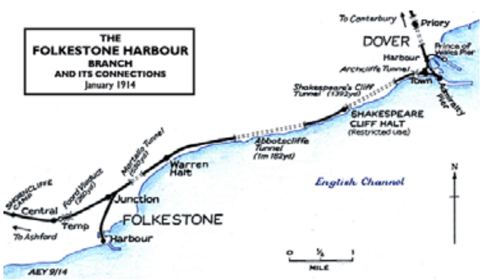
Bills, with full particulars, may be had at all the stations.

By order of the Board,
JOHN WHITEHEAD, Secretary.

February 3, 1844.

<u>Upper Left</u>: caption: "Round Down Cliff prior to being blown up on 26 January 1843"
<u>Upper Right</u>: caption: "Train running alongside Shakespeare Beach, ca. 1840"
<u>Left</u>: caption: "South Eastern Railway Company Timetable for Dover – February 1844"

110



111

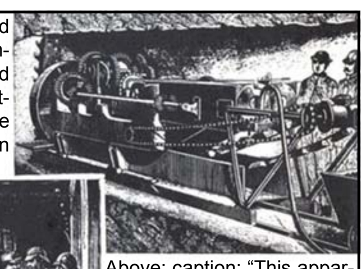
<u>Left</u>: caption: "The Channel Tunnel work site ca. 1882 - seen from Shakespeare Cliff. The shaft head frame between the two buildings is in the centre. Channel Tunnel siding terminates alongside the frame. In the foreground two workers' cottages and a bungalow are seen. These were built by the South Eastern Railway following the construction of the Folkestone to Dover railway line which opened on 27 January 1844."
<u>Right</u>: caption: "The Channel Tunnel work site at Shakespeare Cliff looking west from the bottom of Akers steps ca.1882. Akers steps was a steep zig-zag path with 333 steps cut into the cliff face during the construction of the Folkestone - Dover line and, until Shakespeare Halt was built, was the only means of getting to the site other than by walking through the main line tunnel. Wash hanging on the line confirms the cottages were occupied at this time."

112

"…With the Franco-Prussian war over, the British and French governments again resumed their discussion, and reached an agreement over such questions as the legal jurisdiction over the tunnel. There were then two companies; the Channel Tunnel Company - a British firm - and the French Submarine Company. In 1875, both companies received permission to do preliminary work. Work was begun on the French side, in the vicinity of Calais, at the small village of Sangatte. Here a shaft was dug as deep as the actual tunnel would be, and a tunnel section of miles was constructed…"
***Mechanics and Handicraft,* September 1936**
RE: the first serious attempt to build a tunnel came with an *Act of Parliament* in 1875 authorizing the *Channel Tunnel Company Ltd.* to start preliminary trials and an Anglo-French protocol was established in 1876 for a railway tunnel under the Channel. *South Eastern Railway* and *Suez Canal* contractor *Alexandre Lavalley* conducted exploratory works on either side of the Channel. By 1877, several shafts had been sunk to a depth of 330-feet at the village of Sangatte (France), but initial work carried out at *St. Margaret's Bay* (east of Dover) had to be abandoned due to flooding.

113

<u>Below</u>: caption: "An old print showing forty members of government and newspaper men breakfasting in the shaft of the English Channel tunnel on Feb. 18, 1882"



<u>Above</u>: caption: "This apparatus drilled and cut 1½ miles of the Channel tunnel during the year 1882-83"

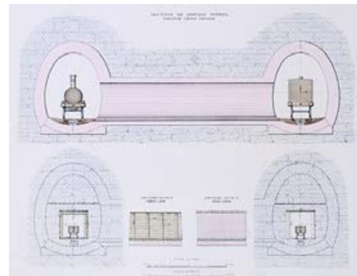
114

In 1880, under the direction of *Sir Edward Watkin,* Chairman of the *South Eastern Railway,* a new shaft (No. 1) was sunk at *Abbot's Cliff* (between Dover and Folkestone) with a horizontal gallery being driven along the cliff (10-feet above the high-water mark). This seven-foot diameter pilot tunnel was eventually to be enlarged to accommodate standard gauge railway tracks, with a connection to the *South Eastern Railway*.

Left: inscription by miner *William Sharp,* recording the start of tunneling

Right: the 7-foot diameter pilot tunnel (dewatered in 1988)

115



Caption: "Double Tunnel Drawings for Watkin tunnel"

116

"…Half a mile of heading has been driven, by machinery, from this point; after which the works were suspended to enable them to be resumed at a point nearer to Shakespeare's Cliff, where the tunnel passes under the sea. The shaft at this point is 100 feet deep. It is sunk close to the western end of Shakespeare's Cliff. The shaft passes through about 40 feet of overlying debris; it then just touches the white chalk, which is pervious to water, after which it goes down to the beginning of the tunnel, which is here 100 feet below the surface of the sea…"

***Scientific American,* April 22, 1882**

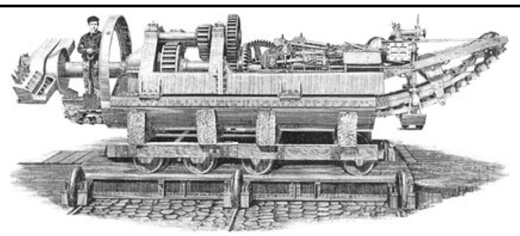
RE: after Welsh miners had bored 800-feet of tunnel and the rotary-boring machine proven, in February 1881 a 160-foot-deep second shaft (No. 2) was sunk further along the coast, at *Shakespeare Cliff*. This tunnel was begun under the foreshore, progressing through lower grey chalk towards a meeting mid-channel with the French pilot tunnel, which extended from Sangatte eleven miles out to sea. The *Channel Tunnel Co.* expected the pilot tunnel to be completed by 1886.

117

"…The shaft is sunk in the chalk cliff at the foot of the Shakespeare Cliff, between Folkestone and Dover, and is about one hundred and sixty feet in depth. The opening is circular, with boarded sides, and the descending apparatus is worked by a steam engine. At the bottom is a square chamber dug in the chalk, the sides of which are protected by heavy beams; and in front is the experimental boring, a low roofed circular tunnel, about seven feet in diameter, the floor of which is laid with a double line of tram rails. This tunnel is admirably ventilated, and on visiting days is lighted with electric lamps, the steam power at the mouth of the shaft being sufficient for all purposes. The stratum through which the experimental borings have been made is the lower grey chalk. This material, while perfectly dry, and very easily worked, is sufficiently hard to dispel any apprehensions of crumbling or falling in…"

***Illustrated London News,* March 4, 1882**

118



Both tunnels were to be dug using a compressed-air boring machine invented and built by *Colonel Fredrick Beaumont,* MP. Beaumont had been involved with the *Channel Tunnel Co.* since 1874 and had successfully bored a number of tunnels without the use of explosives (and 3.5x faster than manual labor). However, it was not Beaumont's boring machine that would be used. In 1880, *Captain Thomas English,* of Dartford, Kent, patented a superior 33-foot-long rotary-boring machine. Powered by compressed air, it was capable of cutting 5/16-inch for every rotation of its cutting-head, at a rate of two-rpm (about half-a-mile per month). Thus, it was this machine - not Beaumont's, that was used on the first attempt at tunneling under the *English Channel.* In *The Engineer* magazine, the tunnel was credited to Beaumont and, despite letters of protest from Capt. English, the editor of the prestigious magazine refused to correct the mistake (Beaumont did nothing to help clarify the situation).

Above: caption: "The Beaumont-English Tunnel Boring Machine Used in the Experimental Headings"

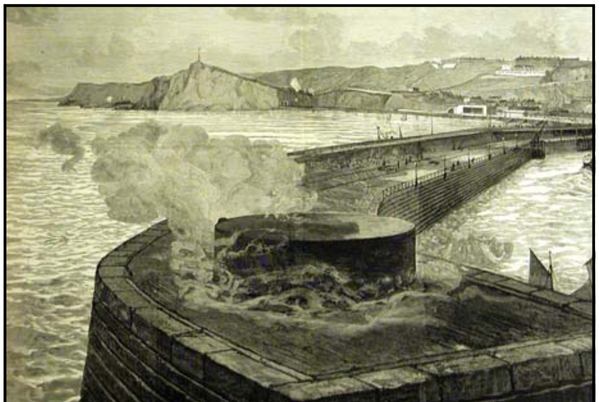
119

"…A heading, now three-quarters of a mile long, has been driven in the direction of the head of the Admiralty Pier, entirely in the gray chalk, near its base, and a few feet above the impermeable strata formed by the gault clay…"

***Scientific American,* April 22, 1882**

Above: caption: "Admiralty Pier – Turret to right of lighthouse"

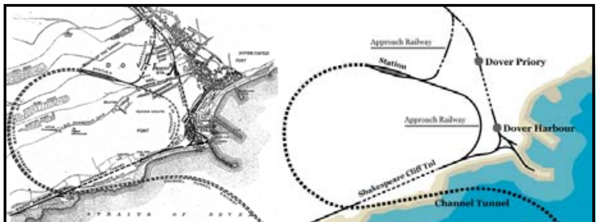
120



<u>Above</u>: caption: "The Channel Tunnel at Dover, view from the Admiralty Pier, showing how the tunnel is defended by existing works" 121

"…The idea of the projectors is so to localize the tunnel, not only in the part already made, but also when it passes out under the sea, that it shall have the body of the gray chalk above it, and that of the gault clay below it, both these strata being in themselves impervious to water, and both alike having heavily watered strata on each side of them; namely, the white chalk above the gray chalk, and the lower greensand below the gault clay. This condition, together with that of providing sufficient roof between the top of the tunnel and the sea, which roof has a thickness of 150 feet, will necessitate the tunnel being turned in a curved line…"
***Scientific American,* April 22, 1882**
RE: the approach railways would fall on a gradient of 1:80 before reaching a depth of 150-feet below the seabed. Operational ventilation would be provided by the compressed-air locomotives used to haul the trains.

122



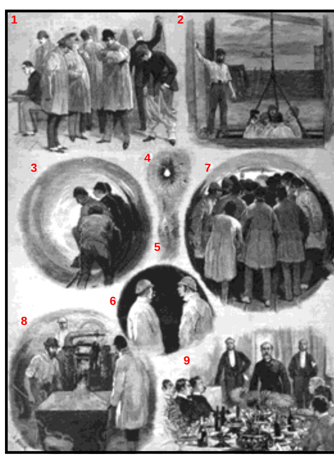
"The length of the Submarine Continental Railway Company's Tunnel, under sea, from the English to the French shore, will be twenty-two miles; and, taking the shore approaches at four miles on each side, there will be a total length of thirty miles of tunneling. The approach tunnel descends from the daylight surface by an enclosed gallery, with an incline of 1 in 80, toward Dover, to a point on the Southern Railway Company's line, about two miles and a half from Folkestone. The exact point is at the western end of the Abbot's Cliff tunnel, at which point the gault clay outcrops to the sea level…"
***Scientific American,* April 22, 1882** 123
<u>Above L&R</u>: caption: "Proposed route of the tunnel"

By 1882, 2,040 yards of the *Shakespeare Cliff* heading was driven, 897 yards at *Abbot's Cliff* and 1,825 yards on the French side. *Sir Edward Watkin* applied to the government for additional funding to complete the eleven-mile section to meet the French mid-channel. However, these funds were not forthcoming thus, Watkin formed a new company: *The Submarine Continental Railway Company.* In 1882, the newly formed company took over the shafts and headings from the *South Eastern Railway* and prepared a new bill to put before Parliament. However, by then the British Government was increasingly anxious about the military implications of a physical link to Europe.

124

"No matter what fortifications and defences were built, there would always be the peril of some continental army seizing the tunnel exit by surprise"
Lt. General Sir Garnet Wolseley
RE: excerpt from his *Military Commission* testimony. Defensive measures against invasion by way of the Channel Tunnel included flooding the tunnel, cutting-off the ventilation and forcing smoke into the tunnel and cutting the cables on the lifts in the shaft, thereby trapping any invader at the bottom. Despite Sir Edward Watkin's assurances, the Commission was not convinced. The *Anglo-French Tunnel Treaty,* which had been warmly received just a few years earlier, was now looked on with suspicion by Parliament and the public-at-large who still had a lingering mistrust of their ancient adversary - the French, whose political instability, at the time, didn't help the situation.

125



To counter the apprehensions, *Sir Edward Watkin* conducted a series of publicized tours of the tunnel, inviting prominent personages (i.e. the *Lord Mayor of London*). The tour/s culminated in a luncheon held in a chamber cut into the side of the heading. One such tour was featured in the March 4, 1882 edition of the *Illustrated London News*.

1. The Mouth of the Tunnel: "Hope the Rope Won't Break"
2. On the Tramway
3. We Pass the Region of Electric Lights
4. And Reach that of Tallow Candles

5/6."I say, Dear Chappie; If We Invade France Through the Tunnel, I hope I Shan't Be Told Off to Lead the Advanced Guard"

7. A Lecture at the End of the Tunnel
8. The Boring Machinery at Work
9. Proposing the Queen's Health

RE: key to illustrations depicting a visit to the tunnel works on the English side by dignitaries 126

IN THE TUNNEL.

127

The English End

128

“The London ‘Telegraph’ gives the following graphic description of a visit to the English end of the tunnel which is eventually to become the submarine road to the Continent; for we cannot believe the present British opposition to the great engineering scheme is anything more than one of the transient ‘scares’ concerning the risk of invasion, which occasionally seize John Bull…”
The Popular Science News, September 1, 1883

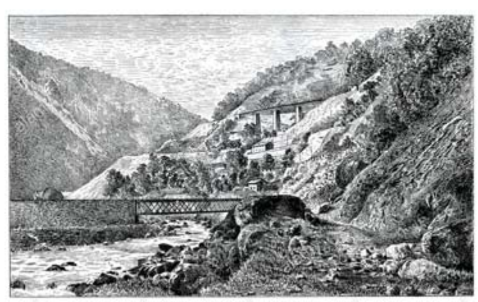
129

“…A tall shaft, a steam-engine, an air-locomotive, and a couple of wooden shanties mark the spot destined, it may be, to abut upon the mouth of the Channel tunnel, or rather of a channel tunnel; for there are other schemes afoot to join London and the extremist point of the continent of Europe in a continuous railway journey, and without change of carriages…”
The Popular Science News, September 1, 1883

130

“…Sir Edward Watkin airily calculates that the cost of the enterprise in which he is interested would amount to three millions sterling, and that the tunnel would allow the passage of two hundred and fifty trains each way every day, at an average speed of forty-five miles an hour; so that the tunnel, of twenty-two miles in length, might be traversed in half an hour, a speed, be it said, very much higher than that kept up in the longest tunnels of the St. Gothard between Switzerland and Italy…”
The Popular Science News, September 1, 1883

131



St. Gotthard Tunnel—The Three Levels near Biasca.

132

"…At the bottom of the shaft at the mouth of the boring, no more than seven feet in diameter from end-to-end, excepting here and there a somewhat wider square opening, technically called 'a turnout,' we found a couple of trollies, fitted with seats on either side, after the manner of tram-cars of the military train familiar to the 'habitues' of Wimbeldon camp. Running along the sides of the trolley, close to the ground, was a footboard like that attached to a railway-carriage; and above the seat was a semi-circular hood, lined with red baize, sufficient to protect the head and shoulders from dripping wet, or particles of falling debris, but not wide enough to save the legs and feet…"
The Popular Science News, September 1, 1883

133

"…By reason of the space taken up in the lower arc of the circle, so as to make a level floor, along which the rails were laid, it was necessary that we should sit with legs drawn up, and heads bent, during the whole time occupied in journeying to the face of the tunnel, and back again…"
The Popular Science News, September 1, 1883

134

"…A Rembrandt or a Salvator Ross might have done pictorial justice to such a scene. Under foot, for a great portion of the way, the ground is almost ankle deep in slush; and the stalwart fellows who drag and push the trollies, trudging manfully along, have enough to do to keep their foothold. The travelers, for the greater length of time moving through a dim twilight, cannot well make out the features, even of those who sit beside them. Now and again the little electric lamps, set in rude niches of the naked gray chalk, cast a brilliant but fugitive light on the passing train; then, for a while, all is again but darkness visible…"
The Popular Science News,
September 1, 1883

135

"…There are shadows above and beneath and all around. Looking backward or forward through the deepening gloom, the traveler sees an ever receding, seemingly endless funnel-shaped perspective, lit at long intervals as with fiery eyes. Onward and yet onward - to no sound wave the splashing made by the tall workmen tramping through mud, and the drip, drip, of the water upon the hood above our heads - we are dragged and pushed beneath the shingle and the sand of the shore, for a time level with the beach, and then down a quarter of a mile deep, past low-water mark, under the bed of the Channel…"
The Popular Science News, September 1, 1883

136

"…The bore has cut clean through the gray chalk in a circle as round and true as the inside of a wedding-ring. So thoroughly, indeed, is the instrument adapted to the work and to the material, that, in dry places, it is possible to see the chisel-marks made a couple of years ago. At intervals along the route, where it is feared the water might come through, the sides and roof have been packed with lead or clay, and held up with solid iron bands apparently about eighteen inches wide…"
The Popular Science News, September 1, 1883

137

"…Sometimes, in the fitful flashes of light, the eye rests upon falling red rivulets, like streams of blood, pouring down the damp walls. Ever and anon there are 'faults' in the clayey chalk not yet remedied. So we go on and on, moments seeming as minutes, until the electric lamps cease altogether, and the long, awful cave is enveloped in darkness which would be impenetrable, but for the glimmer of a few tallow candles stuck into the bare walls of the cutting. Even a mile and more from the mouth of the shaft, it is not difficult to breathe; for the same machine which works the bore-pumps drives a continuous supply of fresh air into the seven-foot pipe, which at present forms no more than the nucleus of a tunnel…"
The Popular Science News, September 1, 1883

138

"…At a distance of twenty-three hundred yards from the pit-mouth, we come upon the simple and wonderful piece of machinery, which can pierce through the bed of the sea with extraordinary celerity, and at a cost cheaper than is required for the making of an ordinary tunnel under a hill. By permission of the president of the Board of Trade, the engineer is allowed to make a couple of turns in order to show our party the method of its working…"
***The Popular Science News,* September 1, 1883**

139

EXAMINING THE BORING MACHINE.

140

"…Presently we remount our not too comfortable carriage, and pass, stooping, once more, along the fearsome, narrow way, pass by spaces of horrible shadows, and glimpses of welcome light; and finally we are swung up through the shaft into the outer air, where the glad sunshine catches the tall cliff's face, and bathes the smiling and yet unbetrayed Channel in an atmosphere of golden glory."
***The Popular Science News,* September 1, 1883**

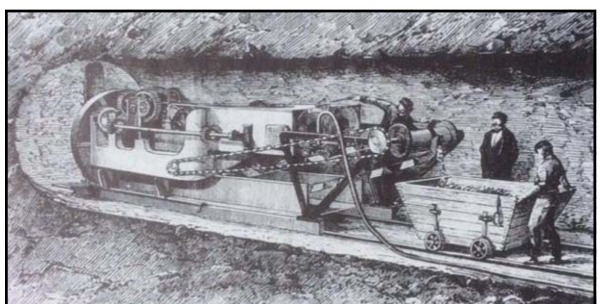
141

The Great Bore

142

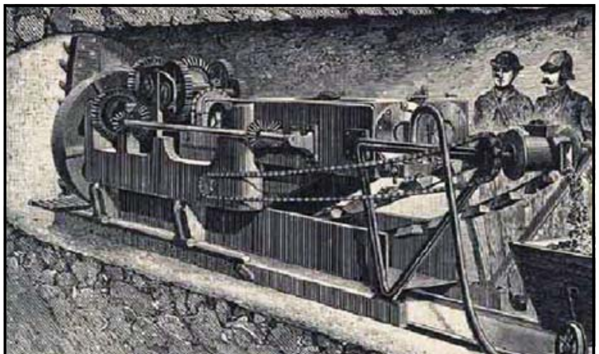
"…The present heading is 7 feet in diameter. Machinery is being constructed by which this 7 foot hole can be enlarged to 14 feet, by cutting an annular space, 3 feet 6 inches wide, around it. This will be done by machinery similar to that already described, but furnished with an upper bore head, suitable for dealing with chalk, to make an annular cutting, instead of acting like the first machine, which makes the 7 foot cutting…"
***Scientific American,* April 22, 1882**
RE: boring machinery was being developed which would have enlarged the heading from 7-feet to 14-feet in diameter, allowing for a 2-foot thick concrete lining to be inserted

143



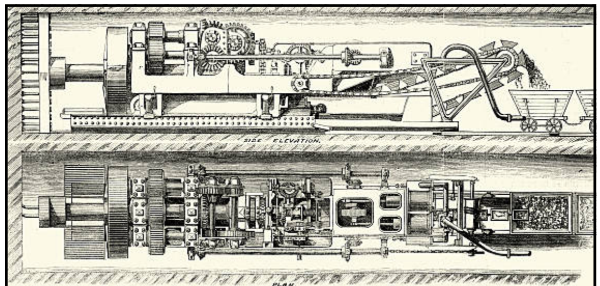
"…The one machine will follow the other, at a proper interval; and the debris from the cutting by the first will be passed out through the second machine. The compressed air, likewise, which is necessary to work the advanced machine, will be similarly passed through the machine coming behind…"
***Scientific American,* April 22, 1882**
Above: caption: "The Beaumont-English boring machine, 1880"

144



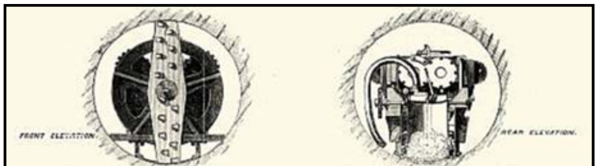
"…There will be no difficulty in speeding the machines so that they shall work along the tunnel at the same rate of progress; and the larger machine can, as well as the smaller one, do its work with a minimum of manual labor; only two men are at present needed for each machine…"
Scientific American, **April 22, 1882**

145



"…The engraving shows the Beaumont & English compressed-air boring machine at work. The length of this machine from the borer to the tail end is about 33 feet. Its work is done by the cutting action of short steel cutters fixed in two revolving arms, seven cutters in each, the upper portion of the frame in which the borer is fixed moving forward five-sixteenths of an inch with every complete revolution of the cutters. In this way a thin paring from the whole face of the chalk in front is cut away with every turn of the borer…"
Scientific American, **April 22, 1882**
Above: caption: "Beaumont and English's Compressed-Air Tunneling Machine"

146



"…A circular tunnel is formed having a diameter of 7 feet. A man in front shovels the crumbled debris into small buckets, which, traveling on an endless band, shoot the dirt into a 'skip' tended by another man. The skip, when filled, is run along a tramway to the mouth of the shaft. At present these trolleys, each holding about one-third of a cubic-yard, are drawn by men, but before long it is hoped that small compressed air-engines will be used for traction…"
Scientific American, **April 22, 1882**
Above: caption: "Front (left) and rear (right) elevations of the Beaumont and English tunnel-boring machine which is being employed in the Channel tunnel"

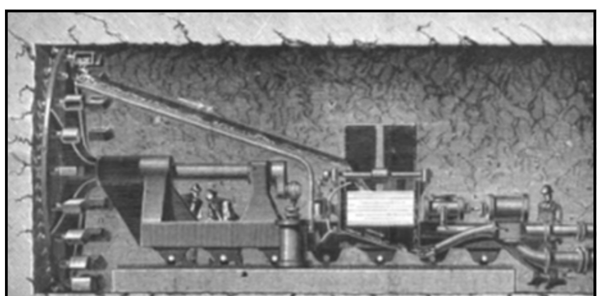
147

Crampton's Tunneling Machine

148

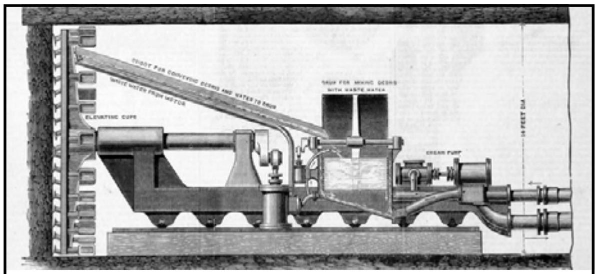
"We have already given some details in regard to the progress being made in boring the Channel tunnel and in the SCIENTIFIC AMERICAN of April 22, 1882, we have described the Beaumont compressed-air machine employed in the work of the excavation…"
Scientific American, **April 7, 1883**

149



"…In Fig. 1, borrowed from 'La Nature,' we present a view of another machine which is being used in the same undertaking, and which differs from Beaumont's in the fact that the power is furnished by water under pressure, thus allowing of greater rapidity being attained in the work. This same water, on leaving the machine, is further utilized for carrying the excavated chalk through a conduit to the bottom of the working shaft, thus doing away with the necessity for cars…"
Scientific American, **April 7, 1883**
Above: caption: "Fig. 1 – Crampton's Hydraulic Tunneling Machine"

150



"…The Crampton machine, which, from a mechanical point of view, is based on the same principle as Bessemer's, consists of a circular disk, two meters in diameter, mounted on a horizontal shaft, which is secured by the piston of the water cylinder. In front of this disk are seventy knives which cut out the chalk in rings 7 centimeters wide by 2 in thickness, and behind it are arranged buckets which gather up the debris from the bottom of the heading and empty them into a chute that carries them to a mixer. The whole apparatus forms a movable frame which is supported by fourteen wheels, and which may be moved forward in proportion as the work advances, so as to keep the knives in contact with the face of the cutting. The water, on making its exit from the cylinder, is directed into the chute in order to aid the descent of the debris into the mixer…"

Scientific American, **April 7, 1883**

151

"…The object of this latter apparatus is to intimately mix the chalk with water to a consistence such that it may be led by pipes to the base of the shaft and be pumped up to the surface. The proper consistence for such purpose is obtained by using a weight of water triple that of the chalky debris. The very arrangement of the tunnel permits of securing this removal of the excavated material automatically…"

Scientific American, **April 7, 1883**

RE: *Thomas Russell Crampton* was born in 1816, in Kent, England, and died at his London home on April 19, 1888. One of the most accomplished inventors and engineers of the Victorian-era, in 1882 Crampton produced a revolutionary automatic tunnel boring system in which debris was conveyed away in pipes by hydraulic motors, mixed with waste water, thus eliminating all locomotives, wagons and lifting machinery. The system was demonstrated in the experimental works of the *Channel Tunnel Company* and described by Crampton in an 1882 lecture presented in Leeds, England.

152

"…The tunnel presents the form of an elongated W, and the excavation reaches, then, its highest point in the middle of the Channel, whence the two sides shelve. This middle point will be at a depth of about 100 meters beneath the bottom of the sea, and the diverging galleries will extend on each side with a slope of 1 in 2,640, sufficient to secure a flow of the muddy current, under the influence of gravity alone, to a distance of 16 kilometers from the center, so as to reach the point C, at a depth of 137 meters, at the bottom of the working shaft at each end. The gallery of wide section, which is to serve for passage of trains, stops at the point D, at a depth of 129 meters, and at a distance of only 12 kilometers from the center. Beyond from D to C, the gallery is prolonged by another use of small section, serving only for the removal of the water. Starting from D, the main tunnel rises with a steeper grade, and ends at Dover. The arrangement of the tunnel is the same at Calais. The distance thus traverses is about 12 kilometers, which, as may be seen, carries the total length to be pierced up to 48 kilometers…"

Scientific American, **April 7, 1883**

<u>Above</u>: caption: "Fig. 2 – Longitudinal Section of Half the Channel Tunnel"

153

"…In the work on the English side, the first well is to be sunk at Fanhole to join the main tunnel at a depth of 36 meters, and another at Saint Margaret, at a depth of 137 meters, to serve as a working shaft…"

Scientific American, **April 7, 1883**

154

"…The motive power is furnished by a head of water. The tunneling machine requires a power of about 425 horses to cut the chalk and crush the debris, and the lifting pumps absorb on their side a power of about 500 horses. The velocity at which the disk of the perforator runs is ten revolutions per minute, which gives the extreme knives a velocity of 850 meters. The crusher is a cylinder 1-2 m. in diameter, and 0-6 m. long, making 83 revolutions per minute. It is capable of crushing about 10 tons per hour, with a power of one-half horse."

Scientific American, **April 7, 1883**

155

…Mr. Crampton's automatic system for excavating long tunnels by the ordinary hydraulic motors, conveying the debris, mixed with the waste water from the motor, along and out of the tunnel in pipes or otherwise, and thereby dispensing entirely with the locomotives, wagons, and lifting machinery ordinarily employed, is well known in engineering circles. Where the material cut is too large to be floated away with the waste water, it is, reduced to the size required, at a nominal cost, by simple means in common use. If desired, particularly in cutting clay, all or part of the waste water, before mixing with the debris, may be caused to lubricate, so as to keep out all dirt from the bearings, and pass over the surfaces of the cutter to their cutting edges, mixing with the debris as cut, and generally preventing the accumulation of debris on the machine. A piece of grey chalk was thus cut out of the Channel tunnel at the rate of five yards per hour, the power used being 1.2 horse-power per cubic yard per hour. Coal takes the same power. Sandstone was cut from the Mersey tunnel at the rate of 1.5 yards forward per hour, with four horse-power per cubic yard per hour. Galt clay was cut at the rate of ten yards forward per hour, wills half a horse-power per cube yard per hour.

The cost of one horse-power per hour is less than one penny. Some years ago, the work done with Mr. Crampton's machine at the experimental works of the Channel Tunnel Company attracted a good deal of attention, and the subject was dealt with by the inventor in a lecture delivered before the Institution of Mechanical Engineers at Leeds in 1882…

RE: excerpt from Thomas Russell Crampton's obituary (April 1888)

156

Part 3

The Protest Lately Raised

157

A Natural Desire to Pause

158

"…Whether we shall be able to connect the English with the French railway system by means of a tunnel below the English Channel is a question that appears dependent at this moment rather upon military and political than technical and financial considerations. The occurrence of a stratum of impervious gray chalk, at a convenient depth below the bed of the Channel, minimizes the engineering difficulties in the way, and must influence the financial question involved…"
Popular Science, **December 1882**

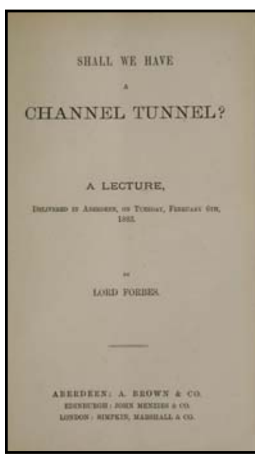
159

"…The protest lately raised against its accomplishment can hardly be looked upon as a public verdict, but seems to be the result of a natural desire to pause pending the institution of careful inquiries. These inquiries have been made by a Royal Scientific Commission, and will be referred for further consideration to a mixed Parliamentary Committee, upon whose report it must depend whether the natural spirit of commercial enterprise has to yield in this instance to political and military considerations…"
Popular Science, **December 1882**

160

Sic Transit Gloria Britannia

161


SHALL WE HAVE
A
CHANNEL TUNNEL?

A LECTURE,
DELIVERED IN ABERDEEN, ON TUESDAY, FEBRUARY 6TH, 1883.

BY
LORD FORBES.

ABERDEEN: A. BROWN & CO.
EDINBURGH: JOHN MENZIES & CO.
LONDON: SIMPKIN, MARSHALL & CO.

SHALL WE HAVE A CHANNEL TUNNEL ?

To this question I would reply "No," decidedly and emphatically "No," and for reasons which it is the purpose of this Lecture to point out and maintain. But before doing so, it will be desirable to make some preliminary observations bearing upon the subject generally…
RE: introduction to lecture given by Lord Forbes in Aberdeen, Scotland on February 6, 1883 entitled: "Shall We Have A Channel Tunnel?"

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…(1) When I intimate, as I have just done, my purpose and intention of opposing any scheme for making a Channel Tunnel, I do not desire to preclude myself or my audience from either listening to or considering any arguments in favour of this scheme, which may be brought forward by any speakers at the close of this Lecture, and indeed I propose myself to bring before you some arguments and evidence in support of it. But I would simply desire at the outset to state my own conviction that the arguments against are overpoweringly greater than any that can be adduced in support of this scheme. But whichever of these two views may be taken by different persons, I claim a fair and patient consideration of the question in all its bearings…

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…I deprecate most strongly the allegation which has been or may have been made against those who oppose the construction of the Channel Tunnel, that they are actuated by unreasonable, imaginary, causeless, and unworthy fears. I wish the matter to be looked at as one intimately connected with the prospects of Great Britain for good or for harm, as in fact a great National question of the deepest moment and concern. Any such arguments as those implying that the opposers of the Tunnel show fear and distrust of their neighbours across the Channel, should be most scrupulously avoided as unfair and ungenerous. Treachery and insurrectionary principles, which lurk hidden and it may be almost unsuspected in the midst of a nation till some favourable opportunity occurs for their outward display, do not by any means involve the whole nation in a charge of holding revolutionary ideas or unneighbourly intentions…

164

…The opposers of the Tunnel may well consider what additional opportunities its construction would give to disaffected persons on this side the channel, at some future time it might be, to coalesce with disaffected persons on the other side, without being accused of entertaining groundless fears, and without being charged with distrusting a whole nation. No indictment is made against a whole people, because precautions are taken against insurrectionary bands. Just as Sir George Grey in regard to Ireland drew this distinction: the alarming increase of crime had taken place only in a few counties, and he said in introducing a bill for the repression of crime in November, 1847, “The present, therefore, is no general indictment against a whole people.” The matter before us this evening is, I venture to say, one well worth *the most careful consideration* of all true lovers of their country, and it is with this view of it that I invite your most careful attention…

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…(2) One observation I must be allowed to make and to maintain most strongly, that nothing further should be permitted to be done on this side the channel in connection with any scheme for constructing a Tunnel, till the opinion and decision of Parliament have been obtained. I do not think that any Government in this country should have the power of supporting or furthering this scheme, or giving it any encouragement without the direct sanction of Parliament, which can alone decide in so weighty a matter. I suppose that money has already been spent and labour employed in view of the scheme being carried out, starting from our own shores, but I cannot consent that these facts should be used or pressed forward as arguments or reasons in themselves for carrying out the scheme, or that they should be allowed to have the least weight in determining so important a matter…

166

…I regret extremely that under the circumstances any such money should have been employed, while the question in all its bearings had as yet never been considered by Parliament, but this cannot be thought of for a moment as a counter-balance in favour of the project, if on national grounds it ought to be opposed. It should not be regarded simply in the light of a private enterprise or as a personal matter in any way, but as a national concern, and if it should receive the approval of Parliament (an approval which I earnestly trust it may not obtain), it would certainly be necessary that the Tunnel, whether constructed by a private company or not, should be sufficiently under Parliamentary control…

167

…It is not intended here to take into consideration the advantages or disadvantages to other countries that might result from carrying out this project, but to view the matter only from a British standpoint; and as this Lecture is not intended to be a scientific one, it will not be debated whether a Channel Tunnel (it may be one or more) could be made, but it will be allowed, for the sake of argument, that there is nothing physically to hinder it. We have the much wider question to consider first of all, whether it would be expedient to do so, if we could, and this Parliament must decide for us, and meanwhile no grievance or hardship can reasonably be shown or proved, in not allowing any works in connection with or preparatory to a Tunnel to be carried on, till such decision has been obtained…

168

…(3) It has been stated that it is not the intention of this Lecture to treat the matter from an engineering or scientific point of view, neither is it my purpose to enter upon any geological enquiry, as to when Great Britain became an Island. Doubtless the animal life in days gone by may have been very different from what it is amongst us at present, and we may at one time have been joined on to the Continent of Europe. It is quite sufficient for my purpose to take you back only as far as the time of Julius Caesar. We know (at least I believe it to be so) that he made two invasions or descents upon England in the years 55 and 54 B.C., and that both times he came by sea. We are, therefore, authorised in affirming that all the after invasions of Saxons and Danes were also made by sea, and that Great Britain was then in truth an Island, a sea-girt land…

169

The Celtic Gauls had been aided in their struggle against the Romans by the Celts in southeastern Britain thus, removing this ally would be beneficial to the Romans in their operations to secure Gaul, where *Julius Caesar* was commander of the Roman Legions. He concluded such a conquest would improve his political fortunes. Thus, on August 26, 55 B.C., Caesar set-off from *Portus Itius* (Boulogne) with two Roman Legions (about 10K men). The next morning, the Roman ships approached the cliffs of Dover, which were lined with British warriors. Caesar prudently decided to avoid a fight by sailing several miles further northeast, landing on the flat, pebbled shore around Deal. After some minor skirmishes on the beach, four days later ships carrying a troop of Roman cavalry were forced to return to France due to a storm. The lack of cavalry impaired Caesar's ability to conduct any large scale action, but some inland reconnaissance was made. After the ships were repaired, Caesar ordered the Romans to return to Gaul. On the morning of July 6, 54 B.C., a second, much larger expedition consisting of five legions and 2K auxiliary cavalry crossed the Channel using a fleet of around 800 ships. Sailing from Boulogne, they once again landed near Deal. After initial successes, Caesar was forced to return to Gaul after a storm damaged many of the ships and problems mounted with the Gaulic Celts.

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Above: caption: "Relief, 'Caesar Invading Britain.' John Deare (1759-1798), Rome, 1796, marble. Victoria and Albert Museum, London." Britain had enjoyed diplomatic and trading links with the Romans in the century starting with Julius Caesar's expeditions of 55 and 54 B.C. A gradual process, the Roman conquest of Britain began, effectively, in A.D. 43 under *Emperor Claudius.* Previously, Britain had frequently been the target of planned and/or actual invasions by forces of the *Roman Republic* and, later, the *Roman Empire.* In common with other regions on the edge of their vast empire, Rome had a significant economic and cultural influence on Iron-Age Britain.

171

…Again the landing of William the Conqueror A.D. 1066, of which it is narrated that, "He passed the sea in a great ship and came to Pevensey," carries us on one step further in this chain of circumstantial evidence, though only to prove so far that the sea was not then our protection from invasion, which it was some years after so signally proved to be. For, pass a few centuries, and what do we see? The mighty forces of a mighty conqueror are gathered on the opposite coast for the invasion of England, and from August to September, 1805, the hostile camp at Boulogne menaced the conquest of England. But it was not to be; the narrow strait, the "silver streak," divided us: his troops were all ready to embark, "but there was no protecting fleet of men-of-war in the channel," and Napoleon had to give it up, to turn away, baffled we doubt not and deeply disappointed…

172

173

…It is then one great and main argument against constructing a Tunnel, that we so far destroy our Insular position by joining ourselves on to the Continent of Europe. We should render our navy, the natural creation and necessity springing from this position, the glory and boast of England, of much less value to us in case of invasion; I should rather say of no value in preventing an invasion, if we could at any time be taken unawares, and either by treachery or stratagem, the Tunnel which we have ourselves made, should point the way to accomplish this and prove our own destruction, or at least entail upon us loss of life and suffering. If then we bring trouble and expense (for that must inevitably follow) upon ourselves or our descendants by under-bridging the channel and thus destroying our present natural safe-guard and defence, we shall have only ourselves to blame, we shall do so with our eyes open to the possible if not probable evil consequences, and in opposition to the valuable military authorities and opinions which I shall presently give you…

174

…4) Before going further, a few observations may be made on the possible motives or reasons or desires or advantages in constructing a Tunnel, and it might be, that different promoters might have especially or more particularly different motives in view. It would of course do away with the discomforts of the sea passage, and that not only as regards the uncomfortable effects arising from the restlessness of the ocean in general, and the fluctuations of the waves in the narrow straits (feelings in which I heartily sympathise) but it would obviate the further discomforts arising from the necessity of the change, as at present from the train to the boat of passage. It would obviously be a great convenience and comfort to travelers from our shores to the Continent, and more especially to invalids seeking a warmer climate with the least amount of fatigue…

175

…But I must calmly submit to you and press upon you the consideration, that all such advantages, be they in themselves ever so great, are as nothing, if weighed against the possible, if not probable, disadvantages that would arise from the construction of the Tunnel, the disadvantages I mean of increased expenses, continual preparation and readiness against invasion, if not fighting itself with all its attendant sufferings and loss of life. In what way or to what extent Trade and Commerce would be affected by a Tunnel I shall not consider, further than to throw out an idea or suspicion I have, that it might be detrimental to the west-end shopping interest of London, if it led to a more certain and rapid method of communication with Paris, that is to say, so long at least as the communication through the Tunnel was in good working order and uninterrupted…

176

…But all questions regarding Trade, whether advantageous or the contrary, equally with considerations of personal convenience, or increase of traveling on the Continent, must all be laid aside as really of no moment till we have solved the really important point, which seems to be simply this. *Should we be doing right in a National or Military point of view to allow a Tunnel to he made, or should we be running possible or probable, great and unnecessary risks? And so we come back to the point from which we started and ask, Shall we have a Channel Tunnel?…*

177

…I cannot forbear giving you here the words of Sir Garnet, now Lord Wolseley, whom I shall in future quote under the latter title, which he has now so honorably obtained. He says "Surely John Bull will not endanger his birth-right, his liberty, his property, in fact all that man can hold most dear, whether he be a patriot or merely a selfish cosmopolitan, and whether this subject be regarded from a sentimental or from a material point of view, simply in order that men and women may cross to and fro between England and France without running the risk of sea-sickness. Even now when protected by our 'silver streak' we suffer from periodical panics, which are as injurious to trade as they are undignified; this Tunnel would render their recurrence much more frequent, thereby increasing the loss they occasion. The night does not follow the day more surely than will a vastly increased annual military expenditure follow upon the construction of the Tunnel. Are we to be taxed additionally for these new military establishments in order to save a certain number of travelers and tourists of all nations from sea-sickness?"…

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PUNCH'S FANCY PORTRAITS.—No. 96.

SIR GARNET WOLSELEY.

Short Service and Quick Returns.

…Lord Wolseley then refers to an argument which had been used in favour of the Tunnel, called by the writer the best argument, that "It is impossible to base the arrangements of a great country like England upon the idea of wars and invasions. To do so would necessitate at once, not only a curtailment of our mercantile activity, and therefore of the population, but even an abolition of free trade in corn." To this he replies, "If this question is not to be discussed on military grounds, but if in pursuit of increased 'mercantile activity' we are to ignore all dangers which this hunt after riches may possibly entail upon the nation, the outlook for the country is bad indeed"…

<u>Left</u>: caption: "Caricature of Sir Garnet Wolseley. Punch magazine, August 12, 1882."

179

…(5) After these preliminary remarks, we are coming to the evidence which is to help us to decide the important question (Shall we have a Tunnel?) which has already been asked, the evidence I mean contained in the Parliamentary Blue Book, and it is to this I shall soon ask your attention, and the references which I give further on are to the pages of this report. Long before I had opened a page of this book or even seen it, I had formed, I believe, a decided opinion of my own against the Tunnel scheme, and that on the ground of what may be called treachery amongst ourselves, that is disaffected persons on this side the channel coalescing (as I have before mentioned) with disaffected persons on the other, and so combining by agreement to obtain possession or the use of the Tunnel for their own purposes, though of course that might only be for a very short time, though long enough to lead to much discomfort and probably to bloodshed…

180

…It has since occurred to me, supposing another Napoleon should arise, what use could he or would he make of the Tunnel to our disadvantage? Would not its existence tend to induce or promote the invasion or attempts to invade this country, when our Island has ceased to be, and we have joined ourselves on to the Continent?...

181

…Such was the opinion of Lord Wolseley, who says, “I think that the existence of the Tunnel would be a great inducement to France to invade England.” But in your own minds you are no doubt refuting these, perhaps you will say shallow reasonings, by thinking there are plenty of ways that we have of blocking the Tunnel and interrupting the communication. Don’t be afraid. I am not going to keep this information from you. You will hear enough about it before I have done. But put it the other way and let us suppose that even in apparently peaceful times, a train starts from our end, and the unlucky passen-gers find a mine has been sprung near the opposite end of the Tunnel or water has been let into it, what would be their situation and their feelings?...

182

…Or let us suppose something less dreadful than this, that the train breaks down half way, and we will call the length of the Tunnel about 20 miles under what circumstances, the reverse of pleasant, would the walk of the ten miles be conducted? And indeed however excellent the arrangements between England and France might be at first starting, and however good, at the time of opening the Tunnel, the mutual understanding between the two countries might be, would there be any sufficient guarantee for their permanency and would not an element of uncertainty, risk, and possible danger to ourselves be introduced?...

183

…However perfect the machinery for blocking the Tunnel or interrupting the communication at our end might be (and it might of course get out of order from want of use and not be found in order when it is wanted), it is impossible, I think, not to allow that the existence of a Tunnel would keep us in a state of frequent, if not perpetual alarms, and involve us in increased military ex-penditure…

184

…There is moreover an air almost of absurdity, if I may say so with-out offence to the promoters or supporters of the scheme, in the idea of constructing a costly Tunnel, which would have to be so jealously guarded and might be partially at least destroyed, if not on our side from necessity, on the other from evil design. But it would be affectation on my part to detain you longer with my own opinions or views, when we have before us the prospect of listening to the words of those competent to give an opinion, and I now therefore apologise for having done so, and proceed forthwith to lay before you the evidence I prom-ised you from…

185

…Conclusion. We have, I trust, heard enough of the dangers and risks, to which this country would be exposed by the construction of a Channel Tunnel, to warn us against giving in any way our consent or approval to such a scheme. The many and elaborate plans for defending the Tunnel and rendering it use-less are themselves the best arguments against its construction. Whatever ad-vantages or gains are to be derived from it, and these I will not discuss, they are all as nothing in comparison of the disadvantages. The Tunnel if made wou-ld be not the messenger of peace and good-will, but the harbinger and fore-runner of increased military expenditure, of panics and apprehensions, of pos-sible invasions, strife and bloodshed, and asking once more the question with which I commenced, “Shall we have a Channel Tunnel?” I reply again, decid-edly and emphatically, “No”…

186

…But I have still one wider and broader reason to give you for not consenting to the Tunnel scheme in view of the increased expenditure it would entail, and that is we have already enough on our hands at present. Egypt is unsettled and may give occupation to our army and navy. And turn your eyes to the East, to Central Asia, and read the articles in the Morning Post of January 29 and 31, regarding the Russian army in the Caucasus, and the Russian Railway scheme. Trouble, expense, and increase of troops to defend our Indian possessions are looming in the future, and it may be no distant future for us, so systematically is the Russian advance seen to be conducted, and we have I say enough on our hands without increasing our defences and our troops on our own shores. One word more and I have done; if the Channel Tunnel should be made, and I trust it will not be so, I will ask as a favour of the promoters and doers of the work, that they will agree to have inscribed in large and conspicuous letters on our end of it, these words,

SIC TRANSIT GLORIA BRITANNIA
(So Passes the Glory That Was Britain)

187

Never Surrender

188

"We shall defend our island, whatever the cost might be, we shall fight on the beaches, we shall fight on the landing grounds, we shall fight in the fields and in the streets, we shall fight in the hills; we shall never surrender, and even if, which I do not for a moment believe, this island or a large part of it were subjugated and starving, then our empire beyond the seas, armed and guarded by the British Fleet, would carry on the struggle, until, in God's good time, the New World, with all its power and might, steps forth to the rescue and the liberation of the old."
***Winston Churchill*, Prime Minister of Great Britain**
RE: speech made in Parliament during the darkest days of WWII when a German invasion appeared imminent

189

The Desideratum

190

"…Whether the Channel Tunnel is constructed or not, the plan proposed some years ago by Mr. John Fowler, of connecting England and France by means of a ferry-boat capable of taking railway trains, would be a desideratum justified by the ever-increasing intercommunication between this and Continental countries…"
***Popular Science*, December 1882**

191

de·sid·er·a·tum

/də□zidə□rädəm/

noun

something that is needed or wanted.

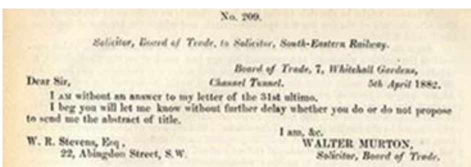
192

All for Naught

193

"…The proposal to make a tunnel under the Channel may, I think, be fairly described as a measure intended to annihilate all the advantages we have hitherto enjoyed from the existence of the 'silver streak,' for to join England to the Continent by a permanent highway will be to place her under the unfortunate condition of having neighbours possessing great standing armies, a state of things which prevents any of the Continental Nations from disarming as long as any one of them refuses to follow suit. The construction of the tunnel would place us under those same conditions that have forced the Powers of Europe to submit to universal service. It is to be hoped, therefore, that these measures may not be treated simply as 'private bills,' but that the question may be dealt with as one of great national importance…"
***Lt. Gen. G.J. Wolseley*, December 1881**

194



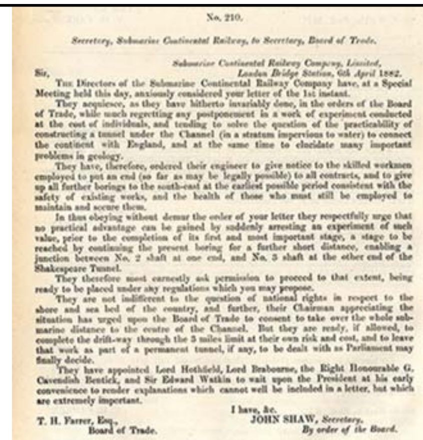
No. 209.

Solicitor, Board of Trade, to Solicitor, South-Eastern Railway.

Board of Trade, 7, Whitehall Gardens,
Dear Sir, *Channel Tunnel.* *5th April 1882.*
I AM without an answer to my letter of the 31st ultimo.
I beg you will let me know without further delay whether you do or do not propose to send me the abstract of title.
I am, &c.
W. R. Stevens, Esq., WALTER MURTON,
22, Abingdon Street, S.W. *Solicitor, Board of Trade.*

"…At this point all plans came to naught. The British Army general staff - influenced by the railway interests - fought the plan. In 1883, both Houses of Parliament passed a joint resolution terming the plan inexpedient. What was really feared was that Britain's 'splendid isolation' would be brought to an end. Little did they dream that, within the next sixty years, a prime minister would publicly say that Britain's coastline lay on the Rhine, not the Channel…"
***Mechanics and Handicraft*, September 1936**
<u>Above</u>: caption: "Document on suspension of Channel works"

195

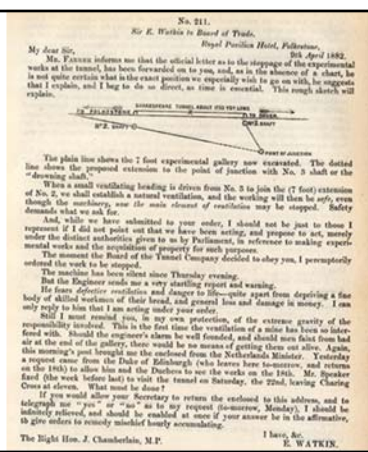


No. 210.

Secretary, Submarine Continental Railway, to Secretary, Board of Trade.

Submarine Continental Railway Company, Limited,
Sir, *London Bridge Station, 6th April 1882.*
THE Directors of the Submarine Continental Railway Company have, at a Special Meeting held this day, anxiously considered your letter of the 1st instant.
They acquiesce, as they have hitherto invariably done, in the orders of the Board of Trade, while much regretting any postponement in a work of experiment conducted at the cost of individuals, and tending to solve the question of the practicability of constructing a tunnel under the Channel (in a stratum impervious to water) to connect the continent with England, and at the same time to elucidate many important problems in geology.
They have, therefore, ordered their engineer to give notice to the skilled workmen employed to put an end (so far as may be legally possible) to all contracts, and to give up all further borings to the south-east at the earliest possible period consistent with the safety of existing works, and the health of those who must still be employed to maintain and secure them.
In thus obeying without demur the order of your letter they respectfully urge that no practical advantage can be gained by suddenly arresting an experiment of such value, prior to the completion of its first and most important stage, a stage to be reached by continuing the present boring for a further short distance, enabling a junction between No. 2 shaft at one end, and No. 3 shaft at the other end of the Shakespeare Tunnel.
They therefore most earnestly ask permission to proceed to that extent, being ready to be placed under any regulations which you may propose.
They are not indifferent to the question of national rights in respect to the shore and sea bed of the country, and further, their Chairman appreciating the situation has urged upon the Board of Trade to consent to take over the whole submarine distance to the centre of the Channel. But they are ready, if allowed, to complete the drift-way through the 3 miles limit at their own risk and cost, and to leave that work as part of a permanent tunnel, if any, to be dealt with as Parliament may finally decide.
They have appointed Lord Hothfield, Lord Brabourne, the Right Honourable G. Cavendish Bentick, and Sir Edward Watkin to wait upon the President at his early convenience to render explanations which cannot well be included in a letter, but which are extremely important.
I have, &c.
T. H. Farrer, Esq., JOHN SHAW, *Secretary,*
Board of Trade. *By order of the Board.*

196



No. 211.
Sir E. Watkin to Board of Trade.
Royal Pavilion Hotel, Folkestone,
My dear Sir, *9th April 1882.*
MR. FARRER informs me that the official letter as to the stoppage of the experimental works at the tunnel, has been forwarded on to you, and, as in the absence of a chart, he is not quite certain what is the exact position we especially wish to go on with, he suggests that I explain, and I beg to do so direct, as time is essential. This rough sketch will explain.

The plain line shows the 7 foot experimental gallery now excavated. The dotted line shows the proposed extension to the point of junction with No. 3 shaft or the "drowning shaft."
When a small ventilating heading is driven from No. 3 to join the (7 foot) extension of No. 2, we shall establish a natural ventilation, and the working will then be *safe*, even though the machinery, *now the main element of ventilation* may be stopped. Safety demands what we ask for.
And, while we have submitted to your order, I should not be just to those I represent if I did not point out that we have been acting, and propose to act, merely under the distinct authorities given to us by Parliament, in reference to making experimental works and the acquisition of property for such purposes.
The moment the Board of the Tunnel Company decided to obey you, I peremptorily ordered the work to be stopped.
The machine has been silent since Thursday evening.
But the Engineer sends me a very startling report and warning.
He fears *defective ventilation* and *danger to life*—quite apart from depriving a fine body of skilled workmen of their bread, and general loss and damage in money. I can only reply to him that I am acting under your order.
Still I must remind you, in my own protection, of the extreme gravity of the responsibility involved. This is the first time the ventilation of a mine has been so interfered with. Should the engineer's alarm be well founded, and should men faint from bad air at the end of the gallery, there would be no means of getting them out alive. Again, this morning's post brought me the enclosed from the Netherlands Minister. Yesterday a request came from the Duke of Edinburgh (who leaves here to-morrow, and returns on the 18th) to allow him and the Duchess to see the works on the 18th. Mr. Speaker fixed (the week before last) to visit the tunnel on Saturday, the 22nd, leaving Charing Cross at eleven. What must be done?
If you would allow your Secretary to return the enclosed to this address, and to telegraph me "yes" or "no" as to my request (to-morrow, Monday), I should be infinitely relieved, and should be enabled at once if your answer be in the affirmative, to give orders to remedy mischief hourly accumulating.
I have, &c.
The Right Hon. J. Chamberlain, M.P. E. WATKIN.

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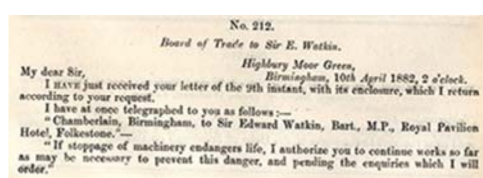

No. 212.
Board of Trade to Sir E. Watkin.
Highbury Moor Green,
My dear Sir, *Birmingham,* 10th *April* 1882, 2 *o'clock.*
I HAVE just received your letter of the 9th instant, with its enclosure, which I return according to your request.
I have at once telegraphed to you as follows:—
"Chamberlain, Birmingham, to Sir Edward Watkin, Bart., M.P., Royal Pavilion Hotel, Folkestone."—
"If stoppage of machinery endangers life, I authorize you to continue works so far as may be necessary to prevent this danger, and pending the enquiries which I will order."

198

"…Now, if the English and French really had been awake to the seriousness of the war, if they had started boring two years ago, the project would be over half finished. For as soon as the franchise was granted, the French company bored a tentative tunnel 6,033 feet long, seven feet in diameter. The British company sank two shafts, one 2,641 feet long; the other 6,075 feet long. Both companies have maintained these tubes in good condition, keeping them free from water by pumping…"

***Illustrated World,* April 1917**

RE: concerned about the military implications of a physical link to Europe, Sir Edward Watkin's well-reasoned reassurances fell on deaf ears and work was halted on the tunnel with the shafts being backfilled. When the idea of a Channel Tunnel was revisited in 1974 and 1988, various remedial works were carried out on the 1880s workings as a result of the new alignments potentially intersecting the 19th century tunnels. This work revealed several roof falls and broken timber supports. A concrete bulkhead was installed 890 yards into the No. 2 heading, effectively entombing the boring machine.

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<u>Above</u>: caption: "Part of the 1880 tunnel intersected by the later excavation in 1988"
<u>Upper Left</u>: caption: "The entrance to the tunnel in 1984"
<u>Lower Left</u>: caption: "The only remaining accessible section of the tunnel at Shakespeare Cliff, as the tunnel dips downwards the water eventually comes up to the roof"

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Part 4

Enemies No More

204

Not Without a Fight

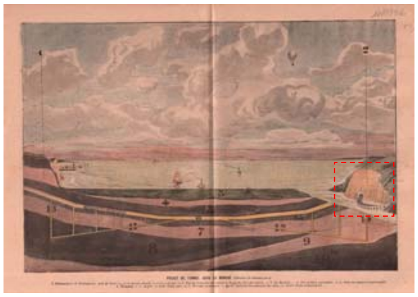
"…The Channel Company was not content to retire defeated. Receptions for the press were held, demonstrating the practicality of the scheme. A new air-driven machine for cutting through rock was exhibited, as were elevators for carrying rock and sand to the surface, and trucks for carrying the debris through the tunnel…"
Mechanics and Handicraft, **September 1936**

"…The tunnel would be no threat to England's security, company officials said. To prove their contention, they revealed how a viaduct, open to the fire of British warships could be built on the French side. Surely this would prevent an invasion of England by means of the tunnel; but the British general staff remained adamant…"
Mechanics and Handicraft, **September 1936**
<u>Above</u>: caption: "How the trains would enter the tunnel on the French side at Sangatte, near Calais"

"Among the objections raised against the construction of the Channel Tunnel, the most insistent has been the risk of invasion which some people suppose it would create against England. It is said that through the Tunnel, either Germany or France could quite suddenly send a troop of determined men to take possession of the English head of the Tunnel, thus admitting, under their protection, bodies of organised and fully armed troops, who would establish themselves firmly in a somewhat more extended circle round the mouth of the Tunnel, and thus facilitate the invasion of England…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)

"…The effective methods of preventing the Tunnel from being of advantage to an invader from either side of the Channel are, however, of a totally different character. From the technical point of view, the promoters of the Bill now before Parliament propose the following measures for the protection of the Tunnel and its approaches…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)

"…1. On the French coast, the entrance to the Tunnel has been marked out at about one mile towards the west of the Cran d'Escalles in the cliffs, called the Blanc-Nez, about 33 feet above the mean level of the sea, that is to say, at a point visible from the warships cruising in the Channel…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)



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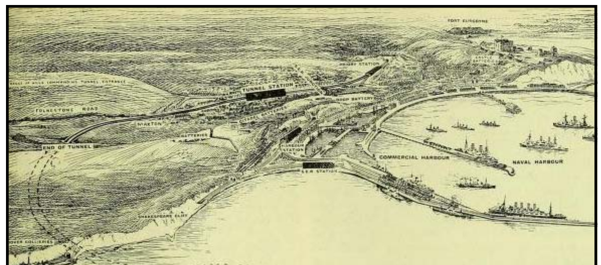
"…At the egress of the Tunnel out of the cliff, the railway would be continued by a viaduct 900 yards in length, and 46 feet in height above the almost perpendicular groove running up to the cliffs - in other words, placed in such a position that warships in the Channel could demolish it by a few cannon shots and, in consequence of the obliquity of the viaduct in relation to the coast, prevent it being repaired or reconstructed, under the fire of the warships which had destroyed it…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)
Above: caption: "The French entrance at Sangatte with the proposed Viaduct that could be destroyed in time of war"

212

"…2. On the English side, the entrance to the Tunnel would be located behind the spur of the cliff situated to the west of Dover, which extends as far as the harbour, narrowing the entrance to the valley from the sea…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)
Above: caption: "The Entrance to the Tunnel at Shalespeare Cliff, Dover (reprinted from the *Illustrated London News,* November 10, 1906)"

213



"…This access occupies such a position (it is sufficient to see the relief model to be convinced of this) that it would be under the direct fire of three forts or batteries. Two of these, the Citadel and the Western Heights, stand on the spur, at 1,300 yards and 1,750 yards distance respectively from the opening, and the third at the rear of Dover Castle at more than two miles distance, that is to say, sufficiently far away to render absolutely inadmissible the hypothesis that these forts could fall immediately into the possession of an invader…"
RE: excerpt from: "The Channel Tunnel - By a Military Railway Expert" (March 1907)
Above: caption: "Sketch plan, showing how the proposed entrance to the Channel Tunnel is commanded by the heaviest batteries at Dover"

214

"…Politics and bigotry triumphed over science. In 1886, the French Submarine Company absorbed the Channel Tunnel Company with the consent of the Board of Trade…"
***Mechanics and Handicraft,* September 1936**

215

WAR PRECAUTIONS

How the Forts
Command the Railway
at the
Dover End
(*Illustrated London News*, November 10, 1906)

216

Above: caption: "THE QUESTION OF DEFENDING THE ENDS OF THE TUNNEL: proposed approach by a long pier. The train to be lowered into the tunnel with lifts some distance from the shore."

Above: caption: "ANOTHER SOLUTION OF THE SEA-ENTRANCE: the train brought to the surface by an inclined plane coming out on a space fenced from the sea by breakwaters"

217

Any Which Way

218

"…Plans and sections of a Channel bridge were submitted. The proposed bridge was to be between Folkestone and Cape Gris-Nez, a distance of twenty-two miles. For the greater part of its length the bridge would carry two railway tracks, but on a length of three miles, about midway across the Channel, there would be a 'passing station' of four lines of tracks. Above the railway tracks it was proposed to build a roadway, 33 ft. wide, to carry four lines of traffic…"
***Railway Wonders of the World,* June 21, 1935**

219

"…The bridge, as designed, provided a clearance of 200 ft. above high water level for a length of 10,000 ft. (five spans of 2,000 ft.) on either side of the two shipping lanes four or five miles from the French and English coasts respectively, to allow for the passage of vessels. The proposers claimed that the bridge would not cause any serious obstruction to navigation, since the spans of 2,000 ft. were greater than those of the Forth Bridge, and the clearance was larger than in any existing bridge. The spans were to be of the continuous suspension type, with inverted three-hinged trusses and cable-wind trusses. There were to be twenty-six spans on the British side and twenty-seven on the French side, each 2,000 ft. in length, and a four-track bridge of twenty-nine spans of 450 ft. each in the middle of the Channel. The cost was estimated at £75,000,000.
***Railway Wonders of the World,* June 21, 1935**

220

"…The Committee did not make a technical examination of this scheme, as they considered that the piers would obstruct navigation. They stated that in times of fog there would be no satisfactory way of lighting the bridge. and that foghorns are not always reliable owing to zones of silence. Also, if the respective Governments gave permission, this could only apply to the international limit of three miles from either shore, and therefore the remainder of the bridge would be over the high seas…"
***Railway Wonders of the World,* June 21, 1935**

221

"…A scheme, submitted from an Italian source, was for a submerged railway tube on the bed of the Channel, to cost as little as £2,000,000. It was to be made of sections resiliently connected to one another in regular succession. These would be joined to one another in relatively short lengths above water, and then sunk and secured in the desired position on the bed of the sea. The lengths were to consist of an inner cylindrical sheet metal tube thick enough to withstand the pressure of the water. The metal tube would be surrounded by a jacket of concrete or similar material, and would be enclosed on the outside by another metal tube. The diameter was to be 10 ft. The inventor claimed that the tube would be rigid, watertight and immobile on the sea bottom, but sufficiently flexible to be raised to the surface of the sea for repairs when necessary. There were to be two towers rising above the surface to provide ventilation and light, and to act as passing stations. The Committee considered this scheme to be impracticable…"
***Railway Wonders of the World,* June 21, 1935**

222

"…A Swiss engineer submitted a project for a double jetty across the Channel. Two parallel dams would be constructed from Deal to Calais, each carrying two railway tracks and a motor road. The water enclosed between the two dams would form a large canal for ships and barges. An additional canal would be built from Deal to Herne Bay, so that the Thames estuary would be connected with the canal system of France and Germany, and the Rhine and the Danube. It was proposed to connect the dams to the coast by bridges high enough to allow ships to pass under. The estimated cost was £80,000,000. This scheme, also, was considered impracticable.
Railway Wonders of the World, **June 21, 1935**

223

"…A Channel bridge to cost £8,000,000 was a scheme put forward by Mr. Cleve F. Shatter, of San Francisco, an American who also made preliminary plans for bridging the Strait of Gibraltar. The Channel bridge scheme was a combination of bridge and jetty. Where the depths would allow there were to be piles of filled jetties supporting a roadway, and where the sea was too deep there was to be a floating bridge composed of multiple units, or floating sections, connected together and anchored. These floating sections would be protected by chain barriers on both sides, as a safeguard against vessels disabled or otherwise out of control being blown against them. Furthermore, in bad weather the sea round the floating sections would be calmed by oil released by means of electric controls from the floats supporting the barrier chains…"
Railway Wonders of the World, **June 21, 1935**

224

"…Two lifting spans, in harbours protected by breakwaters, were proposed on either side of the Channel. The floating sections would not be of the boat or pontoon type, but would be chambers, or floats, placed so that the greater part of the area was submerged. At each sectional join of the floating structure provision would be made for small craft. The height of the road would be 53 ft. above the water, and at the sections there would be permanent openings 100 ft. wide with 40 ft. head-room through which small boats could pass…"
Railway Wonders of the World, **June 21, 1935**

225

"…It was claimed that the two lifting spans would be more economical than a bridge giving the same vertical clearance of 200 ft., and, as they would be sheltered by breakwaters, the largest ships would have no difficulty in passing through the 450 ft. length of the spans, even in stormy weather. In the centre of the lifting span on the French side an hotel named 'Harbour de France' was proposed. The lower part would be used for a garage, and above this would be the hotel, surmounted by a round pavilion of glass providing a dining-room and observation post high above the Channel…"
Railway Wonders of the World, **June 21, 1935**

226

"…That bridge would carry two lines of railway and four lines of motor traffic. At night it would be illuminated the whole length by fog-piercing lights. In the event of war the floating sections, it was claimed, could be uncoupled and towed away in a few hours…"
Railway Wonders of the World, **June 21, 1935**

227

"…As long ago as 1867 Monsieur Thome de Gamond had sketched a plan for a bridge twenty-two miles long. It was to be on 400 stone piers, and to be high enough above the sea to allow ships to pass under it. The estimated cost was so huge that Monsieur de Gamond abandoned this plan for a low-level causeway, with swing-bridge and drawbridge openings for shipping…"
Railway Wonders of the World, **June 21, 1935**

228

"…A scheme put forward by a British engineer was for a row of pontoons, of great height, to be kept in position by heavy chains, with wire cables stretching from the pontoons to support the track for trains. Another idea, put forward more than sixty years ago, was for a floating tube through which trains would run. The tube, of wrought iron, was to be kept buoyant at some depth below the surface of the sea, and anchored to masonry piers to prevent it from floating about…"
Railway Wonders of the World, **June 21, 1935**

229

"…An ambitious project some years ago was for a self-contained electric railway from London to Paris to cost £190,000,000 and to include a Channel tunnel. There was to be a double railway track of 7 ft. gauge for the 253 miles between the capital cities, with twin tunnels under the Channel, each of 23 ft. diameter and forty-four miles long. The tunnel would begin at Monks Horton, to allow of a gradient to below Shakespeare Cliff, and on the French side would emerge at a point nine miles from the coast…"
Railway Wonders of the World, **June 21, 1935**

230

"…The railway was to be self-contained and independent in England and in France, with one new main terminal on the north side of the Thames, near the Westminster bank of Lambeth Bridge, and the other in Paris. Non-stop expresses were to make the journey in two hours forty-five minutes, the maximum speed in the tunnels to be sixty miles an hour. There were to be six tracks from the Westminster terminal to Farningham, four to Monks Horton, and two under the Channel, and the same numerical graduation of tracks on the French side…"
Railway Wonders of the World, **June 21, 1935**

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The Channel Bridge

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ORTION OF THE PROPOSED CHANNEL BRIDGE, 1889. DESIGNED by M.SCHNEIDER, OF CREUZOT, AND M.HERSENT

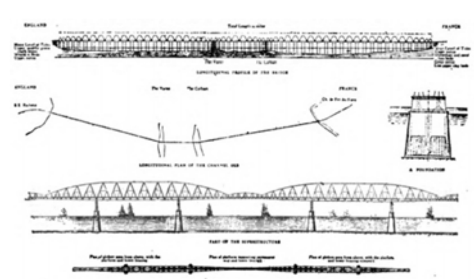
The Proposed Channel Bridge, 1889

In 1889 a rival to the Channel Tunnel scheme appeared in the field in the form of a proposed Channel bridge, designed by M. Schneider, of Creuzot, and M. Hersent, ex-President of the French Civil Engineers' Society, and to which such well-known engineers as the late Sir John Fowler and Sir Benjamin Baker appended their names. The details of the scheme were read before the meeting in Paris of the Iron and Steel Institute in that year. The bridge was to cross the Channel from a point near Cape Grisnez to a point near Folkestone. In this manner it would pass over the shallowed parts of the Channel, such as the Colbart and Varne banks, and connect the shores where they approach closest to each other. The bridge was to be of steel, and the amount of metal required was estimated at a million tons, half of which would be provided by each country. The cost was taken at £34,000,000, and the time needed for construction ten years…(*Railway News,* May 24, 1913)

<u>Above</u>: caption: "LINKING ENGLAND AND FRANCE by a bridge has often been suggested as an alternative to building a tunnel. The above sketch shows a railway bridge designed by three French engineers in 1889."

233

…The widest spans were to extend to some 1,638 feet (the longest span of the Forth Bridge is 1,640 feet), while the narrowest would measure 320 feet. The columns would rest on massive masonry supports, and would be in themselves 130 feet high, so that at high water it was calculated that the lowest height of the bridge above the water would be nearly 180 feet. Subjoined we reproduce some of the drawings.



234

"The latest project of the engineers, who will never be satisfied till they have made England as easy of invasion as Belgium, and have endowed us with the blessings of the conscription, is to throw a huge iron bridge across the Channel. A detailed plan to this end, drawn up by M. Schneider, of Creuzot, was read on Tuesday before the Iron and Steel Institute, assembled this year in Paris…"
The Spectator, **September 28, 1889**
<u>Above</u>: caption: "The proposed railway bridge between England and France"

235

"…The success of the enormous spans used at the Forth Bridge, 130 ft. above high-water mark, have shown the project to be by no means impossible. There are convenient banks in the water-way between Cape Gris-Nez and Folkestone, the nearest points on the coast, which will afford resting-places for the piers, and nowhere will the depth of water be a serious impediment. Then, too, steel, as has been shown at the Forth Bridge, can be used in the construction, and so a saving of 50 per cent. in weight be effected..."
The Spectator, **September 28, 1889**
<u>Above</u>: caption: "Aerial view of the railway bridge over the Firth of Forth near Edinburgh, Scotland"

236

237

"…The distance between the piers for the small spans will be 300 metres, and between those for the large, 500. The scheme, if ever carried out, will cost, it is calculated, about £34,000,000, a fact in itself enough to condemn the proposal, when a system of steam ferry-boats could be managed at a tenth of that sum. Of course, there are to be precautions against the bridge being used by an invading army, which would be about as trustworthy as a declaration by a single French Minister of War purporting to bind all his successors not to use it. Fortunately, the tunnel would be cheaper, and the tunnel is condemned."
The Spectator, **September 28, 1889**

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The Proposed Channel Bridge
The Engineer
(January 27, 1893)

239

BEFORE proceeding to describe in detail the design and construction of a bridge over the Channel, which forms the subject of a very interesting and able communication in a recent number of *Le Genie Civil,* we may briefly advert to the origin and history of this great project, as sketched out in the pages of our contemporary. It is rather more than fifty years since the first idea of this stupendous undertaking was promulgated by M. Thome de Gamond, the engineer-in-chief of the Department of the Straits of Calais. It was further proved by the geological researches of MM. Combes and Elio do Beaumont that a sound and solid foundation could be obtained for a structure of this description. Another French engineer, M. Verard de Sainte-Anne, developed the idea. until it assumed the practical form of an iron bridge, supportod by 840 piers. This gentleman, in prosecution of his design, established in London a society, under the name of tho International Railway Company, Limited. Unfortunately M. Vuard de Sainte-Anne died before his work was much advanced, but several of his former colleagues, who had not given up the great enterprise, registered a society in London on the 12th December, 1884, called the Channel Bridge and Railway Company, Limited. The object of this newly-formed company was to elaborate and carry, if possible, to a successful termination the railway scheme uniting France and England, and to obtain the necessary concessions for the erection of the bridge…

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…Under these auspices, the company set vigorously to work. In 1887 the president, Admiral Cloue, made arrangements with MM. Schneider and Hersent, in virtue of which, those gentlemen agreed to undertake a thorough and complete investigation of the Channel Bridge project. They placed themselves in communication with Sir John Fowler and Sir Benjamin Baker, and the result of this judicious combination was the preparation of a complete set of plans and calculations relating to the construction of a bridge stretching from Capo Gris-Nez to the opposite shore at Folkestone, constituting an iron roadway nearly twenty-four miles in length, carried by 120 piers. This undertaking, the cost of which was estimated at £88,400,000, received the favourable consideration of the Society of Civil Engineers in Paris, as well as of the English Iron and Steel Institute. The possibility of the erection of a structure of this magnitude having been satisfactorily demonstrated, the company next gave its attention to a careful inquiry into the nature of the bed of the Channel, in order to determine the most favourable route for the alignment of the proposed international work…

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…Accordingly, in the year 1890, during the months of July and August, a reconnaissance was made of the Straits of Dover by M. Renaud, the hydro-graphic engineer, whom the Minister of Marine bad very obligingly placed at the service of the Society, and with whom were joined M. Georges Hersent and M. Duchanoy, engineers of mines. Subsequent soundings were made in French waters, on board the Ajax, and in the English by a party on board the steamer Jubilee, which was placed at their disposal by the courtesy of Sir Edward Watkin, M.P. These experiments confirmed the opinions already formed regarding the solidity and stability of the foundations of the intended design…

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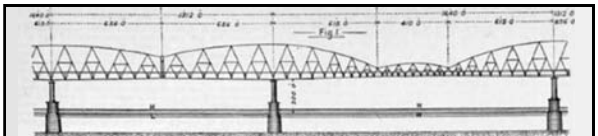

…But at this Juncture, M. Renaud discovered that by starting a little more to the north, and by keeping a straight line from Cape Blanc-Nez to the South Foreland, a bettor route could be obtained for the bridge than the one at first laid out. The advantages of this alternative trace consisted in enabling the foundations of the piers to be bedded on the chalk, in limiting the greatest depths to a maximum of 167 ft., and in reducing the total length by rather more than three miles. This new alignment was adopted by the company, the project revised and modified, the number of piers altered to seventy-three, and the spans arranged alternately in distances of 1812 ft. and 1640 ft., as shown in Fig. 1. Our contemporary devotes considerable space to the influence which the execution of the proposed undertaking might have with respect to other countries generally, to its importance especially for the two nations it would more intimately unite, and to the respective merits of itself and its rival the tunnel. Into those considerations we shall not at present enter, but restrict ourselves to the description and details of the bridge itself…

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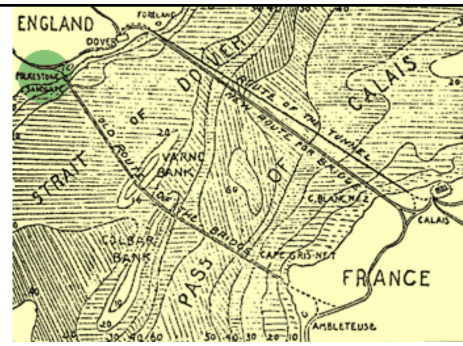

<u>Above</u>: caption: "Map of the Channel." This illustration, from the *Chicago Sunday Tribune* of June 11, 1893 shows the then-current plan to link England with France via either a tunnel or bridge. The "old route of the bridge" (at left), originating at Folkestone (green circle), is the actual alignment of the constructed (20th century) Channel Tunnel.

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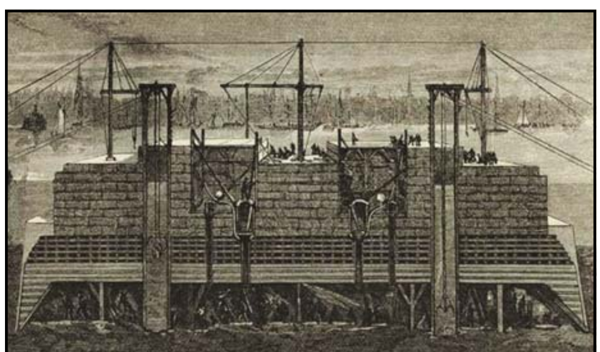
…To the question whether the actual building of a bridge over the Channel is feasible, it is stated that so far as the foundations are concerned, the success, upon a very extensive scale, of the employment of compressed air in deep water has put the matter beyond doubt. The use of steel is also quoted as a sufficient answer to any objection raised with a similar object against the construction of the superstructure. In addition to the Forth Bridge, which has foundations 88 ft. in depth, the example afforded by the Brooklyn Bridge is adduced. Here the foundations are 65 ft. under water, and upon them are raised piers of masonry 275 ft. in height, over which pass the chains, supporting spans of 1640 ft. between bearings. Again, the Americans contemplate throwing a bridge over the Hudson to join by a railway New York and New Jersey, which is to consist of a single span of 2860 ft., placed at a height of 459 ft. over high-water mark…

245



<u>Above</u>: caption: "Sectional view of pneumatic caisson foundation for the Brooklyn tower of the Brooklyn Bridge, rising above the waters of the East River, ca. 1870"

246

247

…Those who may be inclined to assort that a bridge of the dimensions of the proposed Channel structure would never withstand the pressure of the wind, are replied to, by being referred to the Forth Bridge, as well as to numerous suspension bridges of sixty years of age and upwards which for that period have been exposed to the terrific assaults of the mistral, which are equally violent as the storms in mid channel. Besides, people are no longer scared now by the "force of the wind," as they were at the time of the building of the Britannia bridge over the Straits of Menai, which many competent authorities confidently predicted would be swept away by the first heavy gale. A far more important objection against the Channel scheme lies in the question - Will not the bridge seriously interfere with the navigation?

Above: caption: "Britannia Railway Bridge, over the Menai Strait, Wales"

248

The Extent of the Catastrophe

249

"…The extent of this catastrophe and the startling details which were revealed as a result of the subsequent inquiry brought public opinion antagonistic to Sir Thomas Bouch's proposal for bridging the Forth. The Tay Bridge disaster, in a way, was fortunate, as there is no doubt but that, had it been completed, the Bouch Forth Bridge would have come down with the first heavy north-easterly gale which rolled up the Firth of Forth. He had made a wind pressure allowance of 10 pounds per square foot - a ridiculously inadequate provision for such a structure as he proposed. The Board of Trade decreed that if such a bridge were undertaken it would have to be designed to withstand a wind pressure of 56 pounds per square foot on the surface of the side elevation of the structure…"

RE: excerpt from *Railway Wonders of the World* (1913)

RE: on Sunday, December 28, 1879, the first *Tay Rail Bridge,* designed by *Sir Thomas Bouch,* collapsed during a violent storm while a train was passing over it, killing all fifty-nine passengers aboard

250

Above: caption: "The Spirit of the Storm"

251

252

"…But the collapse of the ill-fated Tay Bridge in December, 1879, stopped the further progress of the work, and the investigations into the causes of that disaster, and the disclosures made, shook the public confidence in Sir Thomas Bouch's design, and rendered a thorough reconsideration of the whole subject necessary. As a first result of this, the suspension bridge was abandoned…"
Engineering, **February 1890**
RE: after the *Tay Bridge Disaster,* both the *North British Railway* and supporters of the Tay Bridge were determined that it should be rebuilt. The NBR quickly submitted a Bill to Parliament for the rebuilding of the old bridge. However, since *Thomas Bouch* was associated with the rebuilding project, Parliament rejected the bill. After dispensing of the services of Bouch, *William Henry Barlow* (who had sat on the *Court of Enquiry*) was invited to report on the best course of action. After thorough investigation of the options, his recommendation was to build a new double line bridge, completely independent of the old bridge.

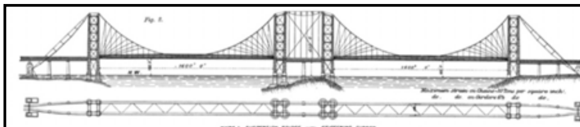
253

Not Insuperable

254

"…Bridging the Forth appeared to be in danger of becoming numbered among the apparently impossible things when it was revived by Mr. Matthew William Thompson, the chairman of the Midland Railway. The latter was interested in the completion of the bridge, and a meeting of the directors of the North British, North Eastern, Great Northern, and Midland Railways was held at York to consider a co-operative proposal. The engineers of the three British companies - Mr. Barlow of the Midland, Mr. Harrison of the North Eastern, and Sir John Fowler of the Great Northern - were requested to investigate the question. They did so, and, as a result, advanced the statement that the bridging of the Forth was not insuperable…"
RE: excerpt from *Railway Wonders of the World* (1913). *Thomas Bouch* died a few months after the final report of the public inquiry into the Tay Bridge disaster was published. At the time of the disaster, work was underway on a railway bridge over the *Firth of Forth*, also designed by Bouch. Construction was ceased immediately.

255



"…An illustration showing elevation and plan of Sir Thomas Bouch's design is shown in Fig. 2. The central towers from which the main chains are suspended were to have been 550 ft. above high water, while the rail level would be at such height as to leave a clear head-room of 150 ft. above high water between the piers. The central tower on Inchgarvie was over 500 ft. long, which brought the foundations upon the sloping rock down to a depth of over 110 ft. below high water. There were two lines of rails carried at a distance of 100 ft. from each other, each line being supported on a pair of strong lattice girders, and these were laterally stiffened by single diagonal bracings reaching from side to side. The piers at Queensferry and on Fife were very nearly in the same position as those of the present bridge, and there were two approach viaducts to reach the high ground upon either side. The bridge was to have been constructed entirely of steel…"
Engineering, **February 1890**
Above: caption: "Figure 2 – Bouch's proposed suspension bridge"

256

"…This disaster could not be allowed to arrest the project of bridging both firths; the matter was too important for that. But Bouch, as an engineer, was discredited. Not only were his plans complete for bridging the Firth of Forth with an immense suspension bridge having 1,600-feet spans and towers 600 feet high, but work on them had already begun. The remains of this earlier attempt may still be seen on Inchgarvie, a rocky islet, in midstream. Fortunately the start had been delayed in various ways, although Parliament had given its sanction more than six years before, and the force of public opinion made it imperative to scrap these plans and start again. Other minds were then brought to bear on the problems. Further, the Board of Trade stepped in, and stipulated that the bridge must be capable of withstanding a lateral pressure of 56 lbs. to the square foot - between five and six times the modest allowance that Bouch had made for wind pressure. This would give security against the most furious hurricane imaginable…"
Wonders of World Engineering, **March 1937**

257

"…On the site chosen for the Forth Bridge, a little east by north of Edinburgh, the Firth of Forth narrowed somewhat, though it still had a width of over one mile. Here there was also a valuable asset in the midstream islet of Inchgarvie, to serve as a foundation for the centre and most massive cantilever of the bridge…"
Wonders of World Engineering, **March 1937**
RE: engineering a suspension-type rail-bridge for crossing the Firth was proving difficult, if not impossible, by the early 1860s. However, in 1863-64, *Thomas Bouch* - Engineer to the *North British Railway* and *Edinburgh and Glasgow Railway,* was working on a single-track girder bridge crossing the Forth near Charlestown (where the river is around two miles wide), but relatively shallow. However, the bridge promoters were concerned about the feasibility of establishing solid foundations in the silty river bottom (borings had gone as deep as 231-feet into the mud without hitting rock). In response, Bouch conducted experiments demonstrating that it was possible for the silt to support considerable weight (experiments in late 1864 with weighted caissons achieved a pressure of 5-tons/sf on the silt).

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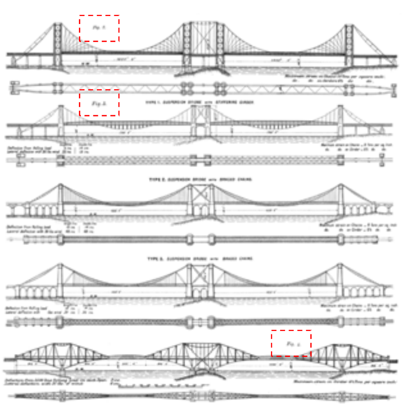
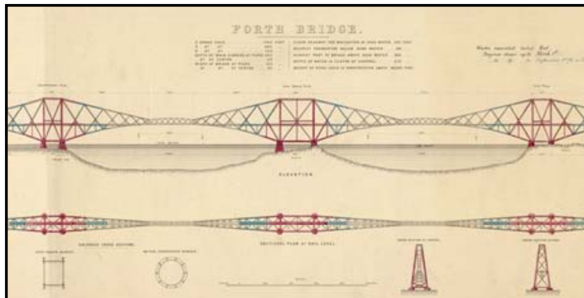
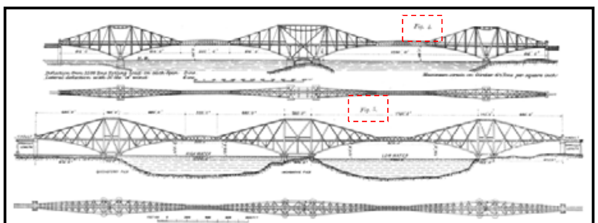
"…With regard to tunnels, it was considered that the great depth of water in the two main channels - above 200 ft. - and the high ground upon both shores, would necessitate very steep gradients and long approaches - making the tunnel many miles long, irrespective of the uncertainty of the nature of the ground through which the tunnel would have to be cut…"
259
Engineering, **February 1890**

"…the four railway companies above named instructed their consulting engineers - Messrs. Barlow, Harrison, and Fowler - to meet and consider the feasibility of building a bridge for railway purposes across the Forth, and assuming the feasibility to be proved, to decide what description of bridge it would be most desirable to adopt. It was fairly well known how many types of bridge there were to select from for such a site; these were (1): Mr. Bouch's original design (Fig. 2); (2) three forms of suspension bridges with stiffening guides and braced chains (Fig. 3); and (3) a cantilever bridge (Fig. 4). The inquiry was most comprehensive. It embraced not only bridges as set forth, but also tunnels, and both of these for different sites…"
Engineering, **February 1890**
RE: after the *Tay Rail Disaster*, confidence in Bouch was lost and work on the Forth bridge stopped. Bouch's design was formally abandoned on January 13, 1881. In the wake of the disaster and investigative report, *Sir John Fowler, W.H. Barlow* and *T.E. Harrison* - Consulting Engineers to the project, were invited to provide proposals for a bridge. 260


261

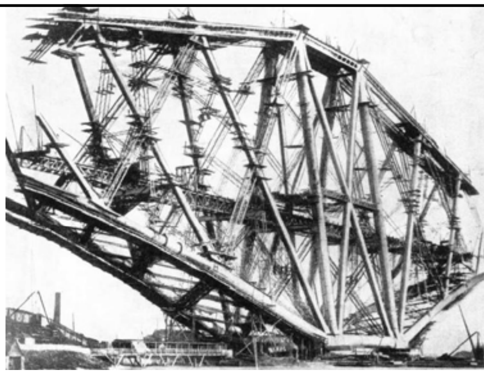


"…Accordingly, they were invited to submit a design which they could recommend for adoption, and which would coincide with the requirements of the Board of Trade. Sir John Fowler, in collaboration with his colleague, Mr. (afterwards Sir) Benjamin Baker, drew up a design for a massive cantilever bridge…"
RE: excerpt from *Railway Wonders of the World* (1913) 262
<u>Above</u>: caption: "Forth Bridge General Arrangement"



"…The original design for a continuous girder bridge (see Fig. 4) - on the cantilever and central girder principle which had been submitted by Messrs. Fowler and Baker - was in some particulars modified to suit the conflicting views of the other consulting engineers, and was then submitted to the directors in May, 1881. After consultation with the officers of the Board of Trade, this design (see Fig. 5) was finally adopted, and Messrs. Fowler and Baker were appointed engineers to carry it into execution…"
Engineering, **February 1890**
<u>Above T&B</u>: caption: "Figures 4 (top) and 5 (bottom) - the original and final design/s of the Forth Bridge" 263

"…The details of the design were investigated thoroughly, and finally it was adopted as being the best possible solution of the problem. Messrs. Fowler and Baker were appointed as the engineers to the undertaking. With much difficulty, and in the face of severe opposition, the requisite Parliamentary Act was obtained in 1882, and at the end of that year the contract for erection was secured by Messrs. Tancred, Arrol, and Co., a firm incorporated especially for this task, and of which the late Sir William Arrol and Sir Thomas S. Tancred, a well-known railway builder, were prominent partners…"
RE: excerpt from *Railway Wonders of the World* (1913). The fact that the *Forth Rail Bridge* was able to be built utilizing three large towers and six cantilevers of equal length was a great achievement given the lack of good foundation points, the poor silty soil and the huge spans over open water required. In the aftermath of the *Tay Rail Bridge* collapse, this bridge had to not only be structurally sound on paper but it also had to look sturdy and strong to instill confidence in a skeptical public, reassuring them that it was possible to build safe bridges across large stretches of open water. 264



Above: caption: "Cantilever of the Forth Bridge with work in progress. Each cantilever arm extends for nearly 700-feet. The gaps between the ends of the cantilevers are spanned by lattice girder bridges 346 ft. 6 in. long. The main spans of the Forth Bridge are each 1,710-feet in length."

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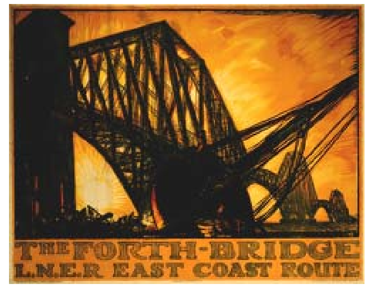

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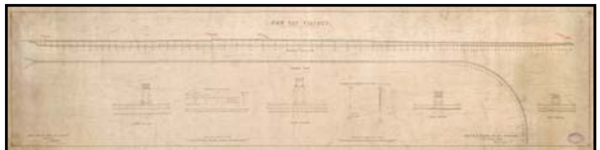
The New Tay Viaduct

267



As for the *Tay Rail Bridge,* Barlow's design for the new, replacement bridge was deeply influenced by the presence of the old. To satisfy stipulations made by the *Board of Trade*, the bridge was to be constructed exactly parallel alongside the old bridge (in order to keep navigation channels open) and its height was to be reduced from 88 to 77-feet. As in the old bridge, the railway line was to run on the top of the approach girders and through the girders of the higher, larger, navigation spans. Barlow recommended that if the spans of the new bridge were to be kept the same, girders from the old bridge - unaffected by the collapse of the high girders, be reused in the new bridge. The new bridge was to be built 60-feet upstream from the old bridge, thus allowing the old bridge to serve as staging for construction of the new bridge. However, the approaches onto the new bridge were altered and tringent weight and wind loading tests were to be undertaken. The proposals for the "New Tay Viaduct" were accepted by Parliament in October 1881, and the firm *William Arrol & Co.,* of Glasgow, was appointed contractor. The new bridge took just five years to build, opening to traffic on June 20, 1887.

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Above: caption: "General arrangement of the New Tay Viaduct"

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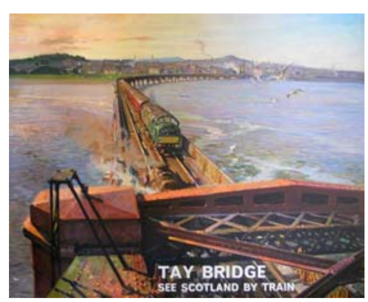

270

…The platform of the structure will be carried at a height of 200 ft. above the level of low water, upon alternate spans of the length already mentioned, while the piers, which will be lined in the most favourable position to suit tidal currents and the sweep of the waves, will be 147 ft. long by 65 ft. wide. Thus, the proportion between the closed and open waterway will be one-twentieth, measured along the axis of the bridge. It is proposed by the author of the communication to guard against all danger to navigation by the adoption of a most comprehensive and elaborate system of illumination signals and foghorns, the details of which we have not space enough at our disposal to discuss. It is stated that there will be no difficulty in ships clearing the piers in calm, fine weather, a condition of things that is frequently not found to prevail in those stormy Straits…

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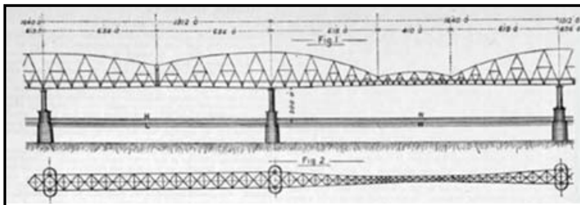

…In Figs. 1 and 2 are represented a skeleton elevation and plan of a couple of complete alternate spans of the projected Channel Bridge, as finally adopted, and having a total reduced length of 20·8 English miles. The shorter span of 1312 ft. consists of two cantilevers, each equal to 656 ft., and meeting at the centre of the span, and the longer of a total span of 1640 ft., comprising two cantilevers each equal to 615ft., and a central girder of 410 ft. in length. One pier will be a land pier, and the rest, seventy-two in number, will be in the sea. Of these piers the deepest will be founded at 167 ft. beneath low water, but the average depth will not exceed 118 ft. below the same datum. The masonry will be carried to a height of 46 ft. above the highest tides, and will be surmounted by steel columns, upon which will rest the main girders of the bridge, the soffit of which will be at an elevation of 177 ft. above the level of high water…

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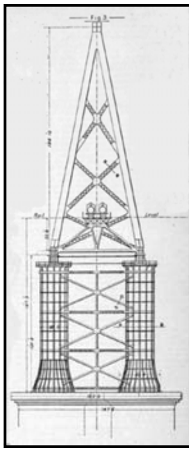

….A cross section of the bridge over one of the piers is shown in Fig. 3, from which it appears tba.t the superstructure consists of a pair of main girders, which are of steel, and inclined towards each other, so as to meet at their upper booms, thus forming in outline a triangular figure, resting at its base upon the steel columns which spring from the piers of solid masonry, as shown in plan in Fig. 2. The cluster of columns at the base measures 38 ft. 4 in. in diameter, and for the remainder of their height 26 ft. 9 in. It will be seen from an inspection of Fig. 1 that the main girders themselves are each constructed of an upper and lower boom, connected or braced together by a. single or Warren system of triangulation with very large openings. The alternate lower halves of these are stiffened by the introduction of subsidiary bracing, thus forming a series of alternate pairs of diamonds tied together at the centre of the diagonals by a horizontal longitudinal stretcher. At the intersection of the long and short diagonals with the lower boom are placed the cross girders, and above them is the rail level shown by the double line in Fig. 1…

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….A slight rise or camber is given to the lower boom of the girders at the centre of the spans, which otherwise would be horizontal, while the upper has a. polygonal contour. Throughout the whole of the shorter or double cantilever spans the breadth of the platform of the bridge is constant, or, in other words, the distance between the centres of the two main girders is the same and equal to 82ft. But in the larger spans the breadth of the superstructure at the piers becomes gradually reduced towards the junction of the cantilevers and the central independent girder, until it reaches a. minimum of 33 ft. In Fig. 3 the distance from the centres of the upper and lower booms of the principal girders is 196 ft. 10 in. The cross bracing between the two inclined main girders and the comparative size of the ordinary locomotives in the same figure afford a. very good idea. of the actual proportions and magnitude of the proposed undertaking. This great height of the girders over the piers diminishes progressively towards the centre of the shorter spans, where it does not exceed 131 ft. In the longer spans of 1640ft. the depth at the centre of the independent girder is nearly 66 ft., and the constant breadth between the two main girders 32 ft. 9 in…

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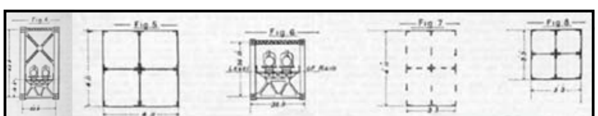

…A cross section of the superstructure of the bridge at this point is shown in Fig. 4. The minimum depth of the elevation of the large girders occurs at the junction of the independent girder and the cantilever portions of the large alternate spans, which become reduced to only 36 ft., as represented in Fig. 6. A section to an enlarged scale of the upper and lower booms, which are identical, of the central girder in the longer spans at its greatest depth is shown in Fig. 5, and similar sections are shown of the upper boom in Fig. 7, and of the lower in Fig. 8, of the same girder, at its ends where it joins the cantilever. These latter are not identical, the upper measuring 4 ft. 11 in. by 3 ft. 3 in. and the lower 3 ft. 3 in. square. All the sections are composed of plates and angle irons, and remind one of the old cellular booms adopted in the now obsolete tubular bridges and box girders…

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…The track will be double and laid upon longitudinal lattice girders, and supported at intervals by cross beams, as shown in the three cross sections of the superstructure of the bridge. The rails themselves will be laid in steel troughs in a. manner very similar to that obtaining at the Forth Bridge, while the expansion of the girders will be limited to the extent of hall a span. Steel is the material proposed for the construction of the bridge, and the total weight required bas been estimated at 755,000 tons…

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…Along the whole of the surveyed route of the Channel Bridge, the bed of the Straits is composed of a description of cretaceous rock, remarkably uniform and homogeneous, which bas been swept so closely and vigorously by the currents as to be entirely denuded of all alluvium. Each pier of the bridge will consist of two distinct parts, the upper and the lower. Of these two, the former, which will be above the level of low water, will take the form of an oblong vertical tower, 65 ft. broad in the direction of the axis of the bridge, and 147 ft. in length between the extremities of the semi-circular cutwaters or starlings. There would be no especial difficulty to be overcome in the building of this portion of the structure. It is with the lower or foundation part of the piers, which extends from low-water mark to the bed of the sea, that the trouble begins…

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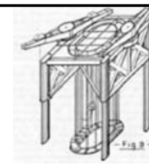

…There are three methods of accomplishing the task-one by floating metallic caissons, a second by means of sunken *beton*, and the third by the deposit of blocks of artificial stone by the aid of movable metallic trestles or scaffold frames. It is the last of these we shall now proceed to describe. Fig. 9 represents one of these adjustable trestles, placed in position over the site to be occupied by one of the bridge piers. A steel girder cradle rests directly on the bed of the sea, ready to receive the artificial blocks, while the floor is 210 ft. by 173 ft., and is supported by four columns or pillars, which can be caused either to slide or to remain fixed within four other hollow pillars, which act as sockets or sheaths for them. In shape these pillars are not circular, but the section is composed of a central square, 13 ft. being the length of each side, and terminated by two hemispherical ends. Steel plates, varying in thickness from 1 in. to 2 in., are built up to form the pillars, and each trestle will weigh some 4000 tons, a weight sufficient to insure its stability…

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…Upon the steel cradle - see Fig. 9 - are lowered the blocks, which form an external ring 16 ft. in thickness. Each block measures 23 ft. in length, 16 ft. in breadth, and 10 ft. in height, and their lateral joints are beveled, commencing from nothing on the outside of the ring, but opening out on the inside to a width of over 3 ft. It is within these open spaces that the steel wire guide blocks, with the cables extending from the upper flooring of the trestle to the foundation, are fixed to the cross girders forming part of the cradle. The blocks, having been raised to their proper position and adjusted on the upper platform of the trestle or scaffold frame, are attached to their respective guide cables, and lowered into the places provided for them. At their lower extremes the guide cables are fixed to the annular elliptical steel frame, constructed of two concentric main girders with radiating cross girders, represented in Fig. 9. The horizontality of this frame or cradle is secured and maintained by particular appliances, the description of which would occupy too much of our space…

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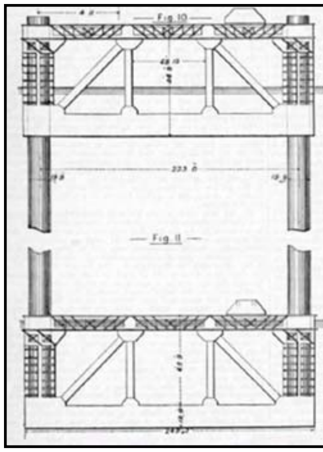

…There are two methods proposed by which the trestles could be floated to their respective situations. One is to construct them so as to be self-floating, and the other to attach pontoons to them. It is not difficult to build a portion of the frame - shown in Figs. 10 and 11 - in hollow compartments, filled with compressed air, and having a displacement sufficient to insure flotation, with a depth of water at the port where the trestle is constructed of from 17 ft. to 26 ft. As the trestle gradually drifted seawards into deep water, the compressed air in the floating compartments would be allowed to expand, so as to cause it to sink gradually, while at the same time the fastenings of the pillars would be loosened to allow them to float of themselves, or to sink slowly by the introduction of water until they were within some feet of the bottom…

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…Fig. 10 shows the trestle or frame in position, and Fig. 11 when it is quitting the port. This system has the disadvantage of demanding a large amount of material to obtain the necessary volume for flotation, and also sensibly to increase the surface exposed to the action of the waves and currents. It also necessitates the providing of a special floating arrangement for each trestle, which is a more costly proceeding than that of transporting in succession all the trestles by an independent floating appliance which will now be described…

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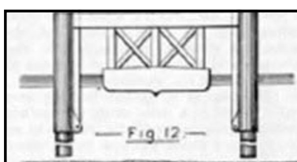

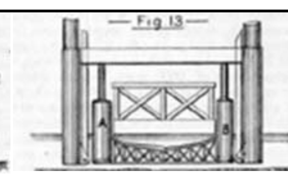

…According to this method the trestle will be constructed as shown in Figs. 12 and 13, with the component parts reduced to such dimensions as are simply necessary for its protection against wave violence. It will then be attached to a. specially built lighter, some 90 ft. in breadth, with twin-screws, and a displacement of 5000 tons, run in underneath the trestle, between the pillars and parallel to their larger dimensions, and upon it the platform of the frame will fixed up. Owing to the great height of the rigid framework, this position can only be insured in water of a depth of 70 ft., and it is therefore necessary to provide special floating arrangements for less depths, which are indicated in Figs. 12 and 13. They consist essentially of a pair of large floats placed parallel to one another, and joined by cross-girders, and of a displacement sufficient to carry their own weight and that of the trestle, with a. depth of water of about 22 ft…

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…When it is required to put to sea with the trestle, these floats are introduced between the pillars, which are in the position represented in Fig. 13. Each of the floats carries two funnels, which being hollow add to the total displacement, and carry on their summit the lower surface of the flooring of the trestle. There is room between the floats for the lighter already mentioned, which can be fastened to them by rings of metal, while at the same time leaving them free to rise and fall in a. vertical direction. It is when arranged in this manner that the trestle, which does not draw over 23 ft. of water, will leave the harbour on a calm day, as shown in Fig. 13. When deep water is reached, the pillars will be loosened in their sockets and lowered down by the introduction of water. A gradual escape at the same time of the compressed air in the floats will also cause them to descend, and the trestle will sink with them, until it rests upon the lighter. The latter will be disconnected with the floats, and leaving the whole floating apparatus behind, will steam a. way with the trestle, which will be now placed at a convenient height for attaining its permanent position, as shown in Fig. 12. A tug, provided with a reservoir of compressed air and other apparatus, will be charged with the task of rescuing the floats abandoned by the lighter, and submerged in deep water, and towing them safely into port ready for the next expedition…

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…By either one or other of the methods described, we have brought the trestle over the site of a. pier, and the next step is to adjust it in place by allowing the pillars to gently descend until they touch the bottom, and tightening up their connection with the platform above, until by this means the whole trestle rests upon the bed of the sea. In order to check the vertical oscillations produced by the grounding of the pillars, spring buffers will be introduced at one or other of the extremities of the pillars, or at their junction with the upper flooring. The exact horizontality of the frame will be insured by the employment of hydraulic jacks placed between the beads of the columns and the platform. Should the weight of the whole frame and its load not be sufficient to prevent the slipping of the feet of the columns, it will be a simple matter to increase the insistent weight by filling them with gravel or concrete…

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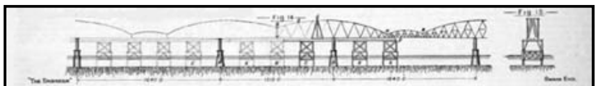

…After the construction of the pier is sufficiently advanced to permit of the removal of the trestle, it can be readily disengaged by reversing the operations which sufficed to fix it in position, and which need not be detailed. These adjustable trestles, besides acting temporarily in the building of the piers, might be found very useful for the erection of the ironwork of the superstructure of the bridge. Figs. 14 and 15 show in elevation and cross-section the main girders supported by them. The total cost of this stupendous fabric is estimated at £32,740,000, and our contemporary adds a financial statement of the probable traffic and receipts, which more than provide for a 5 per cent dividend on the capital expended. Such then is a brief summary of the manner in which it is contemplated to carry out this gigantic undertaking. The realisation of the project would constitute one of the most colossal engineering works of the age. As to the political and international questions involved, it is not necessary here to say anything.

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Déjà vu All Over Again

286

The English Channel Tunnel

It looks at present very much as if Sir Edward Watkin's pet scheme of tunneling the English Channel so as to establish a connection between France and England, which shall be independent of wind and waves, will be carried out. It is twenty-seven or twenty-eight years ago since a tunnel under the channel took shape. Colonel Beaumont, C.E., had charge of the work in 1881. The project, both in design of plan and mode of execution, is practical and ingenious. The chalk strata of England and France are geologically continuous, and the dip of the beds is the same – namely, toward the east – on both sides of the English Channel. The plan was to follow by a descending tunnel the natural dip of the grey chalk toward Dover, until a depth of two hundred feet below the sea bed of the channel was attained. The tunnel was then to be driven horizontally right across from shore to shore…

RE: excerpt from an 1893 article concerning the revival of the Channel Tunnel scheme

287

…A similarly inclined tunnel on the French side, rising along the direction of the dip of the strata, makes communication again with the upper surface of the land. The grey chalk is thus entered and followed throughout along its natural position, from daylight on the one side, and in the subterranean and submarine depths to daylight on the other side of the channel…

288

…The chalk in the portion already made was drilled by a circular disk of iron cutters, worked by a compressed-air engine, by means of a shaft, with bevel wheel gearing, the shaft and engine extending for a length of thirty feet. The cutting disk makes two revolutions per minute, and is fed forward a quarter of an inch at each revolution. The total advance of the whole face of the boring is a half inch per minute. When the English government stopped work on this tunnel some years ago, the tunneling had progressed some two thousand two hundred yards.

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If Only

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"…A word from the French and British Governments, and the work could be resumed at once, finished perhaps, before the conclusion of the war; it would serve as an artery to pump the last ounce of British energy into the western armies. Or, if the war were over, it would bind together the Anglo and French peoples in a bond that would cause any power to think twice before launching an attack upon either…"
Illustrated World, **April 1917**

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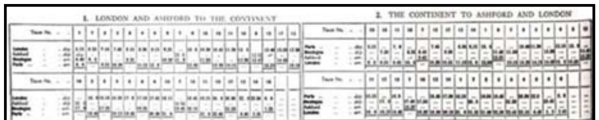
1. LONDON AND ASHFORD TO THE CONTINENT

2. THE CONTINENT TO ASHFORD AND LONDON

"…Because coal-burning locomotives would in a short time make such a tube - of such length, and hence so difficult to ventilate - dangerous to human life, a scheme to employ a compressed-air type of locomotive was worked out. De Gamond had ingeniously attempted to make use of the tides in putting through this idea. Today, if the tunnel were in operation, the electric locomotive would obviously provide the tractive power…"
Illustrated World, **April 1917**
RE: comfortable and continuous railway travel in an electrically-driven train through an electrically-lighted tunnel would take the place of a Channel-crossing which was often a disagreeable experience (i.e. sea-sickness, a/k/a "mal-de-mer")
Above: caption: "Time-table schedule of London-Paris tunnel express"

292

Raised from the Dead

293

"…Twenty years later, in 1906, another unsuccessful bill was raised in Parliament. After the war the proposal was again raised from the dead, as it were; but the Committee for Imperial Defense brought this effort to a quick end…"
Mechanics and Handicraft, **September 1936**

294

"…In 1906, the French, who have always been keenly desirous of seeing the tube put through, made a last appeal to the British public who had been so clamorous that in 1882 the idea had been to all intents and purposes abandoned. The fear of the English had seemed to be that the French could quickly rush an army through the tube, seize London, and, in short, make a speedy conquest of Britain…"
Illustrated World, **April 1917**

RE: by 1906, there were definite plans for a tunnel beneath the *Straits of Dover,* connecting England and France. Twenty-five years earlier, the Channel Tunnel was actually commenced, but suddenly stopped in July 1882, as a result of the action of the *Board of Trade*. This governmental body persuaded Parliament that the scheme was unwise. Great Britain's "splendid isolation" from Europe, they said, must be preserved at all costs, lest it suffer a calamitous invasion.

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"…As a guarantee that they had no such motives, the French proposed to elevate a section of the approach along their coast line, so as to offer a fair target to the British fleet. International, as well as internal politics, make rapid changes as the years fly by, and today the British would be the last to seek a bombardment of the French coast…"
Illustrated World, **April 1917**

296

England and France had long been rivals and/or outright enemies for many centuries. Wars had been fought between the two in the *Hundred Years' War, Seven Years' War* and the *Napoleonic Wars*. In the 17th and 18th century/s, England had grown to dominance and merged with Scotland and Ireland to become "Great Britain" (only to have its North American colonies lost, mainly due to French intervention). In June 1815, Britain struck back by ending Napoleon's empire once and for all at the *Battle of Waterloo.* Over the course of the 19th century, the two European powers came to an implied truce. First used in 1844, "Entente-Cordiale" (cordial understanding) became the term for the common interests of both France and Great Britain. The two had even worked as allies in the *Crimean War* (1853-56) to halt the expansion of the *Russian Empire.*

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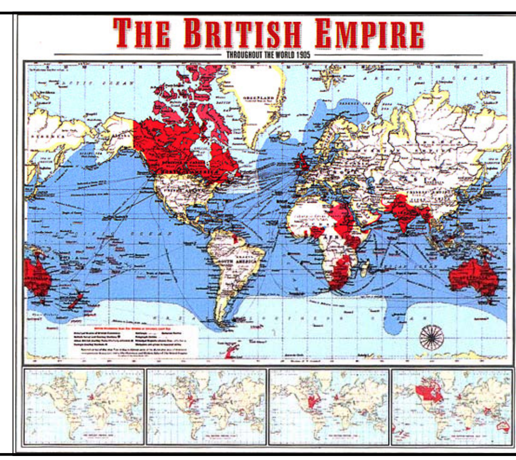
298

By 1900, the agreements toward peace between the two former rivals were still informal. Britain had long enjoyed its policy of "Splendid Isolation," focusing on its vast empire while leaving the matters of the European continent to the "Europeans." However, with the outbreak of the *Boer War* (1899-1902) and the growth of German power in both Europe and Africa, Great Britain looked back toward Europe to re-evaluate its geopolitical position. Talks were held about Great Britain potentially becoming a member of Germany's "Triple Alliance," but *King Edward VII* preferred his realm's isolation. The position of neutrality became more and more difficult to maintain as Great Britain's new ally, Japan, and France's longtime ally, Russia, fought the *Russo-Japanese War* (1904-05). POTUS *Theodore Roosevelt* ended the war with the *Treaty of Portsmouth* through back channel diplomacy which won him the *Nobel Peace Prize* in 1906. Great Britain, which remained neutral during the conflict, returned to its policies of isolation and protection of her vast empire.

299



300

On April 8, 1904, French Foreign Minister *Théophile Delcassé* took a telephone call from *Paul Cambon,* his ambassador in London. "C'est signé!" Cambon roared into the phone - "It is signed!" Progress had begun on the *Entente Cordiale* in 1899, five years before the actual Entente had come to be. French Prime Minister Delcassé had set the course for a rapprochment with Great Britain in the aftermath of the 1898 "Fashoda Crisis" in Egypt. With the retirement of arch-isolationist *Lord Salisbury* from the British Foreign Office, Delcassé proposed a new, more sweeping treaty in 1900. However, old grudges die hard and meaningful official diplomacy did not resume until 1903. the day after he arrived in England, Delcassé proposed a sweeping treaty, telling *Lord Lansdowne,* the British Foreign Minister, he was "entirely in favor of a comprehensive settlement."

301

Between May 14 and October 31, 1908, a large public fair: *The Franco-British Exhibition,* a/k/a "White City" (derived from the exhibition buildings which were all painted white), was held in West London (near Shepherd's Bush). A great success, the exhibition attracted eight-million visitors and celebrated the *Entente Cordiale* signed in 1904 by Great Britain and France.

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Will to Do

305

"…Meantime the French have been busily at work bringing the plans up to date. The total distance from the Paris-Calais railway to the London-Dover line is 37 miles. Of this distance 32 would be underground. In mid-channel the floor of the tunnel would rise from each side to a hump, so as to permit the drawing off of such seepage water as would be certain to find its way in. It is estimated that this seepage at no time would exceed 26,500 gallons a minute for a double tunnel…"
Illustrated World, April 1917

306

"…Each tunnel would be about eighteen feet in diameter. Drainage tunnels would be connected with these two traffic tunnels. According to an authoritative engineering publication, the difficulties of boring these tubes would in all likelihood not be so great as that of completing the Astoria gas tunnel under the East River in New York City.…"
***Illustrated World,* April 1917**
__Above__: caption: "Cross-section of the proposed tunnel"

307

"…It is expected that the tunneling machines can each dig 3.7 miles per year. As it is intended to work from several points at once by making use of the drainage galleries to drive cross drifts, whence new bores may be started on the main tunnel, it is believed the entire job could be finished in five years…"
***Illustrated World,* April 1917**

308

__Above__: caption: "This Pneumatic Battery Tunneling Machine, given its initial try-out on the New York Subway lately, will doubtless be used in the new tube"

309

Return-on-Investment

310

"…The cost of such a task would be not less than $2,000,000 a mile. The French engineer, Albert Sartiaux, says it would be wise to estimate an expenditure of $77,000,000 in all. Five to seven per cent would be realized annually on this investment."
***Illustrated World,* April 1917**

311

Between the Wars

312

"…In 1929 another such bill was brought before Parliament, but this time a bridge spanning the Channel was given precedence. The latest bill came before the House of Commons on June 30, 1930, was favored by the Government's economic committee, but opposed by the Committee for Imperial Defense. By the close vote of 179 to 172, it was rejected…"
Mechanics and Handicraft, **September 1936**

313

Geologically Speaking

314

"…Geologically there remains no reason why a Channel tunnel should not be built. The bottom of the Straits of Dover is of chalk marl, a stone impervious to water. The Channel here is one of the shallowest passages in the world, being only thirty fathoms deep at the lowest point, and there are no sudden jump-offs…"
Mechanics and Handicraft, **September 1936**

315

The Present-Day Scheme

316

"…The present-day scheme favors an original which would be enlarged into two tunnels, each of which would be provided with a railway track. The total length of the tunnel would be only thirty-four miles, twenty-four of which would be under the sea. The greatest depth below the Channel's bed would be ninety-five feet…"
Mechanics and Handicraft, **September 1936**

317

"…Nevertheless, the conservative British members of Parliament and a worried general staff continue to obstruct a scheme which would be, not only a marvel of science, but a boon to trade relations with Britain's ally - France."
Mechanics and Handicraft, **September 1936**

318

Part 5

An All-Rail Route

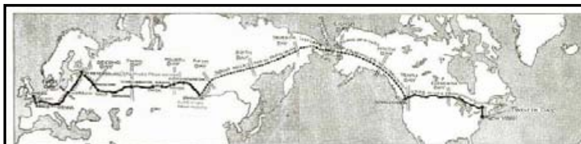
319

London to New York

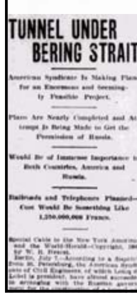
320

Submarine Tunnel of 30 Miles to Connect England and France - Another Tunnel of 38 Miles Between Siberia and Alaska
***Popular Mechanics,* September 1906**
RE: introduction to an article entitled: "All-Rail Route, London to New York"

321



From London to New York by Rail in 12 Days' Time



TUNNEL UNDER BERING STRAIT

American Syndicate Is Making Plans for an Enormous and Seemingly Feasible Project.

Plans Are Nearly Completed and Attempt Is Being Made to Get the Permission of Russia.

Would Be of Immense Importance to Both Countries, America and Russia.

Railroads and Telephones Planned—Cost Would Be Something Like 1,250,000,000 Francs.

"From New York to London by 12 days' travel in a palace car without change is the dream of ambitious railway engineers. Moreover, the dream is likely to come true before many years, as the best expert engineering minds in the world, after exhaustive study, have pronounced the daring conception not only possible, but involving less serious problems in tunnel construction than others which are already built and in daily use…"
***Popular Mechanics,* September 1906**
<u>Left</u>: *Omaha Sunday World-Herald,* July 8, 1906

322

No Great Difficulties

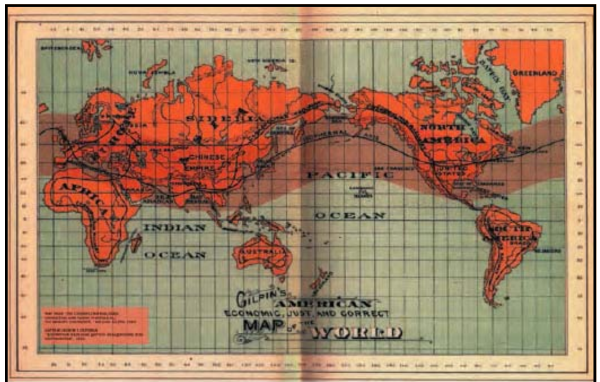
323

"…The idea of a submarine tunnel between Siberia and Alaska has recently received much attention in Russia. In spite of the distractions that government has experienced of late. Neither is the plan as new as generally supposed, for it was discussed nearly 30 years ago, and in 1886 our own geological survey reported on the subject to the United States Senate…"
***Popular Mechanics,* September 1906**
RE: as recently as 11K years ago, the Asian and North American continents were connected by a land bridge
<u>Above</u>: caption: "U.S. Coast and Geodetic Survey, J.E. Hilgard, Supt. Alaska and adjoining territory, 1884"

324

Prior to the ***Russian Revolution*** **(1917), relations between the U.S. and Russia were congenial. Czarist Russia had sold its Alaskan lands to the U.S. fifty years earlier, in 1867, in part as a hedge against British seizure of the territory. The** ***Suez Canal,*** **linking the** ***Mediterranean Sea*** **with the** ***Indian Ocean,*** **was built in 1869. The** ***Panama Canal*** **was completed in 1914. The** ***Bering Strait*** **is similar in width and depth to the** ***English Channel*** **thus, an undersea tunnel was proposed there, as in the Channel, during the 19th century. In keeping with these ambitious projects, a bridge or tunnel across or beneath the Bering Strait has long been suggested. During the early years of the 20th century, a rail line across the** ***Bering Strait*** **was negotiated but languished due to the depletion of Russian capital owing to the** ***Russo-Japanese War*** **(1904-05).**

325



Above: caption: "Gilpin's American Economic, Just and Correct Map of the World. From 'The Cosmopolitan Railway: Compacting and Fusing Together All the World's Continents,' by William Gilpin, 1890."

326

"…Mr. Powell, who made the report, stated the undertaking involved - at that time - no greater difficulties than those which existed during the construction of our first trans-continental railway, and since then great improvement has been made in tunnel work. The original idea was to bridge the straits, taking advantage of the several islands which are directly in the route selected…"
Popular Mechanics, **September 1906**

327

The Only Way

328

"…The advance in tunnel work has taken the bridge feature out of the conditions, and all engineers now agree on the tunnel as the only way…"
Popular Mechanics, **September 1906**

329

"…From East Cape, Siberia, to Prince of Wales Cape, Alaska, is 38 miles, passing through the islands of Diomede and the island of Kruaenstern. The prime mover in the enterprise is a French engineer, M. de Lobel, who has studied the subject for years, and who only recently received an interested hearing at the Russian court…"
Popular Mechanics, **September 1906**

330

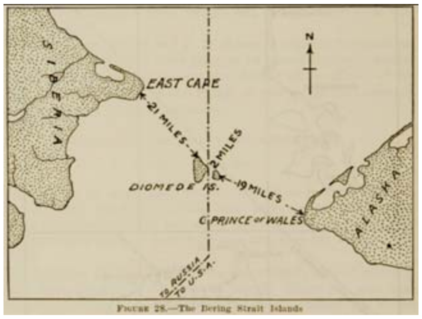


FIGURE 28.—The Bering Strait Islands

331

The Tunnel Under the Channel

332

"…The tunnel under the English channel would be about 30 miles long. This project also dates back 30 years and the company which has a concession from the French government some years ago bored 5,900 ft. of test tunnel and has spent over half a million dollars. Little work has been done since 1894, during which year the British government raised such strenuous objection to the work that boring was discontinued…"
Popular Mechanics, **September 1906**

333

The Proposed Route

334

"…The proposed route and distances are;

	Miles
London to Paris	**230**
Paris to Vienna	**625**
Vienna to Warsaw	**350**
Warsaw to St. Petersburg	**650**
St. Petersburg to Moscow	**400**
Moscow to Irkoutsk	**3,405**
Irkoutsk to East Cape (Behring Sts.), to be built	**3,800**
Across Behring Straits	**38**
Cape Prince of Wales, Alaska, to Vancouver, B.C., to be built	**2,300**
Vancouver to Montreal	**2,209**
Montreal to New York	**310**
Total	**14,317**

Popular Mechanics, **September 1906**

335

LONDON TO NEW YORK BY RAIL.

TO LINK UP EUROPE, ASIA AND AMERICA: THE ROUTE OF THE PROJECTED TRANS-ALASKA-SIBERIAN RAILWAY.

336

The Lost Cause

337

"…For years past the English Channel has been to engineers as was an unconquered nation to Alexander, it offered a field for brilliant achievement; the lure of Progress rose like a sea siren out of its seething waters and beckoned them to dare great deeds. And again and again that weird call has stirred to restiveness the hearts of the English and the French peoples; but ever the cautious islanders, feeling themselves doubly fortified against foreign invasion because of their insular position, hesitated to link themselves by a land route with the European continent, and in their trepidation the cause was lost…"
Popular Mechanics, **September 1906**

338

Feasibility and Amicability

339

"…But the great achievements of the present age, the assurance given by the world's best engineers that the project is wholly feasible and the amicable relationship now existing between England and France have aroused a great enthusiasm for the enterprise on both sides of the channel waters, and the English government is taking measures to authorize its execution - the French government, with all the 'sang-froid' of that race, has long been ready to take it up at a moment's notice…"
Popular Mechanics, **September 1906**

340

sang·froid

säNG□frwä/

noun
noun: sang-froid

composure or coolness, sometimes excessive, as shown in danger or under trying circumstances.

341

According to M. Sartiaux

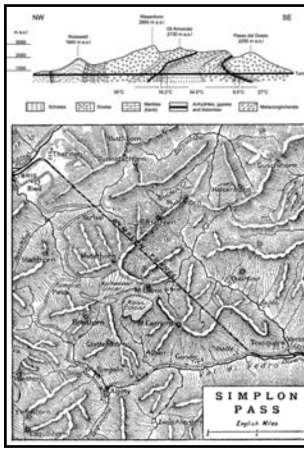
342

"…As an engineering enterprise, according to M. Albert Sartiaux, general manager of the Northern Railway of France, the construction of a channel tunnel presents no greater difficulties than did the construction of the Simplon tunnel. The channel tunnel would be longer, but there would be no danger from infiltration and no such high temperatures to be dealt with as there were in the Simplon. However, the difficulties of removal of waste would be greater. M. Sartiaux discusses the project at length…"

Popular Mechanics, **September 1906**

<u>Left</u>: caption: "Opening of the Simplon tunnel 1906, by Leopoldo Metlicovitz"

343



Providing a shortcut under the *Simplon Pass* route, the *Simplon Tunnel* is a railway tunnel connecting Switzerland and Italy through the *Alps*. Consisting of two single-track tunnels (64,097K and 65,039K-feet-long respectively (built nearly fifteen years apart), for most of the 20th century (1906-1982) it was the longest railway tunnel in the world. Work on the first tunnel commenced in 1898 and it was opened in 1906. Work on the second tunnel began in 1912 and it was opened in 1921. With up to 7,054-feet of rock over the tunnel, temperatures of up to 42°C (108°F) were expected. Thus, a new building method was developed. In addition to the single-line main tunnel, a parallel tunnel was built, with the tunnel centers separated by 56-feet through which pipes supplied fresh air to the workmen in the main tunnel (the parallel tunnel would be upgraded to a second running tunnel).

<u>Top</u>: caption: "Temperature profile in the Simplon tunnel (Switzerland). As in many other tunnels, thermal anomalies have been recognized in carbonate environments."

<u>Bottom</u>: caption: "Map of the Simplon Pass and Tunnel, 1906"

344

345

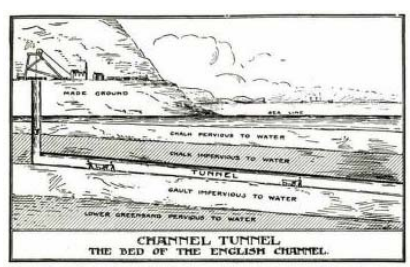
<u>Above</u>: caption: "A monument in memory of the deceased workers of the Simplon Tunnel was erected next to the Iselle di Trasquera railway station on 29 May 1905"

346

"…'Soundings and borings made in 1876 and 1877 gave assurance of the regular succession of strata under the bed of the channel, as they are visible upon the opposite cliffs, that they were without 'fault' at any point, and these assurances were confirmed by the test boring. The several strata are superimposed in curves of large radius and without fissures. The thicknesses of the several strata are practically constant as they appear upon the exposed cliffs'…"

Popular Mechanics, **September 1906**

347



348

"…'The Cenomanian stratum is clearly marked as suitable for tunnel construction. It is about 170 ft. thick and about 140 ft. of the upper part is impermeable. This depth is sufficient for a circular tunnel of from 15 to 20 ft. in diameter without danger from the pressure above and at a sufficient distance from the water bearing strata below. From the information afforded by the test galleries opened in 1883 at Sangatte and Folkstone it appears that the entrance of water would not exceed the capacity of a moderate pumping outfit. In the coal mines of the north of France the least inflow of water is found in this stratum'…"
Popular Mechanics, **September 1906**

349

"…'It is more difficult to lay out the course of the tunnel than to bore it. It must be done by feeling the way, keeping constantly at a certain distance from the treacherous strata above and below. The task is much facilitated by the fact that the use of electricity would permit the adoption of sharper curves and heavier grades than would be possible with other motive power'…"
Popular Mechanics, **September 1906**

350

"…'The tunnel should be built In two independent galleries. Even with the favorable conditions anticipated it might not be prudent to construct a single tunnel 27 to 30 ft. wide and 18 to 21 ft. high. It is infinitely preferable to adopt the plan of two passages 16 to 18 ft. in diameter each and perhaps 50 ft. apart, which would thus have no effect upon each other, while the tubular form would afford the greatest resistance to external pressure. However, the two passages should communicate every 300 ft., for example'…"
Popular Mechanics, **September 1906**

351

"…'For the longitudinal profile there are two possibilities: One assuring drainage by the double passage which will serve for two tracks; the other making the drainage gallery independent of the railway tunnels'…"
Popular Mechanics, **September 1906**

352

"…'To the first plan there is a fatal objection. It forces the adoption of a hump profile; that is, making the highest point in the tunnel at the middle with the lowest points at the ends, whence the water would be pumped. These are precisely the points at which the level of the tunnel should rise or be subject to a material prolongation and grades which would reach the maximum compatible with the adoption of electric traction'…"
Popular Mechanics, **September 1906**

353

"…'The second plan is the one that has been considered from the first with all the more reason that the drainage gallery would serve during the construction of the tunnel for the removal of waste material. For this purpose this gallery should be made about 10 ft. in diameter, and from it would lead branches to the tunnel proper, as described further on'…"
Popular Mechanics, **September 1906**

354

"…'Once provided with a suitable passage for drainage the tunnel proper would require a hump profile only for its middle section of only a few thousand yards in length; from this section it would rise upon a gently increasing slope to the portals'…"
***Popular Mechanics,* September 1906**

355

"…'The work would begin with the drainage passage, having its lowest point in and sloping toward a well or pit upon the bank from which waste material would be hoisted and water pumped. In brief, the course of the work would be as follows'…"
***Popular Mechanics,* September 1906**

356

"…'The drainage tunnel having been constructed to approximately the middle of the channel, the boring of the tunnel proper would proceed from this point toward the shore. As the course of the latter inclines upwardly as it progresses, water of infiltration would flow back and into the drainage tunnel, and as the amount of water would increase with the progress of construction, this should be taken into consideration in estimating the capacity of the drainage tunnel'…"
***Popular Mechanics,* September 1906**

357

"…'With a fixed section, the capacity can he varied by giving a greater inclination toward the point of discharge upon the shore. In order to follow closely the direction of the strata of gray chalk in which the work would be carried on, the line of the drainage tunnel and of the tunnel proper would diverge from the starting point in the middle of the channel'…"
***Popular Mechanics,* September 1906**

358

"…'In the lack of absolute knowledge as to the conformation of the strata, the drainage tunnel would serve for test purposes, from which the thickness of the strata above and below could be ascertained at intervals of from 300 to 500 ft., or about once a week at the estimated progress of boring. If the result of any tests should prove unsatisfactory the actual course of the tunnel could be varied without departing from the theoretical profile, making the tunnel more or less sinuous'…"
***Popular Mechanics,* September 1906**

359

"…'In this manner the actual character of the stratum through which the tunnel is to pass would be reconnoitered, and this knowledge would he further increased by the transverse passages which would be constructed to intersect the course of the tunnel proper at as many points as might be deemed necessary, and from each one of which work could be carried on Independently, working in each case toward the shore. According to the number of these branches and consequently the number of points from which the work could be carried on consecutively, the time required for the piercing of the entire tunnel Is estimated at from five to eight years'…"
***Popular Mechanics,* September 1906**

360

"…'From the traffic standpoint the relations between England and the continent are developed to a very slight extent. It amounts only to about 1,200,000 passengers by all routes, although there is upon one hand the population of 42 millions of Great Britain and upon the other over 100 millions, counting only France, Italy and Central Europe. This smallness of traffic is attributed almost wholly to objection to the water passage, since between France, with 40 millions of inhabitants, and Belgium, Holland and that part of Germany served by way of Cologne, with hardly 50 millions, the annual traffic amounts to over four millions'…"
Popular Mechanics, **September 1906**

361

"…'If the tunnel were ready for operation today, it is evident that it would divert nearly all passengers from the lines to Boulogne and Calais, but it is possible that it would have little effect upon the lines from Southampton to Saint Main. If it Is admitted that it would carry 90 per cent of those now traveling by way of Calais and Boulogne, 70 per cent of those by way of Dieppe, 50 per cent of those by Ostend, 20 per cent of those by Flessingue and 5 per cent of those by other lines, there would be at once a patronage of 900,000 passengers for the tunnel. But by the time within which the tunnel could he completed, this figure, with the proper allowance for natural increase based upon previous statistics, would amount to 1,200,000 passengers. This is the minimum. It is not a matter of doubt that the number would reach five to six millions in a very few years'…"
Popular Mechanics, **September 1906**

362

"…'In the matter of freight, estimates vary from 1,500,000 to 5,500,000 tons per year. This would include most of the merchandise denominated as fast freight, but there would probably be little effect upon slow freight. It is certain that the traffic would support the operation of the tunnel, but it is also certain that at least at first the traffic would be far from dense, amounting to 20 or 30 passenger trains and 30 to 40 freight trains per day in both directions'…"
Popular Mechanics, **September 1906**

363

Far from Probable

364

"…The military objection so long raised by Great Britain would be met by keeping a considerable force of men at the tunnel entrance at all times, and it is far from probable that an enemy could succeed in sending troops through, even unexpectedly - as in times of profound peace…"
Popular Mechanics, **September 1906**

365

The Great Advantages

366

"…The great advantages of unrestricted international intercourse involved in the question are hardly to be overemphasized. The dread of seasickness has kept traffic at its lowest point: but with an electrically lighted tunnel and electric cars, the tourist and the Londoner and the Parisian will think nothing of the little ride between the two shores. Then, too, the shipment of merchandise now entails two additional handlings going in either direction which would be rendered unnecessary with a tunnel route at an estimated saving of $1.25 per ton…"
Popular Mechanics, **September 1906**

367

The Longest Journey

368

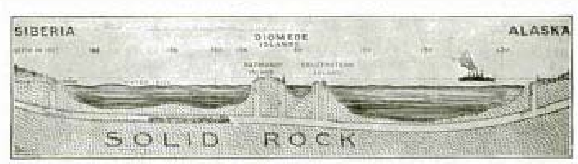
"…The next link to be forged In the international route is a 3,800-mile railway line across Siberia's frozen interior. That Russia in her time of stress and with her fear of political intrigue and her disapproval of American independence should consider linking the two continents is, to say the least, unexpected. The new railway would be an extension of the Trans-Siberian line which now terminates at Irkoutsk. The difficulties of construction owing to rigorous climate and lack of facilities for transporting material would be great, but not prohibitively so. This part of the journey, probably the least enjoyable, would occupy only a little more than three days…"
Popular Mechanics, **September 1906**

369

370

New and Improved

371



Plan of the Proposed Behring Strait Tunnel

"…As stated previously, the old plan of bridging Behring strait, using the Diomede islands as central points of support, has been abandoned entirely with the improved methods of tunnel construction. This undersea tunnel would be 38 miles in length, pierced through solid rock and with a depth of 192 ft. of water above it at one point, yet the time required for construction is estimated at only four years and the cost would be about $250,000,000…"
Popular Mechanics, **September 1906**

372

"…It is said the excavated material would not exceed that taken out for the New York Underground. Naturally both Russia and the United States would establish military stations at their respective entrances to the tunnel…"
***Popular Mechanics,* September 1906**

373

At a Glance

374

"…From Behring strait to Vancouver, B.C., is a distance of 2,300 miles to be covered by a steam railway line which will connect with our transcontinental routes and make them a part of the international line. The advantages accruing to the United States from such a line are apparent to the American, at a glance…"
***Popular Mechanics,* September 1906**

375

Trail of Civilization

376

"…The most northerly railway in Alaska at present is the Council City and Solomon River road which has been built over the frozen ground and serves the transit of gold-miners, but the new line will go far north of this, forming a trail of civilization through a now almost inaccessible region…"
***Popular Mechanics,* September 1906**
RE: the long abandoned C*ouncil City and Solomon River Railroad* operated from 1903 to 1907. The route was from a point near the mouth of the *Solomon River* (adjacent to Solomon City) to a point adjacent to Council City.
Above: the remains of the railroad (at Mile 31 of the *Nome-Council Highway*), comprising three locomotives, two flat cars and a boiler, were listed as an historic district on the *National Register of Historic Places* in 2001

377

Sharing the Burden

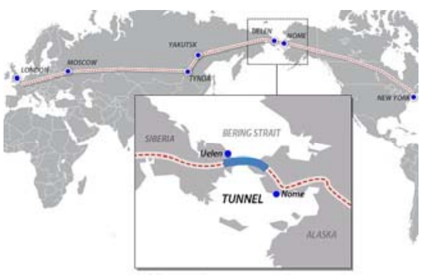
378

"…It is estimated that at a speed of 50 miles an hour, the distance of 14,317 miles between New York and London could be covered in just 12 days. One of the great difficulties is the carrying of supplies for the trip into the frozen interiors of Alaska and Siberia. Not only would it be necessary to provide for the round trip, as it would be impossible and prohibitively expensive to procure supplies in these regions, but it would also be necessary to establish supply stations for relief in case of protracted blockades from heavy snows. But as the lines would he operated independently, both the Russian and the American systems would share this burden."
***Popular Mechanics,* September 1906**

379

"If you're keen on visiting the Big Apple but not on air travel, making the journey by rail could one day be a possibility. Russia has given the thumbs up to a £60 billion project which would see a 65-mile tunnel dug under the Bering Strait, connecting Asia with North America. If plans go ahead, the journey from London to New York could take a mere three weeks, covering three continents along the way…"
***dailymail.co.uk,* August 22, 2011**

380



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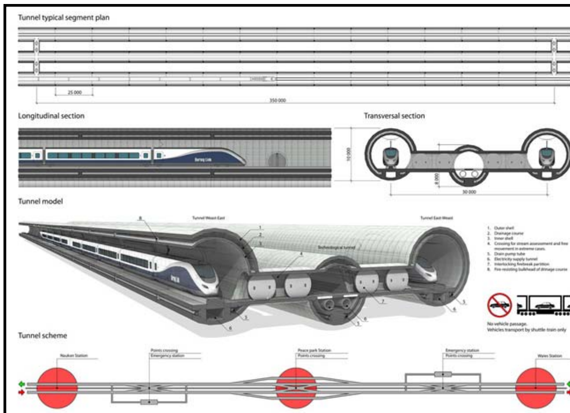
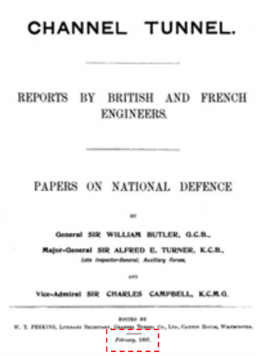


382

Part 6

Fear God and Dread Nought

383



CHANNEL TUNNEL.

REPORTS BY BRITISH AND FRENCH ENGINEERS.

PAPERS ON NATIONAL DEFENCE

BY

General SIR WILLIAM BUTLER, G.C.B.,

Major-General SIR ALFRED E. TURNER, K.C.B.,
Late Inspector-General, Auxiliary Forces,

AND

Vice-Admiral SIR CHARLES CAMPBELL, K.C.M.G.

EDITED BY

384

MILITARY FEARS DISPELLED

By Major-General SIR ALFRED E. TURNER, K.C.B.,
Late Inspector-General, Auxiliary Forces

385

Not a Military Question

386

It must doubtless appear to favoured individuals blessed with the faculty of exercising broad views upon matters terrestrial, that the majority of those who object to the creation of the Channel Tunnel, upon the grounds that its existence would constitute a military menace to this country, and that it would destroy our insular position and alter our geographical situation, have not been endowed with any considerable share of the sense of proportion. To assert that two small borings 18 feet in breadth and height and 36 feet apart, extending for twenty-four miles through the bowels of the earth, underneath the sea, and issuing on the French and English coasts by equally exiguous orifices - on our side completely dominated by artillery fire from opposite heights which, moreover, must be like mines, supplied artificially with air - can constitute a facility for the invasion of England, seems a conception too complicated for any person of normal comprehension to grasp. To many it will seem that the question is not essentially a military one at all, and that if the existence of the Tunnel can be shown to be fraught with advantages to the country, commercial and otherwise, all that remains is for the Government to direct the naval and military authorities to devise plans for the best and quickest way of rendering it useless and innocuous in case of the extremely remote contingency of war with France.

387

The Navy and the Tunnel

388

It is believed that the vast majority of the Navy in no way regard the Tunnel as a danger, or as likely to increase the burden of its responsibility for the defence of the country, nine-tenths of which already rests upon its shoulders. Much has been said of the almost general Military opposition to the scheme. This hostility has been greatly overstated. The scheme possesses no terrors for a large number of Army officers who, being on full pay, are necessarily constrained to desist from expressing their views on the subject. Naturally those who opposed the Tunnel twenty-four years ago adhere to the opinions which they then expressed, from which it would be hard, indeed, to stir them, and doubtless also they still cling to the recommendation of Sir Archibald Allison's Committee, which in 1882 suggested that a large fort, with a permanent garrison of 8,000 to 10,000 men, costing as to its construction £1,500,000 to £3,000,000 and as to its annual upkeep £500,000, should be constructed to cover the English orifice. A fitting parallel to such a precaution would be that of a head-keeper who placed a dozen good guns to cover a couple of adjacent rabbit holes.

389

A Committee of Business Men

390

But, surely, it is out of reason to assert that the Army could not make the country safe, as far as its role is concerned, in the event of the Tunnel being constructed. If, however, the ridiculous proposition be assumed, that the Army is incapable of carrying out such a task, then, as Mr. Francis Fox, the renowned Engineer, has appositely said, the defence of the Tunnel should be handed over to a committee of business men, who have a large stake in the country, and who, at no cost whatever to the public, and with a civilian staff and operators, could effectually forestall all imaginable dangers. Mr. Gladstone once asked a great Military authority whether the idea really existed in the minds of some persons that "England could be invaded by means of a pinhole." One might almost add that it would be easier for a camel to pass through the eye of a needle than for an invading force to make an irruption upon our shores through the Channel Tunnel.

391

The English End of the Tunnel

392

Again, it has been asserted that it is not so much an attack through the Tunnel that need be dreaded as the sudden invasion of England in the ordinary manner by an enemy who would proceed to seize the English end of the Tunnel, and then utilize it for his own purposes. Such irruptions cannot, however, be made without warnings; and, if we allow that they might be attempted without a formal declaration of war, they would certainly be preceded by those strained relations which have ever been the precursor of hostilities, and which would suffice to put all our ports and garrisons on the most acute *qui vive,* and render such surprise impossible.

393

Franco-German War

394

I notice that a distinguished officer has mentioned as a matter of surprise the outbreak of the Franco-German War in July, 1870. In a military sense there was no surprise whatever. The French ultimatum was rejected by the King of Prussia on July 13th. On the following day the French Emperor issued orders to mobilize the Army, and similar orders were given by King William on the 15th July. The frontier was not crossed by the Germans till a fortnight later, and there was nothing like a serious collision till August 2nd, when the combat of Saarbriicken was fought.

Again, it is premised that a fleet of French ships might land a force at Dover under cover of a dense fog, and capture the Tunnel. It is not, however, suggested how the darkness in which the enemy also would be enveloped owing to the fog is to be lightened, nor how, in such a condition of obscurity, he could land troops enough to carry out their fell purpose.

395

The "Treachery" Theory

396

The further suggestion that Dover, and with it the Tunnel, might be handed over to an enemy through bribes and treachery does not seem to merit sober consideration. I am not aware of any instance in the Military history of our country in which an attempt to betray has ever been made by officer or man, and the suggestion that such infamy has suddenly become possible appears to be quite unnecessary and unfounded. People of calm judgment will not forget that if the pessimists had been allowed to have their way the Suez Canal would not have been made. Lord Palmerston and others predicted that it would be a "serious danger to our Indian Empire."

397

Over-Sea Carrying Trade

398

Another curious argument has been used - that the existence of the Tunnel would be a serious blow to our over-sea carrying trade, and to our lines of railway running to the South Coast, as well as to the connecting sea services with France. But the cost of passage and freight by the Tunnel will be higher than that over-sea via Dieppe and other routes, as are now those via Dover and Calais, or Folkestone and Boulogne; and as the traffic on the latter routes by no means takes away from that on the former, so we may rest assured that the cheaper fares and freight will be adopted just to the same extent as now.

399

Not a Scintilla of Danger

400

It is not, however, upon financial or commercial grounds that I venture to enunciate opinions in favour of the Channel Tube. I leave that to others much more competent than myself. All I am anxious to show is, that knowing well the exact site at which it is proposed that the twin tubes should issue into the open, I am firmly convinced that there could not be a scintilla of danger to us from the existence of the Channel Tunnel. Not only, as before stated, would the orifice be completely commanded by the Western Heights, but, without any serious destruction, the mouth of the Tunnel could be effectively blocked by mechanical contrivances, or the tubes could be made to emerge on a viaduct far above tbe level of the ground, so that the destruction of the viaduct would prevent all chances of trains coming out of the Tunnel, except to unutterable annihilation. If this were not considered adequate, sections of the tubes could be flooded without difficulty and without permanent injury to the railway.

401

The Button Absurdity

402

A quarter of a century ago the country was supposed to be guarded by the medium of a button, by pressing which the Tunnel would be actually destroyed by explosives. In this idea the possibility of accidental explosions was involved, and it was argued, and rightly argued, that the responsibility of pressing a button, which act would result in the wholesale destruction of many millions of property, was too great to put upon the shoulders of any one man. Most people will, no doubt, agree that if such a deed of ravage and ruin were even a remote possibility, it would be wiser to have no Tunnel at all. But, as a matter of fact, there is no reality in the supposed existence of the momentous little button, nor in that of the lethal chambers of death-dealing explosives with their awful potentialities.

403

Invasion Impossible

404

It must likewise be borne in mind that the tubes would, like mines, be ventilated by artificial means, which could be at any moment arrested, with the certainty of asphyxiating every living being in the Tunnel. It would thus seem clear, that an attempt to use the Tunnel for purposes of invasion would be infinitely more deadly to the assailants than to the assailed.

The English end of the Tunnel would open out between two hills, and the French Military Staff - who have surely quite as strong grounds as ourselves to feel nervous as regards this submarine communication between the two countries - scout the idea of its being used for purposes of invasion by either country..

405

Railway Transport

406

They point out, moreover, that railway transport is a most delicate and difficult matter, and that it is impossible successfully to carry it out, unless special and detailed arrangements have been made for detraining, without which coordinate concentration is impossible. Surely no one will be so unpatriotic, and so much of a real “little Englander” as to assert that our Military authorities would be less wide-awake and less able to prevent and crush such compensation, than would be the French on their side of the Channel! To meet all possible apprehensions on our part, the French promoters are, however, prepared to construct their portion of the work in such a manner that the line, before entering the Tunnel on the French side, shall make a curve on a high viaduct erected parallel to the seashore, so that it should at all times be exposed to the fire of British warships in the Channel. This shore structure could thus be easily demolished, and the Tunnel rendered unapproachable and, therefore, utterly useless. All objections to the existence of the Tunnel thus appear to be, as termed by the French, the purest *enfantillage*.

407

The Command of the Sea

408

Lastly, with regard to the argument that if the French made a successful invasion of this country the Tunnel would prove of great value to them, there is nothing to be gainsaid, except this, that if such successful invasion by France, or any other nation, were accomplished, it could only be possible after the destruction of the Navy and the loss of our command of the sea, which would imply also the loss of our food supply, and our inevitable submission. It is certain that no nation would attempt the serious invasion of our country till it had secured the command of the sea, nor is it likely that any Power would be so insane as to make a raid of, say, 10,000 men upon our shores. If such a proceeding were attempted, the result would inevitably be a repetition of the disaster that befel General Humbert's brave little force at Ballynamuck in 1798. For the purpose of creating panic, discomfiture, and some loss and destruction, is it likely that any foreign Government would commit bodies of their troops to certain annihilation and capture?

409

The National Food Supply

410

If the Navy should really consider that the existence of the Channel Tube involved any decrease of our sea power, and that it was outside the capabilities of our land forces to guard its exit, the question must come to an end, for the former is not only the means by which we remain a first-class Power, but in war our very existence would depend upon its maintenance. Three-quarters of our wheat and flour, half our meat, a large part of our fruit and vegetables, and all the tea, coffee, cocoa, sugar, rice, sago come from abroad. The annual import of foreign food is reckoned at 14,500,000 tons, of which 9,500,000 tons consist of different kinds of corn. The total amount of wheat and flour consumed is 5,700,000 tons, and of this only 1,360,000 tons is home produced.

411

Industrial Considerations

412

This question of food supply involves the greatest danger that Great Britain can be called upon to face.* Captain Stewart Murray, making use of the inquiries of Mr. Charles Booth and Mr. Rowntree, has estimated that of our population of between 42,000,000 and 43,000,000, 25,000,000 are urban or collected in large populous centres. Of these, there are:

(a) In poverty, supported on wages of 23s. a week or less, 7,675,000.

(b) In comparative comfort, supported on wages of 23s. to 50s. a week, 12,875,000.

Upper and middle classes, 4,450,000.

* "Would War Mean Starvation?" by Mr. Spenser Wilkinson.

413

War with a European Power

414

A war with a European Power would at once mean reduction of our imports and exports, want of employment, reduction of our food supply, and great rise in the price of food, and consequent distress, hunger and starvation. The effects of this would first fall upon our huge proletariat and property-less class, who, when their wives and children began to starve, would rise, and by means which would not be disregarded, force the Government to sue for terms. This terrible condition of things is highly improbable but not impossible in case of war. It is reckoned that there is never more than five to six weeks' supply of food in the United Kingdom.

415

Good Relations with France

416

Let us suppose such a growth of sea power in another nation that it endeavoured to wrest from us the command of the sea. It would be at once the enemy's object to strike us in our most tender spot - attacking by means of fast cruisers our merchantmen, while the bulk of our Navy was employed in endeavouring to destroy that of the enemy. Our greatest trouble and danger - restriction of our food supply - would immediately arise, and, supposing that we were on terms of friendship with France, the existence of the Tunnel would be of incalculable value to us, inasmuch as food could then be poured into the country without obstruction from the enemy's warships. This is a definite and possible benefit which we may derive from maintaining good relations with France, and by constructing in agreement with her the Channel Tunnel. Such a war, however, it must be admitted, is as improbable as a war with France herself.

417

An International Agreement

418

Surely the best, safest and easiest course - and the one most in accordance with ordinary common sense - would be that an international agreement should be entered into between England and France so as to secure that the Tunnel should not under any circumstances be utilised for the purposes of war. Such an agreement would set the fears and apprehensions of the timid at rest as nothing else could do so effectively. The suggestion that Germany might successfully invade France, and then turn her attentions to us through the Channel Tubes, need not seriously be considered, as it may surely be presumed that if there were such a war, or even rumour of such war in the air, the British people and army would hardly be lethargic or asleep.

419

The Potentialities of Aeroplanes

420

The predicted potentialities of aeroplanes, which cannot be obstructed, will doubtless produce in time to come such a ghastly and terrible instrument of warfare that their existence will tend to the preservation of peace, so that out of great evil great good may arise. But that a pair of narrow borings connecting two countries by an underground and submarine passage can be regarded in any way as constituting a serious factor of warfare appears to be inconsistent with calm and collected judgment, and with a knowledge of the true facts of the case. It is hard, indeed, to believe that in this century nervousness and vain fears will be allowed to obstruct or defeat this great project, or that the “pale cast of thought” should be permitted to prevent “an enterprise of great pith and moment” such as is the creation of the Channel Tunnel.

Alfred E. Turner

January, 1907

421

Part 7

Report to the Directors

422

Report by Sir Douglas Fox and Partners

The Following Report on the Project was Presented
to the
Chairman and Directors
of the
Channel Tunnel Company
on
January 1st, 1907

423

Relief Model

424

The model in relief, now exhibited for the first time, has been prepared by direction of the French Submarine Tunnel Company, to show the proposed arrangements for the Channel Tunnel entrance and exit, together with the geological configuration of the stratum through which the Submarine Railway will pass, if sanction be given to the Bill before Parliament.

The scale is 1/20,000 horizontal, and 1/1,000 vertical.

Divided horizontally into several parts, the model shows successively the super-position of the different strata constituting the bed of the Straits of Dover, as well as the formation of the adjacent cliffs on either side of the Channel. Thus, in the lower part, are seen the Jurassic, Wealden, Gault, and the Cenomanian (1), through which the two parallel tunnels, each 18 feet diameter, will be driven; while in the upper part are the Turonian (2) and the Senonian (3).

Vertically, the model is made in two independent parts, so as to exhibit a sectional view of the different strata (variously coloured to facilitate examination), and especially the dip of the strata towards the north. These various strata have been ascertained by means of over 7,000 soundings, which brought to the surface more than 3,000 samples, all geologically accurate. The soundings took over two years to be performed from a boat right through the Channel. This important work occupied more than two years, and involved the employment of a vessel chartered for the purpose by the French Submarine Tunnel Company; and thus it became possible to complete an extensive and careful survey…

The undulations of the sea bottom are shown on the upper part of the model, so as to give an idea of the depth of the sea at various points of the Straits.

425

…This arrangement enables the course of the strata enumerated to be indicated as clearly as if it were illustrated on a map; and it will be observed that the bed of the Channel between Dover and Sangatte, on the French coast, takes the form of a letter “M” very much stretched out.

(1) Upper Greensand.

(2) Chalk marls and Chloritic marls.

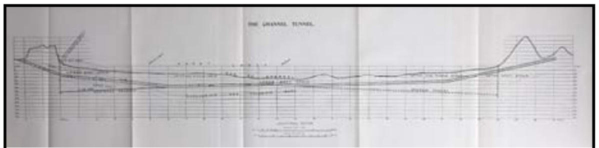
(3) Upper (white) Chalk (with flints) and Lower Chalk (without flints).

The tunnels which it is proposed to carry through one of these beds - the Lower, or Grey Chalk - will follow the line of the “M”

Borings already carried out on the British and French cliffs have been accurately marked; the experimental shafts are also indicated, and the direction of the existing headings is shown.

It is thus possible to obtain some idea of what has already been done, and of the similar conditions under which the construction of the submarine railway would take place…

426



…Finally, the model affords an indication of the proposed outlets of the Tunnel, both on the British and the French side. It will be observed that, on the French shore, entrance will be effected by means of an open viaduct, which would permit, should circumstances require, of its entire destruction from the sea, so as to render ineffective the very improbable seizure by an enemy of England of the Tunnel on the French side.

This viaduct - introduced in the plans for the French portion of the undertaking, with a view to allay the apprehensions excited in the minds of many people in the United Kingdom - would abut nearly perpendicularly to the cliff, so that the British fleet commanding the Straits of Dover would be able to destroy not only the viaduct, but also the mouth of the Tunnel, so as to render entrance impossible by a detour on the mainland.

It will, therefore, be recognised that the model materialises the idea of the Channel Tunnel, and proves the ease with which the technical difficulties in the way of its realisation may be overcome, while at the same time it invalidates other objections urged against the scheme.

Channel Tunnel Co., Ltd.,
Parliamentary Offices,
Caxton House,
Westminster, S.W.

427

Plans, Sections and Models

428

1. In accordance with your instructions, we have given careful consideration to all the circumstances connected with the International work, for the construction and operation of which your Company was formed, and we have, as requested, considered and settled with your Engineer, Mr. Francis Brady, the detailed plans, sections and estimates for the application to Parliament which is now being made in order to obtain the necessary authority to proceed with the works.

2. We have also placed ourselves in communication with M. Sartiaux, the General Manager of the Chemin de Fer du Nord, and have had personal interviews with his representative, M. Paul Emile Javary, and we have visited Dover, Sangatte, and Paris, and inspected the models, showing the respective plans of the British and French Companies.

429

Earlier Schemes

430

3. The numerous proposals which have, during many years, been put forward for bridges over the Channel, for train ferries on the Channel, and for tunnels under the Channel between Dover and Calais, show the importance which attaches in public opinion to the question of improving the means of communication between Great Britain and the Continent of Europe. A full description of these, and of the communications which took place between the British and French Governments, will be found in a report by M. Sartiaux.

431

A Bridge Suggested

432

4. Of the first, the most noteworthy are: Thome de Gamond's suggestion of 1857, to bridge the Straits between East Ness Corner and Calais; A. Motiers' proposed bridge between the South Foreland and Cap Grisnez in 1875; a bridge designed by Messrs. Schneider et Cie., M. Hersent and Sir Benjamin Baker, to pass over the Varne and Colbart Banks, estimated cost £34,000,000; and a similar scheme by Renard in 1890 for a shorter bridge between Cap Blancnez and South Foreland, estimated cost £28,320,000 (it is here interesting to note that M. Renard in a survey of the Channel bed found that it was composed of regular, homogeneous beds of chalk). Speaking generally, bridge schemes have failed through their great initial cost, the expense of maintenance, opposition from navigators, difficulties of deep foundations, and liability of the works to be destroyed by storms.

433

Caption: "It is proposed to carry the bridge on seventy-two piers in the sea, and there would be seventy-three spans alternating 400 and 500 metres. The deepest piers would have to be sunk in about twenty-eight fathoms, and the girders would be at least fifty-four metres above high-water mark. On this side the starting-point would be near the South Foreland, and Sangatte, close to the Watkin tunnel, the French terminus. With regard to the latter, Sir Edward Watkin's present Channel Tunnel project consists of two borings, 18 ft. diameter with cross galleries at every quarter of a mile. The cost of these tunnels, Mr. Francis Brady, the engineer, estimates at about £2,500,000 each. A third scheme indicated in the drawing is that of Sir Edward Reed who advocates a railway to run in tubes constructed of steel or iron and cement concrete, which would be laid on the bottom of the sea." (ca. 1893 print entitled: "The New Harbour at Dover: Channel Communications Between England and France")

434

Proposed Ferry

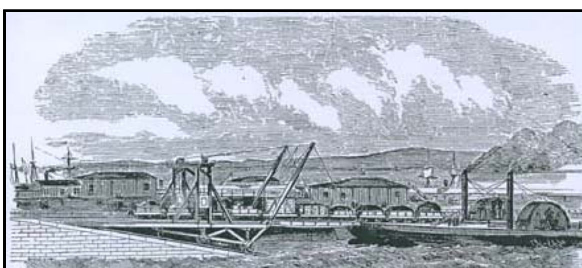
435

5. Of the second, Thome de Gamond's proposal in 1837 for a ferry. Between 1862 and 1870 Sir John Fowler brought forward several schemes for train ferries on fines suggested by Mr. Evan Leigh, and clients of ours, in conjunction with a French company, applied for similar powers in 1905. These schemes failed through opposition from the Admiralty and from harbour authorities. An Act was passed in the last session of Parliament giving general powers to the last named combination, for such a ferry, but without defining its exact position. These projects, though economical from a capital point of view, would not relieve traffic from the uncertainties of the sea and weather, and from the dangers of navigation, and would still involve delays.

436

Scotland's two east-coast Firths (highlighted) have always been a major barrier to communications to and from Edinburgh. This was especially true when the railways were expanding exponentially in the mid-19th Century. Freight traffic posed special problems because goods had to be offloaded at the ferry terminals. The route was operated by the *Edinburgh & Northern Railway*. In 1849, E&NR appointed civil engineer *Thomas Bouch* to be their manager. Only twenty-six years-old at the time of his appointment, he immediately set about improving the ferry service and by 1850, had built what was the world's first roll-on/roll-off train ferry. However, Bouch realized this was only a stop-gap measure. The long-term solution was to build railway bridges over both Firths (estuary).

437



"…Before the building of the bridges, some of the earliest train ferries known made connection between the railways south and north of both firths. Under the heart of Edinburgh a tunnel - now given over to the rather more placid task of growing mushrooms - led from Princes Street down to the water at Granton, whence these ferries plied across the Forth to Burntisland…"

***Wonders of World Engineering,* March 1937**

Above: caption: "The 'Floating Railway' between Burntisland and Granton, opened in 1850 as the first roll-on/roll-off train ferry in the world"

438

439

Tunnel Projects

440

6. Of the third or tunnel projects the following amongst many others may be mentioned: In 1802, a French mining engineer, M. Mathieu, presented to Bonaparte a scheme for a submarine tunnel, which was personally supported by the British statesman, Charles James Fox: Thome de Gamond's proposal in 1859, for a tunnel through the chalk, from Eastware Bay to Cap Grisnez, approved by Brunel, Locke, and Robert Stephenson. The same project was revived in 1867, and the Channel Tunnel Company, formed under the auspices of Lord Richard Grosvernor, Sir Edward Watldn, and the South Eastern Railway Company, brought forward a similar one in 1883. The Bill deposited by this Company was rejected, largely on military grounds, by a Select Committee in July 1883.

Tunnels have also been suggested by J.F. Smith in 1861, and by Zerah Colburn, Thomas Payne, P.T. Bishop, and others.

441

Cross-Channel Service

442

7. Great improvements have, of late years, been introduced into the cross-channel service, but serious delay and much discomfort and inconvenience still arise from the necessity for double transhipment, and from the passage itself. We have met with a very general opinion that through and uninterrupted communication would be of great advantage and convenience, not only for passengers and light and perishable goods, but also for heavy traffic. The existence of through communication between Dover and Calais would undoubtedly tend to increase the transatlantic trade from British ports.

443

The Scheme of 1882-3

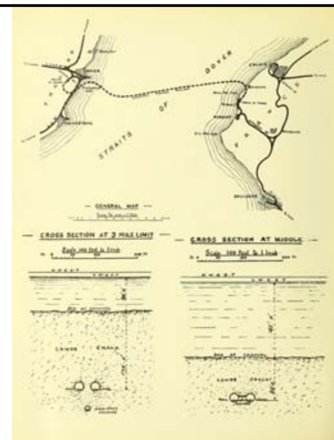
444

8. The preliminary operations of the two Companies at Dover and Sangatte have been of importance, to a great extent, as a practical test of what may be anticipated in carrying out the proposed works.

(a) Dover. A gallery 7 feet in diameter and of true circular form was driven in 1882-3 from the west side of Shakespeare's Cliff by Colonel Beaumont's boring machine. It was completed on a descending gradient of 1 in 80 for a total distance of 2,300 yards, when the works were stopped, the present face being under the sea, near the former end of the Admiralty Pier. The gallery is throughout in the grey chalk, and it proved to be almost dry. The volume of water entering the entire length of the heading is said to have only amounted to 1½ gallons per minute, which gradually diminished. Considering that no iron or brick fining was employed, this amount of water is a negligible quantity.

The engine-wright, who had charge at that date of the machinery, informed us that a piston pump 4 inches in diameter was only required to work half a day in a fortnight, in order to keep the gallery dry.

445



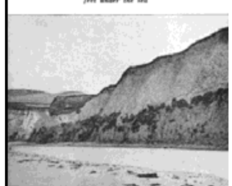
446

French Boring

447

French works at Sangatte

used in 1883 for boring the experimental gallery [illegible] feet under the sea



The Cliffs near Cape Blanc-Nez

showing the grey chalk strata through which it is proposed to bore the tubes

(b) Sangatte. According to the Report of the Committee presented to the French General Assembly, May 9th, 1883, a total length of 1,839 metres (2,009 yards) of similar gallery was driven up to the date when the works were stopped on 18th Marth, 1883. This gallery was chiefly carried out by means of Colonel Beaumont's Boring Machine, and, in consequence of the men becoming accustomed to the work, as much as 115 yards were executed in six days.

The present "face" of this gallery is under the Channel, 800 metres from the beach, measured at right angles to the coast.

448

Slow Infiltration

449

The depth of the sea at this point is 27 feet below low water, and the thickness of "cover" about 100 feet.

We understand that the quantity of water entering the gallery was about 400 gallons per minute. This experimental gallery was unlined.

We are informed that, although the water in the shaft rises and falls with the tide, the volume is very small and the infiltration is slow, as indicated by the fact that, with a rise and fall of tide of 18 feet the water in the shaft rises and falls only to the extent of a few inches.

9. We have studied the opinions of the eminent geologists who have dealt with the strata met with on both sides of the Channel.

450

Geological Investigation

451

10. The strata which form the coast of England between Dover and Folkestone, and of France between Sangatte and Wissant, and which lie beneath the English Channel between those points, dip in a northerly direction.

In 1876 and 1877 the French geologists, Messrs. Potier and Lapparent, took some 7,600 samples of the bottom of the Channel, 3,267 of which they were able to utilise. It was found from these that the lines of outcrop of the strata are very nearly parallel to a fine drawn from Folkestone to Sangatte.

By noting the composition of these samples, and the position from which they were taken, it is possible to follow the outcrop of the strata which appear in Shakespeare's Cliff, and in the shafts sunk close to it, the whole way across the Channel to the coast between Sangatte and Escalles.

The geological system to which these strata belong is the Cretaceous, which is divided into two divisions, upper and lower. It is only necessary to deal with the upper (Fr. Serie Supra-Cretacee). This is divided into four sub-divisions, the lowest being the (a) Gault and Upper Greensand (Fr. Albian), followed by the (b) Lower Chalk (Fr. Cenomanian), (c) the Middle Chalk (Fr. Turonian), and (d) the Upper Chalk (Fr. Senonian).

452

Successive Strata

453

These successive strata are very clearly seen in the cliffs on the French coast between Escalles and Sangatte. They incline gently from the top of the cliffs to the beach in a north-easterly direction.

11. The following are the chief characteristics of these beds (the thicknesses given having been measured at the Channel Tunnel experimental shaft at Sangatte, and at the shafts sunk near Shakespeare's Cliff, Dover):

(a) The Gault and Upper Greensand are equivalents of one another, formed contemporaneously, under different conditions of sedimentation. The Gault is a dark, stiff, blue, and sometimes sandy, clay; the Upper Greensand, an inconsistent group of greenish sands and sandstones.

(b) Above the Gault and Upper Greensand comes the Lower Chalk, at the base of which is a well-defined band of Glauconitic or Chloritic Marl (Fr. Craie Glauconieuse) 11 ft. thick near Dover, 10 ft. 6 ins. thick at Sangatte; a greenish chalk containing grains of Glauconite and Phosphatic Nodules.

Above this lies a layer of Chalk Marl (Fr. Craie Marneuse), 23 ft. thick at Dover, 29 ft. at Sangatte, a clayey chalk, impervious to water.

454

The Grey Chalk

455

Above this comes the great body of the Lower or Grey Chalk, called by the French, Craie Grise and Craie de Rouen, at Dover 87 ft. thick, at Sangatte 80 ft. It is a compact impervious stratum of greyish coloured chalk, containing no flints, and, so far as can be ascertained, free from fissures and slides. It is in this bed of chalk that it is proposed to construct the Tunnel, as being a most excellent material in which to work, and one which possesses the peculiar property of gradually "puddling" itself and becoming impervious.

(c) Above comes the Middle Chalk, white in colour, containing a few flints, and at its base a band of hard nodular chalk (Melbourn Rock).

456

An Impervious Material

457

The division between the Middle and Lower Chalk is well marked on the Cliffs, West of Sangatte, by small springs of water and fines of vegetation growing on the face of the rock. The water which has found its way through the Upper and Middle Chalk is unable to pass through the impervious Lower or Grey Chalk and trickles out, on the face of the Cliff, at the junction of the two strata.

(d) The Upper Chalk is a mass of white pulverant chalk containing scattered flints. It forms the upper portion of the Shakespeare's Cliff near Dover. The Upper and Middle Chalk contain a considerable amount of water, which percolates through the fines of flints.

458

Agreement With French Engineers

459

12. As a result of our interviews and frequent communications we find ourselves in complete accord with the French Engineers upon the following essential questions:

(a) That the proposed Tunnels can be constructed throughout in the Lower or Grey Chalk, a stratum very homogeneous, practically free from, and remarkably impervious to water.

(b) That the occurrence in the Grey Chalk under the Channel of water-bearing fissures is improbable, but not impossible.

(c) That the presence of any such fissure can be foretold with certainty, and without risk to the men employed, by providing a pilot drill to be attached to the boring machine, an advanced trial hole being thus always kept in front of the excavation.

460

Precautions Against Fissures

461

(d) That, should such a fissure be encountered, due precautions can be taken according to well-tried engineering methods, which, in the opinion of the French Engineers and ourselves, would ensure the work being carried past the fault, any water arising from such fault being duly excluded,

(In the Mersey Tunnel and elsewhere we have encountered fissures which we have thus dealt with successfully).

(e) That a Drainage Heading should be driven from each side of the Channel rising towards the centre and connected at Dover and Sangatte with shafts for pumping and winding.

462

Main Tunnels

463

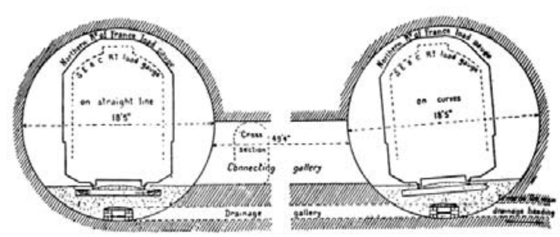
(f) That the Main Tunnels should consist of “two single track” circular tunnels, each of 18 feet nett internal diameter, and thus large enough to accommodate the Rolling Stock of the British and French main lines, except only their locomotives, for which would be substituted electrical locomotives of ample power to deal with the heaviest trains running upon the Main Lines.

(g) That there are several great advantages to be derived from this plan, as compared with the construction of a double “two track” tunnel, viz.: the vertical dimensions are much reduced thereby rendering it easier to adjust the position of the tunnels in the Grey Chalk; the ventilation of the works, both during construction and after completion, is rendered simpler, and more efficient; the cost of any lining is much reduced ; and the work can be more readily carried out by the well-tested system of shield, combined with mechanical excavators.

464

Cross Passages

465



(h) That the Tunnels should at frequent intervals be connected by cross passages with air-tight doors, thus rendering it easy to introduce currents of air, and to exchange workmen from one tunnel to the other.

(i) That the Tunnels should be well lighted and thoroughly ventilated, and the traffic worked by electricity.

466

Diameter and Gradient

467

13. Dealing now with the Specification for the Works which would devolve upon the British Company to execute, we propose to provide for two “single track” Tunnels as above-mentioned, 12 miles in length from high-water mark to the middle of the Channel, each of 18 feet nett internal diameter, one for the “Up,” the other for the “Down” traffic, to be driven chiefly on a descending gradient, but with a slight rise near the centre of the Channel. These tunnels would be placed some 36 feet apart, measured from centre to centre, but connected together at frequent intervals by cross galleries, in this respect being very similar to the Simplon Tunnel.

468

Mode of Construction

469

14. The Tunnels to be driven by shields (the debris being carried by electrically-driven belts to the wagons, which will be removed in trains hauled by electric locomotives), and to be lined throughout with cast-iron segments of ample strength to resist any possible pressure, and grouted on the outside, in the usual manner, by means of the "Greathead" grouting machine. By this method the outside of the Tunnel is completely surrounded by a covering of cement, which not only prevents leakage into the tunnel, but also preserves the plates from corrosion on the outside.

After the plates are in position, the inner face would be lined with concrete in cement, and lime-washed, thus providing a smooth interior surface, so that in case of derailment of a train but little damage would accrue, owing to there being no projection or obstruction which could foul the vehicles. This lining would preserve the plates from corrosion on the inside and would also materially assist the ventilation.

470

Tunnel Under Land

471

15. The length of Tunnel under the land would be of ordinary construction for a double line, and be lined with brickwork.

16. In certain places, where the necessities of the work of construction, or of the traffic, demand it, an enlarged cross section of Tunnel would be provided, where the hauling machinery for removing the debris could be placed, and where pumps and ejectors for freeing the Tunnel from water could be fixed. These would also serve as block stations for the signaling equipment, when traffic is running.

472

Primary Ventilation

473

17. At frequent intervals along the entire distance, cross passages would be constructed, fitted with air-tight doors of suitable design. These galleries should be placed obliquely in order to facilitate the passage of trains of material both from and to the advanced faces and for the primary ventilation.

Thus the construction trains, as also the main air current, could enter by one of the main tunnels, and crossing over by the most advanced oblique passage, return by the other tunnel.

The secondary ventilation would commence at the last oblique passage.

Upon the completion of the work these galleries would, as before mentioned, serve as means of communication between the tunnels for the workmen on the Railway.

474

Drainage Heading

475

18. Having thus described the general arrangement and design of the permanent Tunnels, it is necessary to consider the important question of the Drainage Heading, which would be the first work to be proceeded with.

476

Mersey Tunnel

477

19. In order that the Drainage Heading may be proceeded with independently of the works of the Main Tunnels, and to facilitate the conveyance of spoil and the clearance of any water that may be met with, it is proposed to adopt the system we employed in the case of the Mersey Tunnel - and which is also to be adopted by the French Engineers - of introducing a falling gradient of, say, 1 in 500 from the lowest point of the Tunnel on the British side to the pumping shaft near Dover. This Heading would be driven by a shield and connected with the Tunnels at such points as may be found desirable, thus rendering it of great service, not only for drainage purposes and for the removal of the excavated material, but also as supplementary to the main system of ventilation.

This Heading will probably have to be fined with cast iron, the plates having their edges planed and securely bolted together. These plates would be of sufficient strength to resist the full pressure, and, when grouted up, would be watertight. The only possible water-yielding area would thus be the actual face exposed, and one length of chalk to be covered by the next ring of cast-iron.

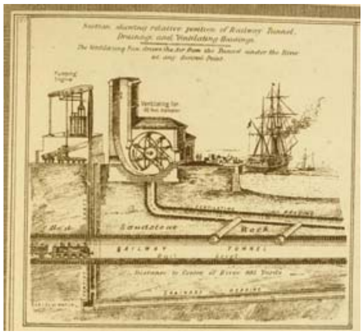
478

Left: caption: "Opening of the Mersey Railway Tunnel, 1886." The *Mersey Railway* provided communication for passengers between Liverpool and Birkenhead, England (which lie on opposite banks of the *River Mersey*) from 1886 to 1948. The railway opened with four stations using steam locomotives hauling unheated wooden carriages. However, the steam locomotives created a polluted atmosphere in the tunnel thus, passengers reverted to using the river ferries and the railway was bankrupt by 1900. Recovery came after the railway adopted electric traction in 1903. Nationalized in 1948 the tunnel and railway are still in use.

479

Construction of the river tunnel started from two 180-foot-deep shafts, one on each bank, containing water pumps. Three tunnels were to be dug; one for the two tracks, a drainage tunnel and a ventilation tunnel, which served as the pilot heading (with a 7'-2" diameter. The geology of the riverbed required the plans to be changed, combining the drainage and ventilation tunnel/s at the deepest section. Also, the grade on the Liverpool side was increased to 1 in 27. Estimates of the influx of water varied from 5K to 36K *Imperial Gallons* (IG) per minute. After the works were completed, the maximum pumped out of the tunnel has been 9K IG per minute. There were two pumping stations; *Shore Road Pumping Station* (on the Birkenhead bank) and *Georges Dock Pumping Station* (on *Mann Island,* on the Liverpool bank).

480



(Caption: "1886 illustration showing the ventilation and drainage system")

481

"…A considerable influx of water, however, had to be dealt with. The Liverpool heading was started first and a special drainage heading, 7 feet in diameter, was driven from the foot of the first shaft up a gradient of 1 in 500 to meet the lowest part of the tunnel under the river. Drainage shafts were driven vertically to connect the pilot headings with the drainage heading. The flow of water in this heading was found to be 2,410 gallons a minute. On the Birkenhead side, however, the influx of water was found to be considerably less and this could be adequately dealt with by the use of pumps. When the pilot tunnels met beneath the river, all the water drained by gravitation into the Liverpool drainage heading, from which the maximum quantity of water pumped was 4,300 gallons a minute…"

Wonders of World Engineering, **March 9, 1937**

RE: officially named "Queensway," the *Mersey Vehicular Tunnel* was begun December 16, 1925 and opened on July 18, 1934 by *King George V*. Like its predecessor, it too had to use drainage headings to deal with the influx of water.

482

"…The purpose of the pilot tunnels, each the size of a London Tube railway tunnel, was mainly exploratory. The lower tunnel was driven in advance of the upper heading and vertical boreholes were made to discover the nature of the rock through which the upper tunnel would have to be driven. Similarly, boreholes were driven in advance of the heading to give due warning of any difficulty that might have to be encountered…"

Wonders of World Engineering, **March 9, 1937**

483

Caption: "UNDER THE RIVER the pilot headings were lined with cast-iron segments only near suspected faults in the rock. Two pilot headings, 15 feet wide and 12 feet high, were driven along the line of the main tunnel for exploratory purposes. Exploratory bore-holes were driven ahead of the pilot tunnels to give warning of possible difficulties."

484

Approved Machinery

485

The Drainage Heading would be excavated by means of the Beaumont or other approved cutter or of Price's electrical digger, now largely used in the tube railways of London. These machines work on a central shaft, an important feature, as will be seen later.

20. An advance of 5 feet per hour can be secured both in excavation and also in the fixing of the iron lining; but, allowing for inevitable delays and for the long distances from the shaft, we are of opinion that, with properly designed machinery and arrangements, a speed of 2½ feet per hour can be relied upon for six days in the week, it being desirable and necessary not to drive on the seventh, the men requiring rest and the machinery slight repairs.

486

GREAT NORTHERN AND CITY TUBE RAILWAY.

487

Rate of Progress

488

Assuming 17 yards per day can be maintained for six days per week, this would represent an annual progress of about 3 miles at each face, occupying a period of four years to drive the Drainage Heading from the English to the French shaft (24 miles).

Three shifts of men would have to be employed, and the changing should take place below and on the spot, no stoppage of work being allowed. This was the system in the case of the Simplon Tunnel, where the drills never stopped even whilst the shifts were changing.

21. An emergency door would always be kept in position near the face of the Heading, not so much for actual use, but rather to induce confidence in the minds of the men at the front.

489

Enlarging Present Heading

490

22. The diameter of the Drainage Heading is a matter of importance. Up to the present time the preliminary work has been carried out with a diameter of 7 feet. But, as this heading will have to serve for the line of communication for all labour and material required for the execution of the Tunnels it is essential that it should be of sufficient size to allow of two sets of wagons passing one another, and, at the same time, to leave sufficient space for air, water and power pipes, cables, &c. In our opinion it should not be less than 11 feet nett internal diameter.

There will be several break-ups into the Main Tunnels, and each will yield a large amount of excavation, and will also require a considerable tonnage of cast-iron plates to be delivered with strict regularity, and consequently a complete line of way in each direction is, in our opinion, important.

491

Scheme Recommended

492

23. As soon as it is decided to proceed with the work we would recommend the following course to be adopted:

The Drainage Heading would be commenced and driven ahead, at as high a speed as was found to be practicable, it being a matter for the Directors to decide whether this should be completed before proceeding with the Main Tunnels, or whether they should be carried forward at the same time.

493

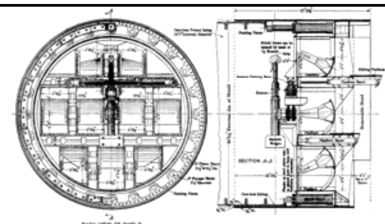
Working Shield

494

The break-ups or commencement of enlarged sections of the Main Tunnels already referred to would be made where the chalk had been found most suitable, and at each break-up a full-sized shield would be erected in order to permit of the excavation to the full external diameter of, say, 20 feet.

These large shields would be fitted with hydraulic or electric erectors, which we have previously employed, and which act like a human arm, take hold of the plates, lift them up and hold them in position until bolted in place.

495



"…The modern tunnel shield is a steel-plate cylinder whose forward edge acts as a cutting edge. Its rear end, extending backward, overlaps the tunnel lining of cast-iron rings. Inside the shield, hydraulic jacks act against the tunnel lining as a thrust block so as to push the shield ahead when pressure is applied. A partition prevents earth from entering the shield except as permitted through suitable openings. As the shield moves forward, the lining is erected under the protection of its rear. In submarine tunneling compressed air pumped into the forward end of the tunnel counter-balances the pressure of the water which tries to enter…"

RE: excerpt from *The Eighth Wonder*

Above: caption: "Back Elevation and Vertical Section of Hydraulic Shield"

496

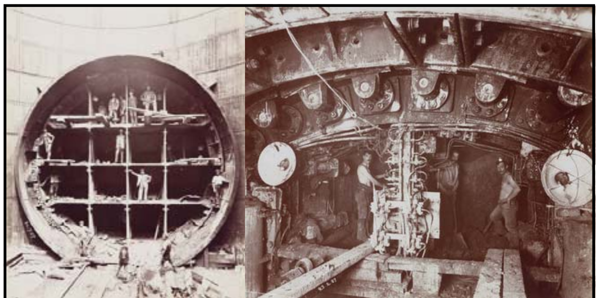
Rotherhithe Tunnel

497

This system of construction has been adopted in the latest instance of subaqueous work, namely, the Rotherhithe Tunnel now being built for the London County Council, and has proved highly successful, a pilot heading 11 feet 6 inches in diameter having been driven in advance, the larger tunnel 30 feet 8 inches in diameter following.

24. Each ring, as it is put in position, would be bolted up and grouted, so that, as already described, the only portion of the chalk laid bare at one time would be the actual working face, and a length of boring equal to one ring of plates.

498



Left: caption: "Construction of the Rotherhithe Tunnel, London, 1907. Tunnel B (south side) front view of cutting edge of shield emerging into shaft No. 1."
Right: caption: "Construction of the Rotherhithe Tunnel, London, 1907. View of two sections of shield showing 'miners' at work"

499

500

Miner's Wedging Crib

501

25. Should broken ground or a fissure be encountered, arrangements would be made for fixing a miner's wedging crib in the nearest sound bed of chalk. This crib would consist of a ring of cast iron in sections, tightly wedged up with dry pitch pine wedges and grouted, so as to prevent water traveling behind the plating.

So soon as the broken ground is passed and good solid chalk again reached, a second wedging crib would be fixed, and thus any water coming through the disturbed strata would be imprisoned between the two cribs, and prevented from traveling along outside the tunnel.

502

Supply of Air

503

26. It will be necessary to keep an efficient supply of air throughout the entire length of the heading for the men employed. This can best be effected by bratticing off the upper portion of the heading, thus forming a conduit of the required size for the volume of air, which would be blown in by high-speed fans.

When the break-ups are begun, this conduit will also have to provide air for the men working at these enlarged faces, until the second tunnel and crossways are in progress. The ventilation can then be effected in a manner similar to that adopted at the Simplon. In that case there are two parallel galleries with connecting traverses. Fans blow the air in at the end of one tunnel, and, after traveling up to the most recently excavated traverse, it returns by the other tunnel.

Fires which have occurred on Electric Railways, both in England and in other countries, have been due either to the motors or to improper "wiring" on the carriages. But in the case under consideration there will be wiring necessary on the existing rolling stock.

504

Primary Ventilation

505

This is known as the primary ventilation, and the volume of air is sufficient to keep all the galleries and traverses in a perfectly fresh condition.

506

Secondary Ventilation

507

27. To ventilate the advanced end at the face, secondary ventilation would be adopted, so as to effectually prevent the stagnation of air so common in advanced galleries of tunnels and mines, and enable the men to work with vigour and in comfort.

28. The question of the permanent ventilation has received our very careful consideration, and it may be desirable to state briefly how it would be dealt with when the Railway is open for traffic.

In the case of long tunnels, worked by steam locomotives, the most efficient system has been found to be: blowing the air against the traffic, by which means the Driver and Fireman, upon whom the safety of the train depends, are kept in fresh air, and free from smoke and steam. But in the case of electrically worked tunnels, where no products of coal combustion exist, the reverse is the better plan. The air will thus be blown in the same direction as that in which the train will be traveling, so that they will assist and not retard the current.

508

Electrical Working

509

The traffic being electrifically operated, the volume of air required is very largely reduced.

We have assumed, as a maximum, a passenger train, each way every ten minutes, carrying 500 people. The volume of air per minute required to keep the tunnels pure and fresh will be about 45,000 cubic feet on each line of way, traveling at a velocity of 6 feet per second, which is equivalent to a very light breeze. There will be no difficulty in dealing with this - it being far less in proportion than we have had to provide elsewhere.

The power required to induce this current of air, assisted as it will be by the trains themselves, will not be large, and the entire problem is simple as compared with that in many large collieries in which not only are far greater volumes of air blown through, but the length of passages through which the air has to be driven or exhausted is considerably greater and impeded by bends, which will not exist in this case.

510

Prevention of Fire

511

29. The prevention of fire in the trains is also one to which much attention has been devoted. In the case of specially built rolling stock for the London and Paris and other Expresses, no inflammable material should be used, and as the motors of the Electric Locomotive will be “armoured” against fire in case of short circuiting, no danger would arise as regards the electrical working even from the employment of ordinary rolling stock.

Assuming, however, that in spite of precautions any stoppage should occur in the tunnels, the passengers would readily pass along the tunnels in the rear of the train, where ample space will be available, as a footpath, clear of the electrical conductors. The passengers would thus be free from smoke, in consequence of the direction of the current of air always blowing from the rear of the train towards the front.

In consequence of the large diameter of the tunnels the electric conductors can be so placed as not to obstruct the permanent way or interfere with repairs.

512

Electric Lighting

513

30. The tunnels would be lighted throughout by electricity, and a separate and special circuit will be provided so that in the event of the main traction current failing, the lights in the tunnels will not be extinguished. The carriage lighting would be independent, each vehicle carrying its own store of light.

31. Similar sanitary and hygienic regulations to those so successfully adopted at the Simplon Tunnel will be enforced during the progress of the works.

32. The French Engineers have satisfied themselves as to the best position, for the Sorting Sidings and Station at Sangatte, and as to the site for the deposit of their moiety of the excavation from the shafts, heading, and tunnels. We concur in their views.

514

Left: caption: “Hot and cold double baths provided for workmen, with 1,500 ropes to raise and dry their clothes, each man padlocking his belongings. This system was adopted in making the Simplon Tunnel, and it would be followed in the construction of the Channel Tunnel.”
Right: caption: “Hospital, fully equipped, for workmen employed in the construction of the Simplon Tunnel, but rarely used, owing to the care taken by engineers and contractors alike.”

515

International Station at Dover

516

33. The plans and sections, as now prepared and submitted to Parliament for the proposed Approach Railways on the British side, provide Sorting Sidings and a Station near Maxton, just within the Borough of Dover.

These Railways are well laid out to accommodate the traffic, and, in conjunction with the Station, where the exchange of Steam for Electric Locomotives and all necessary sorting of traffic will take place, will provide full and complete means of communication with both the existing main lines between Dover, London, and the rest of England.

The Station will be easily approached from Dover by an Electric Tramway, which passes very near the site.

In the immediate vicinity there is a deep valley, affording a site for the deposit of spoil.

34. Good sites are also available for the Generating Stations, and one of the first operations would be to install a portion of the plant for construction purposes.

517

Success of Enterprise

518

35. Summing up the engineering questions relating to the proposed Tunnel, we agree with M. Sartiaux and Mr. Brady in the opinion that the enterprise is one that can be carried out with certainty, and at comparatively moderate cost, the geological and other conditions being of an exceptionally favourable character for the construction of a submarine tunnel.

36. We have not felt it to be within our province to express any opinion upon the question of the best precautions to be taken to secure the Tunnel against its being made use of for aggressive purposes in case of war.

519

Protective Works

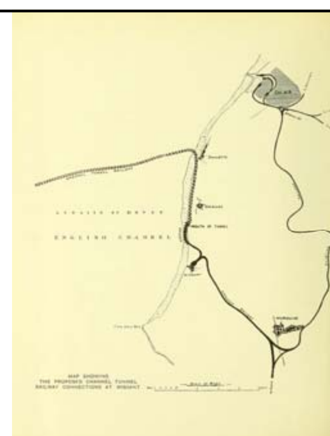
520

Foreign Governments, and notably the French, Swiss and Italian military authorities, have introduced protective works in connection with the great Alpine tunnels, which could be readily reproduced in this case, the levels of the proposed Tunnel lending themselves to arrangements which would give each nation complete and independent control of the portion lying on its side of the centre of the Channel.

37. On the French side, it has been proposed to approach the Tunnel over a viaduct, which would be exposed to fire from the sea, and could thus be destroyed if required.

38. The mouth of the Tunnel on the English side, and the Station near Maxton, be fully exposed, as was recommended by the Parliamentary Committee, to both direct and plunging fire from the existing Citadel and Heights of Dover, whilst heights to the north of the site could be readily fortified.

521



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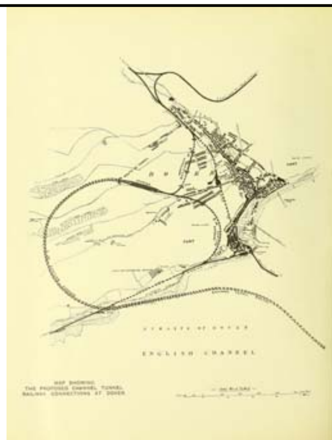


523

Cost of Scheme

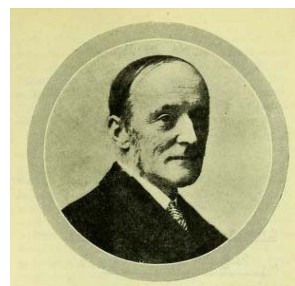
524

39. We estimate the cost of the British half of the undertaking, including the purchase of Land and Buildings and the existing Works at Dover, the Electrical Installation, the Drainage Heading and its Shafts, Winding and Pumping Machinery, the Land approaches, the Sorting Station and the Sidings, Signals, and the Junctions with the South Eastern and Chatham Main Lines, with Administration, Parliamentary expenses, Legal and Engineering charges, Interest during construction and Financial expenses, with the necessary provision for Contingencies, at £8,000,000 (Eight Millions Sterling).

We are, Gentlemen, Yours faithfully,

Douglas Fox and Partners.

525



Sir FRANCIS FOX, M.Inst.C.E.
(Sir Douglas Fox & Partners, Engineers to Channel Tunnel Company, Ltd.)

526

<u>Part 8</u>

A Submarine Enterprise

527

APPENDIX

To the Report on the Project Presented
to the
Chairman and Directors
of the
Channel Tunnel Company
on
January 1st, 1907

528

Project adopted on the 30th May, 1876, by the International Commission of the Submarine Railway - to serve as a basis for the Treaty to be concluded between France and England concerning the Channel Tunnel and submarine enterprise.

529

International Treaty

530

THE undersigned, the Commissioners appointed by the Governments of Great Britain and France to consider the conditions upon which the two Governments should, by means of a Treaty for that purpose, come to an understanding with respect to the proposed Tunnel and Submarine Railway, met at Paris from the 29th of January to the 5th of February, and at London from the 22nd to the 30th of May, 1876. After having considered and discussed the various questions to be dealt with in connection with this enterprise, they submit to the two Governments the accompanying Memorandum, which they recommend should be adopted as the basis of the proposed Treaty between Great Britain and France with regard to the said Tunnel and Railway.

H. W. TYLER.

C. M. KENNEDY.

HORACE WATSON.

Ch. GAVARD.

C. KLEITZ.

A. de LAPPARENT.

531

Memorandum

532

Anglo-French Boundary

533

1. The boundary between England and France in the Tunnel shall be half-way between low-water mark (above the tunnel) on the coast of England, and low-water mark (above the tunnel) on the coast of France. The said boundary shall be ascertained and marked out under the direction of the International Commission to be appointed, as mentioned in Article 4, before the Submarine Railway is opened for public traffic.

534

Rights of Navigation

535

The definition of boundary provided for by this article Navigation, shall have reference to the Tunnel and Submarine Railway only, and shall not in any way affect any question of the nationality of, or any rights of navigation, fishing, anchoring, or other rights in, the sea above the Tunnel, or elsewhere than in the Tunnel itself.

536

Working of Railway

537

2. The French section of the Submarine Railway shall be constructed, maintained, and worked in conformity with the French laws and with that of the 2nd August, 1875, in particular, subject to the provisions of the Treaty to be concluded between the two Governments. The English section of the Submarine Railway shall, subject to the provisions of the Treaty to be concluded between the two Governments, be constructed, maintained and worked in accordance with such conditions as Her Majesty may by Order in Council hereafter impose in connection with the undertaking of the said Company (as specified in the Channel Tunnel Company, Limited, Act, 1875), with such, if any, modifications as may hereafter be made by Act of Parliament.

538

Reciprocal Agreements

539

3. Within five years from the 2nd of August, 1875, the French Company shall be bound to conclude an agreement in writing with an English Company, and reciprocally the English Company shall be bound to conclude an agreement in writing with a French Company, with a view to the construction, maintenance, and working of the Submarine Railway.

540

Land Lines

541

This term "Submarine Railway" applies throughout the present Protocol to the Tunnel, to the Railway, and to all the works connected therewith, such railway being bounded in France by its junction with the railway from Boulogne to Calais, and in England by its junctions with the South-Eastern and London, Chatham and Dover Railways.

This term does not include the works mentioned hereafter in Article 16.

542

International Commission

543

4. There shall be constituted an International Commission to consist of six members, three of whom shall be nominated by the British Government and three by the French Government.

The International Commission shall advise the two Governments on all questions relating to the construction, the maintenance, and the working of the Submarine Railway, and shall have power, on giving notice to the respective Companies, to make such inspections as they consider necessary, and the Companies shall be bound in every wav to facilitate such inspections, and to cause their delegates to be present.

544

Receipts and Expenses

545

Each Company shall render annually to its Government an account of its receipts and expenses in such form as the Governments shall approve, after hearing the International Commission, and shall, if required, afford to its Government the necessary facilities for comparing such accounts with the books of the Company.

546

Settlement of Differences

547

If at any time any difference shall arise between the two Companies as regards the construction, maintenance, or working of the Submarine Railway, such difference shall be settled by the two Governments after having taken the opinion of the International Commission, subject to such legal actions as the Companies may bring in conformity with the Conventions concluded between them and with the legislation of the two countries.

548

Meetings of Commission

549

The Commission shall meet at all times when it shall consider it convenient to do so, and at least twice in each year. It shall also meet at any time at the request of either Government. But no meeting shall be valid unless there be present at least two members appointed by each Government. If at any meeting of the International Commission the members present of the one nationality shall differ in opinion from the members present of the other nationality, reference shall be made to the respective Governments.

550

Reports to Two Governments

551

The International Commission shall report every year to the respective Governments, both upon its own proceedings and upon questions connected with the Submarine Railway. It shall, moreover, submit to the two Governments its proposals for Supplementary Conventions with respect:

(a) To the apprehension and trial of alleged criminals for offences committed in the Tunnel or in trains which have passed through it, and the summoning of witnesses.

(b) To Customs, police, and postal arrangements, and other matters which it may be found convenient so to deal with.

552

Official Inspections

553

5. On the completion of the Submarine Railway, the International Commission shall cause it to be inspected as they may see fit on behalf of the two Governments, and after such inspection, and on receiving from the International Commission their recommendation in writing, but not before, the Submarine Railway shall be opened for traffic.

554

Maximum Charges

555

6. One set of regulations shall be applicable to the Submarine Railway as a whole; the regulation to be subject to the approval of the two Governments on the recommendation of the International Commission; the tariff of maximum charges shall be fixed in accordance with the Tariff hereto annexed.

556

Upkeep of Tunnel

557

7. Each Company shall be responsible for keeping in good and substantial repair the portion of the Submarine Railway situated within its own country; and in case of default, the two Governments, on the recommendation of the International Commission, shall have power, each in its own country, to execute, as may seem right, all necessary works and repairs. The two Governments shall also have power, each in its own country, to receive all moneys payable to the Companies, until the expenses of such works and repairs are covered. These moneys shall be collected in each country in accordance with the existing laws.

558

French Concession

559

8. The concession granted by each Government shall be for a term of ninety-nine years from the opening of the Submarine Railway. At the date fixed for the termination of the concession, or at an earlier period, in the event of the forfeiture of the concession, pronounced in the manner laid down in Article 10 below, each Government shall become possessed of all the rights of the Company, established on its territory, in and over to the Submarine Railway in such country, and shall enter immediately into enjoyment of all the revenues of the Company.

560

Government Control

561

The Company, in each country, shall be bound to hand over to the Government in a good state of repair the portion of the Submarine Railway in such country.

During the five years preceding the date fixed for the end of the concession, the Government of each country shall have the right to receive the revenues of the Company established in its own country, in order to apply them to the maintenance of the said portion, unless the Company takes steps to carry out this engagement fully and entirely.

562

Valuation of Stock

563

With regard to the rolling stock, moveable, and stores of all kinds, the furniture and tools of workshops and stations, each Government shall be bound, at the request of the Company established in its own country, to take all the above-mentioned objects at a valuation which shall be made in such manner as may be provided by the laws of the country; and, reciprocally, if the Government requires it, the Company shall be bound to give up, under the same conditions, the rolling stock and other things above mentioned.

The Government, however, will only be bound to take over the stores necessary for working the railway for six months from the end of the concession.

564

Works of Exploration

565

9. The works of exploration shall be commenced within one year from the 1st July, 1876.

If within five years from the 2nd of August, 1875, the concessionaires have not been able to conclude the agreement referred to in Article 3, or if, in consequence of the result of the borings and other preparatory works, they recognise the impossibility of carrying out the undertaking, the Companies shall have the right of abandoning the concessions.

566

Extension of Concession

567

Within five years from the 2nd of August, 1875, each Company is to declare to its own Government whether such Company proposes to retain the concession. This period of five years can, however, on the application of the Company, be extended in either country by the Government, at its discretion, for three further years, that is to say, for eight years from the 2nd August, 1875.

568

Default

569

In default of such declaration having been made by either Company within the above periods, and also if either Company should declare its intention of abandoning the undertaking, the concession to the Company making such default or declaration shall be considered as null and void; and action shall be taken in accordance with the provisions of Article 10. If one of the two companies abandon its concession, the two Governments shall consult as to the measures to be adopted, without the other Company being entitled to raise any objection or to lay claim to any indemnity.

570

Completion of Railway

571

Twenty years, to date from the day on which the Company shall declare its intention to retain the concession, shall be allowed for the completion of the Submarine Railway and the opening of the said railway for public traffic.

572

Forfeiture Article

573

10. At the expiration of each of the periods mentioned in the preceding Article, the Companies shall cease to have the right to commence or to execute the works which should have been commenced or executed within the period which has so expired, and if at any time after the works have been commenced the Companies shall for a period of one year, without such cause as the respective Governments, after hearing the International Commission, may consider reasonable, cease to carry on the works, and if the Submarine Railway be not opened for public traffic before the expiration of the period of twenty years mentioned in the preceding Article, or if at any time the Companies, without such cause as the respective Governments, after hearing the International Commission, may consider reasonable, cease for a period of six months to work the Submarine Railway, in conformity with the rules laid down by their Governments, then, and in any of such cases, the concessions granted to the company in fault shall be liable to forfeiture, which forfeiture shall be enforced according to the laws for the time being of each country respectively.

The forfeiture can only be pronounced by a Government against a Company after the necessity of that forfeiture has been recognised by the joint agreement of the two Governments on the recommendation of the International Commission.

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Abandonment of Concession

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11. Each Company may, at any time during the construction of the works, abandon its concession, on proving to the satisfaction of its Government the impossibility of continuing the said works.

In such case, forfeiture shall be declared and enforced according to the provisions of the Law granting the concession in France or of the Act of Parliament in Great Britain.

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Government Purchase

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12. At any time after the end of thirty years from the opening of the Submarine Railway, each Government shall have the right to purchase the undertaking of the Company established on its territory. This right shall not, however, be exercised excepting after a joint agreement between the two Governments, and after six calendar months' notice in writing has been given to the Companies. In the event of purchase, the rights of each Government in and over the soil, works, and undertaking shall be limited to its own territory, as defined in Article 1.

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Terms of Sale

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13. The amount of the purchase-money in each country shall be determined as follows, under the supervision of the International Commission: The net receipts of the Company during the seven years immediately preceding the year in which the purchase is effected shall be ascertained; the two years of minimum receipts shall be excluded, and the mean of the annual net receipts during the other five years shall be taken. That mean net receipt will form the amount of an annuity to be payable to the Company for the unexpired term of the concession, or, at the option of the British Government, for the purchase of the English concession, the basis of the calculation of a capital sum representing the value of the annuity at the time of purchase. In any case the amount of the annuity to be so payable, or which is to form the basis of such calculation as aforesaid, is not to be less than the amount of the net receipts during the year immediately preceding the year of purchase.

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Annuity

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Each Government is to provide and pay the annuity or capital sum which will be due to the Company established on its territory.

The Company shall receive, in addition, the payments to which they may be entitled at the date fixed for the expiration of the concession in accordance with paragraph 4 of Article 8.

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Supplementary Convention

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14. The working and maintenance of the Submarine Railway after either the purchase or the termination, or the forfeiture, of the concession in either country, shall be provided for by a Supplementary Convention then to be made between the two Governments.

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Suspension of Traffic

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15. Each Government shall have the right to suspend the working of the Submarine Railway and the passage through the Tunnel whenever such Government shall, in the interest of its own country, think necessary to do so. And each Government shall have power, to be exercised if and when such Government may deem it necessary, to damage or destroy the works of the Tunnel or Submarine Railway, or any part of them, in the territory of such Government, and also to flood the Tunnel with water.

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Extension of Concession

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If any of the powers of this Article are exercised by either of the Governments, then and in every such case neither the other Government nor either of the Companies shall have any claim to any other indemnity or compensation than the following: If any such power is exercised during the term and currency of the concession to either Company, the period of concession to such Company is to be extended for a term equal to that during which the working of the Submarine Railway has been suspended in consequence of the exercise of any of the powers mentioned in this Article. If any such power is exercised before the expiration of the period during which the French Government has engaged not to grant any rival concession, the term of this period shall be extended in like manner as that of the concession.

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Compensation for Damage

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Each Government, however, reserves to itself the right, if it should think fit, to grant to the Company established in its own country, but not to the Company established in the other country, such compensation for damage actually done by its order to the works of each Company as such Government may in its discretion think proper.

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Defence Works

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16. Works for purposes of defence, and such other works as may he required by either Government, shall be executed by each Company in accordance with the laws for the time being in force in the country where such Company is established.

17. It is understood, as regards the use of the Submarine Railway, that equal facilities shall be afforded in the formation of trains, in the running of carriages and wagons, and in the transport of passengers, animals, and goods of every description, whatever may be the points of departure or of destination, and whatever may be the routes followed.

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Legislative Sanction

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18. The provisions of the Treaty to be concluded shall not come into force before they have been sanctioned by the Legislatures of the two countries.

C.K. A. de L.
H.W.T. Ch. G.
H.W. C.M.K.

True copy.
H. Austin Lee.
H. de Lafaulotte.

594

The Agony of Defeat

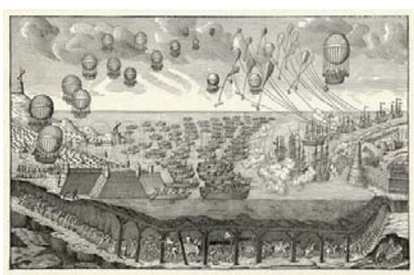
595

English Channel Tunnel Defeated

The construction of the submarine tunnel under the English Channel has been indefinitely postponed. Parliament listened to the war office and voted against the undertaking. This seems strange when one considers the ease with which a tunnel can lie closed to an invading army, and evidently the French have no fears of an English invasion through its medium. The tunnel could be flooded in a few minutes; its entrance could be blocked by closing iron gates or a lifting a few blocks of stone into place; a few rapid-fire guns would hold back thousands; a single 1-in. pipe would carry deadly fumes sufficient to asphyxiate a regiment before it could march 100 ft. In short, no harder military accomplishment can be conceived than an invasion in these days through a tunnel from which escape is impossible and the chances of success not one in ten thousand.

The illustration is reproduced from a French print more than a century old, and shows an invasion of armed forces by means of a tunnel. It is also interesting to note to what an extent the artist, of that day recognized the future possibilities of aerial warfare. His dream of 100 years ago is just coming true in respect to air craft. Will it be another hundred before the tunnel feature also materializes? (*Popular Mechanics,* May 1907)

596



597

Part 9

An Overwhelming Majority

598

The Long Discussed Question

599

Discussion of Channel Tunnel is Revived

Considerable attention has been given lately in engineering publications to the long discussed question of tunneling the English channel. The election of Lord Kitchener to the directorate of one of the English railways revived the matter although the famous British soldier has never given public expression of his ideas in the premises. It is regarded as highly probable that the matter will be seriously considered within the course of the next few years, however, especially in view of the fact that such opposition as has hitherto existed, based upon the military menace to Great Britain such a tunnel would hold, has been entirely dissipated through the arguments of those in favor of the tunnel to the effect that an invading force could easily be stopped and engulfed by the use of a few sticks of dynamite. (*Popular Mechanics,* October 1911)

600

The Present Scheme

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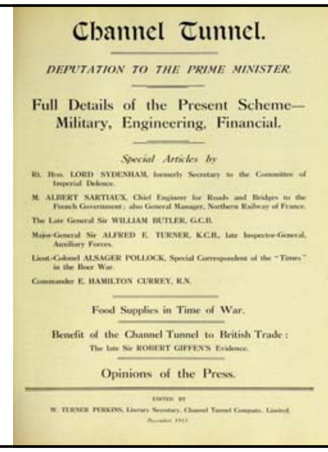

Channel Tunnel.

DEPUTATION TO THE PRIME MINISTER.

Full Details of the Present Scheme—
Military, Engineering, Financial.

Special Articles by

Rt. Hon. LORD SYDENHAM, formerly Secretary to the Committee of Imperial Defence.

M. ALBERT SARTIAUX, Chief Engineer for Roads and Bridges to the French Government; also General Manager, Northern Railway of France.

The Late General Sir WILLIAM BUTLER, G.C.B.

Major-General Sir ALFRED E. TURNER, K.C.B., late Inspector-General, Auxiliary Forces.

Lieut.-Colonel ALSAGER POLLOCK, Special Correspondent of the "Times" in the Boer War.

Commander E. HAMILTON CURREY, R.N.

Food Supplies in Time of War.

Benefit of the Channel Tunnel to British Trade:
The late Sir ROBERT GIFFEN'S Evidence.

Opinions of the Press.

EDITED BY
W. TURNER PERKINS, Literary Secretary, Channel Tunnel Company, Limited.

602

Brief History of the Scheme

603

The following is a brief history of the project for constructing a Submarine Railway between England and France:

1874. A concession was obtained from the French Government by several gentlemen, including M. Michel Chevalier, M. Lavalley, M. Raoul Duval and others, composing the French Tunnel Company. A shaft at Sangatte} near Calais, was sunk to the level of the proposed Tunnel. Boring machines driven by compressed air were employed, and a gallery was driven forward for a mile and a half beneath the sea.

1875. The Channel Tunnel Company obtained an Act of Parliament permitting them to undertake experimental operations at St. Margaret's Bay, east of Dover. No practical work was done, and the company was bought up by the Submarine Continental Railway Company, in 1886.

1881. The South Eastern Railway Company obtained an Act giving them powers for experimental borings and other works in connection with a submarine tunnel. Under this Act, a shaft (No. 2) was sunk near to the west end of Shakespeare's Cliff, 160 feet deep, and then a Tunnel was formed, 7 feet in diameter, for 2,015 yards.

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In addition, two other shafts were sunk - No. 1 at Abbot's Cliff, with 880 yards of submarine gallery, and No. 3 on the Dover side of the Shakespeare Cliff, the latter being intended for the purposes of ventilation and drainage when connected with the Tunnel from No. 2 shaft.

These works and tunnel were taken over by the Submarine Continental Railway Company, who repaid the South Eastern Railway Company their outlay in cash and shares.

The Submarine Continental Railway Company was formed with a capital of £ 250,000 in £1 shares, and 246,883 shares were issued. Registered 12th December, 1881.

1882. The Submarine Company took over the experimental works and Tunnel carried out by the South Eastern Railway Company as previously mentioned, but the shafts, etc., were kept open and ventilated for some considerable time afterwards, proof being afforded that very little water had entered the Tunnel.

Owing, however, to the action of the Board of Trade, the boring ceased in July, 1882, when 2,026 yards of the Tunnel had been made.

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1883. Joint Select Committee of the House of Lords and the House of Commons appointed; heard considerable evidence of the promoters - military evidence and others on the proposal of a Tunnel under the Channel. Report published, consisting of 574 pages of evidence.

Baron Emile d'Erlanger elected a Director of the Channel Tunnel Company, in the place of Sir Phillip Rose, deceased.

1886. Capital of Submarine Company increased to £275,000 to enable the Company to purchase and absorb the Channel Tunnel Company. A meeting of the latter Company was held 10th December, 1886, for the purpose of winding-up that Company.

1887. The Submarine Railway Company having purchased the Channel Tunnel Company, the Board of Trade sanctioned the change of name to the latter title by which, viz., "The Channel Tunnel Company, Limited," it has since been known. Certificate of Incorporation granted 14th March, 1887.

1897. The Capital of the Channel Tunnel Company was reduced by Special Resolution of the Company and confirmed, which was approved by the High Court of Justice 31st July, 1897. Present capital, £91,351 8s.

606

1901. Baron Emile d'Erlanger elected Chairman of the Channel Tunnel Company, in succession to Sir Edward Watkin, who was the first Chairman.

1905. Baron Emile Beaumont d'Erlanger elected a Director of the Channel Tunnel Company.

1906. Resolution in favour of scheme withdrawn in House of Commons owing to opposition of the Government.

1911. Baron Emile Beaumont d'Erlanger elected Chairman of the Channel Tunnel Company, in succession to his father, Baron Emile d'Erlanger, deceased.

1913. Scheme revived by His Majesty's Government calling for reports thereon by the Admiralty, the War Office, and the Board of Trade. These reports to be submitted to the Committee of Imperial Defence, for subsequent decision by the Cabinet.

607

BARON EMILE D'ERLANGER
Chairman, Channel Tunnel Company, Limited.

608

INTRODUCTION

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This pamphlet is issued while the Channel Tunnel Scheme is under the consideration of the Committee of Imperial Defence, with the object of bringing together, in convenient form, particulars for which on the part of the public generally there is now an ever-increasing demand. It will be remembered that the project was revived early in the present year, when His Majesty's Government called for special reports upon the subject from the three Departments immediately concerned - Admiralty, War Office, and Board of Trade. These reports have to be presented to the Committee of Imperial Defence. That body will, in turn, make to the Cabinet recommendations upon which the decision of the Government will be based, and announced to Parliament in the session of 1914.

610

Attention is herein directed to the several inquiries, which, in April last, Mr. Arthur Fell, M.P., addressed to the Prime Minister, and the replies of Mr. Asquith are appended. A verbatim report follows of the proceedings when a deputation, representing all political parties in the House of Commons, waited upon the same right hon. gentleman, and urged that the proposed submarine railway between England and France should be constructed as soon as possible.

611

In view of the fact that the only opposition now offered to the Channel Tunnel is based upon the Memorandum laid, in 1883, by Lord Wolseley before the Joint Select Committee over which the Marquess of Lansdowne presided, the document is reproduced *in extenso*. Even at that time the fears expressed by Lord Wolseley were not shared by the Military Committee (headed by Lieut. General Sir Archibald Alison, Bart.), nor by Major-General Sir Andrew Clarke (Inspector-General of Fortifications), General Sir John Adye, nor General Sir Patrick McDougal. But with the successful advent of aircraft, the conditions of National defence have since undergone very material change, and many of the objections that were formerly advanced by military experts have, as a result, been removed.

612

One of the strongest living supporters of the scheme is Lord Sydenham (late Secretary of the Committee of Imperial Defence), who has made an important contribution to this pamphlet, and supplemented it by a Note, in which every conceivable precaution for the defence of the Tunnel is outlined. Articles by the late General Sir William Butler, G.C.B., and Major-General Sir Alfred Turner, K.C.B., (late Inspector-General, Auxiliary Forces) are reproduced, together with one from the pen of Lieut. Colonel Alsager Pollock (who was at one time strongly opposed to the Channel Tunnel), and another by Commander E. Hamilton Currey, R.N. As an appropriate commentary by a great political leader, space has likewise been devoted to the speech which Mr. John Bright delivered in commendation of the project exactly thirty years ago. Mr. Gladstone's speech in support of the Channel Tunnel (Experimental Works) Bill of 1890, is also reprinted.

613

A full account of the scheme in its present shape is contained in the proceedings of the Franco-British Travel Union Congress, held in September last, when Baron Emile d'Erlanger (Chairman of the Channel Tunnel Company) dealt with its military and financial aspects, and Sir Francis Fox, M. Inst. C.E., with the engineering details. A pamphlet written and issued by Mr. Arthur Fell, M.P., on "The Channel Tunnel and Food Supplies in Time of War," is also republished, and a full translation given of a remarkable article contributed to the *Revue des Deux Mondes* by M. Albert Sartiaux, Chief Engineer for Roads and Bridges, and General Manager of the Northern Railway of France. Another from *Je Sais Tout* has been translated, and, by the courtesy of the editors, is reprinted. Articles have also been extracted from the Press of the United Kingdom, which is giving cordial encouragement to the scheme.

614

Finally, commercial testimony is offered, including a summary of the very striking evidence given by the late Sir Robert Giffen, of the Board of Trade, before the Joint Select Committee of 1883. If the decision of His Majesty's Government be such as to permit full inquiry into the subject by Parliament, ample evidence upon these and all essential points will be tendered by competent and trustworthy witnesses from many parts of the country.

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THE CHANNEL TUNNEL

By LORD SYDENHAM OF COMBE,
Formerly Secretary of the Committee of Imperial Defence

616

I am glad to think that the question of the Channel Tunnel is now likely to receive the careful consideration which has been wanting in the past. When, in 1872, the French Government asked for the opinion of H.M. Government, a most favourable reply was given by the Foreign Office, and for thirteen years following the initiation of the project by an Anglo-French Committee in 1867, no objections were raised, and general approval was forthcoming.

In 1880, when the South-Eastern Railway began to make trial shafts between Folkestone and Dover, the military aspects of the question were discussed for the first time by an Inter-departmental Committee, and differences of opinion were at once manifested. Such differences reappeared in the Enquiry by a Joint Committee of both Houses of Parliament in 1883, when a majority reported against the project. As a result, all motions and Bills were subsequently opposed by Government.

Anyone who studies the handling, during a period of 46 years, of this important national question cannot fail to come to the conclusion that the methods adopted have been pre-eminently unsatisfactory and unscientific. Clearly, before considering the military objections, if any, it was essential to enquire into the economic aspects of the Tunnel. Until it could be shown beyond doubt that British trade and industries would benefit, and that the large capital sum required would be remunerative, it was premature to consult military opinion.

617

In 1870 the Board of Trade appears to have regarded the project as likely to be beneficial to our commercial interests, and some evidence on this point was taken by the Parliamentary Committee; but no attempt has yet been made to ascertain the reasoned opinions of those who alone are qualified to pass judgment upon the first essential point to be decided. It is for the Chambers of Commerce and for students of British economics to speak with authority on this point. If they can show that undersea communications will be to our real advantage in peace, and will in every case, except that of hostilities with France, secure a certain measure of food supply in war, then the military objections will have to be far more cogent than any which have hitherto been imagined to be permitted to prevail.

Since 1883 there have been changes which distinctly favour the Tunnel project.

In the first place our relations with our great neighbour have been placed upon a new basis. It is now much more probable that we may be called upon to send troops to the assistance of France, or to discharge our obligations in regard to Belgian neutrality than that we should be involved in a French war. In my view, the probability or improbability of war with France does not affect the question of the Tunnel, the main justification for which must be based upon its value to trade in peace. But present conditions point plainly to a possible and important military use which was not anticipated in 1883.

618

In the second place, cross-Channel communications are now less easily guarded in war than formerly. The submarine, whether its efficacy is as great as or less than is expected, will without doubt prove, at least at the outset of war, a menace which could not be disregarded. So much the greater would be the value of a line of communication which would be alike secure against torpedo craft and independent of all weather conditions.

Lastly, we now have electricity as the motive power on which undersea transport would necessarily depend. Apart from other great advantages thus resulting, the fact that the generation of this power, and the consequent control of all train movement over the British half of the Tunnel, can be entirely in our own hands must tend to allay the fears to which imagination has given rise.

It may, therefore, be stated with confidence that, if the Tunnel was a project which Government could support in 1872, the arguments in its favour from the national point of view have since distinctly gained in number and in force.

I think that it may be useful to indicate the nature of the military objections as far as they are known; but unless and until they are presented in a clear and definite form, direct refutation is not possible.

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As the views of Lord Wolseley naturally carried great weight in the controversy of the early "eighties," it is desirable to recall the fact that they were based wholly on the hypothesis that the British end of the Tunnel could be seized and held by an act of treachery, at a time when there was not a cloud upon the international horizon. This is made perfectly clear in the Memorandum, which stated:

"The seizing of the tunnel by a coup de main is, in my opinion, a very simple operation, provided it is done without *any previous warning or intimation whatever* by those who wish to invade the country . . . My contention is that, were a tunnel made, England, as a nation, could be destroyed without any warning whatever, when Europe was in a condition of *profound peace* . . . The whole plan is based upon the assumption of its being carried out in a time of profound peace between the two nations, and whilst we were enjoying life in the security and unsuspicion of a fool's paradise."

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This tremendous assumption was supported by a long catalogue of wars begun without a previous formal declaration, which may justly be described as absolutely irrelevant to Lord Wolseley's contention. In modern history there is no instance of such an act as Lord Wolseley contemplated during "a time of profound peace" and "without any warning whatever." The modern danger is of a different kind. The immense increase of rapid means of communication has made nations too susceptible to the smallest symptoms of preparation for aggression, and exaggeration of the significance of small measures, leading to mutual suspicion and irritation, is what we have to guard against. If, as is certainly true, mobilizations are now carried out far more rapidly than formerly, the difficulty of keeping them secret has been enhanced correspondingly.

Lord Lansdown's draft Report of 1883 completely destroys the entire foundation upon which Lord Wolseley's fears were based. "We do not," he wrote, "take the view that the contingency of a *coup de main,* struck by a Power with whom our relations had been friendly and unrestrained, is one which we have any right, or which experience would justify us in placing among the foremost of the probabilities with which we have to deal. It is our impression, on the contrary, that if such an attack were to be made, it would have been preceded by circumstances which would have called for effectual precautions against a surprise. We observe with pleasure that this view is that apparently entertained by His Royal Highness the Commander-in-Chief, and by Sir Lintorn Simmons."

622

I believe that all thoughtful soldiers will agree with Lord Lansdowne that we have no "right" and that we are not justified by "experience" in accepting the hypothesis on which the objections of Lord Wolseley were based.

If, then, as I have always maintained, we may unhesitatingly reject the bolt from the blue theory, and if reasonable warning can be counted upon, then it is manifest that "effectual precautions" can be taken which will guard our end of the Tunnel, and will enable us in more than one way to put an absolute bar to its use, without destroying a structure which will be the joint property of the French and ourselves. It is easy to suggest precautions which could not fail, unless we are to imagine absolute and sustained imbecility on the part of a combination of individuals.

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Another contingency, which may perhaps have influenced opinion, must be noted. In some quarters it has been admitted that, while a *coup de main* is not reasonably probable, England might be successfully invaded, involving the capture of Dover, with possession of the hither end of the Tunnel. I cannot here enter upon the question of invasion, which I have examined at length in the past. I will say only that it is, and must always be, essentially a naval question, bound up, therefore, with our national existence, which could be wrecked without landing a man upon our shores if ever we lose our dominion of the sea. It must be obvious, however, even to those who assume successful invasion as a possibility, that, *ex hypothesis,* super-abundant time to effect the destruction of the Tunnel must be available, and that only to France or to a Power which had successfully invaded both France and Great Britain could the possession of the Tunnel be an object of desire.

Lastly, we have been told that, if the Tunnel existed, the country would be liable to unreasoning panics if ever our relations with France showed the least symptom of strain. I cannot accept so low an estimate of our national intelligence. I believe that the millions of people who would have experience of the undersea passage would be the last to feel alarm, because they would have become familiar with the conditions of working, and would realize that a tunnel does not lend itself to hostile operations.

624

I yield to no one in the firm belief that our insular position has been a supreme national advantage; but I recognise that in our day certain drawbacks inevitably result from the want of through railway communication with the Continent. I hold that the construction of the Channel Tunnel will remove the drawbacks, while preserving the virtues of the “silver streak” and leaving wholly unaffected the naval conditions, on the maintenance of which our existence depends. For these reasons, I have consistently supported the project initiated in 1867, and I have little doubt that, if the question be now dispassionately discussed on grounds of reason alone, misconceptions will disappear, and this great international enterprise will be carried out with lasting benefit to our country.

Sydenham of Combe.

October, 1913.

625

THE CHANNEL TUNNEL

Precautions for its Defence

LORD SYDENHAM has, at the request of the Editor, written the following Note on “Precautions which might be taken to satisfy the alarmists.” Having regard to his brilliant career as a soldier and statesman, to the fact that he is an officer of the highest military and engineering training, and that he rendered, as Secretary to the Committee of Imperial Defence, services which won the unstinted appreciation of three Prime Ministers in succession - Mr. Balfour, Sir Henry Campbell-Bannerman and Mr. Asquith - it may be assumed that Lord Sydenham has here set forth every measure that need be taken for the defence of the Channel Tunnel. It will be seen that he refuses to contemplate in any circumstances the necessity for its permanent destruction.

626

1. FORTS. Two forts should be brought into connection with the defence arrangements of the Channel Tunnel. They should possess well flanked ditches, and be entered by a single road, passing over a drawbridge. Probably at least one existing fort might be utilised; but, as quite small works would suffice, it might prove more economical to build them ad hoc than to adapt existing works. The object of these forts is:

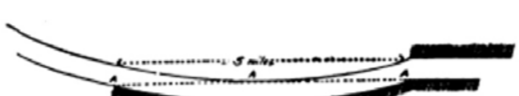
(a) To contain and control certain safeguards, and
(b) To bring fire to bear on certain points.

627

2. TEMPORARY OBSTRUCTION. A portcullis arrangement, combined with a lifting of a section of rails, might be adopted. The portcullis to be at the bottom of a shaft sunk from one of the forts and controlled therefrom. The lowering of the portcullis should automatically actuate the danger signal and hold up a train. The portcullis would be lowered and raised, say, once a week as a matter of routine.

628

3. PARTIAL FLOODING. Arrangements should be made to flood by sluices, actuated from a fort, a portion of the Tunnel, say five miles from the Dover end. This portion might be graded thus:



A gauge would show in the fort when the water level AAA was reached, and would indicate if the level fell. As long as this level was maintained, the Tunnel would be absolutely blocked.

629

4. THE POWER STATION should control movement in the British half of the Tunnel. It should be so placed as to be commanded by the guns of one of the forts.

630

5. OPEN SECTION OF THE LINE. The line should be exposed to fire from the sea for say, half a mile from its point of emergence to the mouth of a second tunnel giving access to the station. The Military Committee objected to this provision on inadequate grounds, and the late Sir John Stokes upheld it strongly. This clear length would, in my opinion, go far to disabuse the public of the idea of mystery connected with a Tunnel. The sea area from which the clear length could be shelled should be commanded by the guns of a fort, which should suffice to prevent small fast vessels from standing in and firing at the exposed portion. A bay of the viaduct should be prepared for demolition, and the exit from the sea as well as the station at which the undersea motive power would cease to operate should be commanded by quick-firing guns in one of the forts. Twelve-pounders would suffice.

631

6. PERMANENT DESTRUCTION. Mine chambers might be prepared to enable the crown of the Tunnel to be blown up. The chambers would need access from a fort involving an independent small shaft and tunnel carried on to a point where there was a good head of water, say not less than five fathoms at low spring tides. The effect would be to create a large leak, which could not be stopped. The electric wires would be always in position, and periodically tested. The charge of explosives could be kept in the fort, and run into position in case of need by a small trolley (I think this last precaution unnecessary).

Sydenham of Combe.

632

THE BRITISH PRESS AND THE CHANNEL TUNNEL.

The remarkable change which has been manifested in public opinion in regard to the Channel Tunnel is clearly reflected by the leading organs of the Press throughout the country, an overwhelming majority of which are now strongly in favour of the scheme. In such circumstances, it is almost invidious to attempt a selection of the thousands of encouraging comments which have been published. Particular mention must, however, be made of the attention devoted to the subject by the *Daily Graphic,* which, in May, June, July and August, 1913, carried on a campaign in furtherance of the project. Just before this pamphlet was sent to press the *Daily Chronicle*, for the second time, entered upon a similar campaign.

633

The *Daily Graphic* wrote:

"It becomes daily more evident that the opposition of the past to the construction of a Channel Tunnel has now practically disappeared. On all sides it is admitted that a Tunnel is bound to be constructed sooner or later, and the majority of the eminent authorities consulted by the Daily Graphic agree that the present would be a most appropriate time to inaugurate this great international work. Admiral Sir Edmund Fremantle, who was at one time very strongly opposed to the idea of a Tunnel, admitted yesterday that with the changed conditions his opinion had considerably altered. We publish also the view of the famous French expert on airships, M. Louis Capazza, and an interesting article by Mr. W.J. Botteril, the originator of the scheme for a great naval base at Norwich.

Admiral Fremantle said: 'I am not so opposed to the Channel Tunnel scheme now as I was, and I expect it will come one of these days. I daresay it will be an advantage in many ways, not only because many people cannot stand a sea voyage, but because of the saving in trouble and time in transporting goods from one country to the other. However, I am not going to take an active interest in the project one way or the other, but I shall be very pleased to read what other people have to say on the matter.'"

634

To the Paris correspondent of the paper, M. Capazza, the President of the Commission of the French Aero Club for Airships, the leading authority in France on the subject of dirigibles, said:

"The moment that England disposes of an airship, it would be impossible to invade the country by means of a Tunnel. The invaders might capture the exit of the Tunnel and entrench themselves against an opposing military force; but they could not protect themselves against airships or aeroplanes. A single airship could carry enough explosives to transform the entrance to the Tunnel into an impassable heap of ruins. As the exit remains immovable it could be shelled again and again. As London, or rather Aldershot, is only about two hours from Dover for swift airships, they could be on the spot before a thousand men could be landed through the Tunnel. Under the circumstances an invasion of England by the Tunnel, the exit of which could be bombarded by the forts of Dover and the warships in the Channel, and shelled by airships and aeroplanes, is a task which no Power in Europe would care to undertake."

635

Continuing its vigorous and public-spirited campaign, the *Daily Graphic* of June 30th contained further valuable testimony in support of the scheme when it said:

"The Channel Tunnel scheme finds an enthusiastic supporter in M. Lucien Coquet, a well-known French barrister, who is now on a visit to. this country.

'The idea is not a new one,' explained M. Coquet to a *Daily Graphic* representative. 'Many years ago your Mr. Cobden and M. Chevalier, a French Free Trader, conceived the project of establishing a system of rapid communication between France and Great Britain by the means of a Channel Tunnel. There is a French Company already in existence. It was founded by Baron Rothschild and by the Compagnie de Nord, which has invested £1,000,000 in the under-taking, and has begun to tunnel under the sea. It meets every year, and is paying regular wages to its employees.'

'But at the present moment we are waiting for England to move in the matter. We in France are under the impression that the French should keep quite quiet, and should make no attempt whatever to influence British opinion, because we do not want it to be thought that the French are commercially interested in the scheme. The French Government has given an official concession to the company, and if we, on our side, began a. movement in favour of the Channel Tunnel it would be said that we had an interest in it. When the British people say 'We are ready,' they will find the French people equally ready. I want, in conclusion, to pay my tribute of homage to Mr. Arthur Fell for the diplomacy with which he has approached this question, and for the energy which he has displayed in dealing with it.'"

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Extensive as is the space herein devoted to the subject, it is quite insufficient to show to what a large extent the project of a submarine railway between England and France is encouraged by British newspapers, but it is, unfortunately, possible to reproduce only a few typical extracts from articles which have recently appeared:

"WHY NOT? Mr. Asquith stated in the Commons yesterday that the project of a Channel Tunnel had not been reconsidered by the Committee of Defence since 1907, and to those who understand how great must be the impulse which moves Ministers to sensible action the statement is not surprising. But the ordinary man may well wonder why the idea of a Channel Tunnel should still lie under an antiquated ban. In six years all sorts of things have happened. International politics have advanced in directions which make the notion of an Anglo-French war unthinkable for many years to come, if not for ever. Military and engineering science has made so much progress that the problem of securing complete immunity from surprise attack at the English end of a tunnel has surely become simple. The new strategic conditions of Europe have forced to the front the question of our food supply in war time - a question automatically settled by a Channel Tunnel, so long as exit and entrance were in safe and friendly hands. Finally, the coming of the air machine has revolutionised both peace and war. We are no longer an island, and the cordon which the sea drew round us has been broken. Channel Tunnel or no, we are open to invasion by a new route, and all our ideas must be re-cast. Surely these circumstances have changed the problem which was considered in 1907; surely it is time to re-open the question then closed. We do not hold any brief for or against a Channel Tunnel. But we do claim that the whole question ought to be reconsidered in the light of new facts." (*Daily Express,* London, April 15, 1913)

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Madame Farman, the Paris correspondent of the *Irish Independent,* writing in July, 1913, devoted one of her contributions solely to the subject of the Channel Tunnel, and said:

"To put matters briefly, France wants the Channel Tunnel, and she hopes before another decade has expired to get it. The coming of the aeroplane, as Mr. Graham-White observes, has quite swept away the old argument that England's strength resides in her isolation. Looking a little ahead, this experienced aviator foresees that ten years will not have elapsed before there will be a regular aerial passenger service between France and England. A tunnel, or no tunnel, in 1918, he is persuaded, will not make the slightest difference in so far as fears of invasion are concerned, because by that date, heavier than air machines, instead of having an engine of 100 horse-power, will have engines of 10,000 horse-power and more. Such a forecast in presence of the amazing development attained within the last few years in flight can hardly be called preposterous."

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The *Railway News* of May 24th, 1913, contained the following:

"In the Railway News of November 9th last a report appeared of the proceedings at a dinner of the Franco-British Travel Union, when Sir Arthur Conan Doyle spoke warmly in favour of the dormant Channel Tunnel project. That distinguished writer returned to the charge in a powerful article contributed to the Fortnightly Review, and dealing with the matter from a military and political point of view is in favour of the building of such a Tunnel because he believes it 'is essential to Great Britain's safety.' Pre-supposing the maintenance of the Entente with France, Sir Arthur points out what an excellent thing it would be if during a war with an European Power we could get overland through France, and thence under the Channel, our food supplies from the Mediterranean Sea. Needless to say, the military opposition to the scheme has been considerably modified in recent years, while its advantages in stimulating trade and travel to and from the Continent are universally acknowledged…"

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"…The advantages which he claims for a national Tunnel are briefly as follows:

1. If constructed by the nation for anything like the estimate advanced by capable engineers it should be a source of great profit to the country.

2. It should stimulate our trade with the Continent, since bulk need not be broken.

3. It should bring to England very many thousands of Continental travelers every year who are at present deterred by the crossing.

4. Should we ever be forced to send troops to the Continent, it provides a safe line of communications, besides ensuring an unopposed transit.

5. It enables food to be introduced into the country in war time, and would help us to hold out, even after a naval defeat. All the supplies of the Mediterranean are available via Marseilles."

6. It passes out some of our exports in war time, and to that extent relieves the Fleet of the duty of conveying them…"

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<u>Part 10</u>

Attaining the Result

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The Channel Tunnel Between France and England

By M. ALBERT SARTIAUX,

Chief Engineer for Roads and Bridges to the French Government;
also General Manager, Northern Railway of France
(Translated from the *"Revue des Deux Monties,"* October, 1913)

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Is a Railway Under the Channel Possible?

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Technical Account

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From the technical point of view, the construction of a tunnel under the Channel presents problems entirely different to those which had to be solved in building other well-known tunnels under rivers or through mountains. The problem will be at the same time easier and yet more difficult.

It will be easier because the strata to be traversed, if the plan is properly prepared, can be pierced with a large auger like wood with a handbrace; and more difficult as, firstly, the tunnel will have a length of more than 30 miles, and no tunnel of this length has yet been built; and secondly, because it will be necessary to follow the course of the proper strata at the most convenient depth, that is in the lower portion.

From ancient history a few examples of tunnels can be discovered; for instance, the tunnel constructed by the Assyrians under the Euphrates, in order to connect two palaces placed on either side of the river.

Remains of aqueducts are to be found in Carthage, and sewers in Rome. The Romans are known to have bored two tunnels for the construction of roads, one on the Flaminian Way through the Apennines, the other in Switzerland near Soleure.

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In the middle ages underground galleries were part of the art of fortification, and they very often attained a length of several miles, but from the point of view of transit, subterranean passages were really only used from the middle of the 19th century. This is natural, as subterranean passages and in consequence tunnels, which are merely large subterranean passages, only came into existence with the railways.

Previously, mountains were not bored through, and it was necessary to pass over or around them

With regard to ordinary roads used for horse traction, and on which only comparatively small loads are to be hauled, we find that up to the present day these roads are built with severe gradients which may reach one in ten, or even one in seven; also, they are built with curves, the radius of which may be as small as 50 or 65 feet, in such a way that with repeated windings it is possible to circumvent without boring the steepest mountains.

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A totally different problem arises when railways are considered; then it is necessary to haul considerable weights which, as in the case of trains running between Paris and Calais, may exceed a load of 400 tons propelled by a single and very powerful motor, which must consequently be very heavy and rigid. It is then only possible to make use of comparatively small gradients, which on lines of heavy traffic do not exceed 1 in 500, and when it is necessary to traverse mountains such as the Simplon, the St. Gothard, etc., for safety, a greater gradient than 2 or 3 in 100 cannot be used.

Furthermore, as curves increase the traction difficulties and prevent high speeds, it is necessary to replace the 50 or 65 radius of the ordinary road by a radius of 800 or 1,000 feet, and this for important lines must be increased to 2,500 or 3,000 feet in order to allow of high speeds.

Given these conditions it will be seen that it is absolutely necessary to pierce the mountains instead of circumventing them, and it was due to this difficulty that the art of the construction of subterranean passages and tunnels received its greatest impetus.

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At the present time these are of every-day occurrence. At the start of the century, about 1840, Brunel constructed the first tunnel under the Thames, quickly followed by numerous subterranean passages, necessitated by the rapid extension of the railways. Some of these involved considerable work of a most difficult character, partly on account of their length, but also on account of the special nature of the strata traversed. Chief among these were the Semmering, with a total length of just under 1 mile; the Mount Cenis, 7½ miles; the St. Gothard, 9 miles; the Arlberg, 6 miles; the Simplon, 12 miles; and the Loetschberg, 8 miles long.

After the plan of the tunnel has been made, boring must be started in the given strata, such as it is. This is usually more or less well known, the work being started by boring a small gallery called the “Advance Gallery,” behind which the actual passage is enlarged by successive steps until it attains the final section of the tunnel. During this work the most varied difficulties are encountered, often of considerable magnitude, such as unsuitable composition of the strata, the inrush of water, etc., etc.

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The problem presented by the Channel Tunnel will be entirely different. In this case the first point to be settled is the placing of the tunnel in a certain strata layer which shall be solid and impermeable, and in which there will be no fear of any infiltration of sea water. It is a well-known fact that there has been in existence for a number of years tunnels of a similar character and of great length built under the sea.

The Cornwall tin and copper mines extend to a considerable distance under the sea without any infiltration, in the coal mines on the Cumberland coast coal is worked in several subterranean galleries extending more than three miles from the shore, and these, together with the transversal galleries used for connecting up the main galleries, make up a total length which is as great as that of the projected Channel Tunnel. The water has never penetrated into these mines, and the miners, well knowing the conditions, boast that some day they will be able to reach the Irish coast, distant about 60 miles, although to do so it would be necessary to bore a tunnel under the sea, the depth of which would be vastly greater than the depth encountered in the Channel.

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Practical experience is, however, better than the best comparison, and we now have exact data with regard to the practical possibility of boring the Channel Tunnel.

The geological studies made by the various geologists of the two countries, the numerous drillings and borings which have been made on each side of the Straits, have completely and clearly shown the nature of the soil, and exactly given the composition of each seam and particulars of their connections.

If we go a little further back than the present time we shall be able to form a better idea of the ups and downs to which the Channel Straits were submitted during the various geological periods, and we will then be able to more fully understand their present condition and how it was reached.

The Straits like the world itself presented a very different aspect in the past to that which they now present; they are continually being transformed by a more or less slow action, but sufficiently rapid to be detected.

Careful observation has proved that at the present time they are being eroded to the extent of approximately 65 feet on each side per century - that is, a total of about 130 feet per century.

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Originally laid down during a geological period which corresponds to the Cretaceous formation, a formation consisting of a seam of chalk, and in which careful studies prove that the tunnel must be placed, the region covered by the Straits was far different to that which it is to-day. The Cenomanian sea covered all the South-eastern part of England and the North of France to much below Paris and the Mans; only a portion of the Cotentin region and the Wales district were above water, together with the Ardenne and Belgium districts, the level of which has since remained stationary.

After this period, that is considerably after the Cenomanian system, a portion of England was lifted up, and the Lutecian sea which still covered Paris gave birth to a kind of Anglo-French headland, of which the Dover cliffs and the Blanc-Nez cliffs are the witnesses. This transformation went on to the end of the period which corresponds to the Miocenian epoch. The uplifting movement being continued, France and England were joined together by an isthmus washed on one side by the Atlantic, and on the other side by the North Sea, which at that time extended over a large portion of Holland.

This isthmus had the shape of a very wide bridge of considerable magnitude, over which most of the animals of the quaternary system crossed from the continent to the British peninsula.

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That is why in England it is possible to find in all the quaternary caves fossil teeth and bones belonging to bears, hyenas, mammoths, rhinoceroses, etc., which usually lived in France; the remains of gerboas and reindeers are also met with, which shows that these animals, essentially land animals, crossed over the Straits on dry land to the peninsula mentioned above.

But a new transformation is in preparation caused by the seas' repeated action. The Atlantic waves on the one hand and those of the North Sea on the other, eroded the isthmus in order to join each other, and the vertical section of the actual cliffs shows their marine origin. It is only at the start of the actual geological period that the transformation phenomena of the isthmus into straits happened gradually and without any jars by a slow action similar to that which is going on under our eyes, with a speed of about 130 feet per century. The "start" of the period does not mean that it was yesterday, as if we suppose that the action proceeded with the same speed which it possesses today, the cutting of the Straits into the shape they now possess would have required at least 100 centuries.

It is absolutely impossible to state the time which it has taken, and the most distinguished geologists are not agreed on this point.

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In Geology as in Politics there are two parties - the first is made up of the people in a hurry, and the second party of people who believe that the speed of these phenomena must have been very similar to the speed with which they are now proceeding.

The first, named the Plutonians, state that the geological transformations happened in a very short time, namely, a few thousand years. Neptunians cannot see why the eroding agents should have possessed more power then than they possess at the present time.

Whatever the case may be, and should it have happened more or less than 100,000 years ago, it has, nevertheless, been made evident from these geological studies that a direct link existed between France and England, and that this link only disappeared by means of an eroding phenomenon, very slow, which washed away the upper part of the link and left as witnesses the Dover and Blanc-Nez cliffs; but the lower part of the link was maintained underneath the level of the sea, where the strata, connecting the two countries, remain in their original position.

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The chalk cliffs at Sangatte, where the Channel Tunnel will enter France.

In the actual state of things the Straits between Dover and Calais are crowned with high perpendicular chalk cliffs; on the French side those of the Cape Blanc-Nez, in England those from Dover to Folkestone.

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When a study of the geological transformations in these districts is made, it is impossible not to be struck by the complete similarity of the two formations from the point of view of the strata composition, which starts from the Jurassic system at the base ending with Tertiary strata on the top. On both sides the composition of the chalk layer is identical, and on the top part the chalk is white and contains flint; lower down the flint disappears and the chalk mingles with clay; finally, at the base, near Wissant and at Folkestone there is a seam of chalky clay, very compact and uniform, on which large cement-stone workings have been established. The chalk is sufficiently soft to be easily cut, and sufficiently resisting not to crumble up; the clay which it contains renders it impermeable.

It is impossible to imagine a strata possessing better qualities for boring a tunnel.

Through the presence of these two conclusive witnesses of the geological identity of the French and English strata, it is reasonable to hope that the seams which are to be found on each side of the cliffs extend from one cliff to the other throughout the whole length of the Straits, and to believe that this seam dips in a regular way on both sides, to the North-North-East, meeting in the middle of the Straits.

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Although this supposition seems most reasonable, the French Tunnel Company deemed it advisable to make a test, and thanks to the admirable work undertaken on its account by a mission composed of two distinguished geological engineers, MM. Potier and A. de Lapparent, and thanks also to the strength of the tides, which keep the bottom of the Straits in a good condition of cleanliness, undisturbed, except in a few places, by any deposit of sand, mud or shingles, this question has been solved in a most complete way.

In 1876 and 1877 MM. Potier and A. de Lapparent took more than 7,000 soundings in the Straits, not only ordinary soundings for discovering the depth of the water, but also by means of a sharp-angled tube charged with a sufficiently heavy weight, so that in falling to the bottom of the sea the tube was enabled to bring away a sample of it, in other words, a core, two or three inches long, sufficient in most cases to allow of geologically identifying the ground from which the sample had been obtained.

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Thanks to these soundings, 3,000 of which are geologically accurate, MM. Potier and A. de Lapparent have been able to continue the geological chart under the Straits with a precision almost as great as their English and French colleagues had displayed in making geological maps of English and French soil. The lines marked on these charts, showing the separation limits of the different varieties of ground, are found to be continuous without any flaw or break right across the Straits. The consecutive order of the strata is reproduced throughout; even the depth of the different seams met with is shown to be relatively constant. In a word, all the stated facts only confirm the supposition that the Straits have been hollowed at a comparatively recent period, and going back to the beginning of the present geological epoch were caused by powerful erosions and not by a breaking up of the ground.

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Now it has been proved that amongst the geological strata is one, the Cenomanian, commonly called the Grey Chalk of Rouen (*craie grise de Rouen*) which seems particularly suitable for the passage of the tunnel on account of its homogeneity, complete absence of cracks, perfect impermeability, and firmness that would allow of comparatively easy working. It is this stratum, averaging a depth of about 200 feet, that the geological studies as they progressed, have shown more and more clearly to be the best in every way for the proposed works. It was in it that the direct experiment of submarine boring was tried and continued until March, 1883, by the French Company under the direction of the eminent director of works, M.L. Breton, who is equally well-known as a geologist and as a mining engineer, and from whom it can be said that the geological formation in the region of Boulogne holds no secret.

The direct experiments in this layer consisted in sinking on the shore at Sangatte a shaft of large diameter to the depth of about 200 feet below sea level, and in starting from the bottom of this shaft a gallery to be used for experimental purposes 7 feet in diameter, penetrating the before-mentioned seam of Cenomanian chalk for a distance of 1 mile 250 yards under the sea.

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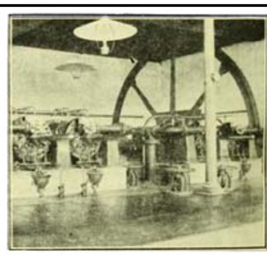
Spicer. Dover.
The Channel Tunnel Works at Sangatte.
Reproduced from *The Illustrated London News*, December 29, 1906.



Spicer. Dover.
The Engine Room, Channel Tunnel Works, Sangatte.
Reproduced from *The Illustrated London News*, December 29, 1906.

The great importance of these works is not sufficiently well-known. Even at the present time there is at Sangatte some fairly extensive works in a very good state, including two steam engines of 300 h.p., several powerful suction pumps and air compressors, shaft and cage, etc.

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It is by means of these works, looked after with religious zeal, that the experimental gallery was bored out, by which it was possible to prove, on the one hand, the almost perfect impermeability of the seam, and on the other the possibility of continuing the boring by means of the drilling machine invented by Colonel Beaumont, with a gradual increase of speed up to 1,300 feet per month. It would have been possible even with this machine to exceed this figure, and now with drills provided with the more recent improvements an even greater speed could be attained.

Added to this, the conscientious studies made by M.L. Breton since 1879, more than 25 years ago, in the region of Boulogne, and in Kent, still further confirm these results. They have proved that the seams of chalk exist without dislocation or out-throw, and have revealed largely curved bends without a break.

This opinion is confirmed by the highly interesting and very remarkable investigations of MM. Barrois, Olry, Gust, Dollfus, Gosselet, and others.

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It is also a very definite opinion of the English geologists, Messrs. Prestwich, Topley, Jukes Browne, and also of one of the most illustrious among these, Sir Archibald Geikie, the learned Director of the Geological Map of Great Britain, who said when examining the relief plan of the Straits which the French Tunnel Company had sent to the Ghent Exhibition that he considered as sure to come true the previsions made in 1876 and 1877 by MM. Potier and de Lapparent, and that it was possible to consider as a fact the regular presence under the Straits of a uniform thickness of about 200 feet of a seam of grey chalk, hard and impermeable, in which the tunnel could be built without any difficulty.

Given these conditions it is possible to state that the scheme of boring the tunnel will consist in starting from each of the cliffs at Blanc-Nez and Dover, from a point located on the open ground above the sea level at the termination of the seam of grey and impermeable chalk. To follow this seam in its dipping and in its various windings, the problem would really consist in not getting out of this seam, and to remain at a sufficient distance from the top and bottom surfaces, and also not getting too close, above or below, to permeable strata, which might allow the infiltration of water into the tunnel, thereby impeding the construction, and also the future operation.

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When the first plans of the tunnel were made towards 1880, the problem of remaining in this seam was not solved without some lack of certainty in the results.

In order to be able to make use of the tunnel for the passage at very high speed of heavy trains, it was necessary, with the traction methods known at that time, i.e., superheated steam traction, to adopt very small gradients, and curves of very large radius, which considerably increased the difficulty caused by the necessity of remaining in the seam of hard and impermeable grey chalk. The advent of electric traction - which enabled the same power and speed to be obtained with a radius which can be as small as 800 or 1,000 feet, with gradients as low as 1 in 100 or 1 in 75 - renders the problem infinitely easier, and it is now evident that there is not the slightest doubt that the tunnel can be constructed to follow the deflections which must be made in order to continue in the said chalk seam.

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It is therefore possible to consider as a certainty that there exists between France and England a seam of hard chalk of sufficient thickness, impermeable and without faults, in which it will be possible to place the tunnel without any fear of inundation. It is also a certainty that owing to the nature of the ground the boring will be easy, far easier in fact than was the case when boring the tunnels of the St. Gothard, Simplon and Mount Cenis. It is evident that the only real difficulties which will be encountered during the tunnel construction mainly consist, especially at the start, in drafting the route to be followed by the tunnel so as to keep it in the layer where it must be placed, and also in commencing the heading which will form the tunnel, and in bringing out the excavations rapidly and at a low cost.

Let us briefly sum up the means which should be employed for attaining this result.

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It will first be necessary to determine the longitudinal section of the tunnel. The tunnel could start from a point on the coast which would be above the sea level, and will then dip towards the centre of the Straits, so that the depth at the lowest point will be about 328 feet below sea level.* The profile which would be obtained by this method might possess some serious drawbacks if, notwithstanding that the seam is impermeable, infiltration should take place.

Water would then accumulate in the middle of the Straits, and it would be exceedingly difficult to get rid of, even with the most modern pumps.

In order to obviate this drawback, the suggestion of M. Breton for an independent draining gallery should be adopted. This draining gallery would start from the coast at a low level, namely, about 400 feet below sea level, and would ascend up to the middle of the Straits where it would meet the tunnel itself. Water would naturally flow into this gallery, and would accumulate at the bottom of the shaft or shafts sunk near the coast, where it would be expelled by means of powerful pumps fixed at the bottom of the shaft.

* Translator’s note - The maximum sea depth on the path of the tunnel is 180 feet, so that there would be a minimum thickness of about 150 feet of solid ground between the bottom of the sea and the top of the tunnel.

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The draining gallery on one side, the tunnel gallery on the other side, which meet towards the middle of the Straits, would diverge from each horizontally and vertically, step by step, as the coast was reached, the gallery dipping while the tunnel would be ascending, and owing to the general slope of the seam towards the North, the gallery would incline towards the North, while the tunnel would, on the contrary, incline towards the South.

This draining gallery would, on the other hand, possess numerous other advantages:

Not only would it serve to drain off all the water when the tunnel is in use, but it will also possess two other advantages which may be still more important: that of enabling the tunnel to be planned out with the utmost certainty, and of allowing it to be built with the minimum delay and the maximum facilities.

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We know for a fact that the special seams of grey chalk exist and possess a sufficient thickness, but we do not know with absolute certainty the position of the underground strata; the drainage gallery would have, amongst other advantages, that of allowing it to be tested. As concerns the choice of location for the boring of the shafts in the ground, the facilities required for this boring should first be taken into consideration. The difficulty will be to avoid as much as possible the superficial sand bed on which the village of Sangatte rests. These shafts should be bored to the bottom of the grey chalk; then the thickness of the chalk should be ascertained at the chosen boring points. The boring should then go on according to the theoretical direction of the draining gallery, and as soon as 350 or 500 feet of gallery have been made, i.e., after about one week’s work, a boring above and below should be made in the chalk in order to ascertain the exact position of the gallery in the bed. A week later similar borings should be made and repeated, once in every eight days, that is to say, about every 500 to 650 feet. When any of these consecutive borings show that the gallery is getting too near to either the upper or lower limits of the chalk bed, indicating that the bed has not the exact formation hypothetically attributed to it, the alignment would have to be modified accordingly without altering the theoretical section, in order to come back to the general position which it is important to keep. The drainage gallery would thus become more or less sinuous. But this is of little importance as it would not hinder the flow of water.

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Before work is started in the main tunnels, the nature of the strata through which they will have to be driven will thus have been ascertained. Observation can be further continued by means of the cross galleries which, as the drainage tunnel progresses, will be driven to meet the proposed line of the main tunnel, giving by means of successive tests at intermediate points definite information for placing the tunnels at the correct depth.

These cross galleries, starting from the drainage tunnel and extending to the centre line of the main tunnel, will enable work to be carried on at as many working points as there are cross galleries. The work must naturally always proceed on the upgrade in order to prevent danger to the workmen in the event of a possible inrush of water.

The number of these cross galleries would vary according to the required speed of boring in the tunnel, a smaller number being necessary if the speed in the drainage tunnel be increased, but whatever the number may be, it is evident that through their very existence in conjunction with a drainage tunnel, it will be possible not only to trace out the lay of the main tunnels with certainty, but also to dispose of quickly and easily the material excavated in boring the main tunnels.

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A small double track electric railway would be installed in the cross galleries and drainage tunnel.

The railway would have a 2-foot gauge and be used for removing the excavated material from the main tunnels and delivering it through the cross galleries and the drainage tunnel to the bottom of a shaft where it would be hauled to the surface by means of elevating machinery.

The organisation of these transports will be very important and interesting, as it will be necessary to carry away not less than 4,000 tons of debris per day, representing about 100 trains per day in each direction, added to the conveyance of at least 1,200 people corresponding to the return journeys of the workmen and staff from the several working points. This staff will be divided in three, more probably four shifts, so as to secure the continuity of the work; 1,200 people and 4,000 tons of excavated material per day, covering an average distance of 6¼ miles, represent a traffic which many railways of local or even general interest would envy.

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Thus, thanks to the scientific progress made in the last twenty years, improvements in boring machinery, the utilisation of electric traction for the removal of the excavated material, the use of electrically driven high-speed pumps for expelling the infiltrated water collected at the shaft sumps, thanks also to minor progress such as the telephone and electric light, the boring of the tunnel and draining gallery will not take more than from four-and-a-half to five years after the completion of the auxiliary and preliminary works, the most important of which will be the laying of tracks to carry away the excavated material and the sinking of large diameter shafts similar to colliery shafts.

It is certain that the sinking of the shafts will be one of the greatest difficulties to be overcome by the engineers superintending these works.

It will, however, be possible to obviate these difficulties by using similar methods to those successfully employed by M. Breton for sinking the two shafts on the western boundary. It will be possible, as foreseen by M. Breton, to have recourse to congelation, and perhaps to cementation. Those borings will not be very expensive, since they will not require more than from £40,000 to £80,000, but they will take a long time, probably not less than two years.

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It is hardly necessary to point out that on the English side the work will be carried out in exactly the same way. The conferences held on this subject with the renowned English Engineer, Sir Douglas Fox, who built the Mersey Tunnel and several of the Metropolitan London tubes, and who possesses a thorough knowledge of the tunnel question, showed that his intention was to adopt on the English side the methods which were going to be used on the French side, and which offered the best guarantee for the final success.

To complete the particulars given on the tunnel construction, it is necessary to state what will be the section of the tunnel, and also how it will be connected to the existing line.

We have stated that the drainage gallery will have a circular section about 10 feet in diameter. The tunnel itself will be built on similar lines to the London electric “Tubes” with two parallel circular galleries, each 18 feet to 20 feet in diameter, placed at a distance of about 50 feet from each other, and consequently not reacting on each other from the point of view of the resistance of the seam, and bringing to this seam the minimum dislocation possible, as the circular section is one which offers most resistance to pressure, both interior and exterior. This circular section is, moreover, rendered necessary by the nature of the boring machines which perform their work in a circular way.

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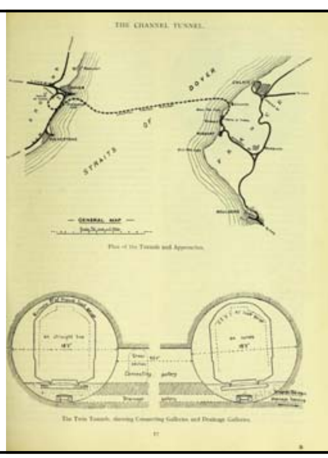


671

Regarding junction lines, recent studies have shown that the route sketched out in 1881 could be notably improved. Owing to the new point chosen for entering the tunnel, a little to the south of Cran d’Escalles, the junction will branch off at Beuvrequent, pass very near Marquise, and end almost on a straight line at Wissant, a pretty little village about half-way between Cape Griznez and Cape Blanc-Nez, well-known by all painters and especially to Jules Breton (brother of the Engineer to the French Tunnel Company).

Here Caesar established a camp before sailing for England, and at this point the Custom House Office and goods station would be built, and the changing of the engines take place, the electric locomotive proceeding to the siding, a steam engine for hauling the train to Paris being simply attached to the rear, which thus becomes the front without shunting or loss of time.

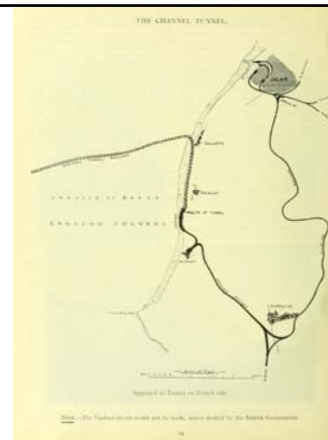
The part of the line in the open will not be of a difficult or expensive character, except the viaduct, which will precede the entrance to the tunnel and which will be constructed if, through a misconception, the military fears* still exist which caused Lord Wolseley to insist that it should be established, so as to be within reach of the guns of the fleet commanding the Straits.

672

* We do not wish to insist on the futility of the invasion risk, which without any foundation twenty years ago, has now become absolutely chimerical. The enemy which was feared by Lord Wolseley has become the friend, and with the present state of affairs in Europe there is nothing to prevent the Entente cordiale from lasting. But even if this were not so, is it possible to believe that a long passage such as the tunnel, without any spare tracks at the arrival station and without any unloading platforms, could allow a passage of an army corps of some importance, including not only men but material. Is it possible to suppose that by a wild rush a small group of men, even ever so determined, could cap-ture the three forts, which at 3,000 feet, 5,000 feet and 10,000 feet, could be built above the tunnel entrance which has been placed at the bottom of a small valley, above which the three forts hem it in. Finally, as the tunnel when finished will have a length of approximately 32 miles, steam locomotives cannot be employed, as these would exhaust the air; electric power will be employed supplied from two Power Stations. The English Power Station would supply current to the trains from France, and vice versa, the French Power Station would feed the trains coming from England. By simply cutting the feeding cable, traction would become impossible, and this alone would be ample to sufficiently prevent the enemy penetrating into England, or to get as far as the tunnel's head, then to conquer Dover and its forts, and to establish itself in order to invade England.

If the above points are kept in mind, and how varied and powerful are the means by which it is possible to prevent access to the tunnel, how completely impossible it would be to bring into England even a small number of men without risking their immediate annihilation, it will be seen from the opinion expressed by the well-known Field Marshal De Moltke that the tunnel should not be built as it could not be used to attack England, but would be very detrimental to Germany in case of war.

673



674

That part would have a length of 8¾ miles only, with gradients not exceeding 1 in 160. So that, in the direction of Paris, the long gradients of 1 in 125 which now exist on the line from Boulogne to Calais, beginning at the gradient of Caffiers, would not be met with.

For the communications with Belgium and Germany, a connection made between the new line and the line running from Boulogne to Calais, would allow the trains to run directly in the northern direction as soon as they come out of the tunnel.

On the English side similar dispositions would be realised, and would consequently allow the direct passage of trains between the two countries, not only between Paris and London, but also between all parts of Europe and Great Britain. The English track gauge is within a few millimetres, roughly 1/16", the same as that of the Continental tracks. Some of the rolling stock will have to be specialised, as a small difference exists in the width of the engines and carriages, the same being larger than that used in England; exchanges will be rendered possible between England and Europe, as they are now made between the various countries on the Continent, with the exception of Russia and Spain, which have adopted wider track gauges than the standard.

675

We must now show briefly what will be the cost of construction. The expense involved by the tunnel construction has been estimated at very different figures; about 30 years ago, after the first studies had been made, the figure for the total cost was very small. A French engineer, M. Bergeron, named £5,000,000. A well-known engineer, Mr. John Hawshaw, put the figure at £10,000,000. According to the more recent studies, these figures are too low, and at any rate, in order to be on the safe side, it is advisable to reckon on a much greater expenditure.

The English engineers, amongst whom was Sir Douglas Fox, estimated the expense for the English portion, about half of the tunnel, would be £6,000,000, and they finally increased this to £6,500,000.

Some contractors from the U.S.A. feel confident that with their methods they could build the tunnel for a lump sum far smaller than the one stated above.

The investigations made on the French side lead to the belief that the sum of £7,250,000 would be a reasonable figure, but in order to allow for all unforeseen items likely to arise during the construction, etc., it has been deemed advisable to fix the cost for the French part at £8,000,000. Allowing for similar unforeseen and accessory expenditure on the English side will bring up the total expenditure to about £16,000,000.

676

The distance between the stations is 32 miles, and the tunnel proper having a length of 29 miles, this is, consequently, an expenditure of roughly £550,000 per mile, which may seem a high figure, but in work of this nature it is far better to be agreeably surprised than otherwise.

It is, however, difficult to compare these figures with those relating to tunnels constructed under entirely different conditions. The large tunnel, 2.4 miles long, which connects the Valhubert Square to the Orsay Station in Paris, was built at a considerably less cost, as it did not exceed £200,000. The cost of the Metropolitan Railway in Paris varied between £100,000 and£135,000 per mile; the Metropolitan Viaduct cost about £270,000. The St. Gothard, Simplon, and other tunnels did not reach such a high figure, but it is necessary to point out that in these cases the conditions were absolutely different.

677

It is almost certain that in the boring of the submarine tunnel such considerable difficulties, and even dangers, will not be rnet with as those encountered in the boring of tunnels such as the Simplon. It will not be necessary to deal with workings flooded by tremendous inrushes of water on with excessive temperatures which caused discomfort to the workmen and endangered their health. The ground encountered will be homogeneous, easy to bore, and more regular, such conditions favouring amore economical construction of the tunnel. On the other hand, it will be necessary to bore a. tunnel of considerably greater length, and unusual difficulties will have to be surmounted in order to properly remove the larger quantity of excavations.

If, as stated; the seams are more homogeneous, more impermeable and easier to bore through with a uniform temperature of 4 or 5 degrees above zero Centigrade, on the other hand it will be necessary on each side of the middle of the Straits to remove at least 21,400,000 cubic feet of excavations which will have to be carried to a distance of at least six miles, and then lifted from the bottom of the shaft by means of bucket dredgers so as to keep the workings clear.

Finally, the various drillings and sinkings which it will be necessary to carry out in order to ascertain the ground and remain in the impermeable seam will entail work which will be fairly expensive.

678

It is very probable that the cost, unless the unforeseen happens, will not reach the figure of £16,000,000 which was previously fixed, but as before stated, it was thought wise to make provision against any disagreeable surprise.

Having described the method according to which the tunnel should be planned out, and according to which it should be built from the technical point of view, a few words may be added on the methods best suitable for its operation. As stated, electric traction will be used between the two common stations belonging to the Tunnel Company and the land Railway Companies, Dover (or Macton, near Dover) on the English side, Wissant on the French side. With reference to the kind of current to be employed, whether single, two or three-phase, the experiments which are now being carried out all over the world will surely demonstrate the one best suited to propel the trains in the tunnel. At the present time it can be stated that through passenger trains, weighing 400 tons or more, between Europe and Great Britain will be drawn by powerful electric locomotives, of sufficient power to haul a train from one end of the tunnel to the other (approximately 32 miles) in 40 minutes, or 1 hour 20 minutes to 1 hour 30 minutes for goods trains weighing 800 to 900 tons.

679

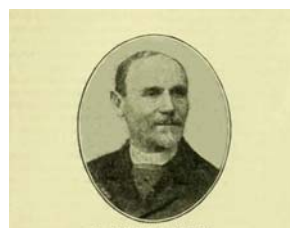
If the Customs do not cause delay, the time taken for the passage between London and Paris will be about 5½ hours, sufficient to allow going and returning from Paris to London on the same day, attending to business in London or in Paris in the afternoon, as it is commonly done nowadays between Paris and large towns on the Northern Railway and even Ghent, Brussels and Liege, the inhabitants of which can come and spend an afternoon (or vice versa) and return the same evening at an hour well within the habits of ordinary life.

This will not be the only progress caused by the opening of the tunnel. At the present time the 22 trains which bring passengers to Boulogne or Calais, and which take them away, are scheduled at times which enable the passengers to be conveyed by six boats only. The cost of these boats, the expense of an ordinary crossing exceeding £100, is so very great that it is necessary to reduce as much as possible the-number of these crossings, and consequently the present day habit is to make the arrival and departure coincide with the trains from Paris, the *"Cote d'Argent"* or the *"Cote d'Azur"* from Switzerland, Italy, Belgium and Germany, and to select times which are not always very convenient, and which lengthen the total time of the journey.

680

With the tunnel, trains from all directions will proceed with the same rolling stock, without stopping, except for the change of locomotive or for the Customs inspection. This will be a considerable progress from the public's point of view. It is possible to foresee that if the tunnel is completed in 8 to 10 years, all the traffic could be taken care of by about 50 trains per day, with receipts amounting to about £2,000,000. The double track tunnel will possess the character of a transit railway, without intermediate local traffic, and will be able to deal with a 400 or 500% increase without any difficulty, and with comparatively very low operating expenses, no part of the traffic being diverted during the transit, and all the traffic being for the full distance, and accordingly paying the tax corresponding to the total length of the line. It is quite possible to foresee the carrying of 10,000,000 passengers, and as many tons of goods, and it will not be necessary to overcome technical difficulties such as the proper distribution of the rolling stock and the full use of the various tracks such as are met with on railways like the Northern Railway, especially near its Paris terminus.

681



M. ALBERT SARTIAUX,
Chief Engineer for Roads and Bridges to the French Government; also General Manager, Northern Railway of France.

682

<u>Part 11</u>

War and Peace

683

War in Heaven

684

"WE don't hear much these days about the proposed tunnel under the English Channel, to connect England and France. Although the engineers have several times during the past 20 years submitted complete plans for such an enterprise - some of which have been published in this magazine - none has gone beyond the paper stage. The minute anyone mentioned channel tunnel, apparently the entire English press broke loose, displaying an opposition scarcely less expressive than the present fear of Zeppelins…"

Popular Mechanics, **July 1915**

RE: there were a total 20 raids in 1915, in which 37-tons of bombs were dropped, killing 181 people and injuring 455

Left: British recruiting poster, ca. 1915

685

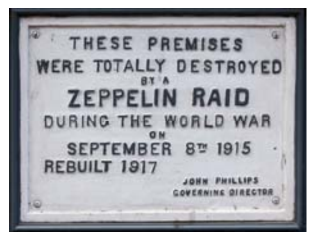
686

"Then we saw the Zeppelin above us, just ahead, amid a gleaming of clouds: high up, like a bright golden finger, quite small . . . Then there was flashes near the ground - and the shaking noise. It was like Milton - then there was war in heaven . . . I cannot get over it, that the moon is not Queen of the sky by night, and the stars the lesser lights. It seems the Zeppelin is in the zenith of the night, golden like a moon, having taken control of the sky; and the bursting shells are the lesser lights."

D.H. Lawrence, **Author/Writer**

RE: describing the Sept. 8, 1915 Zeppelin raid on London

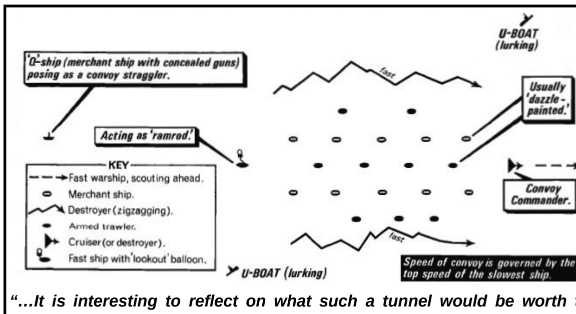
687



688

The Present War

689



"…It is interesting to reflect on what such a tunnel would be worth to England were it in operation today. Where a fleet of battleships are now required to convoy a single transport ship carrying only a few thousand men, the same troops could be moved comfortably and safely through a tunnel in one-tenth the time, to say nothing of the supplies which would flow in an almost unbroken stream…"

Popular Mechanics, **July 1915**

Left: caption: "The Introduction of Convoys, May 1917"

690

"…Loaded on cars at an English factory, these supplies could have traveled to destinations near the fighting line in France without having been once touched. As it is now, there is the transfer from train to ship and ship to train and the constant danger of attack and loss in the channel crossing…"
***Popular Mechanics,* July 1915**
<u>Above & Left</u>: Germany's U-boat campaign was intended to starve Britain. Instead, it brought the U.S. into the war against Germany.

691

692

"…Expressed in dollars alone, the tunnel would have paid for itself the first year of the present war. It would seem that the tremendous advantage of such secure and rapid transportation must have been so demonstrated that the tunnel will become a reality after peace is restored. As a menace - that is only a wild dream: for all highways which are capable of being put out of commission, a tunnel is the easiest. Movable stone gates, water, deadly gases, burning fluids, or explosives are all available and would be made operative before an enemy could advance more than a few hundred feet. Can one imagine anything more surely fatal than some thousands of men part way through an under-sea tunnel when deadly gases, pumped through concealed pipes, are liberated; or sea gates opened and the tunnel filled when an army was ten miles from the nearest escape?"
***Popular Mechanics,* July 1915**

693

116 Years and Counting

694

After a hundred and sixteen years of discussion the English Channel tunnel may be built at last
***Popular Science,* December 1918**
RE: introduction to an article written by *Waldemar Kaempffert* entitled: "By Tunnel from London to Paris"

695

Doing Great Things

696

"'THIS is one of the great things that we could do together.' Napoleon was the speaker. The man to whom he addresses himself was the English statesman, Charles Fox, who visited the First Consul in France after the treaty of Amiens had been signed in 1802. What was the great thing 'that we could do together'? Build a tunnel under the Channel to connect England and France - the proposal of Mathieu, one of the foremost French engineers of his time…"

***Popular Science,* December 1918**

Above: caption: "Signing of the Treaty of Amiens (Amiens Town Hall)"

697

Left: caption: "The First Kiss in these 10 years in the encounter of Britain and the Citizen Francois in 1803, by James Gillray." On March 25, 1802, Britain and France signed the "Treaty of Amiens" (intended to be the "Definitive Treaty of Peace"). *Napoleon* and *King George III,* who were "desirous of ending the calamities of war," laid the foundation of the treaty on October 1, 1801, in London. The *Treaty of Amiens* gave recognition to the French Republic by the "United Kingdom of Great Britain and Ireland" and ended the "War of the Second Coalition" and established the goal of "peace, friendship, and good understanding." It would be an ephemeral peace, at best.

698

Curb Your Enthusiasm

699

"…For one hundred and sixteen years the fear of war has thwarted the men who had the plan at heart. Napoleon was fighting England again soon after the conversation with Charles Fox, and thought no more of the Channel tunnel, His nephew, the Third Napoleon, tried to revive interest in the project, but the Franco-Prussian war quenched his enthusiasm…"

***Popular Science,* December 1918**

Left: caption: "Napoleon III, Emperor of the French, ca. 1863." Nephew and heir of *Napoleon I, Louis-Napoléon Bonaparte* (1808-1873) was the President of France from 1848 to 1852 (he was the first French Head-of-State to hold the title of President) and, as *Napoleon III,* Emperor (1852-1870). His downfall came about by the *Franco-Prussian War* in which France was decisively defeated.

700

Caption: "Clockwise from top left: Prussian infantry at the Battle of Spicheren; Jeanniot's 1886 La ligne de feu (Battle of Mars-La-Tour); Werner's depiction of the capitulation of Sedan; Neuville's 1873 Les dernières cartouches (Battle of Bazeilles)"

701

Military Menace

702

"…England steadfastly opposed the tunnel. For centuries she had been an island. She had developed political liberty after her fashion partly because she was cut off from the Continent; she was safe from invasion because she was surrounded by stormy waters. Direct physical connection with the Continent was a military menace…"
Popular Science, **December 1918**
Left: WWI recruiting poster featuring a map of the British Isles in its "Splendid Isolation" from the European continent

703

704

Much to Gain

705

"…Yet there were broad-minded men in the English government who saw that England had much to gain by the building of a tunnel. In 1875 England and France signed a treaty which defined the tunnel rights of the two countries, provided for the flooding of the tunnel in time of war, and empowered a British and a French company to begin the work of excavation…"
Popular Science, **December 1918**

706

"…In 1875 a French company made a particularly elaborate survey, taking 7,000 soundings in the Channel and obtaining 3,760 specimens from the bottom of the sea. The company put down a boring at Sangatte, sank two shafts, and drove headings through the lower beds of the chalk. In 1880 the French company applied for an extension of its concession, which had lapsed, as no arrangement had been reached with an authorized British company. About the same time the South Eastern Railway Company obtained powers to acquire land for a tunnel. The company sank three shafts between Folkestone and Dover, one near Abbot's Cliff, one west of Shakespeare Cliff, and a third to the east of Shakespeare Cliff. Headings were driven from the first two shafts in a direction more or less parallel with the cliff, through the lower beds of grey chalk, and for some distance under the sea…"
Railway Wonders of the World, **June 21, 1935**

707

708

Moving Heaven and Earth

709

"…Shafts were sunk on both the English and French sides seven years later, and tunnels were driven from these shafts out under the sea for a distance of six thousand feet. Then Joseph Chamberlain, Secretary of the Home Department, stepped in and, with the assistance of the courts, stopped the work. Both the French and British companies moved heaven and earth to recommence operations…"
Popular Science, **December 1918**

710

"…The gallery from the shaft west of Shakespeare Cliff was circular and 7 ft. in diameter. It was completed on a descending gradient of 1 in 80 for about a mile and a third, when the work was stopped. It was driven through the grey chalk by the aid of a boring machine, was not lined, and proved to be practically dry, the total volume of water entering the whole length being estimated at only a gallon and a half per minute. On the French side, at Sangatte, the French company, using the same apparatus - the Beaumont boring machine - drove a gallery of about a mile and a quarter in length, in the years 1882-3. When work was stopped the face of the gallery was about 100 ft. below the sea-bed, and the depth of the sea at low water was 27 ft. The quantity of water entering this unlined gallery was likewise very small…"
Railway Wonders of the World, **June 21, 1935**

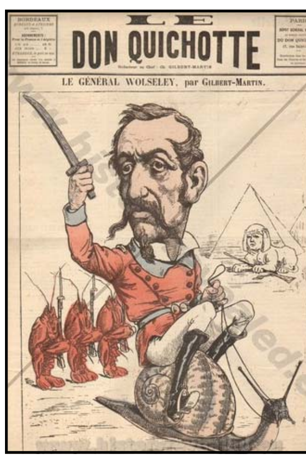
711

"…Many years after this gallery at Sangatte had been abandoned the shaft was examined. By then, of course, the sea, seeping into the unlined gallery, had filled it along the entire length. But although there was a mean rise and fall of the level of the sea amounting to 18 ft., the water in the bottom of the shaft rose and fell only a few inches during the twelve hours. This showed that the infiltration into the galleries was still very slow; otherwise the water in the shaft would have risen and fallen a distance more in keeping with the rise and fall of the tide…"
Railway Wonders of the World, **June 21, 1935**

712

Hail the Conquering Hero

713



"…Wolseley bombarded Alexandria in 1882, thereby hardly improving the feeling of England and France for each other. Wolseley, a popular hero after his Egyptian triumph, branded the whole Channel tunnel enterprise as insane, and voiced the opinion of conservative England when he argued that the tunnel would destroy the military isolation that had saved England from invasion for centuries…"
Popular Science, **Dec. 1918**
Left: September 15, 1882 issue of *Le Don Quichotte*, featuring Wolseley on the cover

714

"Man-shooting is the finest sport of all. There is a certain amount of infatuation about it; that the more you kill, the more you wish to kill."
Garnet Wolseley
RE; excerpt from a letter to his aunt. Born in Dublin, Ireland on June 4, 1833, Wolseley's father had served as a Major in the British Army. Joining the *80th Regiment of Foot,* in Rangoon, Burma, in 1853, Wolseley soon demonstrated his fearlessness in battle, serving with distinction in several colonial campaigns. In 1882, a military coup in Egypt (aimed at overthrowing the British and Turkish control in the region) was put down decisively by Wolseley at the *Battle of Tel-el-Kabir.* For his services, he was promoted to the rank of General, in November 1882.

715

Perish the Thought

716

"…England invaded and conquered! The idea alarmed even such cool-headed scientists as Thomas Huxley and Herbert Spencer, with the result that they carried in person to the House of Commons an enormous petition, signed by tens of thousands, protesting against resumption of work on the tunnel. A Parliamentary committee decided against the tunnel companies in 1883. The tunnel was dead. Nearly every great English engineering project for improving the means of communication with the Continent has met with similar absurd opposition…"
***Popular Science,* December 1918**

717

Staying Alive

718

"…the Channel Tunnel, Limited, and the Compagnie Continentale du Chemin de Fer Sous-marin, the respective English and French companies, must have been composed of extraordinarily cheerful financial optimists. If the tunnel was dead after 1883, they at least were alive. They stayed alive by paying taxes so as to keep their charters in force, and engaged engineers and geologists to make further studies of the technical problems that would have to be surmounted…"
***Popular Science,* December 1918**

719

"…Year after year, application was made to the British government for permission to resume work. France had always been in favor of the project. In 1913 Mr. Asquith gave some hope that the Channel tunnel might be considered anew. Then came the invasion of Belgium by Germany in 1914. Tunnel schemes were thrust into the background again…"
***Popular Science,* December 1918**

720

20/20 Hindsight

721

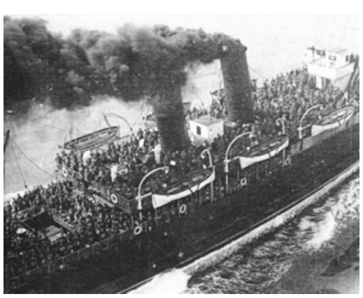
"…Strategists who are now fighting in France realize what a stupid mistake the military advisers of the British government made in objecting to the tunnel. England must henceforth be able to reach Liege or Antwerp as quickly as a rail-borne German army. Besides, England is no longer isolated, in the old sense. The submarine and the airship have destroyed her insularity. To be sure, no invading troops have been landed on English soil; on the other hand, the sea, England's mightiest bulwark, has not been able to prevent attacks on her shipping by submarines or the bombardment of her towns by aircraft…"
***Popular Science,* December 1918**

722

723

"…According to Albert Sartiaux, engineer for the French tunnel company, 20,000,000 passengers have crossed the Channel since the outbreak of the war, and millions of tons of munitions and supplies. A tunnel would have released for Atlantic service 1,500,000 tons of shipping and an army of dock-laborers. He estimates that 30,000 troops and 30,000 tons of supplies a day could have been transported by a Channel tunnel, on the basis of six trains an hour for twenty hours. Think what this would have meant in the early days of the war, when hours were precious!..."
***Popular Science,* December 1918**

724



725

It Can Be Built!

726

"…The tunnel can be built for $80,000,000. It has cost England more than that for the lack of a tunnel…"
Popular Science, **December 1918**

727

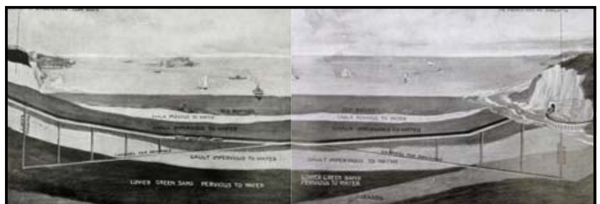
M. THOMÉ DE GAMOND, the eminent French engineer, who first put the Channel Tunnel Scheme into tangible form, by the completion of his detailed plans, in 1856.
(Reproduced from *The Sphere*, January 14th, 1907.)

"…Thome de Gamond, who devoted the best part of his life to the problem of the Channel tunnel, made about fifteen hundred experimental borings in France and England, and went down three times in a diving-bell in order to bring up specimens of the Channel bed. Although Mathieu first proposed the tunnel, Gamond is rightfully its father…"
Popular Science, **December 1918**

728

In All Probability

729

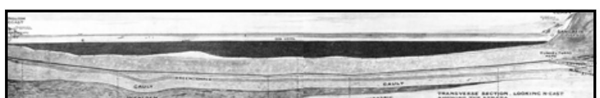


"…The latest plans, for which Sir Douglas Fox of England and Albert Sartiaux are responsible, and which will in all probability be carried out after the end of the war, provide for two tunnels, each eighteen and one half feet in diameter, to be driven under the Channel from Shakespeare Cliff, near Dover, to Sangatte, between Calais and Boulogne. The distance would be about thirty-seven miles, twenty four of which would lie under water. At their lowest point the rails are to lie 325 feet below water-level. For a short distance the maximum grade is ninety-six feet a mile; the prevailing grade is twenty-six feet a mile. At about every two or three hundred yards there are to be connecting passages between the tunnels…"
Popular Science, **December 1918**

730

Marvelously Easy

731



"…The digging of the tunnel would be marvelously easy compared with the driving of the tubes under the Hudson and East rivers or tunneling under New York to provide an aqueduct for Catskill drinking water. England and France were at one time connected. The evidence of that connection is to be found in the similarity of the geological strata in southern England and Northern France. Machines will burrow into the bed and discharge the material excavated on endless traveling belts that discharge their loads directly into cars. There will be no manual labor - no shoveling…"
Popular Science, **December 1918**
<u>Above</u>: caption: "THE GEOLOGICAL STRATA through which the twin Channel Tunnel would have penetrated was composed chiefly of a bed of chalk. The engineers, after test borings, claimed that there was no water in this bed, that it would cut 'like cheese,' and that the construction would encounter no serious obstacles. The tubes were to be lined with cast-iron segments and grouted on the outside, the exterior being thus surrounded by a covering of cement to prevent leakage and corrosion. The inner face would be lined with concrete and cement and then lime-washed, a smooth interior being provided."

732

"…To keep within the grey chalk there was to be a curbed alignment on the submarine portion of the tunnel, requiring great care in the setting out, so that the headings could meet accurately in the chalk under the middle of the Channel…"
Railway Wonders of the World, **June 21, 1935**

733

The Scheme Put Forward

734

"…During the twelve years after the expression of opinion by the Parliamentary Committee, the Channel tunnel was brought forward again in Parliament on no fewer than eleven occasions, each time without success, because of military objections. Then, after a lapse of another twelve years, the matter was raised again in Parliament in 1906 and 1907 without success. Attempts made in 1914 and 1919-20 to reopen the question were rejected on military grounds…"
Railway Wonders of the World, **June 21, 1935**

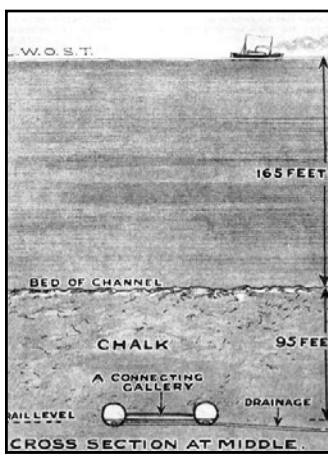
735

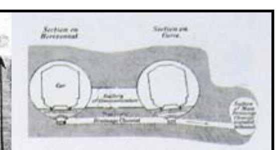
"…The scheme put forward at this period was for a twin-tunnelled project. Separate tunnels, joined at intervals by passages, were to be provided for electrically-operated trains. One tunnel would be for trains going from England to France, and the other for trains going in the opposite direction, this plan being designed to aid the ventilation by fans. The connecting galleries were to be placed obliquely, and were intended to accelerate the work of construction, as they would not impede the transport of materials to the advanced faces. The construction train would enter one of the main tunnels, and on reaching the most advanced passage would proceed through it to the other tunnel and so return. After the completion of the project the galleries would serve as a means of communication between the two tubes for the workmen on the railway They were to be closed by airtight doors when not in use, to avoid interfering with the ventilation scheme…"
Railway Wonders of the World, **June 21, 1935**

736

"…The maximum passenger train capacity was put at six trains carrying 500 persons per hour each way. The electric fans were designed to send air through the tubes at a velocity of about 6 ft. a second, equal to a very light breeze. The main tunnels were to be 18 ft. in diameter, large enough for British and French carriages in each single track tube; the vehicles would be drawn by electric locomotives. It was stated that the advantage of two tunnels over one of larger diameter was that it would be easier to adjust the position of the tunnels so as to keep them entirely within the grey chalk strata. The ventilation would be better, and the cost of lining less. The length of the tubes and the approaches to connect with the main lines of the two countries was estimated at about thirty-one miles. Centre to centre the tubes would be 32 ft. apart…"
Railway Wonders of the World, **June 21, 1935**

737





<u>Above</u>: caption: "A transverse section of the tunnel projected by the French company"
<u>Left</u>: caption: "THIS CROSS-SECTION of the twin-tunnel project gives a clear idea of the scheme. The plan was to keep the tunnels entirely in a grey chalk bed which is favourable to construction.

738

The Drainage Tube

739

"…There were to be two sets of bores, one set being for drainage. This set was to have started from the bottom of a shaft at Dover at 350 ft. below sea-level, and to rise on a gradient of 1 in 500 to about six miles from the shore, here to meet the railway tubes which were to descend on easy gradients to this point. The drainage tube would proceed on a still rising gradient of 1 in 1,000, on one side of the railway tubes, to the summit at a point in the middle of the bed of the Channel where the French part of the work would be met. Pumping stations were to be erected on either side of the Channel. It was suggested that the drainage tubes, which were to be twenty-four miles long, would be completed before the construction of the main tubes was started…"
Railway Wonders of the World, **June 21, 1935**

740

"…First, a trial tube of about eleven feet diameter is to be run from Dover to Sangatte. It will carefully test the ground to ascertain the precise location of any fissures or faults. It will be used as a drainage tube, and will rise up to the center of the Channel, so that water will flow down in each direction and be pumped up at Dover and Sangatte. It will take four years to construct this tube, but it will reduce the time required for the entire work. By it means chambers will be excavate in the middle of the Channel, and from these chambers it will be possible to drive the tunnels both from the shore ends and backwards from the center, and to carry off the excavated material through the tube…"
Popular Science, **December 1918**
Above: caption: "THE TWIN-TUNNEL PROJECT. Separate tunnel, for trains going to and from France, were to be joined at intervals of every 200 or 300 yards by connecting passages. The trains were to be electrically operated, and the ventilating problem solved by large electric fans. The two tunnels were to be some 30 ft. apart. 'It is no more difficult to make the Channel tunnel than it is to make tube railways in London' declared the famous engineer, Sir Francis Fox, in 1914. In the proposed scheme there were to be two sets of bores, one for draining purposes. The diagram's arrows indicate the water flow direction."

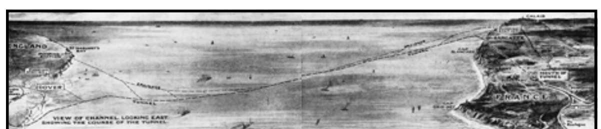
741

"…The main tubes were intended to cross the coast line on the English side close to the south-west face of Shakespeare Cliff tunnel on the South Eastern Railway, but below that line, and proceed from the sea in a spiral fashion, though still underground, round the citadel and the villages of Farthinghoe and Maxton, reaching the surface close to the north-west of Maxton. A new station was to be built east of the face of the tubes, and, just beyond, a junction with the London, Chatham and Dover line which ran to London via Canterbury. Proceeding from this junction to complete the spiral, the approach was to end at a junction with the main South Eastern line close to the eastern face of the Shakespeare Cliff tunnel and thus obtain through communication with London via Folkestone…"
Railway Wonders of the World, **June 21, 1935**

742

"…On the French side the tubes were to cut the coast at Sangatte, turn sharp to the right, proceed parallel with the shore, and emerge to the surface near Wissant, on the coast. The approach was there to form a back-shunt junction, joining the Calais-Boulogne section of the Chemins de Fer du Nord at Beuvrequen…"
Railway Wonders of the World, **June 21, 1935**

743



Above: caption: "IN 1914 a plan to build a double Channel tunnel was considered. It was proposed to make the tunnel twenty-two miles long, with some two or three miles of approach at either end. Pumping stations were erected on either side of the Channel, and a third drainage tube or tunnel of twenty-four miles long was to have been built before the main construction began. On the English side (left) the tunnel was intended to cross from a site near the Shakespeare Cliff, Dover. In France (right), the tunnel was to cut the coast at Sangatte and emerge near Wissant. The cost of this ambitious scheme was estimated at £16,000,000. It was considered again during the Great War in 1916, when the Government received a deputation."

744

In Time of War

745

"…The French have consented that the power-house shall be stationed at Dover under the complete control of the English. The mere pulling of a switch handle would cut off the electrical power in time of war…"
Popular Science, **December 1918**

746

From Rails to Roof

747

"…There is to be a dip in the tunnel which is to form a water-lock. An officer at Dover has only to open a sluice-gate in order to flood the tunnel from rails to roof for a mile. It is an ingenious method of blocking communication with the Continent, and it ought to commend itself to investors who might worry about the cost of restoring the tunnel. The water could easily be pumped out…"
Popular Science, **December 1918**

748

Time and Money

749

"…Thirty-five years ago, when the tunnel was actually in course of construction, it was thought that the work could be completed in six and a half years. American engineers now say that this time could be reduced to a little more than four years. As for the cost, that would remain at the original figure of $80,000,000 - possibly $90,000,000…"
Popular Science, **December 1918**

750

After the War

751

"…From the interest that the British government has been forced to take in the Channel tunnel as a result of the war, it may be inferred that its construction will be the first great engineering feat to be undertaken after the war."
***Popular Science*, December 1918**

752

"…After the war the Channel tunnel was discussed time and again, and in 1929 the then Prime Minister, Mr. Stanley Baldwin, appointed a committee composed of Mr. E.R. Peacock, Lord Ebbisham, Sir Clement Hindley, Sir Frederick Lewis, Bt., and Sir Henry Strakosch, to report on the economic aspects of the tunnel project or other new forms of cross-Channel communication which might be possible. The project was put forward by the Channel Tunnel Company for a railway connexion between the Southern Railway and the Chemins de Fer du Nord, consisting of a pilot tunnel, 10 ft. in diameter and two traffic tunnels, each 18 ft. 6-in. in diameter, of a total length of thirty-six miles, including twelve miles of approach tunnels…"
***Railway Wonders of the World*, June 21, 1935**

753

Cross-Channel Communication

754

"…The committee invited a panel composed of firms of consulting engineers to express an opinion on a number of questions. Four of the five members of the committee reported in favour of the tunnel. They decided that none of the other new forms of cross-Channel communication, such as train-ferries, a bridge, a rail tube on the bed of the Channel, or a cross-Channel jetty, could be regarded as a satisfactory alternative to a tunnel. They thought it probable that the engineering and geological difficulties could be overcome, but there would be a doubt until a pilot tunnel, estimated to cost £5,600,000 had been successfully driven across. If that were built, they thought the practicability of constructing the traffic tunnels would be established. The cost of the traffic tunnels was put at about £25,000,000. The committee believed there would be no difficulty about their operation and upkeep. They considered that the work should not be given any special financial assistance by the Government, as they considered that the tunnel could be built, maintained and operated by private enterprise at a cost which would permit traffic being carried at rates not higher than those then in force on the short cross-Channel route. Their final conclusion was that although some interests would be adversely affected, the tunnel, by creating new traffic and thus increasing trade, would be of economic advantage to Great Britain…"
***Railway Wonders of the World*, June 21, 1935**

755

"…Lord Ebbisham, however, dissented. He stated that the terms of reference debarred the committee from considering the military aspects, but he thought that the decision of previous Governments should be maintained. He also considered that a tunnel would be detrimental to the interests of shipping and agriculture, and, further, that the tunnel would make Great Britain a mere adjunct to the Continent and might well promote a feeling of unrest by adding to anxieties and responsibilities. He considered that this psychological factor should be borne in mind. After having heard all the evidence and taking all the conditions into consideration. Lord Ebbisham declared himself opposed to the scheme on economic grounds…"
***Railway Wonders of the World*, June 21, 1935**

756

"…This scheme, which four of the five members of the committee favoured, provided for two independent traffic tunnels and a smaller pilot tunnel. The English terminal would be at Sandling Junction, five miles west of Folkestone. The line would run parallel with the shore for about ten miles - nearly to Dover - about six miles of this being underground, before finally turning outwards beneath the sea. On the French side of the Channel the tunnel would similarly run for some miles parallel with the coast line, and would emerge ten miles to the east of Boulogne. The whole of the tunnel would be electrically operated, and exchange stations would be constructed at either end of the tunnel…"
Railway Wonders of the World, **June 21, 1935**

757

"…The only hope of surmounting the geological problems, which the Committee discussed, lay in running the tunnel through the lower chalk strata, which reaches a depth below sea-level of about 300 ft. The practicability of the scheme depended upon the continuity under the Channel of this strata. The available evidence suggested that this formation does extend without interruption, but there was a risk that fissures or unfilled valleys might be encountered. If fissures filled with rough gravel, and therefore affording fairly free passage for the sea-water, were met with, cementation would probably fill them up. If close sand, yielding large quantities of water, were encountered, the conditions of the work would be more difficult, and the success of the process doubtful. With the development of engineering resources, fissures, unless of exceptional size, would not present any insuperable difficulty…"
Railway Wonders of the World, **June 21, 1935**

758

"…As to the pilot tunnel, the Committee considered this imperative before any expense was incurred on the main borings. The consulting engineers recommended that, as the pilot tunnel proceeded, advance and radial boreholes should be driven from it to explore the ground ahead and all round it to obtain the fullest information regarding the ground through which the main tunnel would subsequently be driven. The Committee's estimate of costs. Was £5,600,000 for the pilot and drainage tunnels and £24,850,000 for the two traffic tunnels. The total of £30,450,000, included the cost of construction of the works, the disposal of the excavation by specially designed wagons and its dumping into the sea, the provision of permanent-way, electrical equipment and sub-stations, as well as provision for payment of interest on the capital during the construction. But it did not include the cost of exchange stations at either end of the tunnel or of the electric locomotives…"
Railway Wonders of the World, **June 21, 1935**

759

"…The consulting engineers considered that there would be no difficulty in maintaining the track, but the inspection of the permanent way and any repairs would have to be carried out mainly at night, and a careful organization would have to be arranged for the transport of men and materials. It is for this service that the pilot tunnel would be principally used. They considered that the running of the trains would probably create enough ventilation, which could be regulated by openings into the pilot tunnel. If this was not sufficient the ventilation could be supplemented by propeller fans, the pilot tunnel being used to convey air to the running tunnels…"
Railway Wonders of the World, **June 21, 1935**

760

"…The consulting engineers suggested that the pilot tunnel should be driven near the centre-line from shore to shore and about the same level as the future main tunnels, and that it should be about 12 ft. in internal diameter instead of 10 ft., as suggested by the company. This was because the wider tunnel would provide sufficient space for the temporary railways used for the construction both of pilot and main tunnels, and also room for the ventilation and other pipes…"
Railway Wonders of the World, **June 21, 1935**

761

"…The disposal of the spoil from the main tunnels would be effected by passing it through passage ways to the pilot tunnel. Such passages were to be at intervals of about two miles. The internal diameter of the drainage tunnels was suggested as 7 ft. with a gradient falling to the shore shafts so that if water were encountered suddenly, it would flow by gravitation to the pumps, and so would not impede the escape of workmen through the pilot tunnel. They estimated that the pilot and drainage tunnels could be driven in about five years; rotary excavators being employed in both cases. The main tunnels could be completed, and equipped in about three years after the pilot tunnel had been finished…"
Railway Wonders of the World, **June 21, 1935**

762

"…The committee asked the consulting engineers their opinion on the Fougerolles method of disposing of the excavated material, the French railway having expressed the view that this method would not only save time but also reduce the cost of the traffic tunnels to £18,000,000. The engineers pointed out that the machine which M. Fougerolles would employ was a rotary tunneling machine similar in principle to those used on the London underground railways, and in the experimental heading driven in the chalk in the Folkestone cliffs and under the sea at Shakespeare Cliff. These machines can be made to excavate the ground at such a speed that difficulty has been found of disposing of the spoil to keep pace with them…"
Railway Wonders of the World, **June 21, 1935**

763

"…M. Fougerolles proposed to overcome this by mixing the debris with water to reduce it to a slurry capable of being pumped up on to the bed of the sea. To effect this borings would be made to the sea bed, and lined with steel tubes. Sea water would be admitted by these tubes for use in spraying the face of the excavation, and also for reducing the debris to slurry. The consulting engineers suggested that as the shaft and heading on the French side remained, except that they were full of water, the water could be pumped out and a test of M. Fougerolles proposals made there. M. Fougerolles had offered to carry out the test for £40,000, including the cost of the tunnelling machine, which could afterwards be used for driving the pilot heading. In view of the saving which would be made if the system were a success, the engineers thought that a test should be undertaken…"
Railway Wonders of the World, **June 21, 1935**

764

Boring of Channel Tunnel Will See New Methods

If the boring of the tunnel under the English Channel is decided upon, new methods may be inaugurated for doing this kind of work, according to recent announcements. An excavating machine is now being assembled which, it is thought, will have a far greater output than any hitherto used for tunnel boring, and to further insure speed in construction, a considerable number of working points are under consideration. Removing the borings has been made the subject of special study, the way most likely to be employed being that of converting the refuse into semi-liquid form by adding water then discharging it through pumps. (*Popular Mechanics,* September 1922)

765

"…If the scheme did not come up to expectations, there were other methods, apart from the use of wagons, for getting rid of the spoil. If the spoil could be reduced to a slurry, it might be found feasible, by the addition of more water obtained from the shore shafts, to make it flow through the drainage tunnel to the shafts, where pumping would be comparatively easy…"
Railway Wonders of the World, **June 21, 1935**

766

"…Other new forms of cross-Channel communications included a combined railway and road tunnel. The Committee did not receive any concrete proposal, but discussed the idea. Such a tunnel would be about thirty-six miles long, and it would be in the form of an inverted siphon, the lowest part of which would be some 300 to 400 ft. lower than either end. If motor-vehicles were allowed in the tunnel the carbon monoxide gas from their exhausts, being heavier than air, would gravitate to the lower levels of the tunnel. The Committee thought it extremely doubtful if any form of blower or suction fan could be constructed of sufficient power to drive the gas from a tunnel thirty-six miles long…"
Railway Wonders of the World, **June 21, 1935**

767

The White Paper

768

"…Having made their decision in favour of the Channel tunnel by a majority of four to one, the Committee presented their report in March, 1930, and the tunnel became a topic of great interest. Then in June, 1930, a White Paper announced that 'the Government has come to the conclusion that there is no justification for a reversal of the policy pursued by successive Governments for nearly fifty years in regard to the Channel tunnel.' The main factors were: doubt as to feasibility of construction, weakness of the economic case, increased military commitment without any advantage, great cost, and the length of the period for return of capital…"
Railway Wonders of the World, **June 21, 1935**

769

"…Although it seems as though for the time being the Channel tunnel will not materialize, there is always the possibility of a change in Governmental outlook. But most of the several objections raised by Lord Ebbisham in the report to the Government in 1930 are still advanced. But if the tunnel were to be constructed it would receive a warm welcome from cross-Channel passengers…"
Railway Wonders of the World, **June 21, 1935**

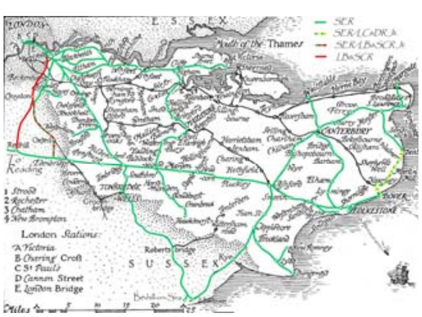
770

The Success of the Undertaking

771

"…The Southern Railway, by virtue of its position, would, of course, be the company most concerned if the Channel tunnel ever materialized. In the event of a tunnel being constructed it would most likely be either wholly or partly for railway operation. In either instance this would mean that the active assistance of the Southern Railway would be absolutely imperative, controlling as it does all the south coast railways…"
Railway Wonders of the World, **June 21, 1935**
RE: the *South Eastern Railway* (a/k/a SER or "Southern Railway") was formed in 1836 to construct a route from London to Dover. Most of the SER's routes were in Kent, eastern Sussex and the London suburbs.

772



773

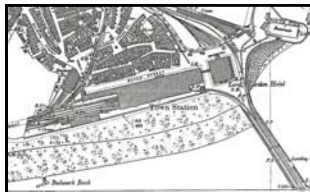
"…The general attitude of the company when approached by the Committee in 1930 was necessarily one of caution, but the company did promise that, if the tunnel were sanctioned, it would do all that it could to ensure the success of the undertaking…"
Railway Wonders of the World, **June 21, 1935**

774

<u>Above</u>: caption: "The trestles along Shakespeare Beach"

Above: caption: "Shakespeare Beach, Dover, ca. 1840, by James Patterson Cockburn. Note the trestle of the SER railway track on right."

775



"…The Southern Railway confirmed the Consulting Engineer's estimate of the cost of the proposed scheme, but as far as the probable volume of passenger traffic was concerned, it put the figure rather lower than the one which the Committee had calculated. The Company assumed a longer period before the tunnel would be finished, and when it was finally opened the novel facilities would not bring a very great increase of passenger traffic…"

Railway Wonders of the World, **June 21, 1935**

Left: caption: "Map of Town Station next to the beach, ca. 1890"

Right: caption: "Former Dover Town Station, ca. late 1920s"

776

"…Had the tunnel of 1930 been built it was probable that an arrangement would have been arrived at between the Southern Railway, the Chemin de Fer du Nord, and the British and French Channel Tunnel Companies which would have given the control of the tunnel into the hands of the two big railways…"

Railway Wonders of the World, **June 21, 1935**

777

"…In the event of the tunnel's construction, the company said that they would stop passenger boat services on the Dover-Calais and Folkestone-Boulogne routes, while on their remaining routes the services would probably he either considerably curtailed or discontinued. This would mean that the capital invested in the ships on the trans-Channel service and the revenue brought in by them would be lost. Such items as this, as well as the extensive alterations which would have to be carried out to meet the new conditions, were, of course, taken into consideration by the Southern Railway. But whatever happened, the Railway thought that, added to a sum of £3,000,000 which would have to be spent by them in various ways, there would, at first, be a loss of perhaps as much as £500,000 a year…"

Railway Wonders of the World, **June 21, 1935**

778

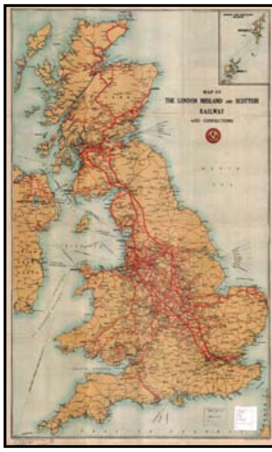
779

"…Another British railway board which was bound to be affected by the construction of the tunnel was the London and North Eastern Railway. This company's views were also obtained by the Investigation Committee prior to presenting their report to the Government. The company reckoned that traffic from the Port of Harwich would decrease by some seventy thousand passengers a year. At the same time, however, it was not thought that the goods traffic carried over the short sea routes would be greatly disturbed. But, nevertheless, the company must inevitably suffer, and the Committee realized that compensation might have to be paid…"

Railway Wonders of the World, **June 21, 1935**

Left: LNER route map, ca. 1925

780

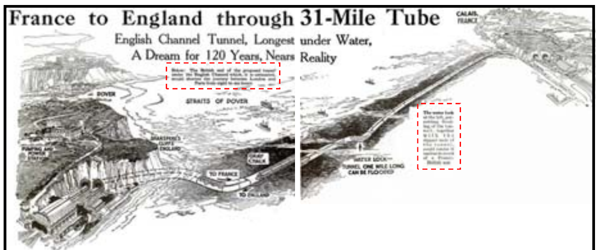


"…The third English railway company to be approached was the London, Midland and Scottish. This company declared that some of its traffic must fall off if the tunnel were built, but an increase of visitors from abroad might counterbalance the loss."
Railway Wonders of the World, **June 21, 1935**
Left: caption: "Map of the London Midland and Scottish Railway and connections, 1927. Also shows other railway lines, steamer routes, and coach routes. Includes inset of the Orkney and Shetland Islands showing steamship routes between the islands. Index to towns, railroad company officers and other information, and notes on verso"

781

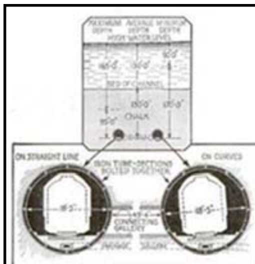
A 31-Mile-Long Tube

782



The two-page drawing reveals graphically the proposed submarine tubes, said to be the most ambitious ever undertaken. The tunneling would be accomplished, not by digging from both ends as engineers always have done before, but by sinking eight shafts in the center of the Channel and burrowing from their bases toward the French and British shores. Diggings would be lifted out of the shafts and thrown overboard into the sea. (*Popular Science,* November 1923)
Left: caption: "Below: The British end of the proposed tunnel under the English Channel which, it is estimated, would shorten the journey between London and Paris from eight to six hours"
Right: caption: "The water lock at the left, permitting flooding of the tunnel, together with the dipped ends of the tunnel, could render it useless in event of a Franco-British war"

783



Left: caption: "Diagram illustrating the construction of the two tubes that compose the tunnel, and their position under the Channel. Note also that where the water deepens, the depth of the tunnel lessens. The distance between the tunnel and sea-level is thus always about 260 feet, a depth that is deemed amply safe."
Right: caption: " New York and New Jersey officials inspecting the new Hudson River vehicular tunnel, The diameter of this great submarine tube, which is nearly 29 feet, makes it easily the world's largest tunnel. The proposed Channel tubes, although much smaller in diameter than the Hudson River tunnel, would be many times longer." (*Popular Science,* November 1923)

784

The Latest Scheme

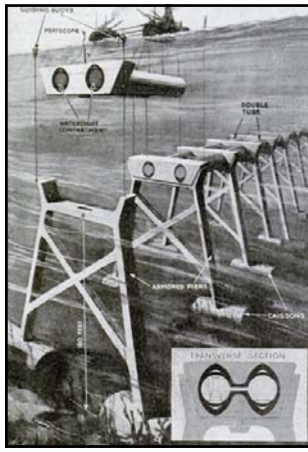
785

Engineer Plans Channel Tunnel Built on Great Concrete Piers
Popular Science, **November 1925**
RE: introduction to an article entitled: "Submarine Trains to Run on Stilts?"

786

"FOR more than a century, one of the most fascinating problems of the European engineer has been the building of a tunnel under the English Channel, to link France and England. One of the latest schemes is that of a Frenchman, Commandant Veyrier…"
Popular Science, **November 1925**

787

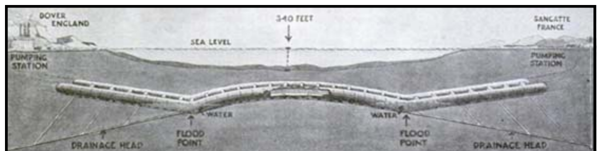


"…He proposes that, instead of boring a tunnel through the bedrock of the Channel, a succession of great reinforced-concrete piers shall be anchored to the sea bottom by means of strongly ballasted caissons. The piers would be sunk 340 feet from the surface. Once the piers were anchored securely, Commandant Veyrier's plan calls for a double-tube railway laid upon them, a section at a time, and fastened firmly to the supports, as shown at left…"
Popular Science, **November 1925**
__Left__: caption: "A French engineer's plan for building an undersea route between France and England across the English Channel by anchoring gigantic concrete piers to the seabed as a foundation for a two-tube Railway"

788

"…At the end of every section of the tube railway would be a watertight compartment similar to the watertight bulkheads with which all modern vessels are fitted. These compartments would insure a greater amount of safety in the tube, since if one part of it were flooded, the rest could be shut-off immediately. Each tube would hold only one railway line – one for eastbound and the other for westbound trains…"
Popular Science, **November 1925**

789



"…Another engineer's plan, submitted to the British Houses of Parliament not long ago, was to bore a tunnel through the bed of the Channel. This tunnel was to be slightly higher at each end, sloping downward perhaps a quarter of the distance, then slightly arched across the center. This was planned so that, in the event of enemy invasion, the tunnel could be flooded from either end."
Popular Science, **November 1925**
__Above__: caption: "An earlier scheme for submarine transportation under the English Channel. This is a double-tube tunnel, built with sloping ends and a slightly arched center. A control mechanism at each end would enable either France or England to flood the tunnel in case of an invasion by an enemy."

790

The New Plan

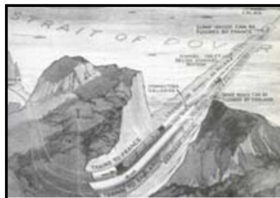
791

"PLANS which have been considered for more than half a century for a railroad tunnel under the English Channel, connecting France and the British Isles, were revived recently in the Parliament, with a strong demand that the government authorize the work. A tunnel company has been in existence for many years, and construction of approaches was naturally begun at one time, but stopped when the British army general staff objected…"
Popular Mechanics, **May 1929**
RE: excerpt from an article entitled: "New Plan for Channel Tunnel"

792

"…The army leaders voiced the same objections again this time, claiming railroad connections with the mainland would imperil England in time of war and require a huge standing army to guard against a surprise attack by train, in event of war with France…"
Popular Mechanics, **May 1929**

793



"…In answer, the tunnel proponents pointed out that the plans provide for a sump near either shore, so that either England or France could flood a section of the tunnel at will, and prevent the other from using it, and that so far as danger to England went, a battery of long-range guns stationed along the French coast near Calais could bombard London as easily as the Germans bombarded Paris in 1918…"
Popular Mechanics, **May 1929**
Left: caption: "Artist's diagram of the proposed Channel Tunnel, with sumps near either shore to permit flooding against an invasion, if France and England should ever fight"
Right: caption: "The answer to the General Staff objections is that batteries of long-range guns on the Calais coast could shell London without sending an army across the channel"

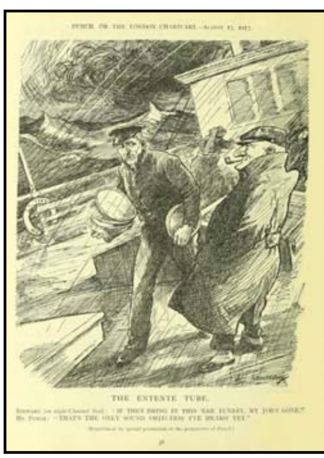
794

"…The plans being considered call for two parallel tubes, one for traffic in either direction, with connecting cross galleries at intervals for use in emergency. Smaller drainage tunnels would be sunk at a lower level, connecting with powerful pumps on shore. The length of the big bores would be approximately twenty-four miles, and the estimated cost of the project is in the neighborhood of $150,000,000…"
Popular Mechanics, **May 1929**

795

"…The main shafts would be 130 feet below the deepest part of the channel, and the bore would be through a layer of chalk marl that is almost impervious to water. Although about three times as long as the longest existing railroad tunnel, the project does not present any serious engineering difficulties…"
Popular Mechanics, **May 1929**

796



"…Proponents of the scheme point out that it would eliminate the rough channel crossing, especially bad in winter; relieve the railroad companies of the expense of building and maintaining a fleet of fast channel steamers; cut an hour and a half to two hours from the journey between London and Paris, and provide an uninterrupted means of transporting troops to the continent and getting food into England in event of another war, as neither surface ships nor submarines could interfere with the tunnel trains…"
Popular Mechanics, **May 1929**

797

Here Comes Everybody

798

"…Not all of the objections raised against the plan come from the general staff. The doctrine of England's 'splendid isolation' was cited in some quarters, and the fear expressed that quick and comfortable train journeys would make England a holiday resort for hordes of more or less undesirable people, who would introduce foreign customs, deface the countryside and otherwise interrupt English habits of living…"
Popular Mechanics, **May 1929**

799

"…Against this view, the friends of the project pointed out that the expenditure on the tunnel would do much toward relieving unemployment, particularly among miners, who could be used in the construction work."
Popular Mechanics, **May 1929**

800

As Above, So Below

801

Caption: "This diagram and the cross-section at right furnish an idea of the way a tunnel under the English Channel might be built, both to accommodate motor and rail travelers and to be secure against invasion in case of war"

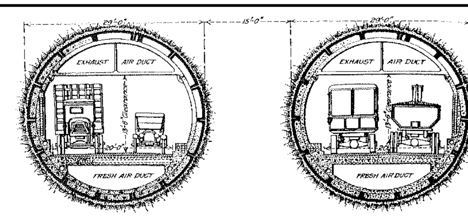
AUTOS MAY RACE OVER TRAINS IN TUNNEL: Greatest Engineering Scheme in History would link countries at $150,000,000 Cost

London – If the proponents of a tunnel under the English Channel win their skirmish before Parliament, they may be encouraged to advance the greatest engineering scheme in the world's history. For not only do some of them look forward to it as a railway link between Calais and Dover, but as a convenient driveway for motorists and truckmen in addition. The tunnel, costing probably $150,000,000, would thus become 10 times the project the Holland Vehicular tunnels under the Hudson river at New York were. But it would recompense the builders in the form of what is expected to be the greatest movement of travelers, both by motor and by train, that England and Europe ever have experienced. (newspaper article appearing in a 1929 British newspaper written by *Milton Bronner*)

802

Mr. Holland's Tunnel

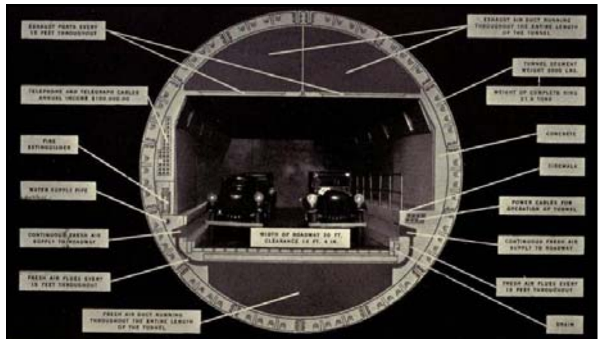
803



"When Clifford M. Holland talks tunnels, his listener is in danger of being convinced that tunnels are the only refuge for mankind; by the time he has finished his hearer sees in a tunnel all the allurement which a mole finds in a nicely constructed borrow. Because Mr. Holland does know tunnels, and he does build them safely."
Brooklyn Daily Eagle, **February 19, 1920**
Above: caption: "Clifford Holland's design for a Hudson River vehicular tunnel made up of twin tubes." Holland's ventilated twin-tube design was selected to be built by the NY/NJ Commission/s in 1919.

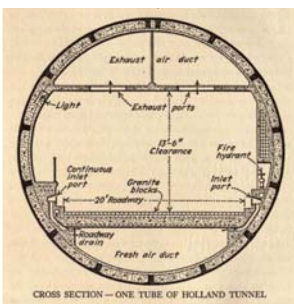
804

805



<u>Above</u>: caption: "Model of the Holland Tunnel showing many of the hidden details"

806



807

"…The Commissions selected as chief engineer Mr. Clifford M. Holland, tunnel engineer of the Public Service commission, First District, State of New York, in immediate charge of the construction of all subway tunnels under the East River. He was regarded as having had a greater and more successful experience in the work of the sub-aqueous tunnel construction than any other member of his profession. A board of consulting engineers was appointted, and a contract or treaty between the two states was drawn up and approved by the Commissions and given the consent of Congress…"

RE: excerpt from *The Eighth Wonder*

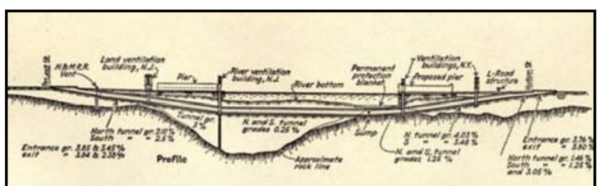
<u>Left</u>: *Clifford M. Holland*, Chief Engineer. Holland gathered a team of experts from the *U.S. Bureau of Mines* (USBM), *Yale University* and the *University of Illinois* to design the world's first ventilated vehicular tunnel. *Ole Singstad* (who completed the tunnel and later went on to design the *Lincoln, Queens-Midtown* and *Brooklyn-Battery Tunnel/s*) led the design team.

808

"…Chief Engineer Holland took office on July 1, 1919, and at once began the organization of an engineering staff. His chief assistants were selected from those who had been associated with him in the construction of the East River subway tunnels. Having had not less than ten years' experience in sub-aqueous tunneling, they were well qualified both by technical training and by practical experience to meet the requirements of the work. Actual construction began October 12, 1920…"

RE: excerpt from *The Eighth Wonder*

809



"…Ever ride through the Holland Tunnel in your car? An easy, effortless and safe trip, wasn't it? Well, don't be alarmed when you learn that certain sections of this sturdy old tube - the granddaddy of all sub-aqueous vehicular tunnels - rise and fall with the Hudson River tides. The reason is simply that part of the tunnel rests on river silt and another section, near the New York pierhead line, on a ledge of rock. Upon the rock the tunnel resists the tides but where it leaves the rock and enters silt, immobility leaves off and mobility sets in…lined the mobile section with cast steel instead of the cast iron used elsewhere. The greater tensile strength of steel absorbs the strain, making the so-called 'bending' perfectly harmless…"

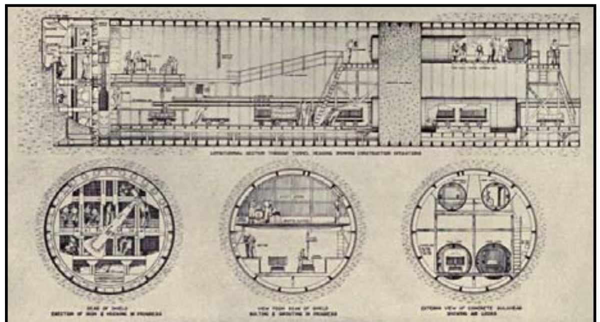
***Mechanix Illustrated*, June 1941**

<u>Above</u>: caption: "Profile of the Holland Tunnel"

810

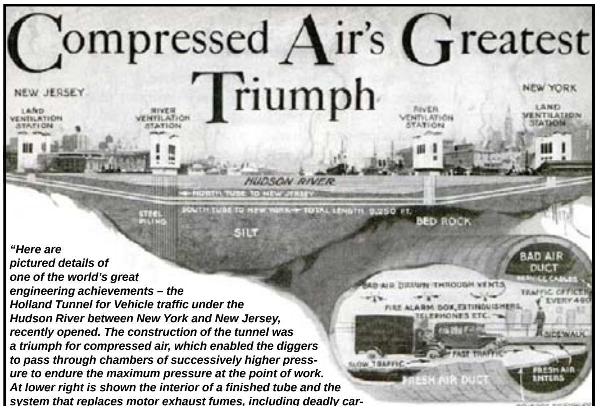
"…The excavation in the part-earth and part-rock section just east of the New York river shaft caisson was carried on by driving a short bottom heading in advance of the shield, in which was placed a concrete cradle with steel rails embedded in it upon which the shield slid. After placing the cradle the rock was blasted out for one or two advances of the shield and then the soft material on top was carefully excavated and supported by poling and breast boards…"
RE: excerpt from *The Eighth Wonder*

811



Above: caption: "Longitudinal Section Through Tunnel Heading, Showing Construction Operation. Below, rear of shield showing erection of iron and mucking in process; view from rear of shield with bolting and grouting in process; exterior view of concrete bulkhead showing air locks."

812



"Here are pictured details of one of the world's great engineering achievements – the Holland Tunnel for Vehicle traffic under the Hudson River between New York and New Jersey, recently opened. The construction of the tunnel was a triumph for compressed air, which enabled the diggers to pass through chambers of successively higher pressure to endure the maximum pressure at the point of work. At lower right is shown the interior of a finished tube and the system that replaces motor exhaust fumes, including deadly carbon monoxide, with fresh air. Above, general diagram view of $50,000,000 tunnel's twin tubes accommodating 3,800 vehicles an hour. The tunnel required seven years to construct."
***Popular Science*, January 1928**

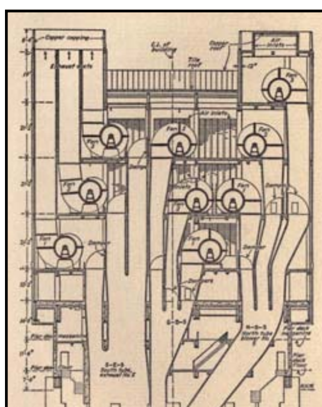
813

"…There are 28 ducts, 14 blower and 14 exhaust, connecting the various sections of the tunnels with the ventilating buildings. Each duct is equipped with three fans, two of which, when operated together, will supply the maximum quantity of air required. Their capacities range from 81,000 to 227,000 cubic feet per minute and they operate at static pressures varying from 0.6 to 3.75 inches of water. This range in pressure and capacity is due to the great difference in length of tunnel ventilated by different sets, those at the outside of the pierhead shafts having 1,700 feet to serve while the inside fans have only 700 or 800 feet. These fans, during an hour of heavy traffic, will handle 84,000 tons of air, or 1,400 tons per minute. They provide for changing the air in the tunnel 42 times per hour…"
RE: excerpt from *The Eighth Wonder*

814

Above: caption: "Sturtevant Silentvane Fan Wheels for the Holland Tunnel"
Left: caption: "One of the 84 Sturtevant Silentvane Fans. Which are the lungs of the Holland Tunnel"

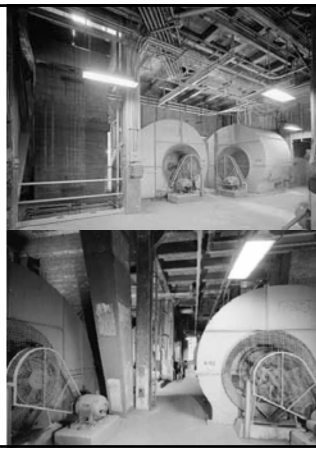
815



TYPICAL VERTICAL SECTION THROUGH VENTILATING BUILDING

"…The placing of the fans is varied to suit the local conditions in the individual buildings. Generally, the exhaust ducts are at the corners of the buildings and supply ducts are in the central portion. Consequently the compartments containing the exhaust fans are located near the corners under the exhaust stacks, leaving the central portion of the fan floors free for intake fans, and the central section of each outer wall for the air intakes. The intakes are made sufficiently large to give low velocities through the louvres…"
RE: excerpt from *The Eighth Wonder*

816



817

Above: caption: "East Blower Air Duct. In Land Ventilation Building, New York City, showing curved back and vanes."
Left: caption: "Holland Tunnel River Ventilation Building, New York City"

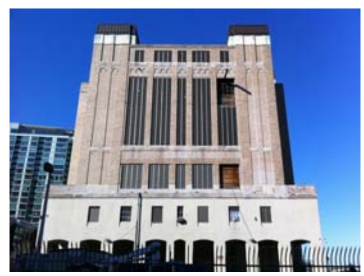
818

"…The louvre blades are made of heavy wire glass to give light to the interior of the buildings as they take up most of the space otherwise available for windows. Heavy bronze screens protect them and also serve to keep out birds. The arrangement whereby fresh air is drawn in through louvres high upon the sides of the buildings and exhaust air is forced out through stacks which ex-tend 20 feet above the roof insures a complete separation of fresh and vitiated air…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "NJ Land Ventilation Building, side view"

819



820

WORK ON TUNNEL BEGAN 7 YEARS AGO

Greatest of Vehicular Tubes, It Presented Herculean Task for Engineers.

COST PUT AT $48,400,000

New Link Between New York and New Jersey Expected to Be Big Aid in Traffic Solution.

The "streets under the Hudson," opened yesterday as the Holland Tunnel, were seven years in the building, cost the States of New York and New Jersey, $48,400,000, and are the largest vehicular tunnels in the world.

The boring of the two tubes under the river was a herculean task and one which taxed the ingenuity of engineers to the utmost.

The new link between the States is counted on to play an important rôle in efforts to cope with New York's constantly increasing traf-

"The 'streets under the Hudson,' opened yesterday as the Holland Tunnel, seven years in the building, cost the States of New York and New Jersey, $48,400,000, and are the largest vehicular tunnels in the world. The boring of the two tubes under the river was a Herculean task and one which taxed the ingenuity of engineers to the utmost…"

***The New York Times*, Nov. 14, 1927**

821

The Martyr Engineer

822

"…That the undertaking cost the lives of its first two chief engineers - not from accident, but from the drain on their vital energy - is perhaps the most striking evidence of the magnitude of the undertaking…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Clifford Milburn Holland, 1883-1924"

823

"Things broke well for me: the choice of engineering, the good school, the right years - when work was booming, the perfect place - New York, the lucky first job - subway shafts to Brooklyn, then my life's pinnacle and purpose - the great tunnel to New Jersey, and my wife, noble, strong. She knew what the project meant to me and the city."

***Clifford M. Holland,* Chief Engineer**

RE: when 41yo Clifford Holland died of exhaustion and heart failure on October 27, 1924, before the completion of "the great tunnel to New Jersey." He was eulogized on the press as the "martyr engineer" for his heroics and dedication. He was also acclaimed as "the most noted tunnel builder in the world" and the engineer of the "eighth wonder of the world." Within two weeks of his death, the project was named in his honor: *The Holland Tunnel*. In 1999, *<u>E</u>ngineering <u>N</u>ews <u>R</u>ecord* (ENR) honored him as one of the ten most outstanding "Landmark Project Engineers" of the last 125 years. Born on March 13, 1883 to an old *New England* family, he told his high school classmates he was going to be a "tunnel man." To that end, he entered Harvard University's engineering program in 1902, earning his B.S. in Civil Engineering in 1906.

824

"If I had known it was tapping his strength so much, I would have urged him to be more careful, but he was so completely wrapped up in his work that I really do not know if any pleadings would have had any effect"

RE: comments made by the wife of Chief Engineer *Clifford M. Holland* upon his untimely death from nervous exhaustion at the age of 41

<u>Above</u>: caption: "Clifford Milburn Holland, 1919"

825

The Holland Tunnel

At Stated Meetings of the **New York State Bridge** and **Tunnel Commission** and the **New Jersey Interstate Bridge** and **Tunnel Commission** held Tuesday, November twelfth, nineteen hundred and twenty-four, the following resolution was adopted.

Whereas the untimely death on October twenty seventh, nineteen hundred twenty four of

Clifford Milburn Holland
Chief Engineer in the Construction
of the Hudson River Vehicular Tunnel

has caused a general expression of sorrow; and

Whereas, by comment in the public press as by resolutions of public bodies and societies and expressions from leading citizens and civic organizations, the opinion is general that Mr. Holland gave his life to the work of the planning and construction of this great public utility; and

Whereas, the members of the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission are in accord with the widespread suggestion that some fitting attribute be paid to the memory of the deceased Engineer; Therefore be it

Resolved, that the **Hudson River Vehicular Tunnel,** now being constructed between Canal and Broome Streets in the Borough of Manhattan, City of New York, and 12th and 14th Streets, Jersey City, New Jersey, be and it is hereby dedicated to the memory of Clifford Milburn Holland, and that the said Hudson River Vehicular Tunnel is hereby designated and named as

The Holland Tunnel

826

827

828

Part 12

The Modern Era

829

A Bold New Plan

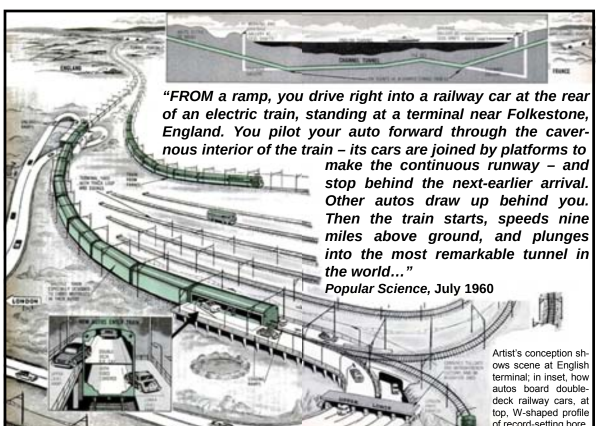
830

A bold new plan promises to make the 158-year-old dream of a Channel-spanning tube come true
Popular Science, **July 1960**
RE: introduction to an article entitled: "32-Mile Tunnel to Connect England and France"

831

Drive-and-Ride

832



"FROM a ramp, you drive right into a railway car at the rear of an electric train, standing at a terminal near Folkestone, England. You pilot your auto forward through the cavernous interior of the train – its cars are joined by platforms to make the continuous runway – and stop behind the next-earlier arrival. Other autos draw up behind you. Then the train starts, speeds nine miles above ground, and plunges into the most remarkable tunnel in the world…"
Popular Science, **July 1960**

Artist's conception shows scene at English terminal; in inset, how autos board double-deck railway cars, at top, W-shaped profile of record-setting bore.

833

"…Still sitting in your automobile, you are borne for 23 miles beneath the waters of the English Channel, at an average speed of 60 m.p.h. In less than 45 minutes, the train rolls to a stop. Motorists restart their engines, and you drive off the front of the train to find yourself in France. As you disembark at the French terminal near Calais, you see another line of autos about to board the train for its return trip to England. That is a preview of high-speed, all-weather, comfortable, and inexpensive travel between England and France by 1967, if a startling plan to drive a tunnel beneath the Channel goes through…"
Popular Science, **July 1960**

834

Peerless

835

"…At 32 miles from portal to portal, it would be the world's longest passenger tunnel by so far as to be in a class by itself. It would dwarf the Alps' famed 12-mile Simplon rail tunnel, and the seven-mile vehicular tube under construction through Mont Blanc, the present and prospective record holders of their kinds. Its cost would exceed the $300,000,000 value of the British crown jewels. Like the Great Pyramid of Egypt and the Panama Canal, the proposed Channel Tunnel would rank among the engineering wonders of all time…"
Popular Science, **July 1960**
RE: on July 16, 1965, Italian President *Giuseppe Saragat* and French President *Charles De Gaulle*, the Mont Blanc tunnel inaugurated the opening of the 11.6 kilometer-long *Mont Blanc Tunnel*. Begun in 1957, construction lasted seven years.

836

The Study Group

837

"…Latest of many schemes to link Britain and France by tube or bridge, this modernized plan brings the 158-year-old dream nearer realization than ever before. Calling for a twin-tube rail tunnel, it is sponsored by influential English-French-American interests collectively known as the Channel Tunnel Study Group. With encouragement from high places, they recently submitted their proposal to the British and French Governments, upon whose approval its fate now hangs…"
Popular Science, **July 1960**
Left: caption: "Why Britain Needs a Channel Tunnel – A Reference Handbook of Facts about a Channel Link - Channel Tunnel Study Group, July 1962"

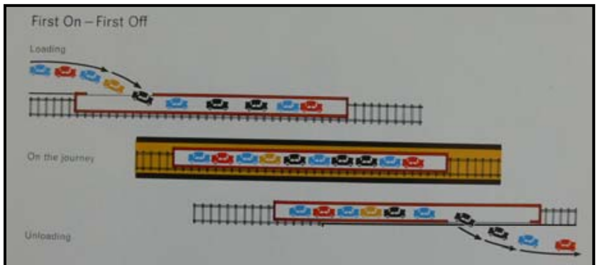
838

The Plan

839

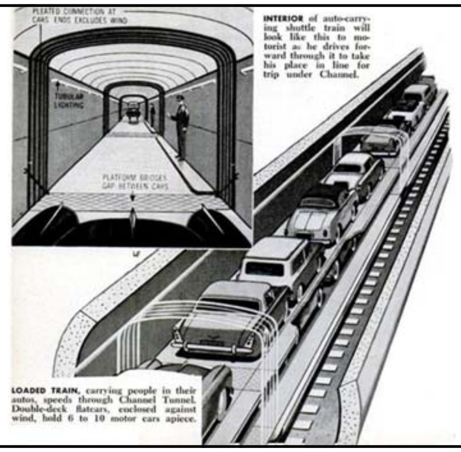
"…The plan envisages two main tubes running side-by-side, 97 feet apart, between portals near Dover in England and Calais in France. Bored through the Channel bed, they dip 100 to 200 feet below the sea floor. Each circular tube has an inside diameter of 21 feet 4 inches and holds a single railway track. 'Shuttle trains,' especially designed to carry motorists in their autos, run through the tunnel at 15-minute intervals, plying the 44-mile distance between the terminals beyond its portals. A loop of track at each terminal turns the train around for the return trip…"
Popular Science, **July 1960**

840

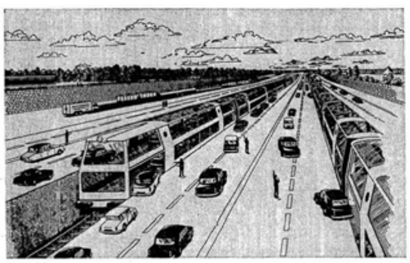


"…While single-deck flatcars may serve at first, the final plan is for double-deckers, enclosed to reduce air drag and shield passengers from wind. Each holds six to ten autos, according to their size. Made up of perhaps 30 cars, the train is loaded at the rear and unloaded at the front, through special drop-sided cars, at two-level ramps. To streamline international formalities, a joint British-French customs and immigration shed is combined with the tollgate spanning the approach to the loading ramps…"
***Popular Science,* July 1960**

841



842



Double-deck drive-on trains for cars, and platforms at two levels for use of the train's upper and lower decks are suggested in this drawing from the Channel Tunnel Study Group's booklet, *The Channel Tunnel.*

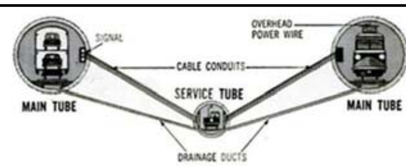
843

"…Through passenger and freight trains use the tunnel, too. Express-train passengers speed from the center of London to the center of Paris, via the tunnel, in only 4 hours and 20 minutes…"
***Popular Science,* July 1960**

844

"…Each main tube normally carries trains one way. But trains can be shunted from one tube to the other at four crossovers – one at each coast, the others seven miles offshore. Thus a section of either tube can be closed-off for repairs or maintenance. At night, when this would be done, trains running back and forth through one tube could handle the light traffic…"
***Popular Science,* July 1960**

845



"…Between and below the main tubes, a service tube about 11 feet across serves for draining them, for maintenance, and as an electric-cable conduit. Cross passages connect it with the others. The service tube slopes downward from mid-Channel to the bottoms of vertical access shafts on each coast. These house elevators, ventilating ducts, and pipes for pumping out seeping water…"
***Popular Science,* July 1960**
<u>Above</u>: caption: "EACH MAIN TUBE, shown in sectional view of Channel Tunnel, has inside diameter of 21 feet 4 inches and carries electric trains in one direction. Smaller service tube below them provides for drainage and maintenance."

846

The Air Down There

847

"…Since the tunnel is used by electric trains, rather than by motor vehicles gulping air and belching exhaust fumes, ventilation is no problem. Engineers anticipate that the trains themselves, like pistons in cylinders, will aid in circulating fresh air through the long underwater section…"
***Popular Science,* July 1960**

848

Put There by Providence

849

"…As novel as the rail tunnel itself is the scheme for excavating it. A giant rotary machine with a 23-foot 10-inch cutting head will literally bore the full-size tube through the Channel bed. It will eat through a kind of rock ideal for tunneling. As if put there by providence, a 1-1/2-mile strip of firm chalk lines the Channel at its narrowest point. All but impermeable to water, strong enough to need no support after being bored, it still is soft enough to yield easily to a cutting tool. So the builders can dispense with compressed air, tunneling shields, and the laborious drilling-and-blasting procedure of traditional underwater tunneling…"
***Popular Science,* July 1960**

850

Mechanical Moles

851

"…Tunnel-boring mechanical moles large enough, and more, for the Channel job already exist. One tungsten-carbide-toothed type recently bored 29-1/2-foot-diameter water tunnels at the Oahe Dam project in South Dakota…"
***Popular Science,* July 1960**
Left: caption: "HUGE ROCK BORER like this mechanical mole, used at Oahe Dam in South Dakota, is expected to drive 23-foot-diameter hole for Channel rail tubes at the rate of 1,475 feet a month"

852

"…Makers of this machine and of similar ones, given test-bore samples of the sub-Channel chalk, reported to the Study Group that it was just what their devices liked to chew into. Their trials showed that a mechanical mole could drive a main Channel tube at an average pace of 1,475 feet monthly. Four machines, simultaneously advancing in pairs from each portal, could excavate the twin tubes in less than five years…"
Popular Science, **July 1960**

853

"…The service passage would be bored first. As it explored the rock strata, pressurized cement would plug any flaws exposed, to prepare the way for the big tubes. Rock from the larger excavations would be removed through the service tunnel, by pulverizing it and flushing it through hydraulic pipelines. A 15-inch layer of concrete, the only lining needed for the main tunnels, would provide a smooth interior wall and seal the tunnel further against seepage…"
Popular Science, **July 1960**

854

"…Complete with railway equipment, the tunnel can be built for $305,200,000, the Study Group estimates. Its traffic capacity is seen as ample for decades to come. It can carry at least 1,800 motor vehicles and their passengers an hour, each way, plus passengers and freight in conventional trains…"
Popular Science, **July 1960**

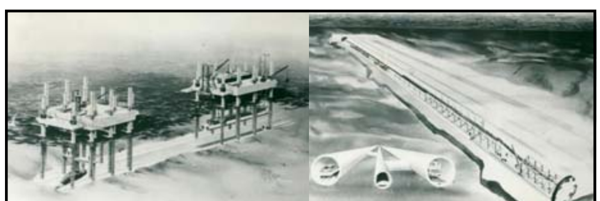
855

The Trench Method

856

"…An alternate engineering plan for building a rail tunnel, of equal capacity, is also offered by the Study Group, instead of being bored through the sea bed, the tunnel could be laid in a trench on the Channel floor, by sinking and joining pre-fabricated sections of a single 45-foot-diameter tube with double tracks. It would take a beeline path across the Channel – a mile shorter than the route of the bored tunnel, which winds a little to follow the favorable chalk formation…"
Popular Science, **July 1960**
Above: caption: "Map shows projected route of 32-mile-long tunnel under the English Channel which will connect England and France (January 24, 1965)

857



Above L&R: caption: "TWO WAYS TO GET THERE. Two methods by which engineers say a tunnel could be built under the English Channel are shown in artist's drawings. At left is the 'build and sink' method, by which Texas towers stilt-walk across the Channel, cutting trenches and laying prefabricated tubes. At right, boring through the chalk by mole, a technique pioneered 84 years ago and now modernized. In lower left is a section of tunnel showing the plan for two rail tunnels plus a ventilation and service tube in the center. Ernest Marples, the Minister of Transport, announced to the House of Commons in London today, Feb. 6, 1964, that the British and French Governments have decided to go ahead with the construction of a rail tunnel under the Channel. He said that among many details to be considered is whether it should be bored or sunk."

858

"…It could be completed in four years instead of five. But it would cost $315,120,000, considerably more than the other. So the Study Group, while leaving a choice open, bases most of its figuring on a bored tunnel…"
***Popular Science*, July 1960**
<u>Above</u>: caption: "Map of proposed routes of the Bored Tunnel and the Immersed Tube" (July 1962)

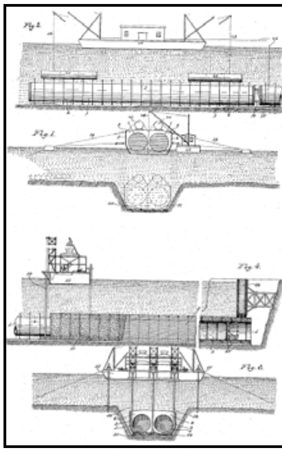
859

Be it known that I, OLAF HOFF, a citizen of the United States of America, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Sub-aqueous Tunnels…This invention relates to the construction of that class of sub-aqueous tunnels, which are formed by a series of pre-constructed tunnel tube sections built on shore, launched and floated to the tunnel site and then sunk to position one after another, in a trench prepared to receive them. My invention embodies certain improvements in the structural features of the tunnel and in the method of carrying out the construction which is especially devised for the building of tunnels across navigable waters where it is important to carry on the work expeditiously and by such a method as will offer the least possible temporary surface obstruction to navigation, and will also make it possible to carry the tunnel to no greater depth than suffices to avoid interference with vessels passing thereover…
RE: excerpt from *U.S. Patent No. US 907356 A* (December 22, 1908)

860

…My construction provides a tunnel built wholly of steel and concrete and resting upon a foundation also preferably built of steel and concrete and forming part of the completed tunnel itself. Each steel tunnel tube section may be several hundred feet in length, and each tube is provided with temporary bulkheads to enable it when launched, to be floated to the tunnel site. In sinking each section to its prepared water bed, water is gradually let into the tube and the sinking is controlled by air cylinders attached to the top of the section and adapted to support the weight of the tube, or nearly so, in sinking. After the section is sunk and joined to the previously laid section, it is embedded in concrete and one of the novel features of my invention consists in so constructing the tunnel tube section that it serves as a form for the concrete, and in providing a continuous foundation of concrete upon the water bed, all as more fully described hereinafter and shown in the accompanying drawings showing my invention as applied to a tunnel constructed of tunnel tube sections of the double or twin tube type…

861



…Figure 1 represents an end elevation of a tunnel tube section in position for sinking: Fig. 2 is a longitudinal vertical section of Fig. 1, showing the tunnel tube section as having been sunk to the water bed and illustrating the manner of connecting it to a previously laid section: Fig. 3 is a cross-section of a tunnel tube section in position upon the water bed and illustrating the method of embedding it in concrete: Fig. 4 is a sectional side elevation of Fig. 3, and showing the shore end of the tunnel section…

862

"…The shield method of construction was adapted for the Holland Tunnel after careful consideration of other schemes, notably the trench method. By the trench method, the work is conducted from a plant floating in the river, and the tunnel is constructed either under a protecting roof or floated into position and sunk in sections in a dredged trench. The longest sub-aqueous tunnel built by this method is the Detroit River tunnel of the Michigan Central Railroad…"
RE: excerpt from *The Eighth Wonder*

863

<u>Top Left</u>: caption: "Launching of a section of the Detroit River Tunnel at the Great Lakes Ship Yard St. Clair"
<u>Top Right</u>: caption: "A section of the Detroit River Tunnel in tow down St. Clair River"
<u>Left</u>: caption: "Sinking cast section of Michigan Central RR Company tunnel"

864

"…It was recognized that in the excavation of a trench under the Hudson River, there would be an unavoidable interference with a great volume of river traffic. Fifteen hundred boats cross the line of the tunnel daily. Such congested river conditions would make every dredge or other machine working in the tunnel an obstruction to traffic. Collisions would be frequent, increasing the time and cost of the work, with danger both to shipping and to equipment of construction. Storms, fog, and ice would cause a discontinuance of surface work for at least two months of each year. At the New York end, a large mass of ledge work, involving blasting and removal at great depth, would be a serious obstacle to open trench excavation under water…"
RE: excerpt from *The Eighth Wonder*
Above: caption: "Bird's-eye view of lower Manhattan and river traffic" (ca. 1914)

865

"…Since there was a real hazard involved in carrying on operations from a plant anchored in mid-stream, the shield method was clearly called for. In addition, silt conditions in the Hudson River were regarded as extremely favorable to this method. In a trench tunnel, soft material greatly increases the volume of excavation, while in the case of a shield tunnel this material is most easily excavated. If the silt is not shoved aside by the shields, it is easily disposed of through the tunnel. The shield may be closed with the exception of certain openings through which the material is squeezed into the tunnel as the shield advances…"
RE: excerpt from *The Eighth Wonder*

866

A Proud Heritage

867

"…The dream of a Channel Tunnel dates back to 1802 when a French engineer, Roger Mathieu, proposed a submarine tube to Napoleon. By 1881 an actual start was made. The British and French each drove a gallery more than a mile out under the Channel – using early but effective tunnel-boring machines, of which today's mighty ones are direct descendants…"
***Popular Science,* July 1960**
Left: caption: "ACTUAL START on Channel Tunnel, in 1880s, produced seven-foot-diameter tube shown in this historic British Railways photograph. Early boring machine, ancestor of big modern ones, drove it more than a mile from the English side."

868

"…Then British fears arose of invasion by tunnel, and Parliament ordered the work abandoned. Repeated attempts to revive the idea were blocked by successive British governments…"
***Popular Science,* July 1960**

869

The Turning Point

870

"…A turning point came in 1955 when Britain's defense minister Harold Macmillan, now Prime Minister, acknowledged that modern weapons and aircraft invalidated strategic objections of the past…"
Popular Science, **July 1960**
RE: *Maurice Harold Macmillan* Left), 1st Earl of Stockton (1894-1986), served as Tory (Conservative) Prime Minister of the UK from 1957 to 1963 (having previously served as Chancellor of the Exchequer). This was a period of prosperity as Great Britain recovered from the economic devastation of WWII. Macmillan's catch-phrase, "You've never had it so good," characterized his approach to governance. Increased production of steel and automobiles led to greater export earnings and pay increases for British workers. Inflation, however, threatened to hinder this growth and how to curb inflation, Macmillan stated, was the "$64,000" question. His main focus as PM was on the economy, but in the end an increase in unemployment and his policy of wage restraints led to the election of Harold Wilson's Labor government in 1964 (Macmillan had stepped down the previous year).

871

Above: caption: "1957 sketch by artist-author Frank Tinsley suggests a twin-tube design for Channel Tunnel to transport pedestrians and varied motorized vehicles"

872

Four Companies

873

"…With that, the dormant project came to life. Taking the initiative, a U.S. group called Technical Studies, Inc., sought international collaboration to sponsor a new Channel Tunnel project. The Americans found a ready listener in the 'Compagnie Financiere de Suez,' a world renowned canal company without a canal, since Egypt seized the Suez waterway in 1956. Interested too were the English and French Channel Tunnel companies of the 1881 venture - both still in existence, and still holding the rights to build a Channel tube. Joining forces, the four companies formed the Channel Tunnel Study Group…"
Popular Science, **July 1960**

874

"…Behind its present plan lie 2-1/2 years of practical on-the-spot investigation by the Study Group - the most thorough Channel-tunnel survey ever made. By ultramodern methods of geophysical prospecting, ships charted the undersea rock strata through which a tunnel would pass. Frogmen brought up specimens of the sea bed. Test borings added samples from as deep as 226 feet below the Channel floor and 814 feet under the coasts…"
Popular Science, **July 1960**

875

All Things Considered

876

"…All possible ways of spanning the Channel by rail or road were considered by the Study Group. Only one was found less expensive than a rail tunnel. That would be a $291,-800,000 two-lane vehicular tunnel, which could carry only 650 vehicles an hour each way - compared to the rail tunnel's 1,800. Its traffic capacity would become inadequate in the near future; its meager earnings in tolls would make it an un-attractive investment, anyway…"
Popular Science, **July 1960**

877

"…A more capacious $321,700,000 vehicular tube would still have less traffic capacity than the rail tunnel, and would be more costly. That would be largely because of the formidable and expensive problem of ventilating a road tunnel - which would require one or two artificial islands for 'breather' sh-afts, and fans totaling up to 56,000 hp…"
Popular Science, **July 1960**

878

"…For other schemes, expense soared. A proposed rail-and-highway Channel bridge of 820-foot spans, with high sections to let the biggest ships pass, would cost a stag-gering $506,800,000…"
Popular Science, **July 1960**

Left: caption: "A plan has been put forward for a super 25-mile-long bridge - from South Foreland, near Dover - to Sangatte, near Calais, as a rival to the much talked of Channel Tunnel scheme. Behind this project are the campaign Francais d'Enter-prises, Dorman Long bridge and Engineering of Bri-tain - and the American Merritt Chapman and Scott Corporation, underwater engineering experts. It wo-uld take 5,000 men five years to build. At a height of 200-feet, the biggest liners afloat could pass be-neath it easily. The cost would be about $200,000,-000 and according to some experts, it would have to yield a yearly revenue of $40,000,000 to make it a success." (*Keystone Press Agency,* June 4, 1960)

879

"…Weighing the alternatives, the Study Group finds a rail tunnel the best answer, at this time (a future road tunnel might be built alongside it, with the aid of cross passages driven from it). The rail tunnel can be built entirely with pri-vate funds, and can pay for itself in 35 years, the Study Group says…"
Popular Science, **July 1960**

880

"…Tolls, scaled accordingly, are to be $16.24 for a motor car and its driver and $4.48 for each passenger. This offers tour-ists a substantially lower fare than by sea ferry, and even a greater saving in time; crossing by boat, including waits at each shore, takes at least four hours. The tunnel trip is as fast as by air ferry and much less expensive…"
Popular Science, **July 1960**

881

Once Approved

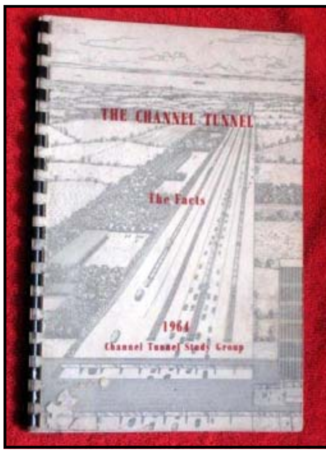
882

"…If British and French governments approve the Study Group's plan, the next step would be an Anglo-French treaty setting up an international tunnel company and granting it the needed rights and concessions. Then the tunnel company would raise the money by issuing shares and bonds. It would foot the $224,000,000 expense of building the 'bare' tunnel from portal-to-portal. The rest of the cost - for track, rail terminals, rolling stock - would be borne by the British and French railways, which would rent and operate the tunnel under a long-term lease…"
Popular Science, **July 1960**

883

A Good Thing

884

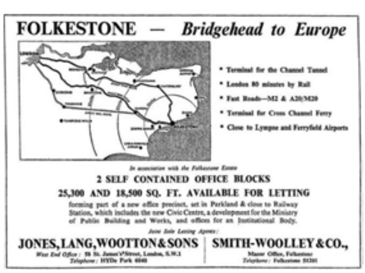


"…The Study Group expects the two governments to take some months to reach a definite decision, possibly by early 1961. Actual digging could begin the following year."
Popular Science, **July 1960**
RE: on February 6, 1964, following meetings with his counterpart - *M. Marc Jacquet,* in France, UK Minister of Transport *Ernest Marples* stated in Parliament: "There are many problems to be solved, but in principle we have decided it is a good thing." Based on estimates, the tunnel was to cost £160 - £170 million. However, the date for starting construction and how it would be financed remained undecided. As well, the two governments were still deciding between the bored or trench method of tunneling.
Left: Channel Tunnel Study Groups' 1964 publication

885

A geological survey was called for and starting in the summer of 1964 and over the next few years, hundreds of bore holes were drilled. *British Rail* said they were supportive of a rail-based tunnel, while the *Times* motoring correspondent noted how a car-carrying rail tunnel could spur motorway construction in the UK. As was to be expected, the French press was more enthusiastic about the tunnel than their British counterparts. A private consortium stated they could raise the money and build the tunnel by 1970, if permitted. At the time, there was considerable government ownership of industry thus, the idea of a private company building such complex undertaking was seen as a "bit too American" (a view which wasn't aided by the fact that the *Channel Tunnel Study Group* was back-stopped by Americans). In the meantime, commercial real estate interests in Kent began to realize the potentials of a Channel Tunnel.

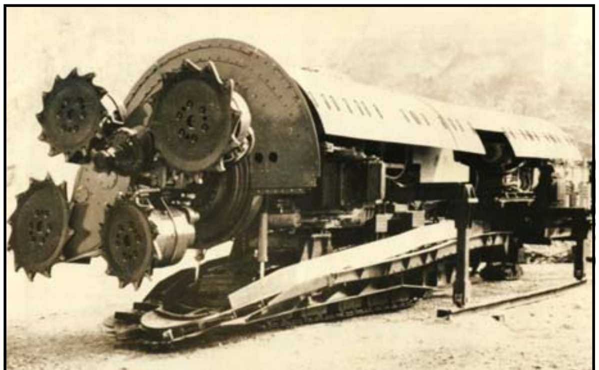
886



887

In the autumn of 1964, Marples and Jacquet met suggesting jointly that the tunnel could be completed within a decade, with an opening somewhere around 1974. Test boring in the Channel continued and in April 1965, a written reply to a question posed by Parliament demonstrated that the drilling work was progressing, but it would be at least the end of the year before it was completed. Both governments came under pressure soon after to start preparatory work immediately as they had enough to make a start on the broad outline of the tunnel (which was to be bored rather than dredged). As 1965, progressed, there was concern expressed about whether the UK government could afford to build the tunnel. Towards the end of 1965, MPs were increasingly seeking, and receiving, assurances that the tunnel was not subject to the same curbs on government spending that other departments were facing. It was expected that construction would start within a year and be completed within five years. The budgeted cost remained at about £160 million.

888



Above: caption: " Machine meant for cutting the Channel between England and France. Krupp prototype Krupp, Stuttgart, Germany, ca. 1967"

889

If and When

890

"Longest undersea tunnel in the world will be built to connect the islands of Honshu and Hokkaido in northern Japan, according to Japanese National Railways. The 22-1/2-mile railway tunnel will cut by about six hours the travel time between Tokyo and Hokkaido (but the 'championship' will move to Europe if and when the proposed English Channel tunnel is built to link England and France. It may have an overall length of 32 miles, with 23 miles underwater)."
Popular Mechanics, **October 1966**
RE: in July 1966, both governments issued a joint statement in favor of the tunnel project proceeding, despite many caveats and uncertainties (the *Times* published an editorial asking whether or not the tunnel was still wanted). At the end of October 1966, the new Minister of Transport - *Barbara Castle,* and her French counterpart, *M. Pisani,* decided to bring in private finance to fund the Channel Tunnel project.

891

"I cannot say definitely that the Channel tunnel will be built, but it is the aim of both governments that it should be"
Barbara Castle, **Minister of Transport (December 1965 – April 1968)**
RE: the fate of the Channel Tunnel project was to be determined upon whether or not private investors were willing to pay for it. It appeared to many that the British Government was trying to extract itself from the project. Likewise, government-owned *British Railways* (BR), once so supportive of the project, was also getting cold feet. BR, with its own plans for sea cargo facilities at Harwich, felt cargo ships would offer cheaper alternatives to the tunnel thus, they started warning investors that they might not want to use it come 1975, when the tunnel was expected to be opened. Nevertheless, banking groups started to line up in order to raise £200 million to fund the tunnel (three such groups were announced in April 1967). By January 1968, the cost had reportedly risen to £250 million and while denied by the government, there was speculation that the project was to be torpedoed. Even the French seemed to be losing their enthusiasm about the project. In May 1968, a surprise amendment to the *Transport Bill* set up an independent committee to oversee the Channel Tunnel project. By July 1968, they still hadn't decided which of the three private banking groups would get the contract to build the tunnel.

892

By October 1968, the cost had risen to £350 million. Once again the project was delayed, this time at least until the Spring of 1969. By July 1969, America had landed a man on the moon, but there was still no decision regarding the Channel Tunnel project and, although the British Government stuck to the £350 million figure, there was talk of the project costing £500-£600 million. By early 1970, the three banking groups were talking about a merger in order to try and force the issue and get the government to commit to a contract. In May 1970, Minister of Transport *Fred Mully* finally admitted (when opening an expansion of the Dover car ferry terminal) that a decision would not be taken until 1972, or later, and construction would not start until 1977, or later. In January 1971, the government commissioned yet another study into the Channel Tunnel project. While the government was openly supportive, studies are a convenient method of slowing-down and/or killing a project. A decision was to be forthcoming sometime in 1972. When it arrived, unsurprisingly, it was generally unfavorable. The tunnel was now expected to cost at least £500 million and traffic would be lower than earlier predicted. Both governments met in August 1972, not to decide on the tunnel, but to discuss a final survey of the project. They agreed to allocate more funding for more studies, effectively "kicking the can down the Road," once again.

893

In the meantime, the *Greater London Council* (GLC) was pondering where the London terminus would be located. They looked at a several options, including *Victoria Station* (the *Surrey Docks* and *White City* were also considered for the jobs that would be created). In March 1973, the survey report was published, but a final decision was now pushed back to the end of 1975, at the earliest. Thus, they would still be deciding whether or not the Channel Tunnel project would proceed in the very same year the tunnel was supposed to have opened to its first passengers. The cost had, by then, risen to at least £800 million. When, in June 1973, a signing ceremony was delayed, the cost was placed at £1.1 billion. By September 1973, the British Government was still publicly supportive of the project, which they expected to be completed by 1980. An interim bill was proposed to keep the project alive while MPs "considered at more leisure" the final hybrid bill that would make manifest the Channel Tunnel.

894

In November 1973, British Prime Minister *Edward Heath* and French President *Georges Pompidou* signed an agreement to proceed and the pilot tunnel was begun at the end of the month. Even so, in an age of austerity the project was dogged by ever more vocal concerns about the rising cost. Multiple newspaper articles were now appearing targeting the public-at-large about the traffic jams, fires etc. which would be caused by the tunnel. Throughout the tail-end of 1974, MPs debated the bill placed before them. As part of the cost savings initiative, the high-speed rail link from Folkestone to White City, London, was dropped as being too expensive. On December 10, 1974, the French government proposed that the project be "paused" at the stroke of midnight on December 31, 1974. The British Government set aside £15.6 million to cover the costs of what had been built, up to that time (the bit of tunnel that was actually dug would be reused as the starting and access point for tunneling operations from the British side in the late 1980s). On January 20, 1975, Secretary of State for Environment *Anthony Crosland* made a statement to the House of Commons, citing rising inflation, rising costs and shrinking traffic forecasts. This served to formally kill the project. For their part, the French had asked for another delay to keep the project on life support, but the British had had enough.

895

Part 13

To Get to the Other Side

896

For Real?

897

For over 100 years the British and French have planned to link the two countries with a tunnel running under the English Channel. Digging was actually started – and abandoned – some 90 years ago. But now a new effort is under way. Or is it?

***Popular Mechanics,* January 1975**

RE: introduction to an article written by *J.A. Maxtone Graham* entitled: "Is the Chunnel for Real?"

898

Fixed Link

899

"Only 22 miles of water separate England from the continent. Each year, millions of people cross the English Channel and millions of tons of goods are shipped over it. It's safe to say that if 22 miles of water separated two such busy parts of the United States, some kind of fixed link would have been provided at least 50 years ago…"

***Popular Mechanics,* January 1975**

900

Over and Under

901

Over the water and under the bay – the newest tunnel-bridge is a 17-1/2-mile wonder
***Popular Mechanics*, June 1963**
RE: introduction to an article entitled: "The Porpoising Highway"

902

"HOW MUCH is a motorist's time worth? To the Chesapeake Bay Bridge and Tunnel Commission, it is worth $1,546,666.33 per minute…"
***Popular Mechanics*, June 1963**

903

"…At a cost of $139,200,000, an engineering wonder is being completed that will cut the driving time on Virginia's north-south highway by an hour and a half. Across 17-1/2 miles of open water, a combination bridge and tunnel will connect Wise Point and Chesapeake Beach, eliminating the seven-ship Chesapeake Bay ferry fleet that has been carrying cars and passengers across the water since 1880…"
***Popular Mechanics*, June 1963**
__Above__: caption: "Profile of Chesapeake Bay Bridge Tunnel"

904

905

Ocean-Going Ferry Designed in Wind Tunnel
Presenting a virtually unbroken line from bow to stern, an ocean-going ferry designed in a wind tunnel has been completed recently. It operates across the entrance to Chesapeake bay. The design was selected after exhaustive tests by Raymond F. Loewy with models. Every possible weather condition that the craft would encounter was duplicated artificially in the tunnel. After the best contour for the superstructure had been chosen, other problems were solved by the same method. These included requirements that the ferry carry sixty to eighty autos and trucks in six lanes of traffic and that there be proper space for passenger quarters, dance floors and special cabins for truck drivers…(*Popular Mechanics,* September 1936)

906

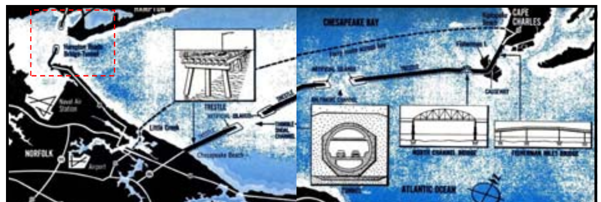
907

…Vehicles are driven in through doors in the bow and out through doors in the stern. The doors in the bow are operated electrically but those in the stern are controlled by hand. The enclosed decks are supplied fresh air by an elaborate ventilating system. The ferry is 260 feet long. Its engines propel the craft at eighteen miles per hour. (*Popular Mechanics,* September 1936)

<u>Above</u>: caption: “This drawing shows some of the features of new ferry. Note extent to which streamline design is carried, even to the Funnel.”

908

909



“…The two-lane crossing will consist of low-level trestles and two-mile long tunnels, over which ships can pass freely into Hampton Roads…”

Popular Mechanics, **June 1963**

<u>Above</u>: caption: “Chesapeake Bay Bridge-Tunnel, world’s longest, will be combination of trestle, undersea tubes, high spans. It dwarfs three-mile Hampton Roads Bridge-Tunnel (upper left) completed in 1957.”

<u>Left</u>: caption: “HRBT – tunnel entrance”

910

(1) HAMPTON ROADS BRIDGE-TUNNEL One of America's major highway projects, this 3½-mile-long expressway is a key link in 27-mile road improvement program in Tidewater Virginia. It provides first direct traffic link between Newport News and Hampton on north side of Hampton Roads with Norfolk and Portsmouth to the south, and -- by eliminating ferry trip -- cuts travel time from 30 minutes to seven Merritt-Chapman & Scott Corporation, of New York, built bridge-tunnel for Virginia's Department of Highways. Parsons, Brinckerhoff, Hall & Macdonald, of New York, designed project and served as supervising engineers.

911

(2) CORE OF TUNNEL: Twenty-three double-shell steel tube sections, each about 300 feet long, served as core for underwater portion of bridge-tunnel project. Octagonal-shaped outer shell of tube section measured 37 feet in diameter, with circular inner shell 33 feet in diameter Sections were fabricated by Baldwin-Lima-Hamilton Corporation at Eddystone, Pa , six miles south of Philadelphia, on special ways built by Merritt-Chapman & Scott. Tube at right -- first of 23 to be completed -- is ready to be launched.

912

(3) EN ROUTE TO TUNNEL SITE: Completed steel tubes, fitted with watertight bulkheads at both ends, were launched from construction ways into Delaware River, just like ships, and towed to Hampton Roads -- 250 miles away -- by way of Delaware-Chesapeake Canal, Chesapeake Bay and Elizabeth River Fabrication of each section required approximately 600 tons of structural steel. Some 1500 tons of concrete were placed in "keel" between outer and inner shells to serve as ballast before a tube was launched

913

(4) 'SHAPE-UP' BASIN This was special 'shape-up' basin established by Merritt-Chapman & Scott at Lamberts Point, six miles from job site, where tunnel tubes -- still afloat -- each were lined with an inner ring of concrete and fitted with a 23-foot roadway slab and a 2½-foot sidewalk By time tubes were ready for lowering, they were equipped with pipelines for water supply and drainage, conduits for power, telephone and traffic controls, ventilation ducts and flues, and electrical boxes and outlets

914

(5) THE INSIDE STORY: Interior of tube at 'shape-up' basin shows forms used for placement of the two-lane roadway slab atop supporting haunches Concrete was placed through an elephant-trunk pipe (center) that entered tube via hatchways spaced along top Webbing of reinforcing steel that lines inner shell was covered with an 18-inch ring of concrete. Slots at lower right were for ventilation system's air ducts. When ringed with concrete, a section weighed 12,000 tons -- comparable to weight of a U S. heavy cruiser

915

(6) GOING DOWN: Towed from 'shape-up' basin by two tugs (foreground), the almost completely submerged tube was maneuvered into position and lowered into gravel-bedded trench dredged across bottom of Hampton Roads. To sink a section, tons of concrete were placed in open 'pocket' between inner and outer shells by floating mix plant (left background) Once the tube became heavy enough to reach negative buoyancy, it was guided to bottom by specially-designed tackle suspended from steel framework straddling two barges in background

916

(7) JOINED TOGETHER: Once in position on bottom of dredged trench, tubes were bolted together by divers and remaining space between inner and outer shells was filled with concrete Next, solid rings of concrete were built around section's outer joints and tubes were covered with a five-foot blanket of sand. Later, as steel bulkheads between sections were progressively cut through, joints were welded from inside and faced with an inner ring of concrete. This is how interior of tunnel looked at this point

917

(8) WHAT MOTORIST SEES In final stages of construction, tubes were 'squared off' with ceiling of pre-formed metal, and 4½-inch ceramic tiles -- some 2,000,000 in all -- were placed on sidewalls. Flourescent lighting fixtures and sidewalk railings were installed, and the two-lane roadway was topped with asphalt. Tunnel, 113 feet below water surface at deepest point, is 7479 feet long from portal to portal Its 6860-foot underwater portion is world's longest tunnel of trench construction

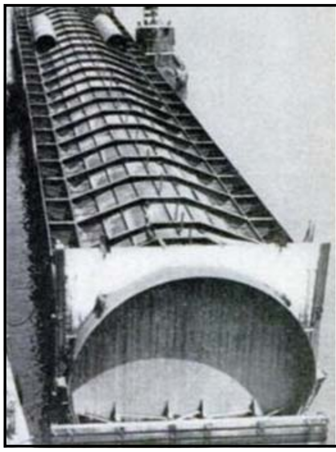
918

(9) MAN-MADE ISLAND Two man-made islands, constructed by Merritt-Chapman & Scott with some 5½ million yards of 'fill' dredged from bottom of Hampton Roads, serve as links between tunnel and the two low-level approach bridges. North Island -- shown in April, 1956, with tunnel entrance ramp under construction (center) -- is 1400 feet long and 170 feet wide, connects tunnel with bridge to Hampton, Va South Island, slightly smaller, measures 1250 feet by 170 feet, links tunnel with bridge to Norfolk, Va

919

(10) READY FOR TRAFFIC This is North Island in October, 1957, with construction of installations virtually completed. Garages for trucks to service disabled vehicles and buildings that house lighting and ventilating equipment are located on islands. Approximately 130,000 tons of heavy stone were required to build island's seawalls In addition to bridge-tunnel, Parsons, Brinckerhoff, Hall & Macdonald was designing and supervising engineers for Virginia Department of Highways' 23-mile network of approach roads.

920

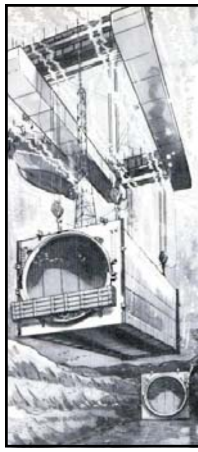


"…The tunnels, double-wall steel cores within an octagonal steel shell, are being built on land at Orange, Tex. Each 300-foot section is sealed, launched and towed by sea 1,700 miles for completion at Norfolk, Va…"

***Popular Mechanics,* June 1963**

Left: caption: "FLOATING TUNNEL SECTION is moved into position by tugs. When lowered into the trench on the bay bottom, the sealed ends are cut open and workmen install the ventilation, communication and power systems."

921



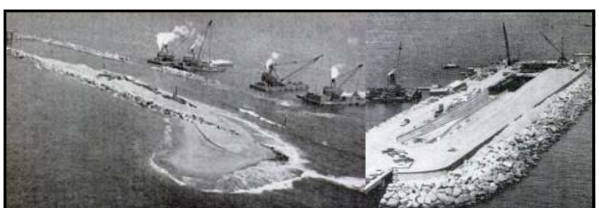
"…The sections are then sunk in a deep trench, connected by divers and sealed with a concrete sleeve…"

***Popular Mechanics,* June 1963**

Above: caption: "TUNNEL SECTIONS like this 287-foot one, sealed for towing, will be sunk in trench below channel bottom. Joined, they'll form tube."

Left: caption: "TUNNEL SECTIONS, 300-feet long, are weighed by pouring tons of concrete between core and outer steel shell. Attached to a special derrick, they are lowered into position and connected by divers."

922



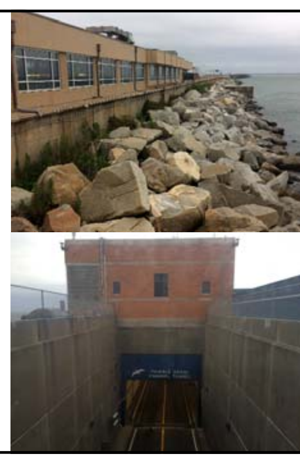
"…Between the tunnels, the road crosses four islands, rising 30 feet above the water, which were built of concrete-reinforced sand and rock in 30 to 40 feet of water…"

***Popular Mechanics,* June 1963**

Left: caption: "MAN-MADE Island, one of four, emerges from Chesapeake Bay. Wall of rocks, which air view shows being built by floating cranes, will be filled with sand from bay bottom."

Right: caption: "ISLANDS TO CONNECT TUNNELS were built in 30 to 40 feet of water by creating a 22-acre pile of sand and rock reinforced with concrete dikes. At the center of each island is the entrance to the tunnel."

923



924



"…The trestle consists of 75-foot long spans of pre-stressed concrete girders and deck, supported at each end by three hollow pre-stressed concrete piles…"

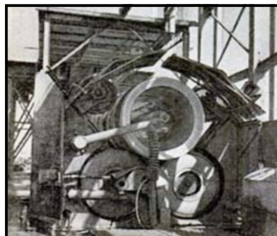
***Popular Mechanics,* June 1963**

Above: caption: "SLAB SETTER, the third and last in the procession of big trestle-building machines, adds the trestle's deck – consisting of four parallel slabs of concrete for each 75-foot span of the trestle. Behind the Slab Setter – at right, in this airplane view – trestle is nearly finished. A black-top roadway surfacing will ready it for coming streams of traffic."

Upper Left: caption: "CONCRETE TRESTLE, glimpsed from plane, is being erected by seagoing machines advancing in distance. Starting point just off-shore left gap that will be closed later."

Lower Left: caption: "DISAPPEARING into the horizon, a completed portion of the trestle stands as a symbol of one of the engineering wonders of the world"

925

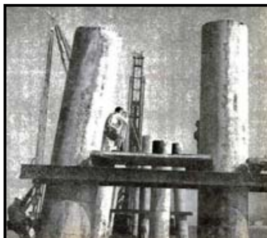
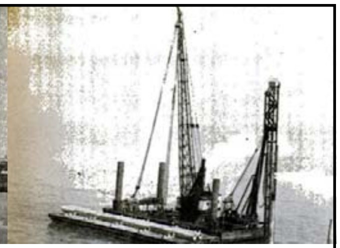


Above: caption: "STACKED IN YARD, standard 16-foot pile sections await assembly into piles of any desired length. Stringing 10 together, for example, makes a 160-footer. Mass-produced at the same casting yard are the concrete slabs for the trestle's deck – which also are pre-stressed – and the concrete crosspieces. From casting yard's site on bay shore, a few miles beyond north end of bridge-tunnel, barges deliver products to scene of construction."

Upper Left: caption: "MAKING A PILE begins with pouring concrete into whirling mold. Spinning mold at 450 r.p.m. gives 16-foot-long pile section final shape: a tube with five-inch wall, 54-inch diameter."

Lower Left: caption: "LIKE BEADS ON STRING, pile sections are assembled on wires threaded through holes in walls. Stretched by jacks, wires pre-stress concrete – put it under pressure, for strength."

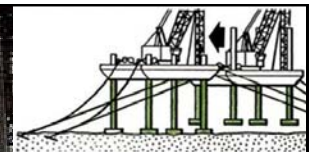
926

Left: caption: "GIANT PILES of concrete for trestle measure 54 inches in diameter and up to 160 feet in length. Every 75 feet, a row of three piles will support ends of adjacent spans of trestle. After hollow pile is driven (by machine in background), a filling of sand buttresses its five-inch-thick wall against impact of colliding boat or ice floe. In photo, surveyor checks alignment of advancing trestle, to assure placing of each pile with required accuracy: no more than three inches in any direction from prescribed location."

Right: caption: "DRIVING TRESTLE'S PILEs is job of Big D, shown with pile-delivering barge moored at its side. Although pile-driver's oblong 70-by-150-foot hull appears to be floating, it actually stands on four legs that extend to bottom, bracing it against waves."

927

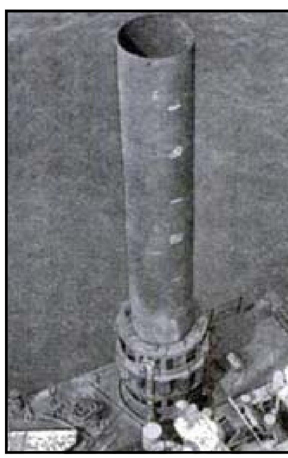
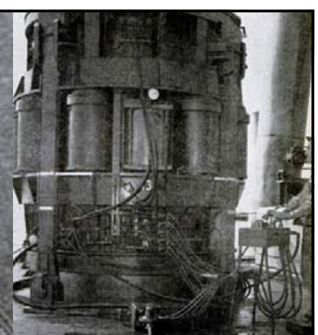
Above: caption: "How Big D propels itself ahead – and stands on bottom. To advance, pile-driver lifts retractable legs (right). Steam winches pull floating hull ahead by anchor cables. Then 100-foot-long legs go down to bottom again (left), raising hull part way from water and steadying it. They'll even lift hull clear of water, and wave battering, in bad storms. So legs won't sink into bottom, 28-foot-diameter pontoons serve as feet."

Left: caption: "TO DRIVE A PILE: Big D's mighty crane, with 185-foot boom, lifts pile from barge. This pile is a huge 160-footer."

928

Caption: "The Big D, a great pile-driver on stilts, leads the procession that builds the trestle:
Left: UP-ENDED PILE is swung into a guiding cradle for driving. It will be the last pile – an outer one – of a row of three.
Middle: GUIDING CRADLE, pivoted at top, swings at bottom to tilt pile to 1-in-12 slant required for the outer one of a row.
Right: STEAM HAMMER pounds pile home – after water jets give it a start by helping it sink of its own weight into soft bottom"

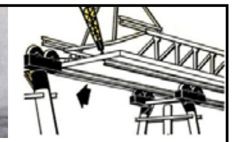
929

Above: caption: "COMPRESSED-AIR JACKS around extensible sleeve raise or lower a leg, in inchworm fashion. Top and bottom of sleeve alternately grip the leg."

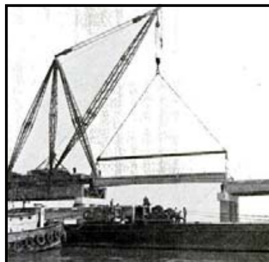
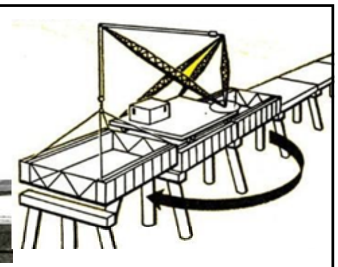
Left: caption: "TUBELIKE LEG of steel, six feet in diameter, is viewed from above – with help of Big D's crane"

930

Caption: "The Two-Headed Monster, rolling on piles' tops, comes next:
Upper Left: BRIDGE-LIKE MONSTER, whose 180-foot deck over-reaches two trestle spans, does two jobs: Front end (at left) cuts off piles evenly. Rear end puts crosspieces on them In photo, it's finishing this and is about to roll forward, over wheels just placed on piles ahead/
Upper Right: MACHINE ADVANCES, on upside-down rail track, by winching in cable attached to pile ahead. Rails on the Monster engage flanged wheels in trucks temporarily set atop leveled piles.
Top Left: AT FRONT of Monster, crane suspends platform around pile to be cut off – and workers chip through concrete with jackhammers on circular track. Wires in wall are cut with torch.
Bottom Left: CONCRETE CROSSPIECE is lifted from barge and set in place on row of leveled piles by crane at rear of Monster. Called a bent cap, it will support slabs forming trestle's deck."

931

Left: caption: "FIRST OF FOUR SLABS for a deck span is lifted from barge and swung into place by crane of Slab Setter. One-piece concrete slab combines deck surface and its supporting girder. Steel pins on crosspiece engage recesses in slabs to fasten them. Like the Big D and the Monster, the Slab Setter is self-propelled. It has its own strange method of locomotion, shown at right."
Right: caption: "TO MOVE AHEAD, Slab Setter rolls its crane to forward half of two-section bed. Then crane reaches back, picks up rear section of bed – and swings it around to front, as shown."

932

"…Slated to open in the fall, the crossing has taken three years to build."
***Popular Mechanics,* June 1963**
RE: financed by toll revenue bonds, the *Chesapeake Bay Bridge-Tunnel* (CBBT) opened to traffic on April 15, 1964. The CBBT combined 12 miles of trestle, two 1-mile-long tunnels, 4 artificial islands, four high-level bridges, approx. 2 miles of causeway and 5.5 miles of approach roads.
Upper: caption: "OVER-AND-UNDER HIGHWAY of trestles and tunnels will cross open-water of the Chesapeake Bay, allowing two mile-wide access openings for shipping traffic. Finished islets will be about 1,500 feet long, 230 feet wide, and 30 feet high. On one, a restaurant for 300 will offer dining and dancing; and one or more will have fishing facilities."
Lower: caption: "SECTIONAL VIEW shows how island joins trestle and tunnel. Two vehicular tubes, 5,738-foot Thimble Shoal Tunnel and 5,450-foot Baltimore Channel Tunnel, duck under main ship lanes."

933

An Englishman's Choices

934

"…But the way things stand, an Englishman bent on visiting the Continent is confronted by a bewildering variety of travel methods, all expensive or inconvenient, or both. Crossing methods include:
- **Walking: Tiring and not available to the traveling public for the past 7,000 years, ever since the sea created the English Channel by eroding the land link.**
- **Swimming: First achieved by Capt. Matthew Webb in 1875. Can be accomplished in about 10 hours in certain states of tide and weather.**
- **Water skiing: Has everything to commend it except practicability.**
- **Balloon: Too dependent on wind direction…"**

***Popular Mechanics,* January 1975**

935

- **"…Boat: Numerous vessels ply between various English ports and Dutch, Belgian, French, Spanish and Portuguese ports. It's a 90-minute crossing: you should book passage several months ahead and be ready to pay about $60 for a car and two passengers. Budget another dollar for seasick pills: Dover to Calais is one of the world's choppiest short crossings…"**

***Popular Mechanics,* January 1975**

936

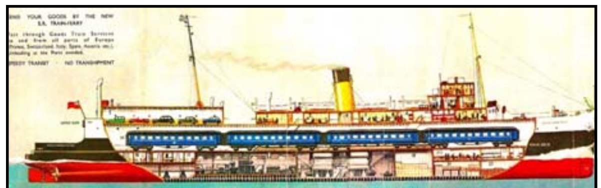
937

- **"…Hovercraft: Unbelievably quick and noisy - 35 minutes and hundreds of decibels, and you are in France. Regarded as dangerous because half the world's maritime collisions occur in the straits of Dover…"**

Popular Mechanics, **January 1975**

938

939



- **Trains: You get into a special train (the Boat Train) at Victoria Station in London, and the train then chugs to Dover. There the train is rolled onto a boat with tracks on its deck and you can stay in your seat while the whole contraption lurches across to France. You reach Paris about seven hours after leaving London…"**

Popular Mechanics, **January 1975**

RE: introduced in October 1936, the "Night Ferry" was an international sleeper train between London's *Victoria Station* and Paris' *Gare du Nord*. Following nationalization on January 1, 1948, it was operated by *British Railways.* At the *Port/s of Dover* and *Dunkirk*, special enclosed docks (with sea locks) were built in order that the train ferry could be kept at a constant level relative to the railway tracks on land. At high tide, the ship could steam directly in or out of the dock, but at low tide the water had to be let out first before departure (like a canal lock). Two ships were required for the service each night (they passed in mid-Channel), the voyage taking about three hours. Road vehicles were also carried along with the trains (above). *Night Ferry* service ended on October 32, 1980

940

941

- **Airplanes: Believe it or not, for several years before Hovercraft service came in, people used to put cars into airplanes to avoid other methods of crossing the Channel. It was quick and efficient, but expensive. Travelers, while grateful for the service, couldn't help wondering why the engineering expertise of France and Britain couldn't contrive some crossing a couple of hundred feet down instead of thousands of feet up…"**

Popular Mechanics, **January 1975**

942

Somehow or Other

943

"…It is now 170 years since some better way of crossing seemed desirable. Britons are splendid people in many ways - I happen to be one myself, so I know - and lead the world in all sorts of specialties like international finance, commodity brokerage, roof thatching and folk dancing. Unfortunately, Britons also seem to lead the world in procrastination…"
Popular Mechanics, January 1975

944

"…Perfectly workable schemes for a dry channel crossing have been on paper for well over 100 years, but somehow or other events have always erupted, leading to a postponement. By the time the political, social or financial climate was once again favorable, the genius behind the scheme was dead, or he, or someone else, had thought of a better idea. Then just when firm parliamentary approval was about to be given, there'd be another crisis…"
Popular Mechanics, January 1975

945

"…Some kind of bridge or tunnel or combination of the two was pretty well fixed up in, let me see, 1856, 1870, 1881, 1907 and 1930. There's a new plan in the works today, but we hear rumors that certain officials are having second thoughts about the wisdom of proceeding…"
Popular Mechanics, January 1975

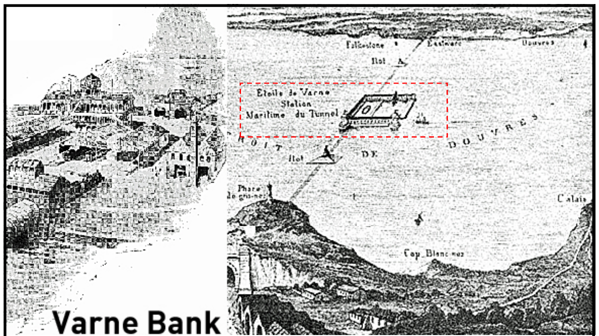
946

A Condensed History

947

"…If you care to examine a condensed history of the Channel Tunnel (or 'Chunnel,' because you can't say Channel Tunnel too often without your tongue getting twisted), you'll see what I mean…"
Popular Mechanics, January 1975

948



"…The first man in the field was a French mining engineer, Albert Mathieu. In 1802, he suggested to Napoleon that there might be a couple of 10-mile tunnels meeting on the Varne Bank, a 30-foot shallow in mid-Channel. Varne Bank would be converted into an island and important international port. It also would permit the carriage horses to come up for fresh air before continuing their journey…"
Popular Mechanics, **January 1975**

949

The *Varne Bank* is a five-and-three-quarter-mile-long sand bank in the *Strait of Dover,* lying nine miles southwest of Dover. With the *Lobourg Channel* running parallel to it, the Varne Bank lies immediately southwest of the deepest point (223-feet) in the *Dover Strait.* Its rectilinear shape is similar to other banks in the strait such as *South Falls Bank* (bordering the Lobourg Channel on the east), the *Colbart Bank* (a/k/a "The Ridge") and others. Rectilinear-shaped banks are only present on the English side of the strait. Lying almost in the middle of the international traffic of the *English Channel,* Varne Bank is a constant concern for navigation in the Channel. The sea above the Bank exhibits strong rippling (especially when strong tides occur) and is noted for its roughness during bad weather. With a minimum depth of about 10-feet, it's marked by light buoys to the West, East and South and an automatic light vessel. Several proposals have been made to eliminate the bank through dredging, but this would negatively affect the rich fishing grounds.

950

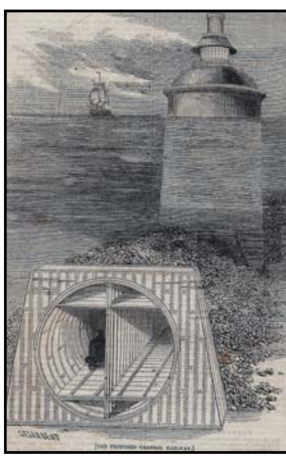
951

"…There followed 30 barren years, during which no one gave the matter another thought. Enter a Frenchman called Thome de Gamond, who, during the next 40 years, was to have more marvelous trans-Channel ideas than all other inventors put together. In 1836, his first year of production, de Gamond produced plans for four different kinds of bridges…"
Popular Mechanics, **January 1975**

952

"…No one paid much attention to these schemes, except an eccentric named Prosper Payerne. Payerne studied de Gammond's plans, discarded them as useless, and came up with specifications for an 'undersea railway.' Prefabricated blocks on the seabed would first form a causeway, as much as 200 feet down. Upon this, more blocks would form a simple tunnel. The work would be performed by men in diving bells, devices which, as it happened, Dr. Payerne had just invented…"
Popular Mechanics, **January 1975**

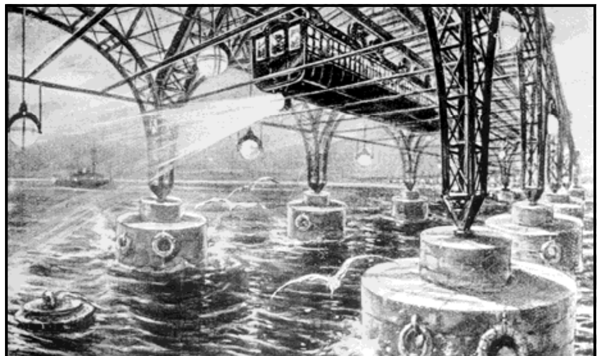
953



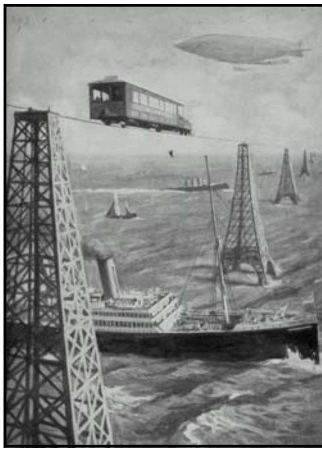
"…De Gamond, clearly scared at the entry of a dangerous rival, hastily produced a viaduct whose granite arches were to carry 400 tubular steel spans. The very next year, however, de Gamond drafted plans for a circular-sectioned railway tunnel, lit by gas, carrying two rail tracks. The French Emperor was impressed and showed it to a committee (this was the first of many thousands of committees that would become involved in Channel schemes within the next century). The committee approved, as did the British, who offered their cooperation…"
Popular Mechanics, **January 1975**
<u>Left</u>: caption: "Cross-section of Thome de Gamond's vision for a rail tunnel under the English Channel"

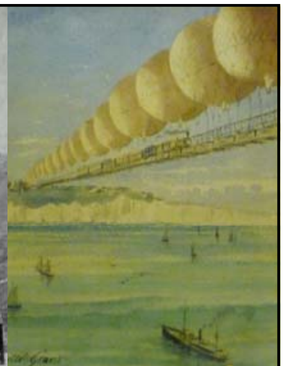
954

"…Then a couple of years later, an Italian named Orsini tried to assassinate the French Emperor. France went to war against Italy, Britain's ally. The result: The plans were scrapped…"
Popular Mechanics, **January 1975**
RE: having become convinced that *Napoleon III* was the chief obstacle to Italian independence, in 1857 *Felice Orsini* went to Paris to conspire against him. On the evening of January 14, 1858, while the Emperor and Empress were on their way to the theater, Orsini and his accomplices threw three bombs at the Imperial carriage. The intended victims were unhurt, but several other persons were killed or wounded (Orsini was wounded). Orsini was condemned to death and executed on March 13, 1858. This assassination attempt brought widespread sympathy for the Italian unification effort and had a profound effect on Napoleon III, who was determined to help the *Kingdom of Piedmont-Sardinia* in their fight against Austria. However, fear of involvement by the German states led Napoleon III to seek a way out of the war, so he signed an armistice with Austria. In 1860, with French and British approval, the central Italian states were annexed by Piedmont-Sardinia. France was given Nice and Savoy in return for fighting against Austria on behalf of Piedmont-Sardinia.
955



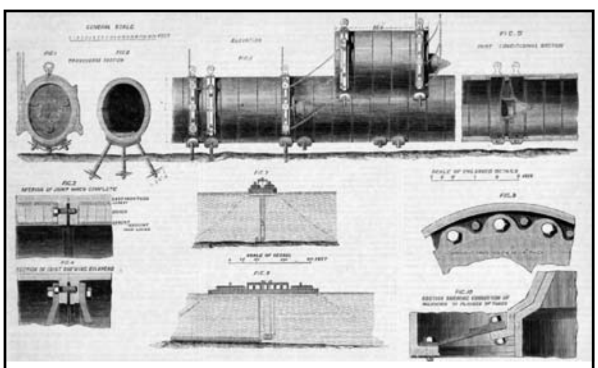
"…While de Gamond took an eight-year rest, others came to the fore. One chap proposed an anchored steel tube that would float midway between the channel's surface and bottom…"
Popular Mechanics, **January 1975**
956
__Above__: caption: "Trans-channel bridge concept"





__Above__: caption: "Balloon bridge across the English Channel, ca. 1850"
__Left__: caption: "Monorail crossing the English Channel"
957

"…Another fellow was even more creative; his idea involved a tunnel resting on the seabed and ventilated at intervals by airshafts that would appear on the surface as turreted Gothic towers decorated with flags and pennants…"
Popular Mechanics, **January 1975**
958



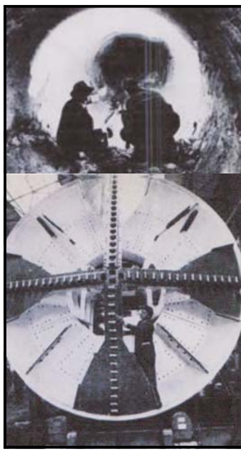
__Above__: caption: "Bishop's Channel Tube (above) was a railway tube intended to sit atop the seabed rather than boring beneath it. Sections of cast-iron lined with bricks and cement, each measuring 25-feet and weighing 273-tons, would be lowered to the seabed from a floating pontoon 400-feet long by 100-feet wide. Using glass sight-holes in the tube's bulkhead, the workmen would guide the cast-iron sections into position. The exposed iron tubes would be protected from the corrosive effects of the seawater via the application of Calley's Torbay oxide paint."
959

"…By 1866, de Gamond was hard at it again. Moreover, he heard that a distinguished English engineer, William Low, was also working on a plan. Creating the first of many collaborations, amalgamations and syndicates in Chunnel history, de Gamond and Low got together to produce a 'Master Plan,' which was exhibited in Paris and approved by the Emperor. Everyone liked it on both sides of the water; work could have started at any time. Then, in 1870, France and Prussia went to war. As was to hap-pen many times in the future, if there was the slightest excuse to defer the Chunnel, the Chunnel would be deferred…"
Popular Mechanics, **January 1975**
RE: the *Franco-Prussian War* (a/k/a "Franco-German War" or "War of 1870") was fought between the *Second French Empire* of *Napoleon III* and the German states of the *North German Confederation,* led by the *Kingdom of Prussia,* from July 19, 1870 to May 10, 1871. The conflict was caused by Prussian ambitions to extend German unification and French fears of the shift in the European balance of power that would result if the Prussians succeeded. The *Treaty of Frankfurt* gave Germany most of the French provinces of *Alsace* and some parts of *Lorraine*, (which became the German Imperial territory of "Alsace-Lorraine"). The German conquest of France and the unification of Germany upset the European balance of power that had existed since the *Congress of Vienna* in 1815. French determination to regain *Alsace-Lorraine* and fear of another Franco-German war, along with British apprehension about the balance of power, became major factors in the lead-up to WWI.
960

961

"…In the interval, one John Hawkshaw produced an entirely different plan for a tunnel, and the Channel Tunnel Co. was formed to support it. Quickly retailiating, Low and de Gamond formed the Anglo-French Submarine Railway Co. At one moment, it looked as though Hawkshaw's tunnel would be built from the French coast, while the rivals' version would emerge from Dover, England. The two governments became involved in unbelievable amounts of paperwork and treaties. Many difficulties were envisaged, important ones like which police force would do the arresting if a crime were committed in the tunnel…"
***Popular Mechanics,* January 1975**

962



"…By 1881, the wrangles and paperwork were over. Although de Gamond was now dead, his plan with Low won the day, and work actually started on the English side of the water, managed by a new enterprise called the Submarine Continental Railway Co. It seemed obvious that within a few years grateful travelers could shuttle between London and Paris without getting seasick…"
***Popular Mechanics,* January 1975**
<u>Top</u>: caption: "Officials examine entrance to an abandoned tunnel"
<u>Bottom</u>: caption: "Latest effort includes use of a huge machine to bore through chalk beneath Channel. Business end of the superborer dwarfs man inspecting it."

963

"…Suddenly, in 1882, the Board of Trade in London commanded work to stop. Among a growing number of British, there was an increasing distrust of all things Continental. There were revolutionaries abroad who would find it too easy to enter Britain. Worse than that, the military risk was one which army commanders were just not prepared to take…"
***Popular Mechanics,* Jan. 1975**
<u>Left</u>: "Hopes and Fears" - an 1882 cartoon from *Punch* magazine

964

"…Precise details of the threat were hard to come by, but the general impression was that one day several trainloads of froggies, armed with muskets and sabres, would draw into the platforms of London's Victoria Station, shoot the porters and ticket collectors, and rapidly take over Buckingham Palace. The following year, the Chunnel was officially abandoned…"
***Popular Mechanics,* January 1975**

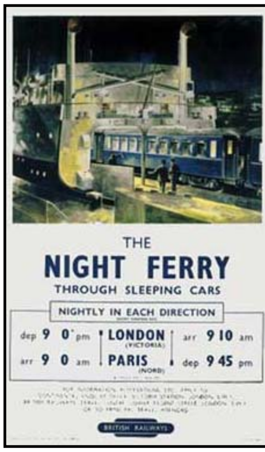
965

"…It was more than 30 years before the next workable scheme came to light. Two first-class engineers - Sir Francis Fox (English) and Albert Sartiaux (French) - came up with a plan in which the trains would be powered by that novel force, electricity. This approach was to solve many problems, and the public had every reason to think that the tunnel would soon be built. But the public reckoned without the top brass of England's Imperial Defence Committee, who firmly quashed the plan on the grounds of national security…"
***Popular Mechanics,* January 1975**

966

"…Seven years later, in 1913, the British prime minister looked at the matter again; once more, the generals turned it down. Perhaps on this occasion, the generals were right; for within months there was war, and France was swarming with hostile German troops…"
Popular Mechanics, **January 1975**

967



"…When war was over the traveling public of Britain and France might have been excused for relegating the Channel to the realms of science fiction: it seemed as unlikely as putting men on the moon. The whole question was reexamined in 1924 and 1929. Each time, the generals turned it down. The year 1936 saw the advent of a train-ferry between Dover and Dunkirk. A passenger could board in London and not leave his seat until he stepped off in Paris…"
Popular Mechanics, **Jan. 1975**

968

"…Perhaps the need for a tunnel now seemed less urgent – although many seasick travelers would not have agreed…"
Popular Mechanics, **January 1975**

969

<u>Above</u>: caption: "Ferry makes its way across the Channel in rough seas"

Isn't it a Pity

970

BOMBS ON NORFOLK: PAGE THREE

BOURNVILLE COCOA

Daily Sketch

BIRD'S CUSTARD & JELLIES

DUNKIRK DEFENCE DEFIES 300,000

FOUR-FIFTHS OF B.E.F. SAVED: STORY ON PAGE THREE

'THE NAVY'S HERE'—WITH THE ARMY

BRITAIN'S LAST WORD TO ITALY: BACK PAGE

"…Came World War II: With 300,000 Allied troops awaiting evacuation from Dunkirk, the generals showed their flexibility. They said it was a pity we didn't have a tunnel…"
Popular Mechanics, **Jan. 1975**
RE: with large numbers of British, French, and Belgian troops cut-off and surrounded by the enemy, evacuation across the Channel was the best course of action. Dunkirk was the last port available for the withdrawal of most of the BEF from the European continent. On May 24, 1940, German field commanders seemed poised to take Dunkirk. Assured by *Hermann Goering,* head of the *Luftwaffe*, that his aircraft could destroy the Allied forces trapped on the beaches of Dunkirk, Hitler issued a halt to the Wehrmacht's advance. *Operation Dynamo* - the evacuation of Allied forces from Dunkirk – commenced on May 26, 1940.

971

972

973

"…The thought gave the War Office considerable worry. What if the Germans went to work on the 60-year-old diggings of Hawkshaw and de Gamond? Fearful that rows of spiked helmets might suddenly pop out of Dover's white cliffs, sensitive electronic instruments kept an ear for underground tremors during the rest of the war…"
Popular Mechanics, **January 1975**

974

A Jolly Good Idea

975

"…By 1947, when yet another study group started to examine the idea, no progress had been made since the embryonic diggings of 1880. The group pronounced it a jolly good idea, but nothing was actually done…"
Popular Mechanics, **January 1975**

976

"…In 1957, the Channel Tunnel Co. held its <u>seventy-sixth</u> (would you believe it?) annual general meeting. Usually, a mere handful of despondent stockholders could be expected to turn up. This time, the hall was packed to hear financier Leo d'Erlanger give his chairman's statement. There were, he said, conversations being held with Suez Canal company to explore building of a tunnel under the Channel! Moreover, an American company had recently been formed to study the possibility of just such a tunnel!..."
Popular Mechanics, **January 1975**

977

"…Everyone there seemed happy with the news - everyone, that is, except Field Marshal Montgomery, who voiced the old military caution: 'Why give up one of our greatest assets and make things easier for our enemies?'…"
Popular Mechanics, **January 1975**
<u>Left</u>: caption: "Field Marshal Bernard Law Montgomery (1887–1976), First Viscount Montgomery of Alamein"

978

Longer Than Expected

979

"…The British government acted predictably – it formed another study group. Three years later, just to introduce further delay, officials decided to spend several million pounds on a geological survey of the proposed route. In 1968, the Minister of Transport gave a progress report: 'There is no point in concealing the fact,' he said, 'that this has taken longer than expected'…"
Popular Mechanics, **January 1975**
<u>Above</u>: caption: "Working model of a rail terminal to serve the English end of a Channel Tunnel, which has been built by the model section of the British Transport Commission's Publicity Department. October 15, 1961."

980

The Latest Version

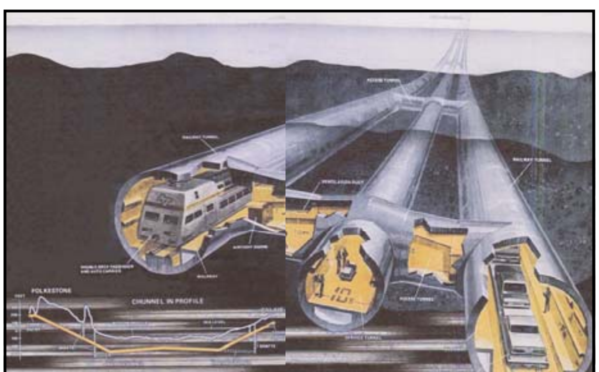
981

"…In 1971, the French and British governments announced that if there were no further obstructions, the tunnel would be completed in 1978. Here's how the latest version of the Chunnel shapes up:

- **Cost: More than $1 billion.**
- **Construction: Two main single-track rail tunnels (about 22-1/2 feet in diameter) on either side of a smaller service tunnel. Total length to be 31 miles – 23 miles under water. Ventilation would rely in the piston effect of trains – they would push out foul air and suck in clean air.**
- **Trains: Electric trains would carry regular and containerized freight, passengers, and autos with passengers. In double-deck trains, passengers would either stay in their cars or wander up and down the train. Time of crossing: one hour, including loading and unloading, and customs inspections. Cost for car and two passengers: about $45.**
- **Frequency of trains: Hourly passenger trains from London to Paris. In peak periods, car-ferry trains would run every four minutes. There's also talk about the possibility of a traveler rolling his car aboard a special train at some distant point, say in northern Scotland, for a continuous ride to any number of destinations on the Continent…"**

Popular Mechanics, **January 1975**

982



<u>Caption</u>: "Proposed plans call for a Chunnel made up of three tunnels – two for trains and one from which the others could be serviced. Trains capable of carrying as many as 260 autos would shuttle between England and France, making the run in some 35 minutes. Total cost would be about $2 billion."

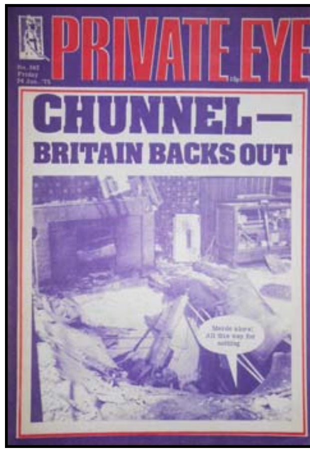
983

<u>Caption</u>: "Researcher uses models of tunnel and trains for airflow studies"

984

Wouldn't it be Lovely

985



"…Oh, wouldn't it all be luvverley? As this is written, however, there are a couple of unsettling developments to report:

• It was announced some time back that the earliest date of completion for the Channel has been put back two years, to 1980. This will automatically increase the cost - to an estimated $2 billion - because of added interest costs and inflation.

• French and British government leaders recently met, conferred and announced that, in view of the parlous economic state of both countries, they 'would not be averse to a slowing down of the project.'

How, one wonders, can you slow down a project that already has taken 172 years <u>not</u> to get started?"

***Popular Mechanics,* January 1975**

<u>Left</u>: *Private Eye* magazine, January 24, 1975

986

<u>Part 14</u>

A Long Time Coming

987

"Sometime early this year, British Transport Minister David Howell has indicated he will approve construction of a tunnel beneath the English Channel to link England and France…"

***Popular Mechanics,* February 1982**

988

"…You say you've heard all this before? Maybe you have. The dream of a Channel tunnel is said to have originated with Napoleon. A tunnel was actually started in the 1880s, but the British military, still fearing Napoleon, forced its abandonment. They were worried that an invading force would troop through, disguised as tourists…"

***Popular Mechanics,* February 1982**

RE: on *April Fool's Day* 1988, the *Daily Mail* published a fictitious story revealing the discovery of a tunnel linking England and France that had been constructed during the *Napoleonic Wars*. Supposedly, the tunnel was wide enough to allow a mule carrying two barrels of brandy to pass through it. The tunnel had supposedly been discovered beneath *Dover Castle*. The article explained, "It would have been used to rescue aristocrats from Napoleonic France, to transfer spies and to trade British goods with Europe."

989


Angry French claim priceless treasures

Consternation as secret Channel Tunnel is found under Dover Castle

By STEVE DOUGHTY
Home Affairs Reporter

A CHANNEL tunnel which could prove a rival to the one under construction has been discovered beneath Dover Castle in Kent.

Blockage

990

False Start

991

"…In 1974, with great fanfare, Britain and France started construction of a 'rolling motorway' to transport cars and trucks under the Channel on double-decked rail flat-cars. To the ire of the French, the British pulled out after 300 meters had been completed. Escalating costs, labor protests about possible loss of seamen's jobs and environmentalist outcry that new highways and rail lines would savage the pastoral landscape prompted the withdrawal…"

Popular Mechanics, **February 1982**

Left: caption: "In 1974, another tunneling attempt was made. Initially quite promising, this endeavor was quickly ditched after just one year thanks to grave financial concerns triggered by the oil crisis."

Right: caption: "Channel Tunnel site in April 1975. Material from the tunnel heading is brought to the surface by conveyor belt."

992

Common Market, Common Cause

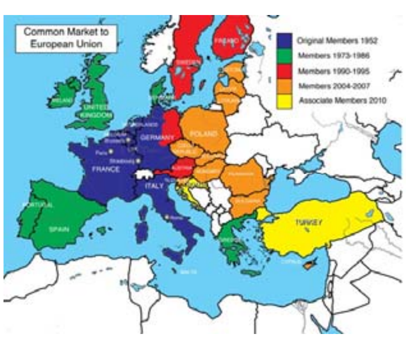
993

"…Since then, Britain has become even more closely tied to the European Common Market: traffic on existing ferries and hovercraft has more than doubled in the past decade…"

Popular Mechanics, **February 1982**

RE: the *European Economic Community* (EEC), a/k/a "Common Market." was established by the 1957 *Treaty of Rome*, preceded by the 1951 *Treaty of Paris,* which established a common market for the European coal and steel industries. Its European member states agreed to coordinate their economic policies and to establish common policies for agriculture, transport, the movement of capital and labor and the establishment of *Common External Tariffs* (CET). With the 1993 *Maastricht Treaty,* the EEC was renamed the "European Community" (EC), to reflect the fact that it covered a wider range than just economic policy. This treaty also founded the "European Union" (EU). The EC existed in this form until it was abolished by the 2009 *Treaty of Lisbon,* which incorporated the EC's institutions into the EU's wider framework and provided that the EU would "replace and succeed the European Community."

994



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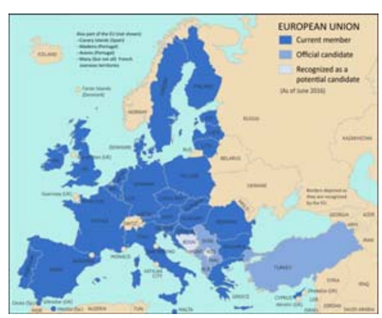


996

997

Cross-Channel Link

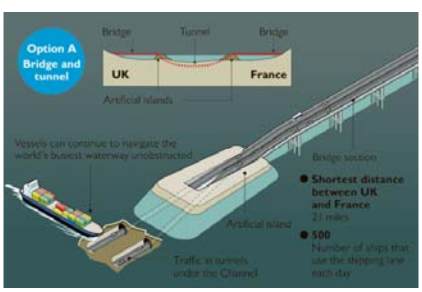
998

"…Accordingly, seven proposals have been made for a 'cross-Channel link': Howell will choose among them. Most are far more daring and dramatic than the stripped-down, economy-style tunnel expected to receive approval. Two construction consortia have suggested road bridges across the 21-mile wide waterway, one of them utilizing unprecedented two-mile single spans…"
Popular Mechanics, **February 1982**

999

"…British Steel Corp. has proposed a combination bridge and tunnel. This would require construction of two artificial islands, five miles off either shore, to be linked to France and Britain by bridge and joined to each other by a 12-mile undersea tunnel. The projects is estimated to cost six times as much as a tunnel…"
Popular Mechanics, **February 1982**

1000



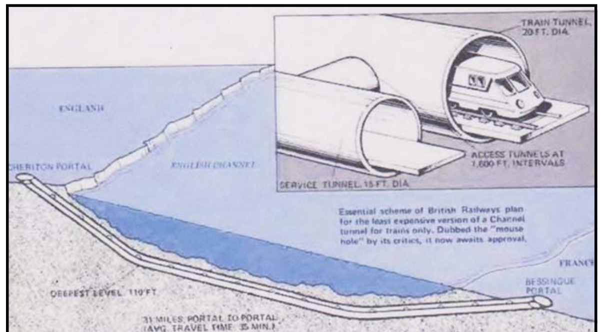
1001

The Mouse Hole

1002

"…'Why try something new when a tunnel has been thoroughly tested?' asks David Williams, project coordinator for the front-running project, advanced by the British Railways Board. This proposal is regarded as simple, uncomplicated and cheap: It calls for a one-way, single-bore, rail-only tunnel without passing places, a mere 6.0 meters (about 20 feet) in diameter – just barely large enough to accommodate current railway rolling stock. Critics call it a 'mouse hole'…"
Popular Mechanics, **February 1982**

1003



"…The tunnel would begin at Cheriton, near Folkestone, behind the famous white-chalk cliffs of Dover, and emerge near Bessingue, near Calais. Total length would be 30.6 miles, 23.2 under the sea. The tunnel would begin with a steep gradient on the British side, dip to a maximum of 110 feet beneath the sea bed, then rise gradually to the level of the less precipitous French shore…"
Popular Mechanics, **February 1982**

1004

"…Both freight and passenger trains would travel through the tunnel in convoy - 10 in succession in each direction, followed by 10 in the opposite direction. Multiple-aspect signals spaced a kilometer apart would allow the trains to operate on two minutes' headway at a continuous speed of 120 mph. A mandatory stop system would halt traffic in the event of a breakdown. The trains would be pulled by dual-voltage locomotives, which could switch from the 25,000-volt-a.c. overhead catenary system used in Britain to the French 750-volt-d.c. hookup. The continuously welded track would accommodate existing freight and passenger cars, although Brit-Rail has already begun design on new luxury passenger cars…"
Popular Mechanics, **February 1982**

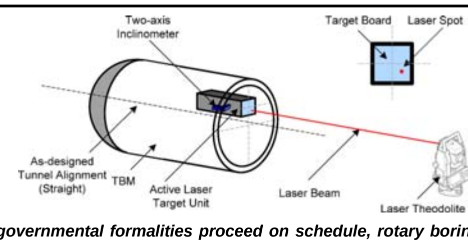
1005

"…The main tunnel would be flanked by a parallel, 4.5-meter (about 15-ft.) service tunnel, connected to the main tunnel at 500-meter (1,640-ft.) intervals. The service tunnel would allow for maintenance and provide an escape route in event of breakdown. Negative-pressure doors on each passageway would seal off the parallel tunnels from each other…"
Popular Mechanics, **February 1982**

1006

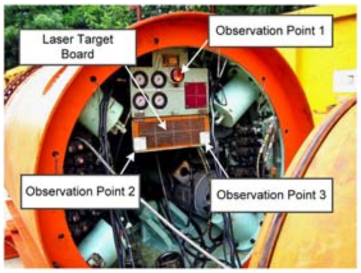
On Line, On Level

1007



"…If governmental formalities proceed on schedule, rotary boring machines could be churning through the chalky sea bed by the end of 1983. Utilizing the latest technology, the boring machine will follow a laser beam, projected ahead to keep the tunnel on line and level and to investigate the texture of the rock ahead…"
Popular Mechanics, **February 1982**
Above: caption: :The TBM's position in terms of point coordinates is continuously and automatically surveyed by a robotic total station, thus making it feasible to derive any line and level deviations from as-designed tunnel alignment in real time. Furthermore, given the coordinates of three observation points on the TBM, the attitudes of the TBM, which are described by three rotation angles of yaw, pitch, and roll, can be determined by a vector observation algorithm."

1008

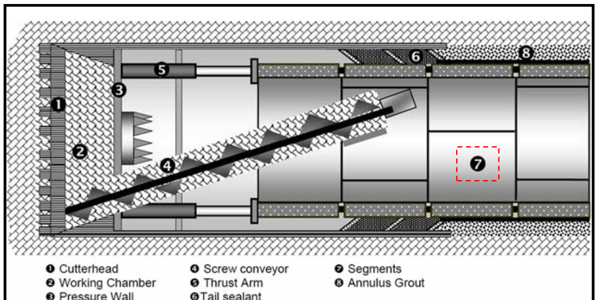


1009

"…Probably no bit of real estate on earth has undergone so many test borings. More than 60 samples from the 1970s project have given engineers nearly a foot-by-foot picture of the sea bed. 'The chalk is almost ideal tunneling material,' one of the engineers says. 'It's like going through a bit of cheese.' The chalk is solid enough, however, that no supports will be needed. In fact, the unsupported 1880s Beaumont Tunnel is still intact (filled with surface run-off, not with seepage from the sea)…"

***Popular Mechanics,* Feb. 1982**

1010



"…Working from either side, British and French should link up in seven years. As each section is dug, a pre-fabricated concrete liner will be moved into place…"

***Popular Mechanics,* February 1982**

<u>Above</u>: caption: "Schematic representation of Earth Pressure Balanced Machine (EPBM). Delhi Metro Contract BC18."

1011

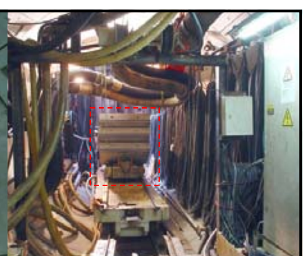


<u>Upper Left</u>: caption: "Assembling and welding of steel reinforcement cage for tunnel lining segment on template"

<u>Upper Right</u>: caption: "Lowering steel reinforcement cage into curvilinear tunnel lining segment form that matches radius of reinforcement cage"

<u>Left</u>: caption: "Removing tunnel lining segment from form after concrete casting is completed"

1012

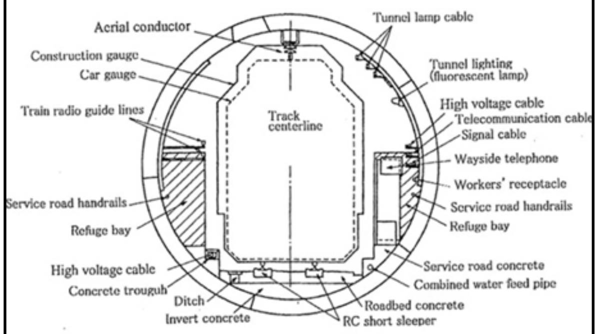



<u>Above</u>: caption: "Lining segments are being lowered down from shaft to the locomotive"

<u>Left</u>: caption: "Close view of segment lining. A typical ring of lining: 1.4-meter width with six segments to be joined by bolts. Note that the joint of neighbouring rings to be staggered."

1013

1014



A typical rail tunnel section with its components
(Delhi Metro)

1015

The Question Asked

1016

"…Why build such a small tunnel when cross-Channel traffic is increasing so rapidly? That question was also asked last year by a select committee of the British House of Commons. They voted for a 7.8-meter, one-way rail tunnel, large enough for double-decker car ferries, so voters could 'drive' their cars to Europe. The larger tunnel would be insurance against future demand, the committee said, whereas it would be impossible to enlarge the 'mouse hole' once dug. Howell has indicated that he will also consider the larger version, while noting that it would increase the cost by an estimated 25 percent…"
***Popular Mechanics*, February 1982**

1017

"…By 1980 estimates, the small-tunnel bill would be 765 million pounds (about $1.5 billion) to be divided roughly equally between the two countries. Terminals and track improvements would cost another 83 million pounds. Prime minister Margaret Thatcher's austerity government has made clear that Britain's share must come from private financing, which would be recouped from the tunnel tolls…"
***Popular Mechanics*, February 1982**

1018

Twice Shy

1019

"…Still stung by Britain's 1975 withdrawal, France has not publicly agreed to start again. But the matter was discussed at a recent meeting between Thatcher and French President Francois Mitterand, who hinted afterward that he favored the project…"
***Popular Mechanics*, February 1982**

1020

Waterloo International Station

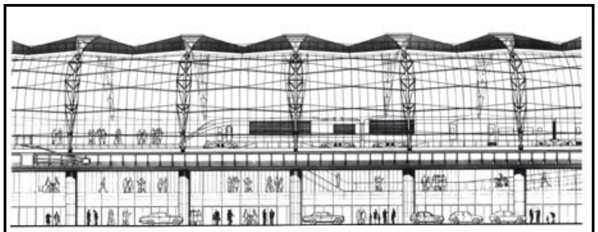
1021

"…According to Williams, fares on the new service would be competitive with aircraft; and trains will use only one-fourth as much energy per passenger as a plane. He estimates that about six million passengers would switch to trains when the first express starts rolling in 1990."

Popular Mechanics, **February 1982**

RE: in 1982, *British Rail* approached the *Lambeth Council* with plans for a terminal at *Waterloo Station* for cross-Channel trains

1022



The Channel Tunnel Terminal is a railway station that serves the same purpose as an airport. It is in direct competition with air travel and has most of the services and facilities normally associated with an airport as well as all the necessary back-up required to handle up to 15 million passengers a year. Less than ten minutes walk from Trafalgar Square, it has a taxi drop-off only 15m from the ticket barrier…

EUmiesaward 2017

<u>Above</u>: caption: "Main Elevation"

1023

…The focus of both technical skill and architectural spectacle is the roof, essentially a flattened three-pin bow string arch whose most striking quality, the asymmetry of the trusses, derives from the position of a single track tight onto the western edge of the site, and the resulting need for the structure to rise more steeply at this point to clear the trains. This side is clad entirely in glass with the structure on the outside, creating a showcase for the trains and allowing arriving passengers a glimpse of Westminster and the River Thames…

EUmiesaward 2017

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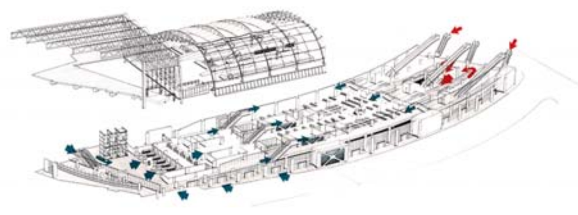
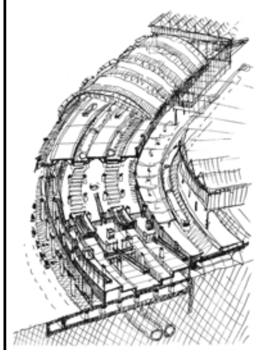
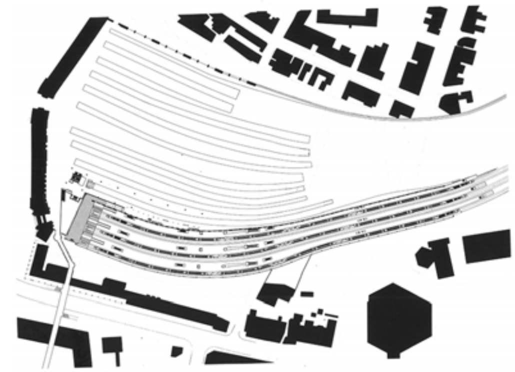


…The skin or cladding on the structure raised problems of complexity and cost which, to overcome, a loose fit approach was adopted in which a limited number of different sized glass sheets overlap each other at top and bottom like roof tiles. They are joined at their sides by concertina-shaped neoprene gaskets, which can flex and expand to accommodate turns and varying widths…
EUmiesaward 2017
Above: caption: "Axonometry"
1027

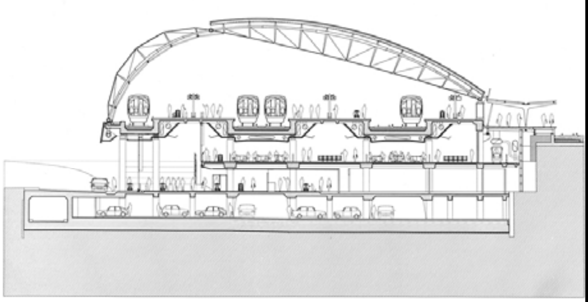


…The rest of the project divides into three major parts: a basement car park which spans over the Underground lines immediately below and forms the foundation for the terminal. A two-storey viaduct sits on this base and supports the platforms, forming the enclosure for two floors of passenger accommodation. The final component is works to the brick vaults under the existing station, many of which were badly damaged during the war and were extensively refurbished to accommodate all the essential back-up operations.
EUmiesaward 2017
Left: caption: "Sketch"
1028

Ground Floor Plan
1029



Upper Level Plan
1030



Cross Section
1031

1032

In 1984, BR looked into the possibility of establishing a helicopter terminal atop Waterloo Station for helicopters capable of ferrying two-hundred people between London and Paris. In fact, for a brief period in the 1950s a helicopter terminal was, indeed, based at *Waterloo Station* (*Waterloo Air Terminal*), acting as a shuttle service to and from London's airport.

1033

1034

Part 15

Above and/or Below

1035

An Inconvenient Ditch

1036

"For some Britons, it forms the felicitous barrier that has kept the country pure - Shakespeare's 'moat defensive…against the envy of less happier lands.' A geological remnant of the late Ice Age, the English Channel has defined much of the character of this island, seagoing nation. For many others, however, the channel is an inconvenient ditch. Expensive and time-consuming to cross by ship, it separates Britain and its economy from true integration with Europe…"
***The Washington Post,* November 1, 1985**
Left: caption: "At the end of the last Ice Age, Britain formed the northwest corner of an icy continent. Warming climate exposed a vast continental shelf for humans to inhabit. Further warming and rising seas gradually flooded low-lying lands. Some 8,200 years ago, a catastrophic release of water from a North American glacial lake and a tsunami from a submarine landslide off Norway inundated whatever remained of Doggerland."

1037

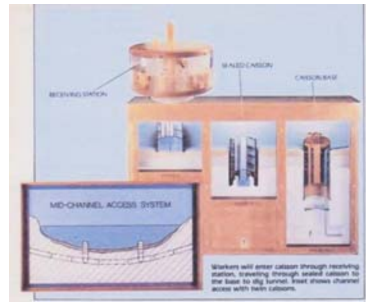
"…Plans to build a tunnel under the channel or a bridge spanning it for two centuries have fallen victims to skeptical engineers, exorbitant costs or governmental trepidation. The shoreline near Dover's white cliffs, the closest point to the French coast 22 miles away at Calais, is dotted with the industrial debris and abandoned boreholes of past efforts. Despite the failures, Britain and France still think it is worth trying to build a road - above or below the water - between them. …"
***The Washington Post,* November 1, 1985**

1038

Channel Tunnel

England and France have long been talking about building a tunnel under the English Channel. The main problem has been the cost. During the construction, interest rates alone would cost hundreds of millions of dollars. But Taurio Corp. engineer J. Vincent Harrington has designed a tunnel-building caisson system that promises to cut the project time in half, and now the French and English are talking tunnel again. The caisson system allows engineers to tunnel in opposite directions at mid-channel with one caisson. That cuts construction time in half. If two caissons are placed equidistant from the channel center, construction time would be two-thirds shorter. A model made by the Stone and Webster engineering firm of Boston has been shown to the Europeans and they like the concept.(*Popular Mechanics,* January 1985)

1039



1040

Brunnels, Chunnels & Brubbles

1041

"…Today marked the deadline for submission of industrial proposals to the governments of France and Britain to span that ditch. It brought the official unveiling of what local wags have dubbed the 'brunnel,' the 'chunnel,' the 'brubble' and a handful of lesser multibillion-dollar variations of bridge and tunnel, road and railway projects that all promise to revolutionize the channel crossing by the mid-1990s…"
The Washington Post, **November 1, 1985**

1042

Promises and Fears

1043

"…Following a go-ahead last year from Prime Minister Margaret Thatcher and President Francois Mitterrand, Anglo-French consortiums have been drawing up projects that meet the principal criterion of their governments - that no public money will be needed. Each of the main contenders promises to be able to raise all the money needed from private sources in Britain, France and on the international financial markets, with returns of up to 20 percent to investors. Each promises tens of thousands of construction jobs and a revitalization of heavy industry in both countries. Each promises that it will accommodate a projected doubling of cross-channel traffic by the turn of the century and will constitute what Thatcher last year called 'something our generation can perhaps do for future generations'…"
The Washington Post, **November 1, 1985**

1044

"…Each of the proposals is roundly opposed by a separate group of predictable critics. They range from the operators and employees of the cross-channel ferries, which last year carried about 40 million passengers and three-quarters of a million freight trucks between Dover and France, to environmental groups fearing destruction of the pastoral countryside. Most local governing bodies in the seaside area fear a net loss of jobs and income once the building is over and the ferries disappear…"
The Washington Post, **November 1, 1985**

1045

The Short List

1046

"…For the next three months, the two governments will listen to the critics and study the proposals. They have promised to decide on one, or none, of the projects by late January…"
The Washington Post, **November 1, 1985**

RE: in 1984 - after a total of twenty-seven false starts - French President *Francois Mitterand* and British Prime Minister *Margaret Thatcher* jointly announced that, at long last, the tunnel under the channel would be built by private funding. In 1985, the governments of both Britain and France invited private companies to come up with proposals for a channel crossing. This resulted in four schemes being short-listed:

- **<u>Eurobridge</u>: a vast suspension bridge for cars, with the traffic lanes contained in an enclosed tube suspended 70 meters above the Channel. The estimated cost was £5.9 billion;**
- **<u>Euroroute</u>: a £5 billion road built across a series of tunnels and bridges which would have been linked by artificial islands;**
- **<u>Channel Expressway</u>: a large tunnel for both cars and trains with ventilation shafts jutting out in the middle of the Channel. Cheaper at £2.1 billion, the tunnel would have seen road and rail sharing the same space (traffic would alternate, with cars being halted every hour to let trains through), and;**
- **<u>Eurotunnel</u> (a/k/a "Channel Tunnel Group"): A straight-forward railway tunnel. In 1985, the estimated cost for the Eurotunnel was £2.3 billion.**

1047

The Brunnel

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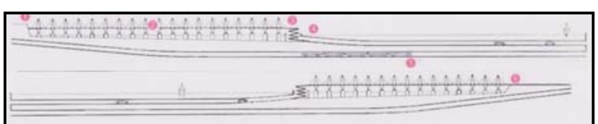
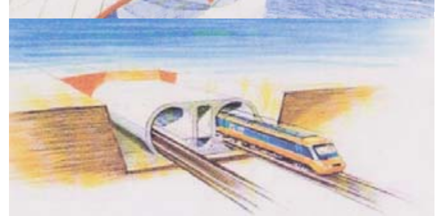


"…So far, the front-runner appears to be the 'brunnel,' the bridge-tunnel combination proposed by Euroroute Ltd. It is the most expensive and futuristic, and has the advantage, in the words of its voluminous and polished press kit, of 'freedom of choice' for channel-crossers…"
The Washington Post, **November 1, 1985**

<u>Above</u>: divided into thirty-one all-steel bridge spans, each 500-meters-long (2) and 50-meters above the waves, *Euroroute* would have projected 5-miles into the Channel from the English side (1) to one (of two) artificial islands (3). Once there, the roadway would gently corkscrew *down* into a tunnel (4); 12-miles long, furnished with emergency parking and cross-over points. Above, the shipping lanes would exist as they always had, without any impediment to safe navigation. On the second artificial island, vehicles would corkscrew *up* at a 4% gradient to another series of bridge spans (just over 4-miles long) to complete the journey to France (6). Running parallel to the surface bridges and road tunnels would be a twin-tube, bi-directional train tunnel (5) to allow both passenger and freight trains to connect directly, on either shore, to existing rail networks in both England and France.

1049



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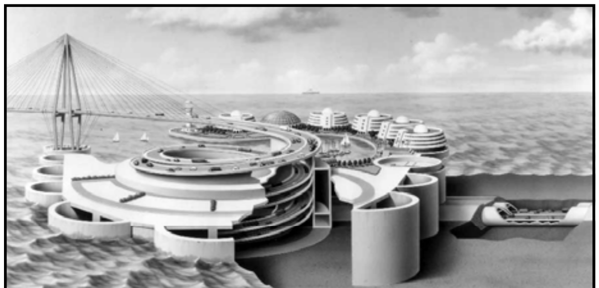


"…On Euroroute, a vehicle is driven from Dover five miles out into the channel to an artificial island, where a spiral ramp descends to a 13-mile tunnel. The tunnel ends at another ramp, island and bridge five miles off the coast of France. A separate, parallel rail tunnel also runs 23 miles, coast to coast…"
The Washington Post, November 1, 1985
Above: caption: "Euroroute, which would have linked Britain and France with a combination of bridges and tunnels"

1052

"…The projected cost for Euroroute, without loan interest or cost over-runs, is $7 billion, to be paid by shareholders, institutional investors and bond flotations. Sir Nigel Broakes, chairman of Euroroute, heads Trafalgar House, a British engineering, construction and shipping firm with projects worldwide. Euroroute's advisers and backers include Barclays Bank, British Steel and Kleinwort Benson, and its French partners are Banque Paribas and Societe Generale. Surveys done by Euroroute indicate that most channel-crossers prefer to drive their own vehicles, an advantage of the 'brunnel' that also is said to appeal to Thatcher…"
The Washington Post, November 1, 1985
RE: _Euroroute_ boasted that rail passengers could get from London to Paris in three-and-a-half-hours and promised "Glasgow to Geneva non-stop" and "Birmingham to Brescia." Emergency services would be on "24-hour standby" and there'd be "sophisticated surveillance devices to cut the risk of fire, accident or sabotage." Two "driver psychologists" were hired to study the effect the drive across the channel would have on motorists. Backed by _Barclays Bank, BT, British Steel_ and _Associated British Ports_, Euroroute was seriously considered by the _Department for Transport_. Its promoters claimed the plan would net £1.3 billion-per-year in tolls by 2003 and wipe out all its debt after fifteen years of operation. As part of the agreement, the backers demanded a 50-year "exclusivity clause" from the British and French governments.

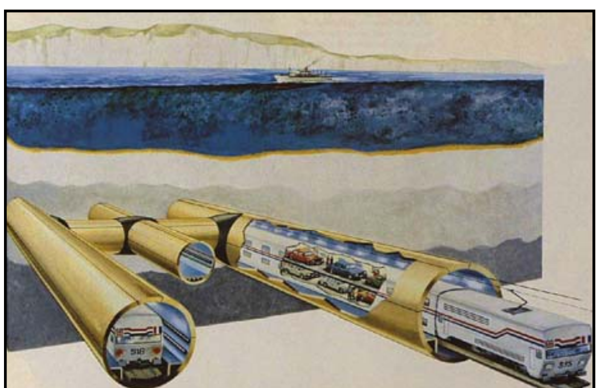
1053

The Chunnel

1054

"…But many here are banking on the 'chunnel' project, proposed by the Channel Tunnel Group headed by Sir Nicholas Henderson, former ambassador to the United States and to France. For $4 billion, it offers a modern variation of a plan proposed to Napoleon Bonaparte in 1802 for a double bore-hole dozens of feet under the chalky channel bed. It also closely resembles an Anglo-French project begun in the last decade and abandoned by the British government in 1975 with only a half-mile hole near Dover to show for the effort…"
The Washington Post, November 1, 1985

1055



Above: caption: "The Channel Tunnel, as envisaged in 1985

1056

"…The 'chunnel' is rail only, with two parallel tunnels, connected by a separate service tunnel, for electric trains on which cars and trucks would be loaded for high-speed shuttle. Its designers promise a train leaving every five minutes, and a capability of 4,300 vehicles per hour. Henderson's backers include NatWest and Midland Banks in Britain and Credit Lyonnais and Banque Nacionale de Paris…"
The Washington Post, **November 1, 1985**

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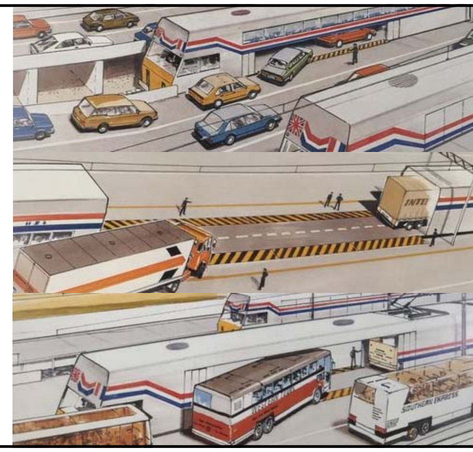

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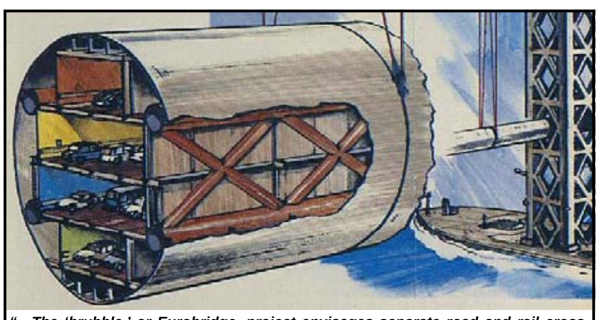
1059

The Brubble

1060

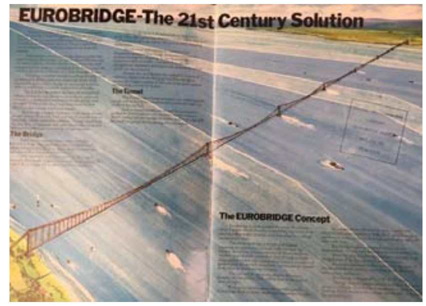


"…The 'brubble,' or Eurobridge, project envisages separate road and rail crossings costing about $7 billion. Vehicles would travel on a road inside a multi-decked plastic tube suspended from eight towers built across the channel between Dover and Calais. Trains would use a rail tunnel bored beneath the sea. Critics say a bridge spanning the busy channel sea lane is too dangerous…"
The Washington Post, **November 1, 1985**
Above: caption: "Cross-section of the tube containing road decks which would have hung from the proposed Eurobridge"

1061

1062

Like its rivals, the £5.9 billion, quadruple-deck “Motorway-in-a-Tube” *Eurobridge* was to include seven, three-mile-long suspension spans with twelve lanes of traffic. Each span would have exceeded by far the longest suspension bridge span in the world - then and now. The bridge towers would have risen to a height of 340-meters while 1.4-meter-wide cables would support an enclosed tube 70-meters above the Channel. The tube would have been made of a material called *Parafil* - equipped with “acoustic, visual, laser and electronic” sensors. Despite admitting a crash with an oil tanker “cannot entirely be excluded,” the plans boasted the towers would actually be a “valuable aid to shipping,” capable of withstanding a collision by a 250K-ton vessel travelling at 17 knots. Below it all would have been a Channel Tunnel, carrying an entirely separate railway. The entire cost of the project was to be paid back in six to eleven years, funded by tolls which would be comparable to a ferry ticket. As far-fetched as it may appear, its promoters stated that “protracted discussions” had taken place with governmental authorities. Tory MP *Sir David Price* warned at the time: “Eurobridge would be three times the length of the longest suspension bridge at present open anywhere in the world, crossing one of the most heavily used and liveliest seaways in the world. As far as I am concerned, the Eurobridge proposal is strictly for the birds.” 1063



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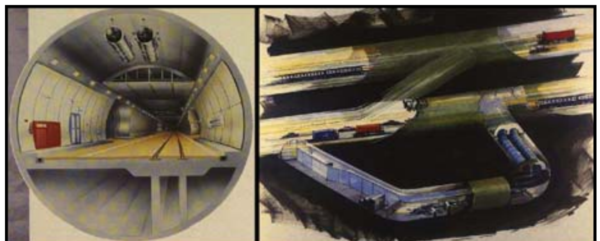
Channel Expressway

1065



“…A fourth proposal, Channel Expressway by Sealink British Ferries, one of the channel ferry companies, is for a $3 billion rail-and-road tunnel…”
The Washington Post, November 1, 1985
RE: *Sealink* - designers of this £2.1 billion under-channel tunnel, conceived of a motorway with cars travelling at 62 mph on a roadway with an integral pair of train tracks
Above: caption: “Channel Expressway would have seen road and rail traffic using the tunnel at alternating intervals” 1066

Once an hour - between 6:00 a.m. and midnight, a cross-Channel train would transit through the same tunnel as motor vehicles. A “special service vehicle” would follow behind the last of the automobiles, equipped with a bogie on the rail track that would link to the signals to stop the train ramming into a car in its path (motorcycles would be advised not to drive in the lane with the train tracks in it, in case their wheels slipped). The promoters assured that, “Vehicles will not be permitted to drive alongside a moving train.” Staggered along the tunnel’s length would have been ventilation shafts, each a cluster of nine concrete tubes emerging above the waterline, supposedly able to withstand an “ultra-large” oil tanker at 17 knots. This scheme also demanded a 50-year exclusivity agreement. *Sealink* promised to “withdraw entirely” from its ferry routes to Ostend, Dunkirk, Calais and Boulogne should its *Channel Expressway* scheme be selected. Paradoxically, Sealink backed the “No Channel Tunnel” campaign. 1067

1068

1069

Also Rans

1070

"…There are also some dark-horse contenders. Eurolink is a plan by four London businessmen for a road and rail bridge, with the bridge piers incorporating hydroelectric generators that would produce power for sale to Britain and France and allow bridge users to travel free.
The Washington Post, **November 1, 1985**
RE: *Eurolink* - a futuristic plan by four London businessmen for a road-and-rail bridge in a suspended tube, was described as a "dark horse" contender for the "Fixed Link" in 1985. The bridge piers were to include hydroelectric generators that would serve both countries and create enough revenue to allow bridge users to travel toll-free. However, the ambitious plan didn't make it to the "final four" stage for consideration. At 22-miles-long, Eurolink's projected cost was $14 billion (in Oct. 1985).

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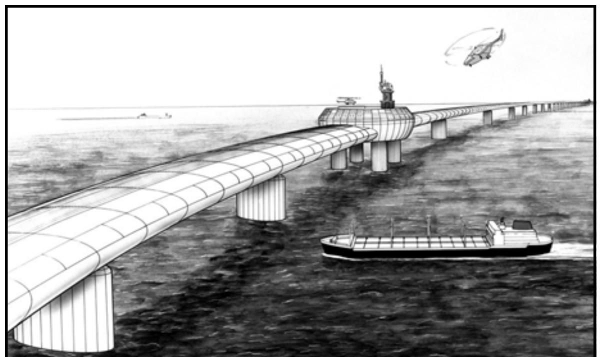
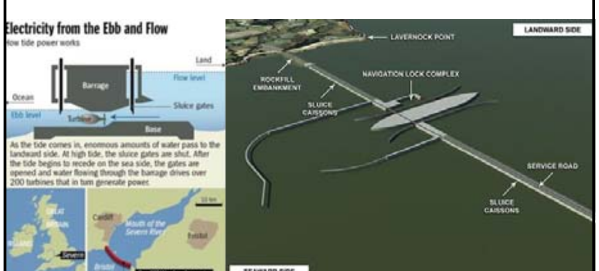


Above: caption: "An artist's impression of the Eurolink bridge, a plan by four London businessmen for a road/rail bridge across the Channel, one of the contenders for the cross-Channel link. The Eurolink bridge provides support piers containing turbines to generate electricity by tidal action, which the designers claim will provide sufficient revenue to operate without tolls."

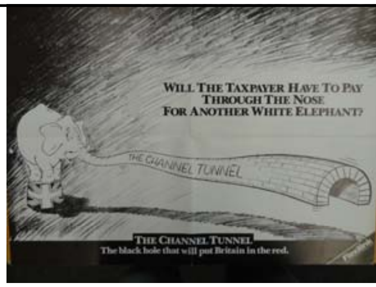
1072



1073

"…A businessman from Bournemouth, on the southwestern English coast, submitted a plan to the Department of Transport today but did not make public its details. A retired French inventor turned in a proposal that, like the Euroroute 'brunnel,' involves a combination of bridges, tunnels and artificial islands…"
The Washington Post, **November 1, 1985**

1074



"…Flexilink, a consortium of ferry and port operators opposed to any project that takes business away from them, released a proposal last night for a fleet of ferries twice as big as the current ones, charging half the fare of the current car-ferry system…"

***The Washington Post*, November 1, 1985**

<u>Above</u>: anti-tunnel poster sponsored by Flexilink

1075

Constructive Criticism

1076

"…Tonight, British Transport Secretary Nicholas Ridley described 'a complex process of evaluation' that the two governments will begin Friday. 'They will look at the environmental impact, the economic effect on the region, landscaping, everything.' The governments will look at legislation needed for any of the projects to go forward, and projected alterations in treaties. 'Everyone affected by the proposals will have a right to make representations,' Ridley said. 'We do want everybody to be consulted.' But, he warned, 'we do not want to take 20 years to do it.'"

***The Washington Post*, November 1, 1985**

1077

<u>Part 16</u>

A Day to Remember

1078

It's Official!

1079

Channel Tunnel Treaty Signed

President Francois Mitterrand and Prime Minister Margaret Thatcher - at a news conference in Canterbury, England, announced the signing of a treaty to allow construction of a 31-mile, twin-rail tunnel linking France and Britain beneath the English Channel. With them were Sir Geoffrey Howe, British Foreign Secretary, and his French counterpart, Roland Dumas. The treaty must be ratified by both Governments. Leaders hope work can begin next year and the tunnel opened in 1993. (*The New York Times,* February 13, 1986)

1080

Above: caption: "The Fixed Link Treaty, part of the legal arrangements for the Channel tunnel is 'sealed' with a handshake by Mrs. Margaret Thatcher and French President Francois Mitterand today, February 12, 1986, in the 15th century Chapter House at Canterbury Cathedral" 1081

The Anglo-French treaty for the construction and operation of the Channel Tunnel was signed by both governments in *Canterbury Cathedral* thus, it came to be known as the "Treaty of Canterbury." It was signed by British Prime Minister *Margaret Thatcher* and French President *Francois Mitterrand* on February 12, 1986 and is the original document providing for the subaqueous tunnel between the two countries. The treaty actually modified the national borders of both the UK and France: the Treaty draws a land frontier between the two countries in the middle of the Tunnel (above). 1082

Above: caption: "The Treaty of Canterbury - signed in the historic Canterbury Cathedral, was not just a renewal of the Entente Cordiale but the green light to what is regarded as one of the greatest civil engineering accomplishments of the 20th century" 1083

Above: caption: "Canterbury, February 12, 1986. Channel Tunnel Treaty: Prime Minister Margaret Thatcher shakes hands with President Mitterand of France at Canterbury Cathedral today when the two premiers met to sign the Channel Tunnel Treaty" 1084

The Treaty prepared the *Concession* for the construction and operation of the *Fixed Link* via privately owned companies by outlining the methods to be used for arbitration in the event of a dispute and set-up the *Inter-Governmental Commission* (IGC) which was responsible for monitoring all matters associated with the construction and operation of the tunnel on behalf of the British and French government/s (along with a *Safety Authority* to advise the IGC). The *Treaty of Canterbury* was followed a month later by the *Concession Agreement,* (CA) which was signed on March 14, 1986. The Concession Agreement is a binding agreement between the British and French government/s entrusting *France Manche* and the *Channel Tunnel Group* with the design, financing, construction and operation of the Channel Tunnel for a period of 55 years (the CA was later extended to the year 2086). The Agreement specifies, in particular, the purpose of the CA and the conditions applicable to its termination. 1085

TRANSPORT

Treaty Series No. 15 (1992)

Treaty

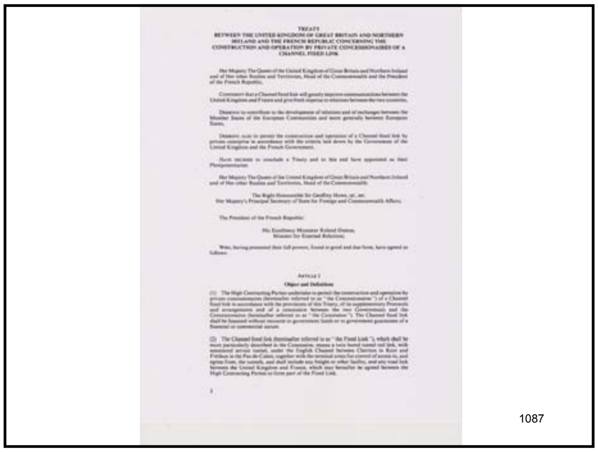
between the
United Kingdom of Great Britain and Northern Ireland
and the French Republic

concerning
the Construction and Operation by Private
Concessionaires of a Channel Fixed Link

with an Exchange of Letters relating to the
Arbitration Rules

LONDON : HMSO

1086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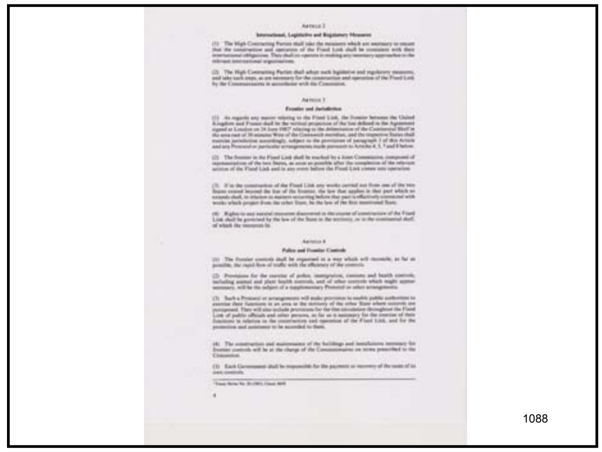
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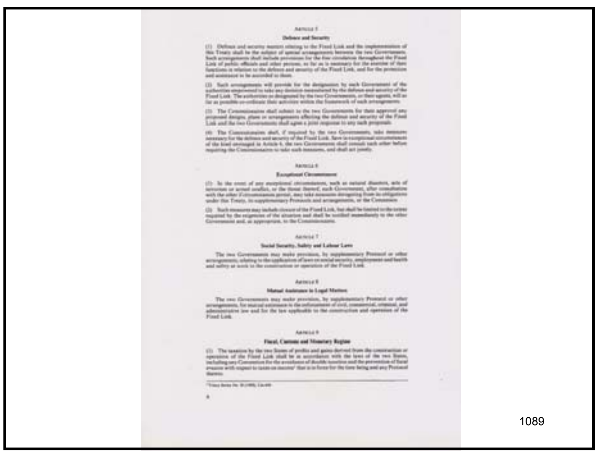
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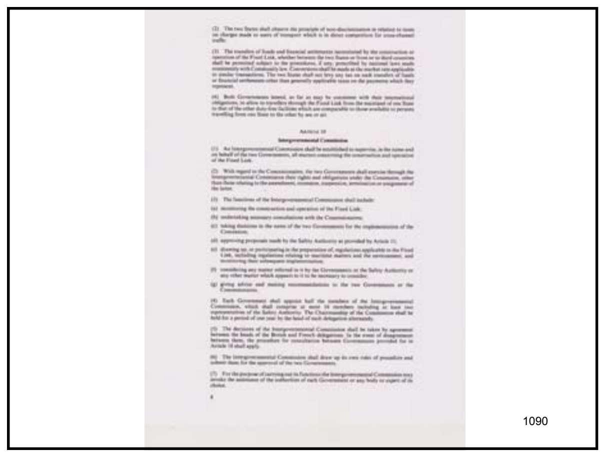
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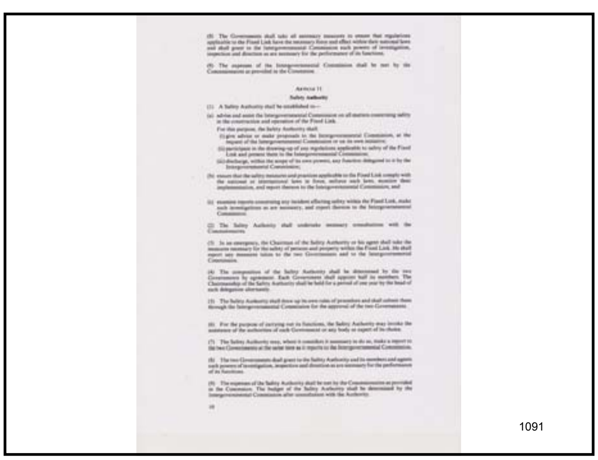
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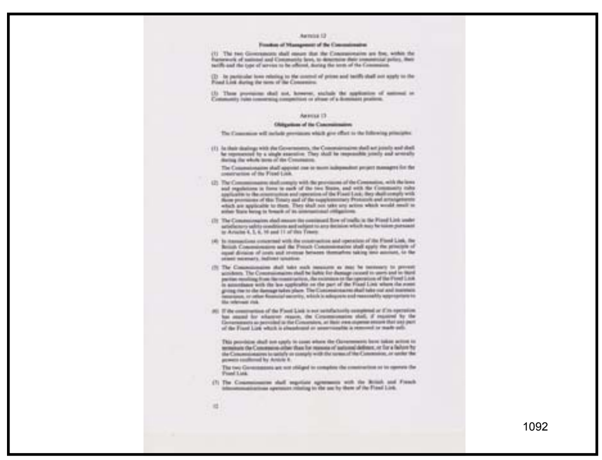
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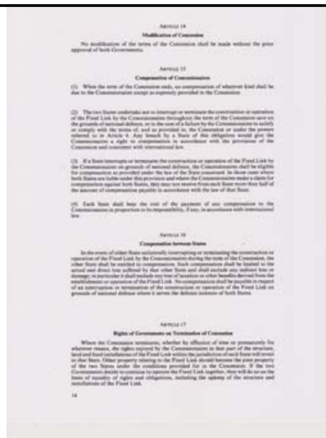

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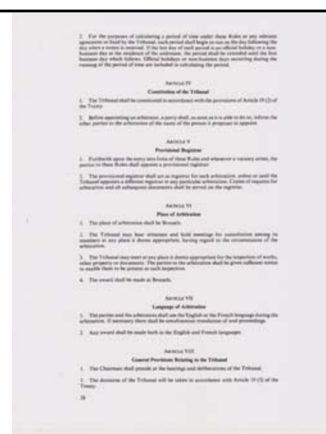

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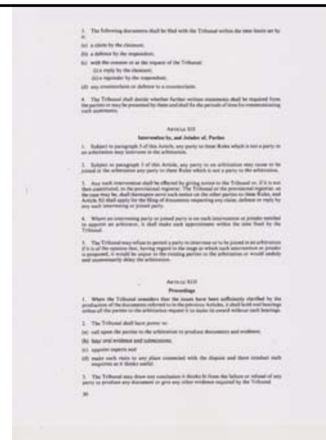


1100

1101

1102

Part 17

Proceed With Caution

1103

An Ideal Medium

1104

Europe's biggest civil engineering project, twin rail tunnels beneath the English Channel, will penetrate an ideal medium - soft, watertight chalk. But engineers, wary of potential hazards along the route, are calling on the latest technologies.
***Popular Science,* May 1986**
RE: introduction to an article written by *John Free* entitled: "Chunnel for the Channel"

1105

Delayed No More

1106

"Colorful British and French flags bedecked city hall in the French city of Lille early this year. School-children waved tiny flags, and bands played the 'Marseillaise' and 'God Save the Queen' before French President Francois Mitter-and called it 'grandiose vision of the future.' British Prime Minister Margaret Thatcher, although not fluent in French, dubbed it 'pas-sionnant' - exciting. It should be exciting; it's been delayed more than 200 years. 'It' is something that was set in motion by an ag-reement, signed in Lille, between the French and British: the const-ruction of the Chunnel - a tunnel under the English Channel – to link the countries…"
***Popular Science,* May 1986**

1107

"The British and French Governments announced plans to-day to dig a tunnel under the English Channel that would realize a centuries-old dream of linking their two countries. At a meeting in this northern French city, President Francois Mitterrand and Prime Minister Margaret Thatcher gave the go-ahead for construction of a double railway tunnel running for 30 miles under the sea between Dover and Calais. In addition, they called for a separate motor tunnel to be built by the end of the century…"
***The New York Times,* January 21, 1986**

1108

"…Work on the privately financed tunnel, which is expected to cost almost $7 billion, will start next year and is expected to be completed in 1993. Cars, buses and trucks will then start making the 30-minute journey between Britain and France aboard special trains running some 130 feet beneath the Channel bed. France also plans to run its high-speed ex-press trains through the tunnel, cutting the travel time bet-ween central Paris and central London to 3 hours and 15 min-utes and thus providing serious competition for airlines on one of the world's busiest air routes.…"
***The New York Times,* January 21, 1986**

1109

"…The rail tunnel plan ch-osen today over three riv-al projects was put for-ward by a consortium of British and French banks, construction companies and engineering concerns called the Channel Tunnel Group in Britain and Fra-nce-Manche on the other side of the Channel. …"
***The New York Times,* January 21, 1986**
Left: caption: "Ten giant con-tractors - five UK and five French - won the concession to design, build, own, oper-ate and finance the const-ruction of the Channel Tun-nel. Eurotunnel, the client, had to be created by these companies."

1110

COMPOSITION OF
THE ANGLO FRENCH
PROMOTER

The Channel Tunnel Group comprises the following British civil construction companies and banks as owners:

Balfour Beatty Construction Limited
Costain U.K. Limited
Tarmac Construction Limited
Taylor Woodrow Construction Limited
George Wimpey International Limited

National Westminster Bank PLC
Midland Bank PLC

Robert Fleming & Company Limited and Morgan Grenfell & Company Limited are merchant bank advisers to CTG.

Granada Group PLC is an associate member of CTG.

The combined turnover of the above construction companies is over £5 billion p.a. (FF 58.5 billion). The assets of the two participating banks total £133 billion (FF 1,556 billion).

"…On the British side, the main members of the Channel Tunnel Group are the National Westminister and Midland Banks and two construction companies, Wimpey and Costain. Leading members of the consortium's France-Manche team are three state-owned banks, Paribas, Credit Lyonnais and B.N.P., and two big building companies, Bouygues and Societe Generale d'Entreprise…"

The New York Times, **January 21, 1986**

1111

"…But at the insistence of Mrs. Thatcher, who favors a drive-through road tunnel, the group must start work on a separate motorway under the Channel by 1990 or loose the tunnel monopoly the two governments are giving it until the year 2020. The loss of this monopoly would enable other interests to dig a rival road tunnel between Britain and France if they believed it technically and economically feasible…"

The New York Times, **January 21, 1986**

1112

"…Marcel Sarmet, the finance director of Franche-Manche, the French half of the winning consortium, predicted that the new rail tunnel would take two-thirds of the traffic now crossing the Strait of Dover on the two major ferry lines, though only one quarter of the freight. 'That is the level which is most compatible with maintaining a certain level of ferry services,' he said. Both the British and French Governments want to keep a ferry service to provide competition with the tunnel. Mr. Sarmet said the consortium believed that adding a road tunnel now would double the project's cost while bringing only a 10 percent gain in traffic…"

The New York Times, **January 21, 1986**

1113

"…The Channel Tunnel Group says more than 30 international banks have provisionally agreed to provide around $5.3 billion in development loans. In addition, the consortium plans to raise $1.4 billion by selling stock. About $350 million worth of shares are to be offered in New York and Tokyo by Salomon Brothers and Nomura Securities. A further $455 million will be raised in London and Paris and the rest on other European stock markets. The consortium plans to seek a full listing for the Channel Tunnel shares on the London and Paris stock exchanges in mid-1987…"

The New York Times, **Jan. 21, 1986**

Left: certificate from *Eurotunnel P.L.C./S.A.*, issued in 1988

1114

"…The consortium won out against three main rivals. A plan for a huge suspension bridge across the Channel was ruled out first, officials say, because of the unproven state of the technology. A plan for a joint bridge and tunnel link was also rejected on the ground of cost. The closest rival was a Channel expressway proposal put forward by an American businessman, James Sherwood, who controls the Sealink cross-Channel ferry fleet. This provided for a combined rail and road link. But France appeared strongly opposed, partly because of doubts about the technical feasibility of ventilating the road tunnel and also because only a few French companies were involved."

The New York Times, **January 21, 1986**

1115

Oozing Superlatives

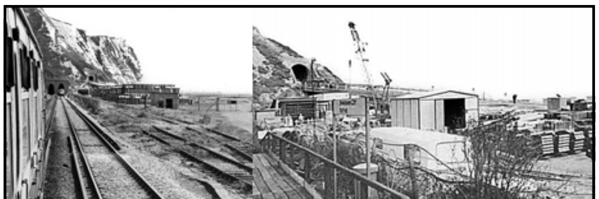
1116

"…The Channel project oozes superlatives. It will be the largest civil engineering project in the history of Western Europe. Thousands of workers will support some of the world's most advanced tunnel-boring technology to push three parallel tunnels the 31 miles from Cheriton, in Kent, England, to Frethun, in northern France. Work is slated to begin next year. The first paying customers should zip between England and France in 1993. Following the announcement, I visited London to learn more about this frequently delayed project…"
***Popular Science*, May 1986**

1117

"…The most remarkable thing about the Chunnel is that the countries now seem serious about building it. Perhaps the earliest tunnel proposal came from French engineer Nicolas Desmaret in 1753. Napoleon resurrected the idea in 1802. In the 1870s, British and French companies began drilling shafts from opposite sides, then quit. The idea surfaced again in 1907, 1916, 1924, 1930, and the early 1960s. A POPULAR SCIENCE article in July 1960 outlined plans. That project, actually started in the 1970s, halted when the British pulled out, saying it would cost too much…"
***Popular Science*, May 1986**

1118



<u>Left</u>: caption: "The abandoned Channel Tunnel work site looking east seen from a passing 4-VEP unit on the down line with a Class 73 diesel loco just visible emerging from the western portal of Shakespeare Tunnel"
<u>Right</u>: caption: "Following the signing of the Treaty of Canterbury in Feb. 1986, preparations were underway in this view from Aug. 1987 to reactivate the construction site used for the failed 1974/5 Channel Tunnel attempt. In this view, seen from the up platform of the staff halt, large quantities of building material have been arriving at the site."

1119

Will to Do

1120

"…So why will it work this time? Says Bill Shakespeare, a publicist for the British group promoting the project: 'We're convinced the political will to build exists. The reality of the traffic buildup across the channel forces a solution of some kind on both governments.' The numbers bear him out. Surveys estimate that cross-channel traffic will double by the year 2000. That would far exceed the capacity of present cross-channel ferries, which are subject to delays from weather and labor conflicts…"
***Popular Science*, May 1986**

1121

"…The Chunnel will initially handle 1,000 vehicles an hour. Its maximum capacity is four times that - enough to handle traffic well into the 21st century…"
***Popular Science*, May 1986**
<u>Above</u>: caption: "Map of Channel Tunnel"

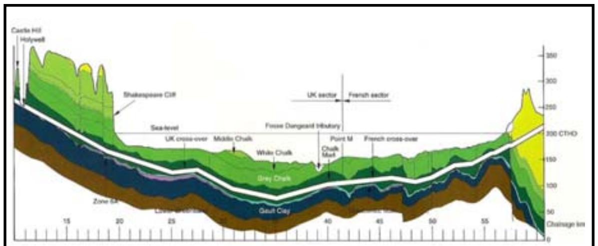
1122

Reasons to Believe

1123

"…Other reasons to expect success: Technology is available to do the job, and planning is exhaustive at the Channel Tunnel Group and its French partner, France Manche, a privately funded consortium selected for the project…"
Popular Science, May 1986

1124

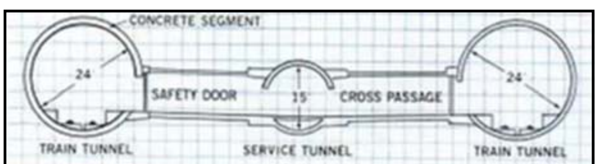


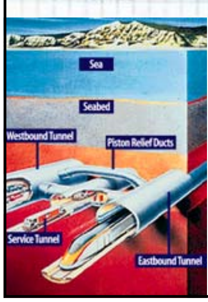
"…To uncover details about their scheme, I first visited Michael Gordon, managing director of the Channel Tunnel Group, at his temporary offices in a trim central-London house. 'The costs of our construction are fairly predictable,' says the Cambridge-educated mechanical engineer, showing me drawings and summaries of proposals that fill a long bookshelf. 'It's conventional tunneling through a medium that is well known and well researched'…"
Popular Science, May 1986
<u>Above</u>: caption: "Geological section of the English Channel at the crossing of the Channel Tunnel"

1125

Troika

1126



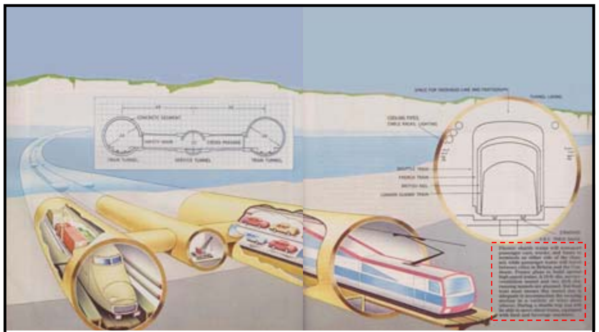


"…The project calls for two 31-mile-long, 24-foot-diameter train tunnels with a 15-foot-diameter service tunnel between them. Every 1,125 feet, the three shafts will be connected with cross-links. 'You can walk through to the service tunnel,' says Gordon. 'These cross-links are necessary for security in case you have a breakdown or fire'…"
Popular Science, May 1986
<u>Above</u>: caption: "Channel Tunnel cross-section"

1127

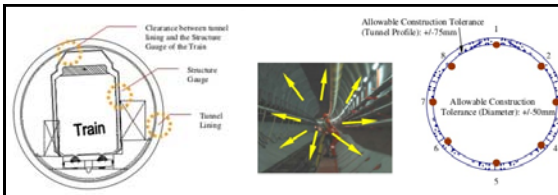
"…The train tunnels are 31 miles long but will cross the channel at its narrowest point, 22 miles from shore to shore. They will be carved through a chalk layer about 130-feet below the channel floor. Double-deck shuttle trains for passenger cars and other shuttles for trucks and buses will cross the channel in 30 minutes - at up to 100 mph…"
Popular Science, May 1986

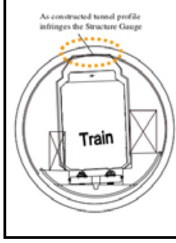
1128



Caption: "Electric shuttle trains will transport passenger cars, truck, and buses to terminals on either side of the channel, while passenger trains will travel between cities in Britain and the Continent. France plans to build special high-speed trains. A 15-ft.-dia. service-ventilation tunnel and two 24-ft.-dia, running tunnels are planned. But final tests must ensure this tunnel size is adequate to accommodate the swaying motion in a variety of train sizes (above). During a shuttle trip you will be able to move about trains, equipped with food and beverage machines."

1129





Above L&R: an eight-point "Wiggle Survey" of the as-built profile of the tunnel lining determines dimensional checks and tolerances of the tunnel diameter
Left T&B: The "Structure Gauge" is the boundary related to the designated normal coordinated axis of the train, which encloses the space for the safe operation of the train (top). No fixed structure/s, including the tunnel lining, should infringe on the Structure Gauge. If the ***Wiggle Survey*** determines that the tunnel infringes on the Structure Gauge (bottom), remediation is called for (i.e. realignment of tracks to fit the as-built tunnel profile).

1130

Almost Impervious

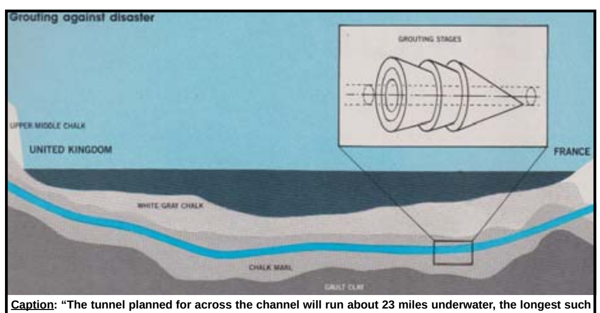
1131

"…Although technology planned for the privately financed project is conventional and engineers know the geology, no one expects the job to be easy. Most of the work will be done by giant moles - tunnel-boring machines with circular cutting faces the size of the tunnel being bored. The giant cutter heads, driven by up to 2,400 horsepower, push dozens of carbon-steel discs against the tunnel face with up to 50,000 pounds of pressure. Fortunately, most of the path planned for the Chunnel project is through a chalk-clay material. 'It's an ideal material,' says Gordon. 'It's easy to bore through and almost impervious to water'…"
Popular Science, **May 1986**

1132

"…Because the chalk-clay substance is almost waterproof, the workers will not have to pressurize the tunnel. 'What we're going to do,' explains senior engineer Colin Kirkland, 'is drive the fifteen-foot pilot, or service, tunnel several kilometers ahead of the other tubes. About every hundred and fifty feet we'll stop and probe ahead another hundred feet to find out if there are any areas likely to cause problems.' If faults are detected, holes will be bored into the rock and injected with a cement-like grout to seal and strengthen the area ahead (see diagram)…"
Popular Science, **May 1986**

1133



Caption: "The tunnel planned for across the channel will run about 23 miles underwater, the longest such run in the world. Tunnels will be some 300 ft. beneath the water surface, creating hazardous tunneling conditions only when fissures are present. That's because most of the system will be bored through chalk marl, a soft rock that is impermeable to water and an ideal tunneling medium. But on the French side, the tunnel must pass through two upper chalk beds that are fractures, Cave-ins produced by water under high pressure could be disastrous to workers boring the tunnel. To minimize this danger, a technique called grouting will be used to strengthen the ground: In one grouting technique, small angled holes are drilled into each side and above and below the tunnel face. A mixture of cement and other chemicals, such as sodium silicate, is pumped into these holes under pressure. The grout penetrates tiny cracks and quickly hardens, forming a series of protective cones as the boring advances. The diameter of this protective curtain is varied according to the strength of surrounding material."

1134

"…'At the same time we'll drive a fan of holes from the pilot tunnel into the path of the other two tunnels and similarly study the ground and pre-treat it where necessary,' says Kirkland. As the tunneling machines advance, the cylindrical hole left behind will be lined with either concrete or cast iron, depending on conditions…"
***Popular Science,* May 1986**

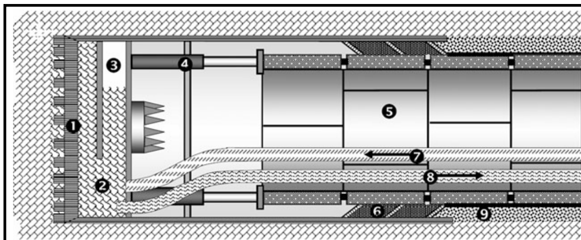
1135

All According to Plan

1136

"…Drilling problems for the French are more complex. Unlike the British, they must tunnel through water-filled fractured layers of rock to reach the chalk-clay tunneling layer below. Says Jean Renault, director general of the French construction team: 'We have a good idea of what we're going to meet and have planned our methods accordingly'…"
***Popular Science,* May 1986**

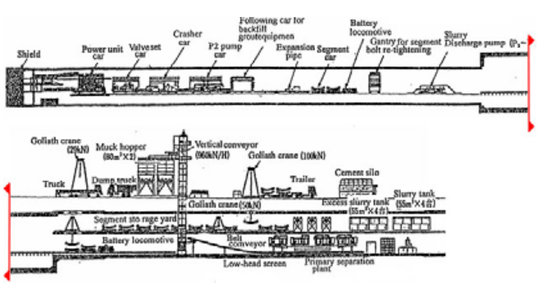
1137



❶ Cutterhead ❷ Bentonite Slurry / Soil ❸ Air Bubble
❹ Thrust arms ❺ Segments ❻ Tail sealant
❼ Bentonite Slurry Feed ❽ Bentonite Slurry/ Soil Return ❾ Annulus Grout

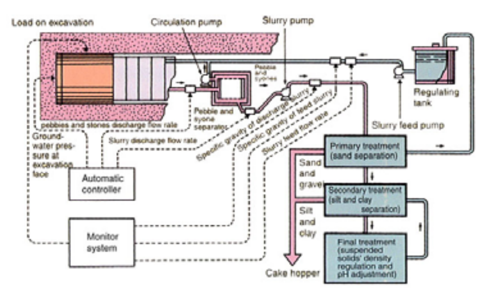
"…The first part of this strategy is to use a different kind of tunnel-boring machine. The French have been negotiating with Japan's Kawasaki to obtain machines with full-face pressure shields: These develop a powerful localized pressure with a slurry or other materials to counteract water pressure at the drilling face…"
***Popular Science,* May 1986**
<u>Above</u>: caption: "Schematic Representation of a Slurry-Type Shield Tunnel Boring Machine (TBM)"

1138



Section View of the Site Utilization for the Slurry Type TBM

1139



Slurry Type TBM: Slurry Circulation System

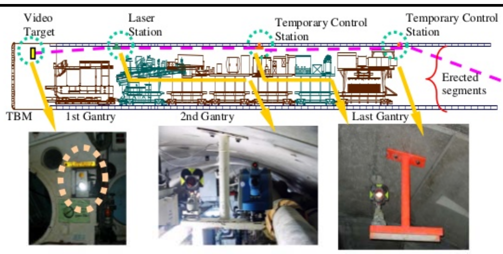
1140

Meeting in the Middle

1141

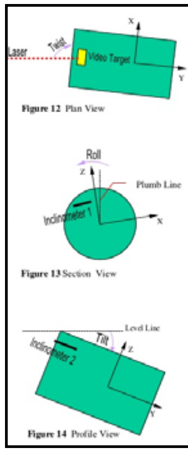
"…How do you ensure that French and British workers starting 31 miles from each other will meet in the middle of the channel? Lasers will play a key role from start to finish, said project engineers I talked with. The trick is to lay out survey lines across the channel above ground, then use these to align lasers that help steer the drilling machines…"
Popular Science, **May 1986**

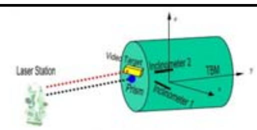
1142



"…Because a laser beam is perfectly straight and spreads very little over many miles, it has become a useful tool for guiding tunnel-drilling machines. Normally, the drill operator watches where a laser beam falls in front of the tunneling machine after it passes through a set of cross hairs in the rear. The operator keeps the beam centered by adjusting support legs as drilling progresses…"
Popular Science, **May 1986**
<u>Above</u>: caption: "The Laser Station carries the coordinates from the control station; shot the prism target affixed to the bulkhead of TBM to determine the absolute spatial coordinated (x, y, z) of the TBM at that point. The tunnel guidance system and the dual axial inclinometers simultaneously measured the amount of rotation along the three perpendicular axis of the TBM to determine the orientation of the heading of the machine."

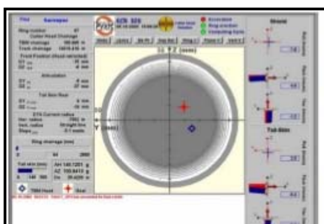
1143

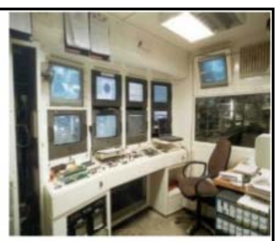


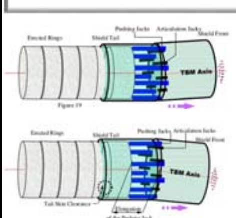


"…But clouds of dust and strong vibrations make this centering job tough. So automatic-steering systems have been developed in which the guiding laser beam hits a light-sensitive panel of photodiodes. A micro-computer in the system then calculates the machine's position to within a few inches and makes necessary corrections. 'With lasers,' says John Taberner, engineering director of the British tunnel group, 'you can have a tolerance of, say, two centimeters whether you're going one mile or ten miles'…"
Popular Science, **May 1986**
<u>Above</u>: caption: "The mechanism of data acquisition of the Tunnel Guidance System"
<u>Left (top-to-bottom)</u>: caption: 'Plan, section and profile view of Tunnel Guidance System"

1144

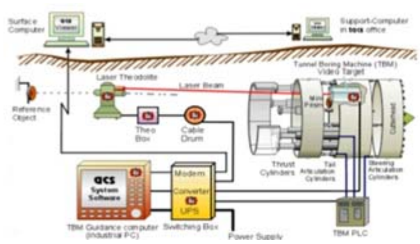






<u>Above L&R</u>: caption: "The system linked to the TBM control cabin (right) where on the screen the positional deviation of the TBM with the Design Tunnel Axis was displayed (left) instantaneously in graphical and numerical formats at all times to aid the pilot to steer the machine"
<u>Upper Left</u>: caption: "The extension of the Articulation Jacks allows the TBM to turn flexibly and advance forward in the direction of the design tunnel axis"
<u>Lower Left</u>: caption: "The elongation of all pushing jacks and the shield tail clearance are measured by sensors and sent to the computer to derive the position of ring just erected"

1145



Processing of Captured Data of a Moving TBM

1146

Y2K or Bust

1147

"…One unresolved problem of the project involves drive-through automobile tunnels. The current plans don't call for any; all vehicles travel on special shuttle trains. But the agreement between the British and French governments says that the tunnel group must build a car tunnel before the year 2000 or lose its monopoly…"
***Popular Science,* May 1986**

1148

"…Whether that can be done is uncertain. The tunnel group studied a drive-through tunnel and concluded that - at least for now - it isn't feasible. There are two reasons. First: 'A road tunnel with sufficient safety for two lanes must be in excess of thirty-three feet in diameter,' says Kirkland. But the chalk tunneling layer thins near the center on the French side, so tunnel walls may not have enough structural support overhead, or be too close to the soft clay layer below…"
***Popular Science,* May 1986**

1149

"…Second, technology can't yet overcome the smog caused by vehicles moving at slow speeds for safety. 'You would have to have massive injections of air into the tunnel that would result in winds of some seventy miles per hour,' explains Gordon. Still, the tunnel group plans to probe the thickness of the chalk layer as the Chunnel is built to see whether it could support 33-foot car tunnels. 'We could also pre-treat the ground as we go through this time,' says Taberner. 'Then the decision to build a road tunnel could be made later on the basis of available traffic.'"
***Popular Science,* May 1986**

1150

Part 18

Ready, Set, Dig!

1151

All in Readiness

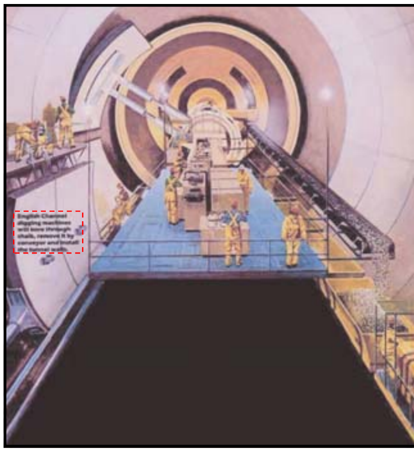
1152

The equipment is ready and digging starts soon on the tunnel that will connect England and France
Popular Mechanics, **September 1986**
RE: introduction to an article written by *Frank P. Davidson* entitled: "England's French Connection"

1153

The Juggernaut

1154



"The juggernaut moves along ponderously, chewing out the inside of the White Cliffs of Dover and splitting chunks of rock into a conveyor behind it. The machine is huge, but the most impressive part is a simple device in the nose end, a 15-yard-diameter hydraulic razor with dozens of modular ceramic teeth that nibble at the chalk beneath the English Channel…"
Popular Mechanics, **September 1986**

1155

1156

A Shared Dream

1157

"…Some 40 years ago, this scene was a dream shared by myself and a handful of men interested in macro engineering - the creation of huge public works projects. But now that dream is a reality. The long-awaited English Channel Tunnel will soon be under construction. The 30-mile tunnel, slated for completion within nine years, has a projected price tag of $3 billion or more, depending on inflation…"
Popular Mechanics, **September 1986**

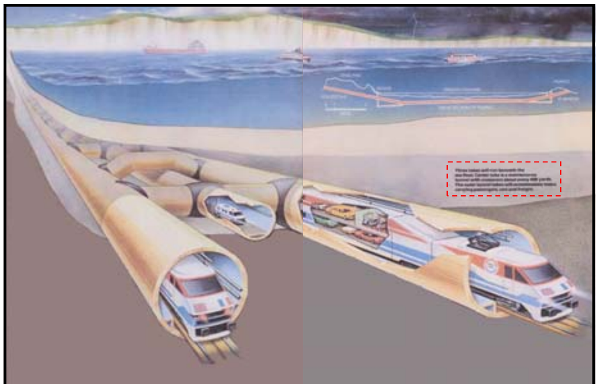
1158

The Channel Subway

1159

"…You may have in your mind's eye the image of a tunnel filled with autos, buses and trucks, but the designers have opted for something swifter - a 3-tube tunnel that I call the Channel Subway. The center tube will serve as a service tunnel with crossovers to either side spaced some 400 yards apart. The two outer tunnels will carry rails for trains running in opposite directions. Trains clattering through the tunnel at high speeds will carry motor vehicles piggy-back on railroad cars. Passengers sitting in the forward part of the train will load and unload their vehicles at terminals in Calais, France, and Dover, England…"
Popular Mechanics, **September 1986**

1160



Caption: "Three tubes will run beneath the sea floor. Center tube is a maintenance tunnel with crossovers about every 400 yards. The outer tunnel tubes will accommodate trains carrying passengers, cars and freight."

1161

"…The spectacular 'Chunnel' will allow travelers to go from London to Paris in 4-1/2 hours, about the same time it takes to fly, including trips to and from the airports. Only now, the travelers won't care about the frequent drizzle and fog that grounds commercial aircraft. Later, when France's high-speed rail system is extended all the way to London, the trip will take 3-1/2 hours…"
Popular Mechanics, **September 1986**

1162

Geologically Speaking

1163

"…Europe has long considered the value of an English Channel tunnel, but only in the last couple of years have all the roadblocks been cleared away. More than 3,000 automobiles will be transported each hour through the tunnel that will be bored as 15 miles below sea level through the chalk between the British and French cliffs. Geological studies have shown that the makeup of the channel is perfect for the tunnel. In prehistoric times, a land bridge linked the two sides. As the earth shifted and the channel widened, it became submerged. The result is a channel floor of continuous chalk from England to France. The porous material is relatively easy to cut and remove as construction progresses…"
Popular Mechanics, **September 1986**

1164

The End Result

1165

"…The construction methods will be nothing short of ingenious. Trial tunnels were excavated from 1973 through 1975 on the British and French sides. Each country uses different equipment and different sealing methods running from the opposite ends, but the end result is designed to meet at the channel's mid-point beneath the chalk floor…"
***Popular Mechanics*, September 1986**
Left: caption: "Workmen drag cables out of the French trial tunnel that was completed in 1974"

1166

Trial and Error

1167

"…The British trial tunnel was dug with a special machine built by the Robert L. Priestly Co. Its head cuts at a top speed of 4-1/2 rotations per minute and could be turned in either direction. Behind the head of the locomotive-like machine is a system of conveyors and erectors. The pieces cut chalk fall to the ground as the hydraulic-driven cutter-head turns. They are then scooped up in buckets behind the head. These buckets dump the chalk into conveyors that carry the waste to small boxcars on rails…"
***Popular Mechanics*, September 1986**

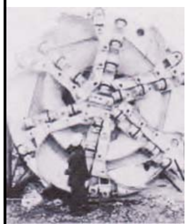
1168

"…Also behind the head is the erector system, which uses hydraulic jacks to place preformed, reinforced concrete segments against the cement-grouted wall of the tunnel. At a few points on the British side, engineers expect to find weak chalk formations or water leaks. Instead of reinforced concrete, the tunnel linings at these points will be made with preformed cast-iron, ready to set in place against a grouting. These cast-iron linings would later be bolted and coated for reinforcement…"
***Popular Mechanics*, September 1986**

1169

"…The trial tunnel finished on the French side in 1974 encountered a slight variation on the geology. There was a great deal of water seepage in parts of the tunnel. The French will line their side entirely with spheroidal cast-iron plates. The special iron is highly ductile, so it has a little give. It also is extremely strong. Bolts and a special adhesive will hold the French wall coverings in place…"
***Popular Mechanics*, September 1986**

1170



"…The French machine used in the trial tunnel phase was built by Robbins Engineering of Seattle, Washington. It works in almost the same way as the British model, but the cutting head is slightly more convoluted in anticipation of harder rock formations…"
Popular Mechanics, September 1986
Left: caption: "The cutter head on the Robbins machine features replaceable ceramic 'teeth'"

1171

"…When construction begins by the middle of next year, the Channel Tunnel's dimensions may be inches different from that of the trial tunnel. Also, since the original work was completed in the 1970s, equipment advances have changed some of the construction methods. Thus, the Channel Tunnel agency is letting out bids for new contracts, and companies other than Priestly and Robbins may bring in new equipment…"
Popular Mechanics, September 1986

1172

The Back Burner

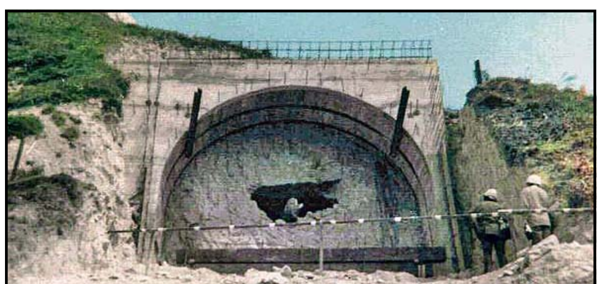
1173

"…Prior to the current Channel Tunnel agreement, England and France signed a tunnel treaty in 1972. On the eve of the third and final reading of the treaty in the British Parliament, Prime Minister Harold Wilson became worried about his nation's financial liability for railroad and other improvements. So the plan went on the back burner…"
Popular Mechanics, September 1986

1174

Risk Management

1175



"…The trial tunnels were sealed pending further developments. The Britons even sprayed the dusty construction roads leading to the site with a cement mixture to preserve the contour of the roads. The revived plan largely leaves the two governments out of the system's financing. The governments are guaranteeing construction bonds, but the money is to be raised by the private sector and the tunnel is to be run by a private international company…"
Popular Mechanics, September 1986
Above: caption: "Tunnel breakthrough at the base of Shakespeare Cliff in 1973. Construction workers stand back as the chalk beneath the concrete archway is breeched."

1176

New and/or Improved

1177

"…A forthcoming proceedings book from a Massachusetts Institute of Technology and Macro-Engineering Research Group symposium suggests several interesting construction methods that will be considered before next year. Among them is a method suggested by J. Vincent Harrington and myself to submerge caissons to permit digging from the middle of the channel outward in both directions. This could cut construction time by a year or more…"
***Popular Mechanics*, September 1986**

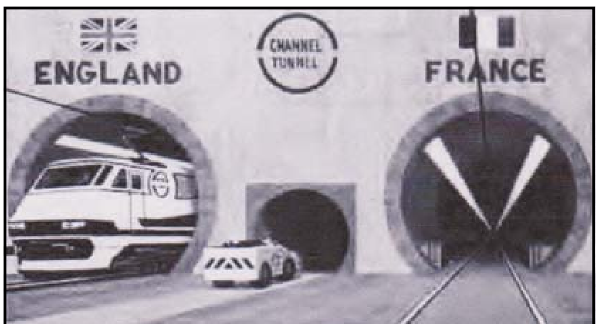
1178

The Final Result

1179

"…However construction takes place, the final result will be a 3-tube tunnel. Inside the tunnel, trains will move at a steady rate five minutes apart. No reservations will be needed. Passengers in a hurry will be able to take advantage of a drive-on, drive-off system behind the lead cars of each train. Those who have extra travel time will be able to leave their cars and go forward to air-conditioned refreshment parlors in the front. The train's cars will be soundproofed and comfortable…"
***Popular Mechanics*, September 1986**

1180



"…Between the terminal at Cheriton on the Dover side and Frethun on the Calais side, the trip will take about a half hour, traveling at speeds up to 80 mph. Freight will also move through the tunnel in special cars that open at the rear, allowing a tractor-trailer to drive-in, and close again for the trip…"
***Popular Mechanics*, September 1986**
Above: caption: "Artist's concept shows design of tunnel entrances and lighting arrangements"

1181

1182

Special Measures

1183

"…A publication of the Channel Tunnel Group promises that 'special measures will be introduced to forestall or deal with terrorism or sabotage.' Since the tunnels are bored through the rock, rather than constructed atop the sea floor, they are considered less subject to sabotage than traditional tunnels…"
***Popular Mechanics*, September 1986**

1184

Yes, it Will

1185

"…Will the tunnel pay for itself? The answer is yes, and almost immediately. Employment generated by the tunnel construction is expected to have a significant impact on the British and French economies. But once the tunnel opens, revenue is expected to be even more impressive. One study suggests that the tunnel will generate upwards of $1 billion a year in revenue from passenger and freight. That is based on a 1-way ticket tariff of $50 per passenger and about $20 per ton of freight…"
***Popular Mechanics*, September 1986**

1186

Tangential Benefits

1187

"…More importantly, the English Channel Tunnel is expected to generate billions of dollars a year in new trade and tourism. The economic and strategic value of the tunnel has never been seriously questioned. Only international politics have stood in the way of completing this great project…"
***Popular Mechanics*, September 1986**

1188

"…The French proposed channel tunnels in 1802 and 1804, the latter being Napoleon's idea for the conquest of England. In 1880, British engineer John Beaumont dug an exploratory tunnel on the Dover side with a machine he invented called the mole. The tunnel was never completed, but it was dug hundreds of feet beyond the English shore. Beaumont's tunnel was used in 1973 to monitor ground shifting and other problems that might have arisen during the digging of the new trial tunnel. His mole machine became a major tool of mining and tunneling…"
Popular Mechanics, **September 1986**

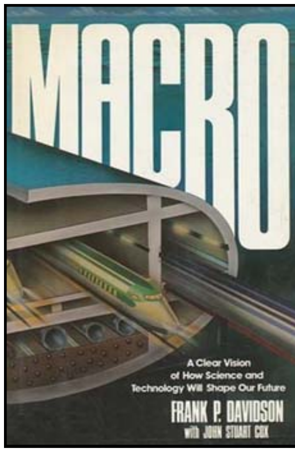
1189

"…The current tunnel design is so well formulated that everything is ready to go once the funding is in place. Since the trains will use electric overhead lines and pantographs, they will actually become an environmental asset. To complete the London-to-Paris run, no new tracks will have to be placed except inside the tunnel itself…"
Popular Mechanics, **September 1986**

1190

Present and Future

1191



"…In my book 'MACRO, A Clear Vision of How Science and Technology Will Shape Our Future' (William Morrow, 1983), I proposed the use of a tunnel for ultra high-speed magnetic levitation train lines. These could travel safely at record-breaking speeds once air was evacuated from the tunnel. An air supply inside the train would be needed for passengers. The advantage of an evacuated tunnel is that there would be almost no friction produced by the movement of the maglev train. The proposal has been given some serious discussion, but maglev developments are still something for the future. For the present, 80 mph seems to be fast enough for most travelers…"
Popular Mechanics, **Sept. 1986**

1192

"…Earlier proposals for the Channel Tunnel called for motor vehicles to move through it as in any other tunnel. This idea was discarded for environmental, efficiency and safety reasons…"
Popular Mechanics, **September 1986**

1193

"…It has been about 40 years since an article in POPULAR MECHANICS and a trip across the English Channel gave me the inspiration to work for the building of this project. Now that the dream is about to become realized, I look forward to a time when tunneling methods are so far advanced that even a transcontinental tunnel would be feasible for America."
Popular Mechanics, **September 1986**

1194

Point of Conflict

1195

Channel Hassle

The British and French are taking turns walking out in a huff from meetings over the Chunnel these days. The point of conflict: whose high-speed train will go through the under-the-channel tunnel. The French want that honor to go to the 186-mph TGV – *train a grande vitesse.* The British, on the other hand, want to use the 140-mph train scheduled for London-to-Edinburgh run. (*Popular Science,* November 1986)

<u>Left</u>: caption: "The Channel Tunnel exhibit at the National Railway Museum in York, England, showing the circular cross section of the tunnel with the overhead line powering a Eurostar train. Also visible is the segmented tunnel lining."

1196

Financiering

1197

Channel Update

The financial underpinnings for one of this century's most ambitious public works projects – the high-speed rail tunnel linking England and France – is taking shape, according to Frank P. Davidson, author of PM's recent "chunnel" feature (*England's French Connection, Sept. '86*). Davidson reports that the consortium has raised an initial 206 million pounds sterling of equity. While the English and French governments are not guaranteeing construction bonds, a bill to ratify the Channel Tunnel cooperation treaty has passed its second reading in the House of Commons and is now working its way through the House of Lords. The final reading of the bill is expected soon. Ratification of the treaty will trigger an equity offering on the world's stock exchanges totaling 750 million pounds. Once the equity issues have been sold, about 40 major banks worldwide are expected to provide the approximately 5 billion pounds sterling it will take to carry out the project. Envisioned since the time of Napoleon, the tunnel complex will run approximately 100 meters below sea level at its deepest point, with rock thickness above it varying between 27 meters and 40 meters. Two rail lines – with interconnecting service tunnels – will transport people, autos and truck freight between London and Paris in 4½ hours. (*Popular Mechanics,* June 1987)

1198

This Wretched Project

1199

"Hundreds of French and British engineers are gearing up for a brutally hot, humid and deafening grind that promises to fulfill a centuries-old dream - a tunnel beneath the English Channel. If they emerge as planned in the early 1990's, high speed shuttle trains will link Britain to the continent of Europe; travelers from downtown London might eventually reach downtown Paris in three hours…"

***The New York Times,* October 6, 1987**

1200

"…The tunneling effort, tentatively scheduled to begin Dec. 1, involves complex engineering and logistics with brute force on a grand scale. Giant tunneling machines have been specially designed for the geology beneath the channel floor and engineers have devised new ways to prevent the tunnels from flooding during construction. Engineering advances have made the job 'not such a great tunneling challenge as it was,' said Colin Kirkland, technical director of Eurotunnel, a consortium formed by French and British banks, which will finance and operate the system. But Mr. Kirkland, who said he first worked on 'this wretched project' in an aborted effort in the 1950's, added, 'The intricacies of the engineering are humbling'…"

***The New York Times*, October 6, 1987**

1201

"…Nearly $10 billion will be required to finance the tunnels, terminals, track and specially designed double-deck trains that will shuttle cars and truck. Much of the financing is in place, although the consortium plans a crucial $1.2 billion stock offering in November. Still, on both sides of the channel there is little doubt that this time the project will go forward. Transmanche-Link, a corporation that has designed and will construct the tunnel, has already fashioned a huge access shaft at Sangatte, near Calais, France. The shaft is 55 meters in diameter and 70 meters deep…"

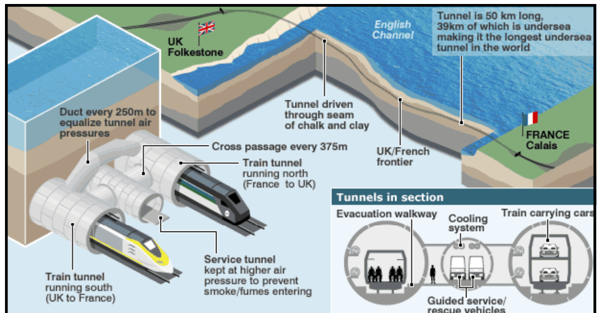
***The New York Times*, October 6, 1987**

1202

"…Eleven tunnel boring machines, the most complex of which are 1,300-ton behemoths costing as much as $42 million a pair, will take more than three years to complete their work. In the process, 7.8 million cubic meters of soil - enough to build three more Great Pyramids of Egypt - will be hauled to the surface. Some 700,000 concrete and cast iron modular segments will pour off assembly lines in Britain and France to line the tubes…"

***The New York Times*, October 6, 1987**

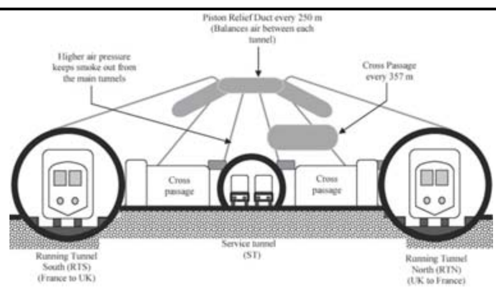
1203



"…The channel link will actually be three parallel tubes, one for service and two for trains, each 52 kilometers long, running from a terminal near Folkestone, England, to another near Calais, France. European railroads would pay Eurotunnel for the right to send their trains through the tunnel. Eurotunnel itself will operate shuttles carrying cars, trucks and other commercial vehicles. These shuttles might depart as often as every six minutes in peak periods. The trains will run will through two main tubes; a narrow service tunnel will run between them for ventilation, maintenance and escape…"

***The New York Times*, October 6, 1987**

1204



"…A series of ducts, which Mr. Kirkland called a first in modern tunneling, will connect the two main tubes every 250 meters. These will relieve the air pressure that builds up in front of a train going through a tunnel, he said. When two trains pass in opposite directions, dampers at the ends of the ducts will close. Air-pressure in the service tunnel will be kept higher than in the main tunnels to keep it free of smoke or fumes if trouble develops…"

***The New York Times*, October 6, 1987**

1205

"…Not until 1955 did the British formally drop their defense-related objections, and in 1957 the Channel Tunnel Study Group, an Anglo-French consortium, was born. Mr. Kirkland, then in his early 20's, joined the engineering staff. The project, advancing in fits and starts, was dropped in 1975 as an economy move by Britain. Mr. Kirkland went on to other tunnel projects…"

***The New York Times*, October 6, 1987**

1206

"…Much of the optimism about this tunnel attempt rests on the geology of the English Channel, which Mr. Kirkland said 'lends itself beautifully to today's tunnel boring machines. We've got this benign, beautiful rock stratum nearly all the way across the channel,' Mr. Kirkland said. The channel floor is formed of a relatively soft variety of limestone called chalk marl, which Mr. Kirkland said 'is beautiful stuff to cut.' The faults and joints are tight, and water seepage is rare…"
The New York Times, **October 6, 1987**

1207

"…If all goes as planned, the first tunnel boring machines or 'T.B.M.'s' will be lowered piece by piece into a shaft near Folkestone this winter. Others will follow at the base of the Sangatte shaft. The electricity-driven machines will be assembled and sealed into the rock face. Then, in stages, tunnels on each coast will be bored inland toward the terminals and seaward. The Robbins Company of Kent, Wash., is designing Eurotunnel's most complex drilling machines in joint ventures with Kawasaki Heavy Industries Ltd. of Tokyo and Markham & Company, a British concern…"
The New York Times, **October 6, 1987**

1208

"…Modern surveying technology makes it 'a certainty' that the tunnels from England and France will be no more than 10 inches out of alignment, Mr. Kirkland said. Each drive will be started from the surface using ordinary optical surveying techniques. Underground, lasers fixed to the tunnel wall will line up with reference points backward to the surface and forward to a target at the rear of each tunneling machine. Computers on the tunneling machine analyze laser readings and instantly correct any drift as the machines' rotary cutters slice and chip the chalk…"
The New York Times, **October 6, 1987**

1209

"…Behind each T.B.M. will be a rolling assembly line running back as much as 750 feet. Fist-size chunks of chalk will pass through the cutting head onto a conveyor and land in 'muck cars' that will roll on tracks to the surface. Components to line the tunnel will flow in on a parallel track. We're going to have to run a major freight operation in that tunnel before it's even opened,' Mr. Kirkland said…"
The New York Times, **October 6, 1987**

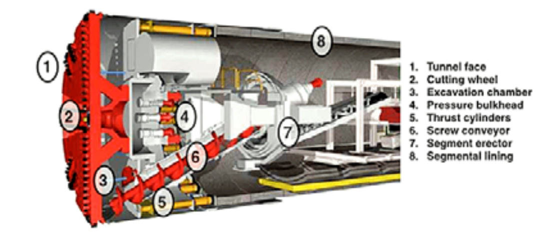
1210

"…Some of the spoil will be used to level construction sites. In Britain, the rest will be poured behind an extended sea wall at the base of cliffs near Dover. In France, a coastal hollow still pitted with World War II bomb craters is being diked to receive a toothpaste-like muck…"
The New York Times, **October 6, 1987**

1211

"…Boring near the French coast is expected to present the greatest challenge. There, the chalk marl plunges away from the tunnel path, leaving the machines to slice through five kilometers of a highly fractured chalk laden with water under pressure…"
The New York Times, **October 6, 1987**

1212



"…Recently designed boring machines will swallow the wet chalk and form a slurry behind the cutting head to counteract water pressure at the front of the cutter. These 'earth-pressure balance machines' did not exist when the last channel tunnel project was begun in 1973, then aborted by Britain two years later in an economy move. Since then, similar machines have cut 'wet rock' projects in Japan and subway tunnels in Lyon, Frankfurt and Washington, Mr. Kirkland said…"
The New York Times, **October 6, 1987**
Above: caption: "Cross-sectional diagram of an Earth pressure balance (EPB) TBM"

1213

"…The cutter head on the Robbins-Kawasaki T.B.M.'s will have 49 steel rolling disks and 236 picks. The disks slice the rock and the picks chop off chunks and flick them backward. In wet rock the boring machines will thrust forward off of the edge of the tunnel lining and off hydraulic 'gripper pads' jutting out like stubby legs from the sides of the machine…"
The New York Times, **October 6, 1987**

1214

1215

"…Running round the clock, Eurotunnel's T.B.M.'s are expected to advance at an average rate of about 1.5 meters an hour. On the Robbins machines, the spoil will be pushed backward by a screw spiraling backward, moving chunks of chalk to a conventional conveyor…"
The New York Times, **October 6, 1987**

1216

"…Even the machines that will drive through part of the drier British rock can be sealed off if water is encountered. An operator hits a 'panic button' and a shield encloses the face of the machine in less than a minute…"
The New York Times, **October 6, 1987**

1217

"…Robbins is producing T.B.M.'s that can work quickly in dry rock or extend a shield, like a hollow tin can, over the rotating cutter in wet rock. Other machines for the project have been designed by James Howden & Company of Glasgow…"
The New York Times, **October 6, 1987**
Above: caption: "Howden TBM in manufacture for the UK Service Tunnel heading"

1218

"…Another Tokyo concern, Komatsu Ltd., is providing a special technique for the 'wet-ground' machines to keep water outside the shield. Rubber seals would wear too so the rear edge of the shield will be wrapped with a series of narrow steel brushes much brush fabric one might use to insulate the edge of a door. The brushes will be surrounded by a petroleum-based substance for waterproofing…"
The New York Times, October 6, 1987

1219

"…The service tunnels are scheduled to meet in late 1990. The last 50 meters will be bored with hand-held drills to 'close the survey.' Once sight lines are established, the T.B.M.'s will be steered manually toward each other with the 'tin cans' extended. The cans will remain buried, the boring machines disassembled and the last lining segments erected."
The New York Times, October 6, 1987

1220

Part 19

Macro Engineering

1221

Fantastic Journey

1222

Giant tunnel-boring machines longer than two football fields are grinding the world's longest underwater tunnels between England and France. Climb aboard for a breathtaking ride.
Popular Science, June 1990
RE: introduction to an article written by *Robert Gannon* entitled: "Journey Down the World's Longest Underwater Tunnel"

1223

"ON a clear night, from a second story room at Gill Pratt's Bed & Board in Folkestone, England, you can see the 'Varne Light Ship' flash every 20 seconds, nine miles out across the English Channel. Put yourself a mile beyond it. Now, if you can, imagine plummeting down through 200 feet of water to the sea floor. Now go down through another 100 feet of muck and chalk. Just about there, right now, three giant metal moles - tunneling machines hundreds of feet long - are eating their way toward France. Another trio, off the French shore, are chewing their way toward England…"
Popular Science, June 1990

1224

__Above__: caption: "Trade and Industry Secretary Lord Young (centre) presses the start button on the tunnel boring machine in the south marine running tunnel at Dover, watched by Richard Lewis (left), of the machine's manufacturer, Robins Markham. May 6, 1989."

1225

TML

1226

"…Possibly as soon as December, two machines boring the middle tunnel will meet. Napoleon's dream of being able to ride a horse from France to England will finally have come to pass. At something in excess of $12 billion, the Chunnel is by far the most ambitious European civil engineering project ever. Its owner is Eurotunnel, a privately owned Anglo-French corporation, and the builder-contractor is TransManche-Link (TML) a consortium of 10 major construction companies…"

Popular Science, **June 1990**

RE: in April 1985, the British and French government/s invited proposals for the construction of a fixed-link between the two countries to be privately funded. In January 1986, the two governments selected the *Channel Tunnel Group/France Manche* proposal for the construction of the subaqueous link. On February 12, 1986, the two governments signed the *Treaty of Canterbury,* approving construction of the Channel Tunnel. In March 1986, the *Concession Agreement* (for the operation of the tunnel) was authorized to the *__C__hannel __T__unnel __G__roup* (CTG) and *__F__rance __M__anche* (FM). Thereafter, CTG was subsumed by the newly formed *Eurotunnel plc* and FM was similarly replaced with *Eurotunnel SA,* together forming the *Eurotunnel Group*. In July 1985, the British contractors formed *Trans-link Contractors* and the French consortium formed *Transmanche Construction*. On October 18, 1985, these two groups were merged to create *__Trans____M__anche __L__ink* (TML). TML was thus contracted to build the tunnel for its customer; *Eurotunnel,* who would own and operate it.

1227

Leave the Driving to Us

1228

"…At 32.2 miles (23.7 of it beneath the seabed), running between a terminal near Folkestone to another near Calais, these will be the longest underwater tunnels in the world. You won't be able to drive through. But when it opens, in June 1983, you'll drive __into__ a two-level electric train; it will run every 10 minutes. Then at 75 mph, you'll be whisked under the channel in a half hour. When new highways leading to the tunnels are completed a few years later, you'll be able to go from London to Paris in your car in four hours. That's not much longer than it takes to fly…"

Popular Science, **June 1990**

1229

On the Dover Side

1230

"…To get a better idea of the project, early this year, just outside Dover, I cleared four layers of security, donned a hard hat, rubber boots, and a smock, and strapped on an ominous self-rescuer emergency breather. Then, in an open double-tiered elevator, I dropped down into the earth through one of the coast's white cliffs, down 39 stories to the bowels of the British operation…"
***Popular Science,* June 1990**

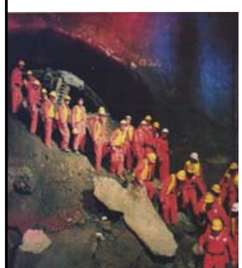
1231

Dante's Inferno

1232

"…In a mishmash of sprayed concrete caverns, there are humping, segmented trucks that lurch - gnashing and churning. There are muck-carrying trains that lumber past with beeps and squeals. There are grinding conveyor belts, dragging out chalk spoil under your feet, beneath metal floor grates. And all around grow sinewy tubes and pipes and cables, tentacle tight to the ceiling. From somewhere deep in the psyche slithers a memory, a nightmare of an eight-year-old who somehow found himself in the entrails of a dragon…"
***Popular Science,* June 1990**

1233



"…The shift is changing. Workers, all in startle orange jump suits, shout to be heard in dialects of Irish, Welsh, and Scottish. They cough a lot. Except for those suits, all color down here has dulled to gray, layered with dust from the tunnel work faces, now miles away…"
***Popular Science,* June 1990**
Left: caption: "Workers, brightly clothed for visibility in heavy dust, file to work some 300 feet beneath the English Channel"

1234

"…Despite huge ventilation pipes, the chalky air, laced with diesel fumes, wafts through the tunnel, dusting your eyes, dimming the lights down the corridors. Three of those corridors stretch toward London. They emerge on the surface at Cheriton, the British terminal. Three more lead out under the channel (later, they'll connect). And two more - adits through which supplies enter and tunnel tailings leave - slice at an angle slanting upward…"
***Popular Science,* June 1990**

1235

He's Seen it All

1236

"…The south tunnel end is only a mile out so far, and Joe Stacey, Eurotunnel's site construction manager, and I hike the distance in surroundings relatively silent, cool, and empty, except for the trains that carry out tailings. Earlier we had hung our brass dog tags on a display board. At the end of each shift they are checked, a guard explained, 'to make sure as many come out as go in'…"
***Popular Science,* June 1990**

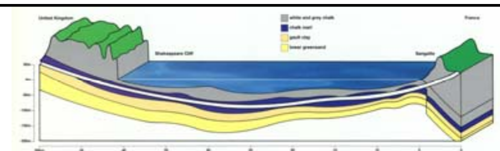
1237

"…Stacey strides with confidence, verve, enjoyment. He likes the tunnel. You can tell. He's comparing it with other tunnels he's worked on, those in Liverpool and Lancaster, in Scotland and Sri Lanka, in Hong Kong and Singapore. He's seen it all - cave-ins and fire and flooding and death - and this job, he says as we adjust our stride to the rail ties, is easy. 'The service tunnel is nine miles out now, and it's going like a train,' he says with some exaggeration…"
***Popular Science,* June 1990**

1238

Two-to-One

1239



"…The reason for the smooth going on the English side is the material: chalk marl - a bluish-gray two-to-one mixture of calcium carbonate and clay, which makes it water impenetrable and soft (1,500 psi compression strength compared with granite's 30,000). That means, one, it's easy to gouge through yet it supports itself, and, two, it holds out the sea. Tunnel expert Frank Davidson, who heads MIT's Macro-engineering Research Group, calls it 'a lovely thing to bore through - the world's best material for tunneling'…"
***Popular Science,* June 1990**
Above: caption: "Channel cross-section." Before construction of the Channel Tunnel commenced, extensive geological surveys identified the best route the excavations could take. Consequently, the vast majority of the 50 km of three tunnels lie within a wide vain of *chalk marl,* considered to be one of the most stable and safest of all tunneling mediums, running between 25 and 45-meters below the seabed.

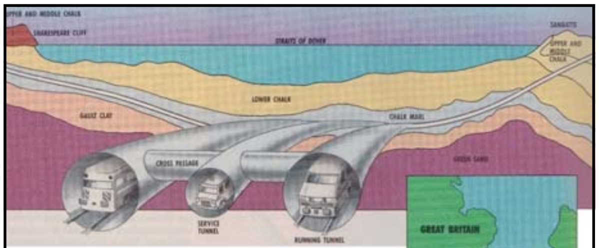
1240

That Means Water

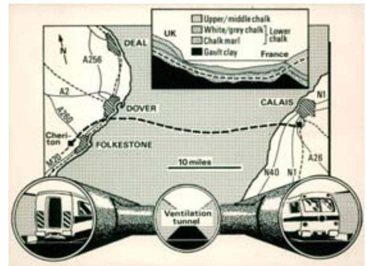
1241

"…The chalk layer we're walking through runs smoothly all the way across the channel, until near the French shore, where it begins to undulate. French tunnelers must contend not only with layers of harder material folded in, but fractures, and that means water…"
***Popular Science,* June 1990**

1242



Caption: "Geological surveys for the Eurotunnel route conducted in the 1960s and '70s revealed that the tunnels could be drilled almost entirely through chalk marl, a soft but watertight English Channel seabed layer. To strengthen some fissure areas, a mixture of cement and clay is injected into the ground. Twin rail tunnels now being bored through this chalk will route passengers and freight in both directions. Shuttle trains will carry road vehicles under the channel. Standard and high-speed trains will link the railway networks on the continent with those in the United Kingdom. Crossovers between these single-track tunnels will enable trains to continue running even if a section in one tunnel is closed for routine maintenance or emergency repairs. Drilling for the rail tunnels is slated for completion next year. Eurotunnel officials worry about fires, but say the risks are small. Almost nothing used in the tunnel will burn or produce toxic fumes. A tunnel section could be evacuated through crossover tunnels. Meanwhile, construction has begun on high-speed rail lines to the capitals. A 145-mph between the tunnel and Paris (1993) and a 180-mph link between the tunnel and London (1998)." 1243



1244

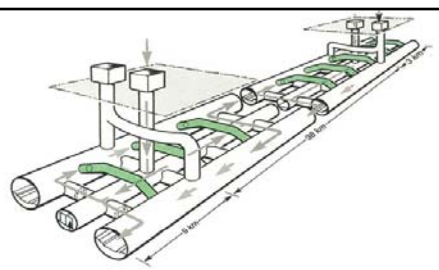
Pressure Relief

1245

"…We pass a seven-foot tube shooting off to the north toward the center service tunnel. It's a cross passage. Such accesses run every 1,200 feet. And there's another kind of cross tube: 'piston relief.' The trains fit the tunnels like pistons, shoving air before them at hurricane force. So every 650 feet, six-foot ducts, dug by hand with jackhammers called air spades, run between two running tunnels to relieve pressures…"

***Popular Science,* June 1990**

<u>Above</u>: caption: "Pressure relief duct in Channel Tunnel (at left in photograph)" 1246



<u>Above</u>: caption: "Pressure relief ducts in Channel Tunnel to reduce traction power demand of trains (green)." Pressure relief ducts help to reduce the traction power demand in a tunnel. The ducts allow an air-exchange between the tubes. Trains push air though the tunnel due to the piston effect. Because of the pressure relief ducts, the air can bypass the train through the parallel tube. The air does not need to be moved through the whole tunnel thus, the power demand of the trains is substantially reduced. As a result, shuttle trains can be operated with standard locomotives and traction power supply 1247

EMV

1248

"…Through the center 16-foot service tunnel will run electric multipurpose vehicles, not yet designed, to be built by Mercedes-Benz. They'll be rubber-tired, long, and thin, guided by wires embedded in the roadway, and able to run in both directions…"
Popular Science, **June 1990**
Above: caption: "This is one of the specially designed ambulances that service the channel tunnel by accessing the small service tunnel" 1249

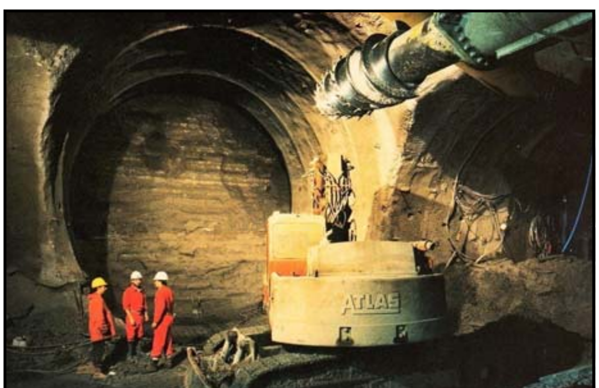
TBM

1250

"…We hop to the side, to a ledge a little way up on the tunnel wall, while a train of flatcars rumbles past. It's delivering tunnel-lining sections to the mole up ahead, and that's where we're going to…"
Popular Science, **June 1990**

1251

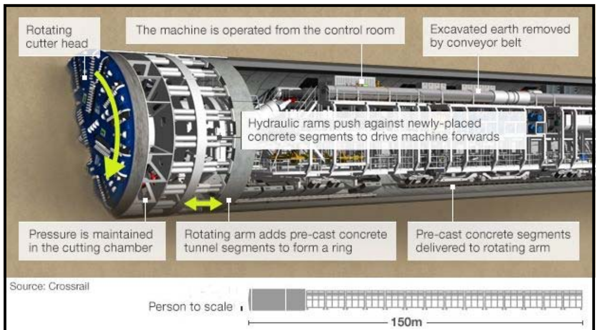
"…This mole - nowadays they call them TBMs, tunnel-boring machines - was built by Scotland's James Howden & Co. Others, of various styles, were designed jointly by The Robbins Co. of Kent, Wash., Markham & Co. of Chesterfield, England, and Komatsu Ltd. And Kawasaki Heavy Industries Ltd. in Japan. In both England and France, the TBMs were lowered down access shafts in massive hunks, then assembled at tunnel level…"
Popular Science, **June 1990**
Left: caption: "Main body of TBM being lowered down into launching shaft" 1252
Right: caption: "Main body of TBM at bottom of shaft"



Above: caption: "Tunnel Workings at Lower Shakespeare Cliff Site, May 1988. The machine pictured excavates the chambers in which landward and seaward boring machines will be installed." 1253

"…As we near the rear of this TBM, the temperature rises a dozen degrees. Heat is generated by electric motors, by metal grinding on metal, by the raw friction of metal claws ripping into rock. We climb up on a gantry walkway and make our way forward over humming metal grating. We're in an erector-set cage that stretches 663 feet back from the work face. Around us the sound intensifies and the air thickens. Here the level of dust reaches sandstorm proportions. It grits our mouths, lines our throats…"
Popular Science, **June 1990**

1254



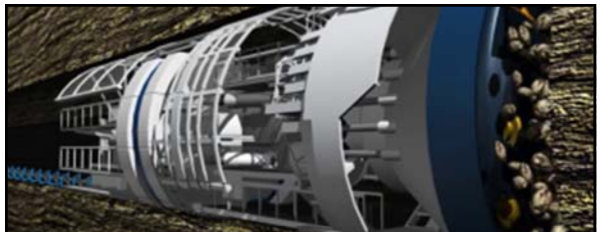
"…Finally, just this side of the tunnel end, smack in the gizzard of this $15.5 million machine, amid the clanks, clatters, and 'foofs' of escaping air, I stand surrounded by walkways and conveyors, by wires and tubes, and I look toward France. It's a long way…"
Popular Science, **June 1990** 1255
<u>Above</u>: caption: "Cut-away view of a TBM"

"…The scale of this whole project is too immense to comprehend easily. After the TBMs have bored more than 10 million cubic yards of chalk marl from the seabed and these tunnels are completed, some 85,000 passengers are expected to speed through them daily…"
Popular Science, **June 1990**

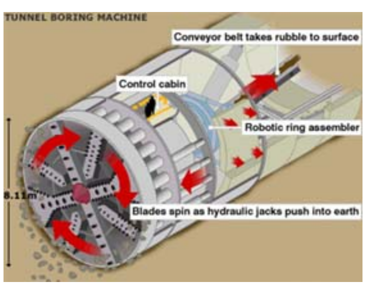
1256

"…At the south tunnel face, the TBM is moving forward now, hauling along its massive hulk. But it does so barely perceptibly. It takes five minutes to go one foot. The faceplate grinder, 27-1/2 feet across, is quiet. The TBM either grinds the rock or hunches forward, but not both at once…"
Popular Science, **June 1990**

1257



"…When boring, the whole machine is held fast by powerful hydraulic 'grippers' pressing outward, hunched against the tunnel sides. As the face digs into the wall, other cylinders, pushing back against newly emplaced tunnel lining, ram it forward. Then, after it's burrowed ahead five feet or so, the head pulls back, the grippers pull in, and the back-pushing rams slowly press the TBM and its gantry forward. All 1,500 tons of it…" 1258
Popular Science, **June 1990**



1259

"…Guidance is by laser, with a system so accurate that when the tunnels meet they should be off by less than a foot. The gun rests about 1,000 feet back from the TBM cab, bracketed to a wall. It points forward, firing through 1/4-inch holes in two equidistant plates, to a target of photodiodes on the cab. When the spot moves off center, a microcomputer system adjusts those rams…"
Popular Science, **June 1990**

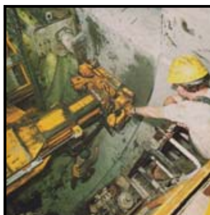
1260

"…When the grinding face is pulled away from the tunnel end so that worn teeth can be replaced, if you carefully climb forward you can glimpse the chalk marl, the color of dirty tennis shoes. It looks awfully solid. It's grooved like a target, dug out by 236 tungsten-carbide gouging bits on the grinding plate. They form a star pattern on the machine's face - like a colossal sand dollar…"
Popular Science, **June 1990**

1261

"…Back in bore position finally, the massive cutting disc begins to rotate, slowly revving to its maximum of 3.3 rpm. It grinds out the chalk in fist-size hunks that are scooped up and dumped onto a conveyor leading through the TBM's innards to its rear. There, in a dust bowl of swirling grit, the chalk dumps into small boxcars to be shuttled off…"
Popular Science, **June 1990**
Left: caption: "One of the tunnel-boring machines used for the chunnel is assembled. The huge cutter head grinds rock into a long conveyor-belt system."

1262



"…As the waste rumbles out, precast concrete tunnel sections ride in. They're hard (12,000 psi, four times the compression strength of standard bridge concrete) and smooth. Run your finger along their surface and they feel like marble. They vary in thickness from 6.5 to 20 inches and weigh up to nine tons each. 'It depends on the maximum possible overburden pressure,' explains Stacey. 'We say, how far is it to the surface of the water? And then determine the strength as though the overburden were mud.' The crescent cement slices are set into place by five men directing hydraulic lifters with hand-held switch boxes. The last section is a shaped keystone, shoved snugly into place by one of the rams. The tunnel diameter shrinks to 24 feet…"
Popular Science, **June 1990**
Left T&B: caption: "Hydraulic lifters and rams built into TBMs press curved concrete wall sections into place (top). As TBMs advance, electrical cables are mounted on tunnel wall (bottom)."

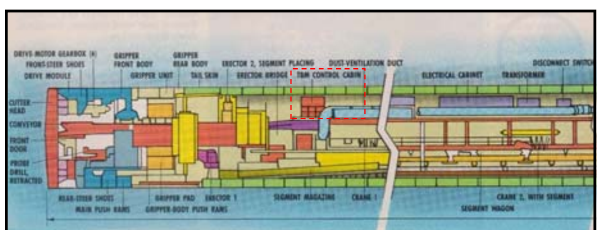
1263

Best and Worst

1264

"…Later, the grouting crew, wielding fire hoses of mortar, fills any gaps between plates. They inject the mixture under pressure, squirting it between the sheathing and rock - and often onto themselves. It seeps into rock cracks, strengthening and forming a barrier. 'It's a nasty job,' one of the workers told me later. 'It's especially bad when you're working overhead - the worst job down there…"
Popular Science, **June 1990**
Left: caption: "Casting of the segments for the UK tunnel headings"

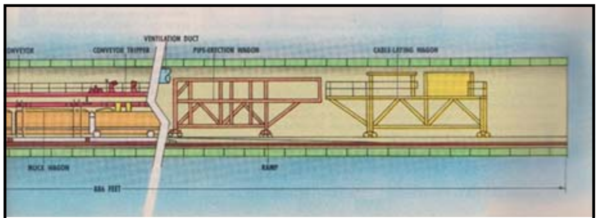
1265



"…The best job, perhaps, is in a little metal cabin riding forward, with a picture-window view of the rams. There you'll find the TBM operator, the single man who runs the whole affair. He sits there with his TV screens and his ram-monitoring lights, controlling the hydraulics, the rotation, and the conveyors with a cockpitful of switches. He's paid a lot: $1,700 a week…"
Popular Science, **June 1990**

1266

Above: caption: "Front half of Chunnel TBM shown above"



"…Other men are crawling on the machine's framework, installing equipment - air ducts, electric lights, pipes. There are 26 of them, and they and everything else - supplies, workshops, even a canteen - are being dragged along on this single machine and its erector-set gantry longer than two football fields…"

***Popular Science,* June 1990**

Above: caption: "Cutting three tunnels under the English Channel involves a dozen tunnel-boring machines (TBMs): six moving seaward toward each other, and six moving landward toward terminals on both sides. Two machines for the land-tunnel operation on the United Kingdom side, made by James Howden & Co., each weighs 1.5 million tons and is 886 feet long (rear half of Chunnel TBM shown above)"

1267

An Awesome Sight

1268

"…The tunnel tailings come spewing to the surface at a point near Dover where the 180-foot-high cliff slash down into the sea. If, late at night, you make your way up behind the site, up to the top of Shakespeare cliff, and peer down over the edge, you see an awesome sight…"

***Popular Science,* June 1990**

1269

The Channel Tunnel reaches the UK coast at *Shakespeare Cliff,* to the west of Dover and close to a platform created on the foreshore in 1843 during construction of the London to Dover railway. An exploratory adit was driven from this platform during an earlier phase in 1974/5 and this was used as the main access for construction of the UK tunneling works. The spoil from the works was used to extend the platform westwards and the area later formed the *Samphire Hoe Nature Reserve.* The 9 km of tunneling between Shakespeare Cliff and the portal at *Castle Hill* follows the *Marly Chalk* with the underlying *Glauconitic Marl* (1 to 2-meters thick). *Gault Clay* was encountered at *Holywell Combe*.

Left: caption: "Shakespeare Cliff and Lower Shakespeare working site"

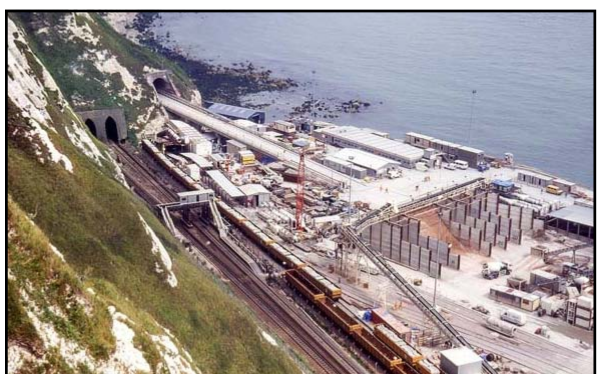
Right: caption: "UK portal at Castle Hill with Holywell Combe now crossed by the A20/M20 highway. Six major landslides were identified along the escarpment in the area, the major engineering challenge being to ensure the stability of the Castle Hill portal"

1270

"…You see a small city. You see cranes as big as stadiums, piles of earth the size of county courthouses, and acres of blue-topped metal buildings lit by sodium vapor. You see bulbous-backed cement trucks, slug-like fuel carriers, fleets of microvans. You can see tiny figures only because of this orange jump suits. And drifting upward are the sounds - honks, crashes, deep rumblings - that seem even to shake the cliffs…"

***Popular Science,* June 1990**

1271



Above: caption: "The Channel Tunnel construction site seen from Shakespeare Cliff in Aug. 1989. The halt has been refurbished with a lengthened up platform and a new footbridge with offices on the bridge. The road access tunnel built in 1974 is seen to the right of Shakespeare tunnel. Between the two, the ramp down to the Channel Tunnel is seen."

1272

"…Supplies, arriving by train, are going down one adit, while up the other come the tailings. They're coming out of the ground on conveyors fed by 400 muck wagons hauled by 100 20-ton locomotives. 'When this job is over,' says Stacey, 'we'll be glutting the market for used muck trucks.' The spoils are dumped into a 12-acre lagoon that stretches out from the shore, carefully monitored by environmentalists to see that it remains contained. When the whole project is completed, all this industry will be hauled off; the park that's left will be public…"

Popular Science, **June 1990**

RE: after considerable discussion in which about sixty sites were proposed for the disposal of the UK Channel Tunnel spoil, it was decided that the least "ecodisruptive" option was to reclaim land at the base of *Shakespeare Cliff*

1273

<u>Above L&R</u>: extensive research revealed then that depositing spoil at the base of *Shakespeare Cliff* in artificial lagoons constructed with sheet pile walls was the least environmentally disruptive option. This also had the added advantage of providing an increased work area as tunneling works progressed. There already was access to the site from the Dover to Folkestone railway line and through a tunnel in the cliff left from the 1974/5 tunnel attempt. The main advantage of this location was:

- **no need for any transportation of the spoil to another site, and;**
- **the creation of a large platform to be used as a work site as the tunnel was dug.**

1274

***Samphire Hoe* was formed using nearly five million cubic-meters of spoil resulting from the construction of the Channel Tunnel. Extending to some 30 hectares, it was opened in 1994 by HRH *Queen Elizabeth II* and French President *Francois Mitterrand*. Along with an abundance of wild flowers, birds and animals, visitors enjoy hiking, cycling, birdwatching, angling and many other outdoor activities (not to mention the stunning views of the majestic cliffs and France, across the Channel). In 1994, a competition was organized by *Eurotunnel* and a local newspaper to establish an appropriate name for the site. The competition proved popular and was eventually won by a local resident, *Mrs. Gillian Janaway,* who named it "Samphire Hoe." The name is derived from the fact that the plant *Rock Samphire* grows in the area and "Hoe" refers to a piece of land which extends out into the sea.**

1275

1276

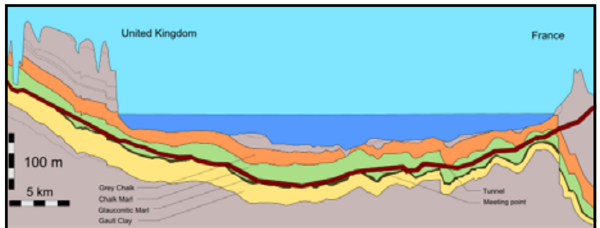
1277

Diminished Expectations

1278

"…The design speed for TBMs on this job is about 100 feet a day, and they're pretty much making it now. But progress at times has been agonizing. On the British side, geologists had expected everything to be nice and solid, easy to work, and dry. Instead, when the service tunnel had advanced a mile or so, the nice dry chalk suddenly turned to broken, sodden muck. Water spewed in through fractures, wetting the men and making the chalk gunk. It lasted for a mile. They got through, slowly, by installing cowling around the head, and switching when necessary from concrete to preformed cast-iron linings set in place, then bolted tight…"
Popular Science, **June 1990**

1279



Above: caption: "At its deepest point, the Channel Tunnel has 75-meters of rock cover overhead." All three Channel Tunnels (service and running) are located in the most favorable tunneling medium; the *Chalk Marl* (a/k/a "West Melbury Marly Chalk"), towards the base of the lower chalk. This *Marly Chalk* is free from flints, in general, has a very low permeability and is usually less fissured than the overlying chalk strata. The lowest member of the lower chalk is the *Glauconitic Marl,* which in the undersea section was found to be a moderately strong, green *Glauconitic Sandstone* with low permeability. It has markedly different physical properties from both the overlying Marly Chalk and the underlying *Gault Clay*. The tunnels reach their lowest point at 115-meters below sea-surface level, approximately 13-km offshore at a point where the rock cover is at its greatest (75-meters).

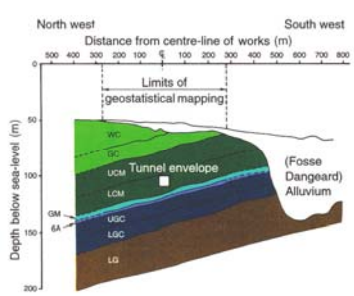
1280

The Fosse Dangard

1281

"…More trouble for the British is expected this coming November: the ominous Fosse Dangard, a dip in the sea floor. This feature, say geologists, may mean 'weathering,' and that means a crumpled, water-soaked sea floor that may stretch down to the tunnel path…"
Popular Science, **June 1990**
RE: from the low point in the UK section, the tunnels continue in the *Marly Chalk* and gently rise towards the mid-Channel position. Over this central section, the tunnels run relatively close to a major geological feature; the *Fosse Dangeard*, a massive buried valley formed by scouring of the sea bed to a depth of 85-meters. The French tunnel drives left from the coast at a depth of 35-meters below the seabed, remaining within the Marly Chalk wherever possible. However, due to geological folding, faulting and fracturing, the TBMs had to be able to operate in closed mode in this much more permeable ground.

1282



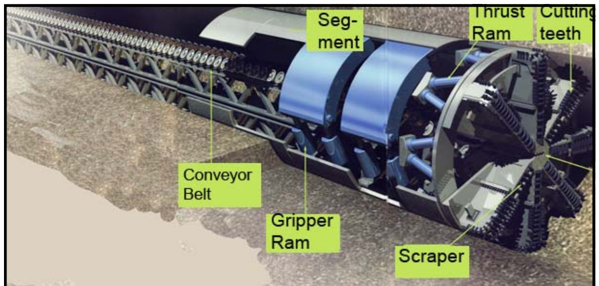
1283

"…They'll know beforehand. Preceding the service-tunnel TBMs are three-inch probe drills exploring out 330 feet ahead. 'They're rotary percussive, water-jetted, with a constant read-out of penetration and torque,' explains Stacey. You measure the water you send forward, measure water coming back, and if the numbers vary, you worry. But you've got 330 feet to prepare…"
Popular Science, **June 1990**

1284

Painful and Grueling

1285



"…Such conditions, for the French, are by now 'painful' and 'grueling,' as one report puts it, but routine. Test borings had shown the chalk marl folded near shore, requiring TBMs to work through water-filled rubble. The machines were designed for that, outfitted with full shields capable of operating almost in slush. The eastern ends are being bolted and sealed with ultra-tough grout to counteract the water pressure…"

Popular Science, **June 1990**

1286

Above: caption: "Main components of a shield TBM"

1287

Worst Case Scenario

1288

"…For the French, it's slow, slogging, miserable work. But nobody seems to be worrying about catastrophic failure. The builders worked out a worst-case scenario in which a TBM would run into an open test-bore hole. Some 100 six-inch holes were bored from the channel surface, and were all sealed with concrete. But what if one had been accidentally left open?..."

Popular Science, **June 1990**

RE: the *Glauconitic Marl* was easily recognizable both in the geophysical records and in borehole cores, providing an excellent "marker horizon" during the site investigation surveys. It was possible to correlate this horizon at the bottom of the lower chalk across the Channel via the intense use of multichannel digital geophysical seismic surveys, with a limited number of additional (very expensive) deep marine boreholes (drilled from offshore oil field jack-up rigs). Earlier boreholes were also tied in to the geophysical surveys.

1289

"…The maximum inflow, somebody calculated, would be 73 gallons a minute. At that rate, in three hours the water would be only three feet deep (Stacey has been in tunnels with water pouring in at twice that - with no danger, he says). Further, any of the machines can close down, hunch itself outward, and act as a mammoth plug…"

Popular Science, **June 1990**

1290

Less than Expected

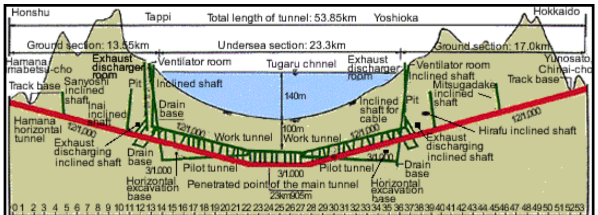
1291

"…Nevertheless, all is not safe. At the same moment I wandered about the south tunnel, a 34-year-old worker, crushed by a muck truck, died in the north tunnel. His was the fifth death. That's less than expected…"

Popular Science, **June 1990**

<u>Left</u>: in *Samphire Hoe* (part of the *White Cliffs Countryside Park*), formed from 1986-1992 by the UK Channel Tunnel excavation, a memorial was erected in memory of the eleven workers who lost their life during construction of the Channel Tunnel

1292



"…The workers here certainly don't seem concerned – although they do bring up the Japanese Seikan tunnel, opened in 1988. There, mostly because of unforeseen rock fractures that led to massive flooding, it took 21 years to complete and it cost 34 lives…"

Popular Science, **June 1990**

<u>Above</u>: the *Seikan Undersea Tunnel* is 240-meters deep (140-meters of water and another 100 meters of seabed). Although the Japanese first used TBMs, the variable type of rock in the seabed caused them to abandon this method in favor of the "Drill-and-Blast" method.

1293

The Daily Routine

1294

"…But British tunnel workers only shrug. Talk with them in the pubs of Dover and Folkestone, in the 'Fox and Hound,' the 'Lifeboat,' or the 'Prince Albert' (they laugh at the TML directive that says talking to the press is grounds for immediate dismissal), and they'll say that digging under the sea has become routine…"

Popular Science, **June 1990**

1295

A Legend in the Making

1296

"…What you find instead is a surprising excitement, a spirit unexpected. As one burly electrician with hands the size of frying pans told me: 'We're making history. This isn't the Cairo sewage system, you know.' Added his friend: 'We're working on a bloody legend here…'"
Popular Science, **June 1990**
<u>Above</u>: caption: "Track construction team on October 30, 1992"
<u>Left</u>: caption: "A French worker writes his name on the last segment to be erected in the service tunnel"

1297

On Schedule

1298

"…The first machine began to dig on Dec. 1, 1987 - despite problems that had been looming all year: inadequate sales of stocks, criticism of bureaucratic inefficiencies, and abrupt changes in top management. Alastair Morton, for example, was brought in as co-chairman of Eurotunnel in February 1987 for his clout. Soon Morton was accusing British members of TML, the construction consortium, of falling behind three months and of being more interested in milking the public than in digging a tunnel. TML was furious, especially when fined some 25 million pounds in late-schedule payments. Morton also reminded the contractor that if the tunnel opening was delayed it would be fined 354,000 pounds a day. TML is still angry, but the tunnel is now on schedule…"
Popular Science, **June 1990**

1299

Linked Forever

1300

"…Early in December when the two service tunnels meet, hoopla for the event should be as momentous as it can be 350 feet under the sea. Construction manager Joe Stacey has stated already. 'The UK finally will be linked forever with mainland Europe, never to be the same again,' he says grandly. 'It seems to me that it will be the biggest political event for the U.K. since the end of the second world war'…"
Popular Science, **June 1990**

1301

The Blessing and the Curse

1302

"…Along the Northern French coast, citizens can hardly contain their excitement - mainly because property values have exploded. One big reason: The English are buying vacation homes. They're cheap, and now access will be easy. The biggest arguments on the French side revolve around which town the terminal will be named after…"
***Popular Science,* June 1990**

1303

Above: caption: "Aerial view of the Eurotunnel Terminal at Coquelles"

1304

"…On the English side, though, citizens aren't happy at all. The influx of workers has saturated school classes, clogged roads, and strained facilities. Locals worry that when the tunnel opens, the ferries will disappear, and with them thousands of jobs. They worry about losing tourism too. Says Keith Rosens, Folkestone tourist bureau representative, 'People boarding tunnel trains won't come to town. Folkestone will become a dead end…"
***Popular Science,* June 1990**

1305

"…When Folkestone citizens drive by the new terminal site they remember what it used to be: 'Beautiful country fields with sheep,' recalls Eric Pratt, a phone company trouble-shooter. 'Lovely little houses by a picturesque stream. Now there's not even a dip.' The land was leveled with 6.6 million cubic yards of sand dragged from the channel then slurried up through culverts…"
***Popular Science,* June 1990**
Above: caption: "Aerial view of the Eurotunnel Terminal at Folkestone (Kent)"

1306

Above: caption: "FOLKESTONE: April 29, 1994. An aerial view of the Channel Tunnel complex at Folkestone, due to be opened by French President Mitterand and Britain's Queen Elizabeth II on May 6, 1994"

1307

1308

An Island No More

1309

"…To an outsider, the most interesting unhappiness among the English is the psychological fear of a loss of identity, and ancient worry born of living on an island. 'When I talk to people about the tunnel,' says Eurotunnel's Stacey, 'the old generation asks, 'But what if there's a war?' I answer that we ceased being an island with the advent of the airplane'…"
Popular Science, June 1990

1310

Abandon-in-Place

1311

"…And what will happen to those six multi-million-dollar TBMs when they end up nose to nose? They'll be shunted off to the side and buried mid-channel in the chalk."
Popular Science, June 1990

1312

Part 20

Chunnelvision

1313

On Foreign Soil

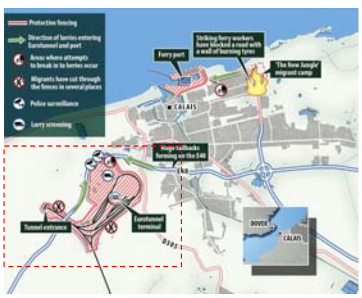
1314

"When the evening is clear in Folkestone, the lights of France throb gently just across the English Channel, as though Europe were creeping westward under cover of darkness. With a strong throw, a good flat rock, it seems, could skip all the way to Calais. Among the bright pinpoints strung along the coast, one radiates like a fuzzy headlight. It is the construction site for the Channel Tunnel, at Sangatte, floodlighted throughout the night as hundreds of workers carry on with the largest construction project Europe has seen this century…"
***The New York Times*, September 16, 1990**

1315

Above: caption: "Aerial View of Sangatte Construction Site, June 1988. The main shaft for tunnel construction is under the building complex in the center of this picture."

1316



1317

A Milestone Event

1318

"…In just two months, British workers will meet their French counterparts somewhere under the middle of the Channel - La Manche, to the French - and for the first time in 8,000 years England will again be linked to the Continent. The project will still have a long way to go. The two railway tunnels flanking the completed service tunnel will not be finished until early autumn 1991; trains will not roll the 32.2 miles from Folkestone to Calais until June 1993…"
***The New York Times*, September 16, 1990**

1319

"…But when the two massive boring machines digging the service tunnel bump noses in November, a gale-force sigh of relief, and much orchestrated cheering, will emanate from Eurotunnel headquarters in London, followed by weak but hopeful hurrahs from the 210 banks and half million shareholders financing the whole affair…"
***The New York Times*, September 16, 1990**
Above: caption: "Margaret Thatcher in Channel Tunnel during construction"

1320


TUNNEL BOOB HITS POLL TAX

CLANG: The French tunnel will miss ours by 14ft

EUROTUNNEL experts have owned up to an incredible £4 billion blunder—the French and English sides will NOT meet in the middle.

And Cabinet sources have admitted that the vast cost of correcting the problem is likely to add an extra £57 to EVERYONE'S poll tax bill.

By NICK PAUL
Science Editor

For Government grants to councils are now to be diverted to Eurotunnel—leaving householders to foot a larger proportion of the bill for local services.

French contractors who supplied concrete "sleeves" for the Calais side of the tunnel used metric specifications.

But England and France had initially agreed to use Imperial—"feet and inches"—measurements.

A Eurotunnel engineer explained: "Any small deviation at the start of the tunnel ends up in us being way off course."

The French section has now been sent BELOW the English end and engineers predict a 14ft drop where the two sides should meet.

Professor A. Prilfubel of Dortmund, an expert on sub-oceanic engineering, said: "The error could cost £4billion."

Such an amount would be bound to translate into higher poll tax bills.

County councils have already been told to levy an extra charge—thought to be at least £57 per person—in June.

And to ensure efficient collection, large firms have been empowered to deduct it from salaries.

A Government insider said: "Many people predicted the tunnel would answer all our troubles. But with this news coming out on April 1, they all look a bit foolish."

Tunnel vision—Page 40

Chunnel Blunder

The News of the World reported that the two halves of the Channel Tunnel, being built simultaneously from the coasts of France and England, would miss each other by 14 feet, the reason being that French engineers had used metric specifications, whereas the British had used imperial feet and inches. The error would cost $14 billion to fix. (April 1, 1990 – _April_ _Fool's_ _Day_)

1321

Another Milestone Event

1322

Above: caption: "November 20, 1990: Folkestone. Another milestone was reached today in the building of the Channel Tunnel when the final underground section between the Kent coast and the terminal site broke through. The workers are pictured celebrating their arrival in Folkestone."

1323

1324

Breakthrough!

1325

"At 11:21 A.M. today, Robert Graham Fagg of Dover climbed through a 3-by 4-foot hole in a wall of chalk marl 130 feet below the seabed of the English Channel, shook the hand of Philippe Cozette of Calais and shouted, 'Vive la France!' The English and French construction workers then hugged each other as a crowd of 100 onlookers cheered, celebrating the breakthrough of the Channel Tunnel - known as the Chunnel - which rejoined Britain to the European continent after 8,000 years of isolation…"
The New York Times, **December 2, 1990**

1326

1327

Underground, a compass doesn't work due to magnetic ore and GPS can't function. Fortunately, in 1921, ***Max Schuler*** invented a ***gyrotheodolite*** (above) which uses the rotation of the Earth to calculate direction. However, due to problems on the French side of the tunnel, Fagg and Cozette didn't actually meet in the center of the tunnel. With the Brits digging a little further, when the two tunnels did meet, they were 300-millimeters off course.

1328

"…Suddenly, the centuries-old dream shared by Napoleon - and the fear still shared by many English - was no longer a fantasy. While people will not be able to drive from England to France, in two and a half years, when the project is finished, trains will zip beneath the Channel, carrying people, cars, trucks and freight…"
The New York Times, **December 2, 1990**

1329

Above: caption: "A worker on the British side of the Channel Tunnel poses underneath a banner showing the closeness to breaking through to the French side"

1330

"…The breakthrough occurred 13.9 miles from the English coast and 9.7 miles from the French coast. It happened three years to the day after digging began on the English side. Most of the passage was cut by two giant laser-guided boring machines, which set out from the opposite shores. But it was workers using hand-held pneumatic drills who chipped through the remaining 25 feet…"
The New York Times, **December 2, 1990**
RE: an exploratory probe in the service tunnel broke through to the French side on October 31, 1990. This created a 50-millimeter hole linking the two countries for the first time since the *Ice Age*. The hole allowed surveyors to check the alignment of the two service tunnels.

1331

"…At 11:11 A.M., the two who won the honor in a lottery - Mr. Fagg, 42 years old, and Mr. Cozette, 37 - broke through. One minute later, they had created an opening large enough to shake hands and to take turns leaning through the hole. 'Bravo,' said Mr. Fagg, who had worked on a Channel tunnel project in the mid-70's that was abandoned. 'Welcome to France,' Mr. Cozette, who was dressed in smart khaki coveralls, said in French to his new friend, who seemed a bit underdressed for the occasion in an orange T-shirt. They waved French and British flags…"
The New York Times, **December 2, 1990**
Top: caption: "British and French tunnel workers make contact for the first time"
Bottom: caption: "Dec. 1, 1990: Tunnel workers Graham Fagg (left) shakes hands with Frenchman Phillipe Cozette (right) after breakthrough"

1332

"…Before everyone boarded shuttle trains to complete the first land journeys across the English Channel since the Ice Age, another first was in order: a champagne party for 100 beneath the Channel. The proper attire seemed to be khaki coveralls for the French, bright orange ones for the British and hardhats for all. The guests included executives and workers from Transmanche-Link, the consortium of 10 British and French construction companies building the tunnel, and from Eurotunnel, which is financing the project and will operate the tunnel. Government dignitaries, including Malcolm Rifkind, the British Transport Secretary, and his French counterpart, Michel Delebarre, were on hand, too…After the train rides to Sangatte, France, and Folkestone, England, there was more champagne and waving of passports…"
The New York Times, **December 2, 1990**

1333

"…But the two leaders who had played the leading role in getting the project off the ground were noticeably absent. The French President, Francois Mitterrand, was said to be sick. And Margaret Thatcher, who resigned as Britain's Prime Minister on Wednesday, was said to be avoiding public appearances for awhile…"
The New York Times, **December 2, 1990**

1334

"…Political leaders and executives of the companies responsible for the project heralded the tying of Britain to the mainland as a symbol of the coming together of the 12-nation European Community, which is in the process of scrapping trade barriers and turning itself into a single market of 325 million consumers…"
The New York Times, **December 2, 1990**

1335

Above: caption: "November 29, 1990: Channel Tunnel. Left-to-right: TML Construction Director Peter L. Allwood; TML Tunnels Director John J. King; TML Chairman Philippe Essig and TML Chief Executive Jack K. Lemley"

1336

"…In a statement, John Major, the new British Prime Minister, said: 'This is one of the great engineering feats of all time, and a symbol of opportunities that will exist throughout the new Europe.' In his message, President Mitterrand called the link a 'striking sign of the vitality of the two countries and the efficiency of their cooperation'…"
The New York Times, **December 2, 1990**

1337

"…Stopping to chat in downtown Folkstone today, Gladys Golding, 68, made it clear that she was not excited about the tunnel breakthrough. 'It's taking away our British heritage,' she said. 'It would be nice to have kept ourselves as an island. I don't honestly think I'd ever use the tunnel.' One of the few who was enthusiastic was Douglas Francis, a 46-year-old accountant. 'It's absolutely wonderful,' he said, shaking his head in disgust at the 'little England attitude' that he said prevailed in Folkestone…"
The New York Times, **December 2, 1990**

1338

"…The future may look grand, but the breakthrough today was the first major triumph in a project that has been marred by nine worker deaths, cost overruns and a financing crisis…"
The New York Times, **December 2, 1990**
Above: caption: "Official Commemorative Cover – Service Tunnel Break-through, December 1, 1990"

1339

"…In November 1987, when Eurotunnel made its first major stock offering, the project was expected to cost 4.87 billion pounds, or $9.46 billion at current exchange rates. Thanks to cost overruns and higher inflation and interest rates, the amount has soared by $5.32 billion…"
The New York Times, **December 2, 1990**

1340

Top: caption: "Folkstone, UK. December 1, 2000: Philippe Cozette and Graham Fagg re-enacted their meeting in the tunnel to celebrate the 10th anniversary of the breakthrough between the two countries"
Bottom: caption: "February 10, 2014. Channel Tunnel workers Phillipe Cozette of France, right, and Graham Fagg of England, left, reenact their historic meeting in the service tunnel which occurred on December 1, 1990."

1341

"…With about 10,000 workers and an anticipated cost of 7.61 billion pounds ($14.78 billion), the tunnel is Europe's biggest construction project and the largest privately financed engineering project in history…"
The New York Times, **December 2, 1990**

1342

Shrinking Frontiers

1343

"…The Channel Tunnel - or 'the Chunnel,' as it is sometimes called - is the largest privately financed engineering project in history, and, with 23.6 miles of it under water, the longest undersea tunnel ever built. As the most dramatic example of shrinking European frontiers, it's already carrying heavy symbolic freight. It has been called the 'first great infrastructure project of the new Europe,' a crucial link in the emerging high-speed rail system that will soon give Europe the finest transport network in the world…"
The New York Times, **September 16, 1990**

1344

"…'Oh yes,' says Roscrow, now the publishing director of Housebuilder magazine, 'the 'Chunnel.' I'd forgotten about that one. 'I guess when you think about it, 'Channel Tunnel' is not that difficult to say.' But who came up with the word? According to the Oxford English Dictionary, that honour goes to a K. Howard who wrote in a publication called the 'Sketch' in February 1914: 'Another word that will be stolen from me is 'Chunnel.' This, naturally, will be the pet name for the Channel Tunnel when we get it.' And for a while, he was right…"
bbc.com, **May 5, 2014**

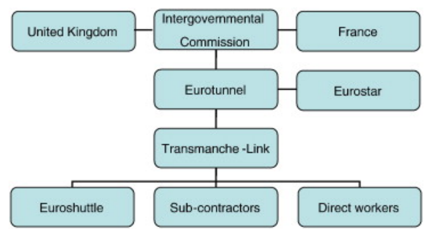
1345

"…A survey of published material shows the word Chunnel reached its apogee in 1992, but then fell out of favour. But outside of the print media - where Chunnel may have been popular among headline writers for its brevity - the word never really caught on at all. Certainly, the French didn't opt for Le Chunnel, instead settling on 'Tunnel Sous La Manche'…"
bbc.com, **May 5, 2014**

1346

"…If all goes as planned, passengers will be able to board a British Rail train at Waterloo Station in South London and reach Paris in three hours or Brussels in 2 hours 45 minutes - in either case, half the present time by rail and Hovercraft. Yet from its inception, the Channel Tunnel has been beset by financial and technical woes, blown schedules, worker fatalities and highly public battles between Eurotunnel - the Anglo-French company managing the project - and its contractors, a consortium of five British and five French construction companies called Transmanche Link…"
The New York Times, **September 16, 1990**

1347



1348

In Too Deep

1349

"…Cost estimates for the tunnel, originally budgeted at $9 billion in 1986, have gone up four times. The latest figure, $14 billion, was announced last spring, requiring Eurotunnel to return once again to its banks, since by contract it must have enough cash on hand to see the entire project through. The company drew up plans for an additional loan of $4 billion and a stock offering of $1 billion…"
The New York Times, **September 16, 1990**

1350

"…But this time the banks balked. Half of them refused to sink another penny in the project, and at press time were still holding out; the impasse may force Eurotunnel to postpone its stock flotation, which had been timed for late autumn, to coincide with breakthrough on the service tunnel. At the moment, Eurotunnel is technically in default on its original loan agreement, and as a result, the entire project could collapse. No one believes that will happen. The banks are in too deep, and the tunnel has come too far. But once again, the Channel Tunnel has entered crisis mode…"
***The New York Times*, September 16, 1990**

1351

An Irreversible Transformation

1352

"…Meanwhile, the digging continues, at record rates. Recently, Eurotunnel even began running a jaunty 'Breakthrough for Britain' advertising campaign that shows an odometer counting down the distance before the service tunnel is finished. A taxi dashboard might have been more appropriate, with the meter clicking over at the rate of $4.75 to $5.7 million a day and the gas gauge hovering near empty. The tunnel has turned out to be a wild, and wildly expensive, ride. But the destination is exciting - nothing less, says Andre Benard, Eurotunnel's French chairman, than 'the irreversible transformation of Europe'…"
***The New York Times*, September 16, 1990**

1353

A Beehive of Activity

1354

"…The hazy ball of light at the village of Sangatte takes on distinct, less romantic form by day. Heading southwest from Calais, a two-lane coastal road runs past open farmland, passing by the beach where the French aviator Louis Bleriot touched down after making the first Channel crossing by air in 1909…"
***The New York Times*, September 16, 1990**

1355

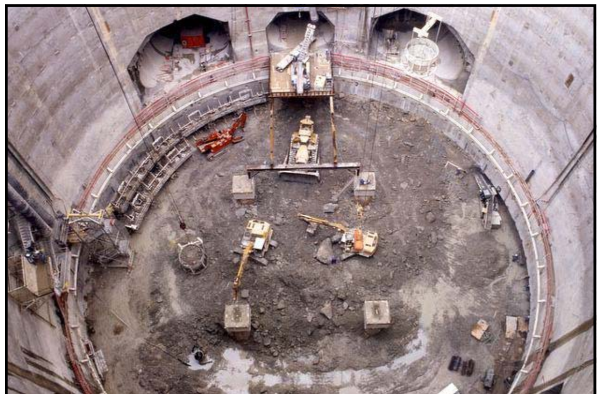
"…Near Sangatte, an enormous construction crane rises above the horizon, a gaunt index finger crooked over what looks like a nuclear-reactor cooling tower that has been hammered halfway into the ground. Through this concrete maw, 165 feet wide, men and machinery descend 250 feet to the digging…"
***The New York Times*, September 16, 1990**
Left: caption: "Sangatte access shaft under construction"

1356


In order to excavate the tunnel, an access shaft was constructed in Sangatte. Due to the presence of an aquifer, the access shaft was built inside a waterproof form. Measuring 55-meters in diameter and 75-meters high (the volume of excavated material was 390K cubic-meters), it allowed TBMs to be lowered and assembled under dry conditions.

Left: caption: "After completion of the construction phase, the well will house the ventilation facilities and other essential services"
Right: caption: "Lowering TBM via access shaft"

1357

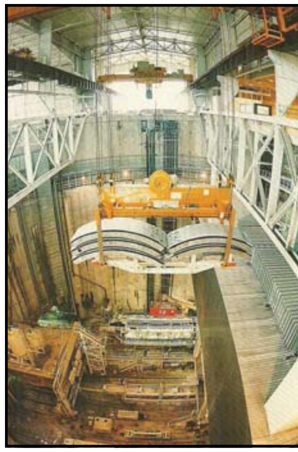


Above: caption: "Channel Tunnel construction – Sangatte access shaft from above, July 1987"

1358

"…You can hear the gentle sizzling of high-tension wires from the electrical substation serving the construction works. Hundreds of precast concrete tunnel segments lie baking in the sun - Snack Chips of the Gods. Barely 50 feet away from the tunnel works, a solitary farmer picks at a row of vegetables with a hoe, his back turned indifferently to the epic project unfolding behind him…"
***The New York Times,* September 16, 1990**

1359



"…The elevator that services the shaft descends smoothly, disgorgeing its passengers onto a scene that looks like low-budget James Bond. Men in brightly colored overalls and hard hats circulate on metal catwalks with the spurious purposefulness typical of a Spectre operation. Mini-trains shuttle workers nine miles out under the Channel to dig the three seaward-drive tunnels toward England. On the opposite side of the shaft, three short tunnels head a mile inland, toward the future shuttle-train terminal at Coquelles, nearly two miles south of Calais…"
***The New York Times,* Sept. 16, 1990**
Left: caption: "Access shaft at the Sangatte site, 1989"

1360

Above: caption: "Sangatte, France. July 27, 1987: At the bottom of a 55m diameter and 60m deep vertical well, 450 workmen took turns night and day. Eleven specially built tunnel borers (six British and five French) made it possible to advance up to 500m a month"

1361

"…The French are lucky. The open countryside gives them plenty of room to move. Directly across the Channel, the British are digging their tunnels from a thumbnail-size dab of land at the foot of Shakespeare Cliff, two miles south of Dover…"
***The New York Times,* September 16, 1990**
Above: caption: "Aerial view of Sangatte construction site"

1362

1363

Subterranean Submarines

1364

"…The protagonists in this drama are the tunnel boring machines - 1,000-ton glossy white submarines with an obsession. The technology is not subtle. Though a sophisticated laser guidance system keeps the machines precisely aligned, the actual digging comes down to brute force…"
The New York Times, **September 16, 1990**

1365

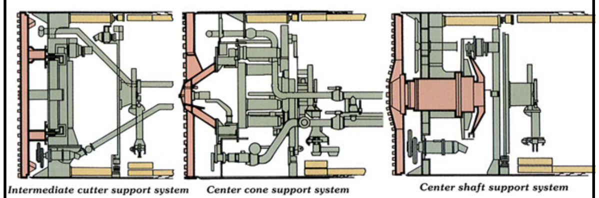
Above: caption: "The tunnel boring machines are transported through towns and villages on a trailer towed by three tractor trucks (two at the front and one at the rear). The total weight of the convoy is 600 tons, for a length of 60-meters

1366

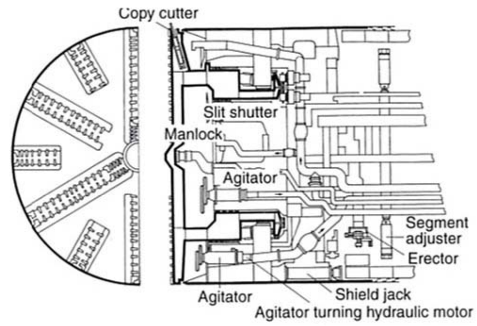
"…The business end of the machine - an 800-ton drill-and-drive unit - is a sleek, self-propelled battering ram. It pushes forward to cut the chalk, pauses as the curved tunnel-lining segments (brought forward by an overhead conveyer) are picked up and pressed into place by two mechanical arms that operate like a body-builder doing lateral arm raises, then slowly lurches forward again…"
The New York Times, **September 16, 1990**
Above: caption: "Self-propelled train transports 40-tons of liner panels from the access shaft"

1367

1368



"…The typical cutter head (details differ from one machine to another) is not unlike a giant Norelco razor: its blade - a 27-foot circular plate equipped with cutting disks and picks - rotates at up to three revolutions per minute, slicing and chipping at the chalk, throwing the chunks back to be picked up by a conveyor belt for transport to muck wagons…"
***The New York Times*, September 16, 1990** 1369
<u>Above</u>: caption: "Types of cutting face of slurry type shield"



Cutting Head Sketch of Slurry Type Shield

1370

"…As it happens, the medium is ideal: a waterproof chalk stratum, 65 to 100 feet thick and 30 to 160 yards below the sea bed, running in a continuous band all the way from England to France. Known as chalk marl, or blue chalk, it is soft enough to scratch with a fingernail but holds together until the tunnel linings are pressed into place…"
***The New York Times*, September 16, 1990**

1371

"…When things are going well, as they are now, the crews can bore and line over 1,000 feet a week. But the work can be dangerous. So far, nine workers have died, most of them struck by trains or crushed by moving machinery…" 1372
***The New York Times*, September 16, 1990**

<u>Above</u>: caption: "Nord-Pas de Calais, France. Jan. 28, 1988: The French president, Francois Mitterrand, visiting the construction site of the tunnel under the Channel" 1373

Raison d'etre

1374

"…As the digging picks up speed, it's easy to forget that Eurotunnel's purpose is not to dig a hole in the ground but to build and operate a railway. British Rail and S.N.C.F., Societe Nationale des Chemins de Fer Francaise, the French national railroad, will use the tunnel for passenger service and, during off-peak periods, for freight…"
***The New York Times,* September 16, 1990**

1375

"…Alternating with the rail service, and sharing the tunnel, will be special shuttle trains owned and operated by Eurotunnel. Cars, trucks and buses will simply exit from the highway, at Folkestone on the British side and Coquelles on the French side, pick up a ticket at a tollbooth and drive onto the shuttle trains - single-deck wagons for trucks and buses, double-deckers for automobiles - crossing the Channel in 35 minutes…"
***The New York Times,* September 16, 1990**

1376

"…Passengers will remain in their vehicles throughout the journey. After discharging their vehicles, the shuttles will loop around the terminal to begin a new trip. By the year 2003, Eurotunnel predicts, the tunnel will handle 44.6 million passengers a year, with trains departing at 12-minute intervals during peak hours…"
***The New York Times,* September 16, 1990**

1377

The Big Picture

1378

"…While the tunnellers measure progress by the meter, Europe's transport ministers spread out the map and see the Channel Tunnel as just one segment in a massive new high-speed rail network. The French are preparing to lay down track for a new Train a Grand Vitesse line, the T.G.V. Nord, connecting Paris to Brussels and Calais via Lille. New Inter-City Express trains are already running at 150 miles an hour between Wurzburg and Hanover in West Germany, and Italy has just finished a high-speed line between Rome, Florence and Milan…"
***The New York Times,* September 16, 1990**

1379

1380

"…A $2.5 billion rail tunnel connecting the Danish islands of Funen and Zealand, scheduled to be finished in 1996, is phase one of Scanlink, a three-part mega-project that will connect Denmark, West Germany and Sweden by bridges and tunnels. Spain, which will complete a high-speed rail line between Madrid and Seville by 1992, wants to tunnel through the eastern and western ends of the Pyrenees…"
The New York Times, **September 16, 1990**

1381

The Economic Periphery of Europe

1382

"…As Europe races to the future, Britain could miss the train. Plans to build a high-speed link between Folkestone and London collapsed in June when the Government refused to invest any money in the project. The decision means that passengers from Paris will whiz along at 186 miles an hour to Calais, roll through the Channel Tunnel at 80 miles an hour and then limp to London on standard British Rail track at an average speed of 50 miles per hour. John Prescott, the Labor Party's shadow Transport Secretary, warned that the decision 'will condemn Britain to the economic periphery of Europe'…"
The New York Times, **September 16, 1990**

1383

"…As though to rub it in, in June the French national railways, which have broken the world speed record twice in the last year, announced a $100 million development program for high-speed trains capable of commercial speeds of 186 miles an hour, and France's transport minister, Michel Delebarre, pledged $38 billion to build and equip 14 new T.G.V. lines over the next 20 to 25 years, a program that will give France 3,000 miles of high-speed track by the year 2005…"
The New York Times, **September 16, 1990**

1384

And Loving It

1385

"…Can the English learn to love the Tunnel? On a wall in the office of Alastair Morton, Eurotunnel's British deputy chairman and chief executive, hangs one of Britain's most famous newspaper front pages: a copy of The Daily Mirror from 1930 with the headline 'Fog in Channel: Continent Cut Off' - not Britain, proud in her splendid isolation…"
The New York Times, **September 16, 1990**

1386

"When the Channel Tunnel was under construction, there were some bold predictions about what the consequences might be…So what did people think might happen after the tunnel opened?..."
***bbc.com*, May 5, 2014**

1387

*"…***Rabies.** *Such was the British concern about rabies-infected animals passing through the tunnel, that it made headlines in the U.S. and elsewhere. The New York Times, for example, felt the British were 'uniquely, stubbornly obsessed by the disease.' So concerned were the British public, that in 1990 the then-government minister Baroness Trumpington addressed the House of Lords about what anti-rabies measures were being taken. She told the House: 'Eurotunnel has implemented measures agreed with the Ministry of Agriculture, Fisheries and Food to prevent the possible entry of rabies-susceptible animals while the tunnel is being built. Those include fencing, staged security zones, visual observation at openings in fencing and a system to ensure that any animals which are seen in the tunnel are reported'…"*
***bbc.com*, May 5, 2014**

1388

1389

"…The electric anti-rabies fences - which proved susceptible to salt erosion - are no longer operational (and have not been for a while). In spite of this, the Department of Food and Rural Affairs (Defra) says not a single case of animal-to-human rabies had been recorded in the UK since the opening of the tunnel. In fact, the last case where someone was infected in the UK occurred in 1922…"
***bbc.com*, May 5, 2014**

1390

"…Although Public Health England said it could not comment on whether those initial fears were justified, more recent concerns have centred not on how animals arrive in the UK but how their documents stack up. Last October, senior veterinary figures warned a relaxation of the Pet Travel Scheme (which included a 21-day rather than six-month wait after a rabies vaccination) had increased the risk of rabies in the UK. Defra maintains the risk of a rabid dog coming into the UK remains very low - once every 211 years, it suggests, with the possibility of a person dying from rabies obtained from a pet once in every 21,000 years…"
***bbc.com*, May 5, 2014**

1391

Above: caption: "Calais, France. February 28, 2000: The first time pets were allowed to be brought back into Britain by their owners. Daisy (a Jack Russell Terrier) being scanned."

1392

"…The UK would become more Francophone. *There were some who felt a physical link between the UK and France might make Britons feel more European and more enthused about speaking a foreign language. Has this happened?...*"
bbc.com, May 5, 2014

1393

"…No. Across England, Wales and Northern Ireland, the number of pupils learning GCSE French has fallen from 324,-000 in 1994 to 318,000 in 2004 and to 177,288 last year. This is despite the opportunities for learning French never having been greater, says Prof. Charles Forsdick, chairman of the Society for French Studies. Not only is there the tunnel, he says, but also a string of low-cost airlines offering cheap flights across Europe as well as access to multilingual media from the internet. 'However, this does not seem to have had the impact one might have hoped on the appetite for learning French (and other languages)…So many people in the UK are anxious because they feel that languages acquired at school do not equip them well for the challenges of travel abroad. This is a fallacy - it is never too late to learn, or re-learn, a language, and French remains an excellent starting point. French is the language of our closest continental neighbour'…"
bbc.com, May 5, 2014

1394

"…Greater 'entente cordiale.' *The numbers of British people visiting and living in France have never been greater. According to the Foreign and Commonwealth Office, there are about 17 million visits to France by British nationals each year. Some of those will include trips by the estimated 400,000 British nationals living and working in France. The flow works both ways. Although claims London was France's sixth largest city now appear exaggerated, the UK is home to a sizeable number of French people. But the motives for the population exchange are usually very different. Powered by a growing network of low cost flights to airports beyond the main cities, Britons moving to France are most often seeking a quieter life in the French countryside. The bulk of French people in the UK, meanwhile, come to London for work. Different motives, different countries…"*
bbc.com, May 5, 2014

1395

Au Contraire

1396

"…The contrast with France could not be sharper. For France, the tunnel is a showcase for its technical expertise and a source of national pride. The Eurotunnel exhibition center at Sangatte is now the country's third most popular tourist attraction outside Paris. 'The French instinctively favor les grands projets internationaux,' says Morton. 'Jack in the street feels that a big project - like Ariane, high-speed trains, nuclear power stations, Airbus - is going to make his grandchildren's life better in some way that he isn't able to define, but he believes it.' That belief is reflected in the ownership of Eurotunnel shares: 436,000 of the 560,000 shareholders are French…"
The New York Times, September 16, 1990

1397

"…'In Britain, big projects - whether it's Concorde or power stations, or a massive railway and motorway investment - are regarded with alarm,' says Morton. 'It could be fear, it could be said to be tinged with an element of self-mockery. But there is not an attitude of, 'Good, we're getting on with that.' The British sentiment that Morton hears is 'a slightly whining voice saying, 'Must we really do this?' It's a sort of disappointed noise.' Andre Benard can only shake his head: 'I think it's amazing that the British do not see what the tunnel can do for them, or that they see it and do not draw the consequences'…"
The New York Times, September 16, 1990

1398

"…Some Britons see the consequences and don't like them. For centuries, the Channel has been a protector against foreign aggression - and against foreignness. 'I've put up with being attached to Wales,' one petitioner wrote to Parliament. 'But the thought of being attached to the French is beyond belief.' There is widespread fear that rabies will return to England, and there are even a few tunnel opponents who worry that the speeding trains will push a garlic-laden column of air ahead of them…"
The New York Times, **September 16, 1990**

1399


I HAVE a solution to the rabies threat. Brick up the wretched Channel Tunnel. The majority of British people did not want it in the first place.

Mrs Joan W Trott,
Worthing, West Sussex

1400

Hitler's Dream

1401

"…The prospect of unification with Europe brings on a certain queasiness among the English. Here, Margaret Thatcher shares the instincts of her people. In a Durham pub, I was surprised to hear a youngish, articulate woman inveigh passionately against the tunnel. 'Everything we've fought for for 1,000 years we're now handing over to Europe on a silver platter,' she said, and then struggled to find words equal to her disgust. 'This dream of a united Europe - that's Hitler's dream'…"
The New York Times, **September 16, 1990**

1402

On the Waterfront

1403

"…Not all opposition to the tunnel is quaint. The channel ports fear the loss of over 6,000 jobs. Jonathan Aitken, a Conservative M.P. whose district includes Ramsgate, one of Britain's largest Channel ports, argues that the French have put one over on the British, who are giving away their near monopoly of the cross-channel industry; the tunnel will allow foreign ships to unload cargo destined for Britain at French ports. 'I think we should have driven a much harder bargain,' he says…"
The New York Times, **September 16, 1990**

1404

Above: caption: "Gull's eye view of the Port of Ramsgate"

1405

The Garden of England

1406

"…Rural Kent, the so-called Garden of England, trembles at the steady march of progress, fearing the arrival of ugly businesses and a stream of heavy trucks. Although Ashford, a charmless market town, is pushing hard for development, and the Rouse Corporation is helping develop a business park on a former air base, the rest of affluent Kent worries more about protecting the status quo than about attracting development…"
***The New York Times*, September 16, 1990**

1407

1408

1409

North-South Divide

1410

"…In the rust-belt cities of the Midlands and the north, the tunnel symbolizes government indifference to the old manufacturing regions and yet another missed opportunity: the right kind of rail network, able to cut through the present bottleneck around London, could pump blood to the north. Ports like Liverpool and Clyde would suddenly make sense for trans-Atlantic ships, which could shave more than 24 hours off the trip to the major European port of Rotterdam. 'Our fear is that the tunnel will accentuate the north-side divide,' says Kerry Hamilton, head of the Transport Studies Unit at the University of Bradford…"

The New York Times, **September 16, 1990**

1411

"…Derek Bateman, chairman of Getting the Best from the Channel Tunnel, a group representing all of Britain's local governments, says businesses from York, Liverpool, Manchester and even Penzance, fearful of being left on the fringes, are buying up land near Lille to gain a competitive foothold in the new Europe. As things now stand, Bateman says, 'British companies can't even export to London efficiently, never mind Europe'…"

The New York Times, **September 16, 1990**

1412

A Glass Half Full

1413

"…Meanwhile, France moves rapidly ahead. The Nord-Pas-de-Calais region is economically depressed, long dependent on declining coal, steel and textile industries. More than 130,000 industrial jobs were lost between 1975 and 1984, and the local unemployment rate of 14 percent is well above the national average. Now the tunnel offers the hope of employment and growth. And northwestern France is grabbing for it with both hands…"

The New York Times, **September 16, 1990**

1414

"…The city of Calais, although initially traumatized at the prospect of losing 5,000 port jobs, is pushing hard for investment. Plans are under way to make the huge terminal at Coquelles a business park, conference and hotel center and warehouse depot. The French Government is pouring money into new roads and improved port facilities. Two English companies have jumped in to begin major developments. Arlington Securities will build a business park on 270 acres near Calais, and the Brent Walker Group is developing a hotel and 'quality properties' at the old seaside resort of Le Touquet. It has been estimated that the population of the Calais area could double to 200,000 by 1998…"

The New York Times, **September 16, 1990**

1415

Land Grab

1416

"…The region is already feeling the effects of the tunnel. Legions of British buyers have been snapping up houses at a quarter the price they would pay in Kent. Rutherfords, a London real-estate agency specializing in French properties, experienced an immediate 10 percent jump in business when ground was broken for the tunnel and expects another surge when the digging is completed. Most buyers are looking for a vacation home, but some plan to live in France and commute via the tunnel to jobs in Kent. The British worry that businesses may follow…"
***The New York Times*, September 16, 1990**

1417

The Cross-Channel Market

1418

"…The ferries, of course, can't move. So they are fighting hard to compete, after failing in a vicious and xenophobic advertising campaign to kill off the tunnel before it got started. Now the ferries have begun to improve efficiency and service, introducing 'Club Class' luxury service and high-speed catamarans. The two largest companies, Sealink and P&O, will almost certainly merge their Dover to Calais service. The ferries will lose an enormous amount of business to the tunnel, as well as revenue from duty-free shops, which will disappear with 1992. But the overall growth of the cross-channel market - and Eurotunnel's problems - has given the companies hope…"
***The New York Times*, September 16, 1990**

1419

1420

Coexistence

1421

"…If the tunnel and ferries can coexist, it will be an uneasy relationship, says Jonathan Sloggett, managing director and register of the Dover Harbor Board. 'It could happen that the tunnel, burdened with debt and desperate to squeeze every penny out of the market, will set off a price war.' It's a war that the ferry companies would be terrified to win. A bankrupt tunnel would be taken over by the British or French Governments, or perhaps the European Community, and its debt erased. The tunnel could then turn around and annihilate the ferries. 'My fear is not that the tunnel will be successful, but that it won't,' says Sloggett…"
***The New York Times*, September 16, 1990**

1422

"Protesters crippled cross-Channel services for the second time in a week yesterday after striking ferry port workers started fires on the tunnel tracks in Calais. The Government described the situation as 'completely unacceptable' as motorists faced huge tailbacks on both sides of the Channel in temperatures reaching up to 93F (34C). There were dramatic scenes of roaring flames and black smoke as piles of tyres were set alight on the railway by protesters trying to sabotage the line approaching the Eurotunnel terminal…"

***dailymail.co.uk,* June 30, 2015**

Above: caption: "Carnage: Striking French ferry workers from MyFerryLink burned tyres in the Eurotunnel tracks around 300 metres from the entry to the tunnel linking France and Britain"

1423

1424

1425

Upper Left: caption: "Transport chaos: Travelers on both sides of the channel faced serious delays due to the striking workers and migrants attempting to enter Europe"

Upper Right: caption: "Turmoil: Truck drivers wait near their lorries blocked on a road which leads to the Channel Tunnel terminal in Coquelles near Calais, northern France. Kent Police warned that the Port of Calais would be closed until Thursday while Eurotunnel described the situation as 'grim,' particularly for freight traffic"

Left: caption: "Travelers wait at St. Pancras after services to Paris and Brussels were suspended as striking French ferry workers blocked the tunnel"

1426

"…With lorries and cars gridlocked for ten miles on the approaches into Calais, hundreds of migrants again tried to break into vehicles headed for England. Motorists in Kent also faced long tailbacks as police launched Operation Stack - closing part of the M20 to allow lorries trying to make the crossing to queue. Kent Police said the situation was 'grim' and drivers should expect 'significant disruption' until after the strike ends at midnight today…"

***dailymail.co.uk,* June 30, 2015**

Above: caption: "Desperate migrants could be seen trying to clamber on board stationary lorries as they were held in gridlock traffic jams approaching the port"

1427

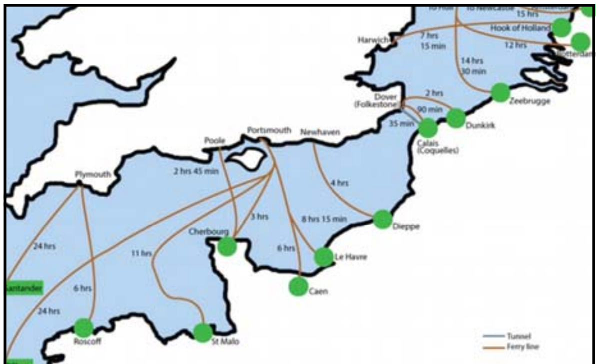
1428

"…All Eurostar and Eurotunnel travel was suspended as tunnel workers rushed to extinguish at least three fires on the railway lines at Coquelles, close to the terminal…Striking ferry workers are blockading the French port to all users, meaning the 'the local environment is in chaos . . . there is gridlock,' according to a Eurotunnel spokesman. He said that in recent days the pattern of migrant activity has spread from attacking trucks on motorways to trying to access the terminal…"
dailymail.co.uk, **June 30, 2015**
<u>Above</u>: caption: "Ghost town: A general view of the empty harbour of Calais. Police have warned that the Port of Calais will remain closed until Thursday"

1429

"…The chaos began on Monday when workers at MyFerry-Link launched a wildcat strike in protest at the firm being sold to a rival. The strike shut the Calais ferry port…The sale came after a competition authority ruling and left up to 600 jobs, including 70 in Dover, under threat. MyFerrylink, which runs 16 crossings from Dover to Calais, was due to officially stop all services from a minute past midnight on Thursday. The firm could not promise that services will restart before th-en…"
dailymail.co.uk, **June 30, 2015**

1430



<u>Above</u>: caption: "The Dept. for Transport has issued this map for cross-Channel travelers facing disruption at Calais, showing details of alt-ernative routes for returning to the UK - including crossing times"

1431

"…The French ferry company workers are protesting plans by Eurotunnel to sell two of their cross-channel ferries to rival Danish firm DFDS. Eurotunnel announced in May it was halting its operational partnership with MyFerryLink due to legal complications, and this month decided to sell its ferries to DFDS. The Danish ferry operator has said it plans to provide work for only 202 of the current 600 MyFerryLink workers. The sale of the two ferries would leave MyFerryLink with just one boat in operation, meaning over half the work-force faces redundancy. Migrants took advantage of a wildcat strike last week by trying to board UK-bound lorries held up in queues at Calais. Migrant numbers close to the port have swollen to more than 3,000 since April."
dailymail.co.uk, **June 30, 2015**

1432

1433

The Battle of the Chunnel

1434

"…The Recent Rebuff by Eurotunnel's banks is but one more disappointment for a project that has struggled from the outset, and in the last two years has been ravaged by internecine warfare and financial crises that, The Financial Times noted in February, 'are becoming as regular as fatal accidents on 'Dallas,' with Mr. Alastair Morton in the role of J.R.'…"

The New York Times, **September 16, 1990**

Left: caption: "Margaret Thatcher visiting the Eurotunnel site in the late 1980s and, left, with the late Eurotunnel co-chairman Alastair Morton in 1988"

1435

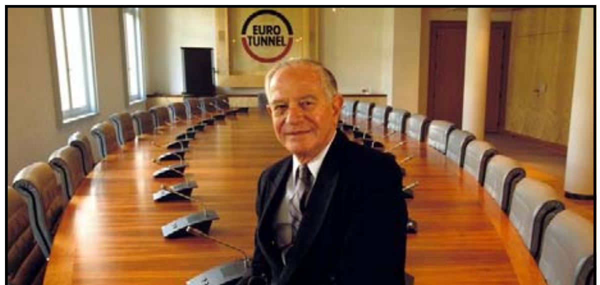
"…The last 12 months have been particularly exciting. Since October, when Eurotunnel's revised estimates jumped the project's cost by 50 percent, leading to Eurotunnel's current cash crisis, the project has been a page-one tabloid story, with Eurotunnel and Transmanche Link slugging it out before an enthralled public. Eurotunnel accused Transmanche Link of dragging its feet and running up the bill, protected by the lenient cost-overrun terms the consortium had written for itself. Transmanche Link saw Eurotunnel demanding an ever more complex and expensive project without being prepared to pay for it. Back and forth the battle went, as the banks stood on the sidelines, watching nervously…"

The New York Times, **September 16, 1990**

1436

Opposite Number

1437



"…In February, as the two sides struggled to an conclude agreement on containing costs, the atmosphere became so heated that Andre Benard, Eurotunnel's statesman-like French chairman, warned that personalities were in danger of destroying the entire project. He referred specifically to his opposite number, Alastair Morton…"

The New York Times, **September 16, 1990**

Above: caption: "Andre Benard helped lead the construction of the Channel Tunnel linking France and Britain. He retired as co-chairman of Eurotunnel Group after the 31-mile tunnel opened in 1994."

1438

A Bit of a Reputation

1439

"…One enters the office of Alastair Morton with some heistation. He has a reputation. For some time now the British press has feasted on lurid tales of Morton's bending the contractors to his will through bullying, epic outbursts of temper and crude threats. Most chilling of all, he seems genuinely to enjoy a good eye-gouging session. 'I always felt he did not believe there had been a good meeting unless he had had a row,' a former executive of Transmanche Link has said. 'He left feeling uplifted, thinking the air had been cleared. We were left like limp rags'…"

The New York Times, **September 16, 1990**

1440

"…Abrasive and sharp-tongued, Morton has accused the contractors of shoddy management and poor productivity. By contract, they are forbidden to talk to the press, another sore point, since Eurotunnel can package its own version of events for public consumption. But in January, Peter Costain, head of one of the British construction firms, leaked a letter in which he characterized Morton as 'provocative, disingenuous, gratuitous and tendentious,' and his version of the proposed cost-containing agreement as 'inaccurate, incomplete, and calculated to mislead'…"
***The New York Times*, September 16, 1990**

1441

"…Morton roams his Eurotunnel office in shirt sleeves. He is a lanky man of 52, with a snaggle tooth, a preppy style and the trace of a South African accent. Genial and easily amused, he has an eager manner and a slightly manic gleam in his eye. He also has an unnerving, strategic laugh that he uses to good effect when driving home key points…"
***The New York Times*, September 16, 1990**

1442

"…The laugh first comes up when Morton talks about John Neerhout, an executive in the giant American construction firm Bechtel, who was brought in to oversee construction work as part of the agreement, which was finally reached in February. Transmanche Link had demanded that Morton be fired. In a last-minute compromise brokered by the Bank of England, Neerhout was drafted as a 'buffer' between Transmanche Link and Morton (Morton also dropped the title of co-chairman and became chief executive, leaving Andre Benard as sole chairman). 'Some buffer,' Morton says. 'More like a killer shark.' He laughs the laugh, lets it continue for a while, and gives a hard look. There's a message here for the shareholders and banks: Don't think for a minute that Eurotunnel isn't keeping a very hot fire under the feet of Transmanche Link…"
***The New York Times*, September 16, 1990**

1443

"…The laugh makes a return appearance when Morton describes his relationship with the contractors - in his view, a warm and rather touching friendship that the press just doesn't want to understand. The recent blood-letting he dismisses with a casual wave, letting drop in an aside that 'losing one's temper is, of course, standard negotiating strategy'…"
***The New York Times*, September 16, 1990**

1444

"…Morton came to Eurotunnel reluctantly, drafted by the Bank of England to work some of the same magic he had used to turn around Guinness Peat, an insurance and merchant banking group on the verge of collapse when he stepped in in 1982. As Morton set about reviving the company, the fledgling Eurotunnel was in chaos. The company's initial share offering, in October 1986, reached its goal of $390 million only after the Bank of England energetically twisted the arms of British institutional lenders. A second misfire would mean disaster, since bank loans could not be completed until the equity finance was in place…"
***The New York Times*, September 16, 1990**

1445

"…In February 1987, with a major share offering looming, the Bank of England turned to Morton, who joined Andre Benard, recruited six months earlier from Royal Dutch Shell, where he had been managing director. Now 68, Benard makes a striking temperamental contrast to Morton: diplomatic, soothing, even bland, speaking fluent English with a languid elegance…"
***The New York Times*, September 16, 1990**

1446

"…Morton postponed the stock offering, buying time to build up investor confidence in Eurotunnel. Despite the stock market collapse of October 1987, Eurotunnel emerged from its stock flotation wobbling but still upright. Perhaps most important, Morton brought optimism and energy, even a bit of swagger, to the project. At a time when everyone else was wondering whether the thing could be built, Morton talked of constructing a second fixed link with the profits that the Channel Tunnel would be bringing in…"
***The New York Times*, September 16, 1990**

1447

"…Morton's optimism will be sorely tested in the next few months. The banks, balking at the new loan package, have painted Eurotunnel into a corner, refusing to let the company go to outside sources for money and at the same time failing to come up with it themselves. Eurotunnel could float more stock, but the market seems unlikely to respond. Frantic negotiation with the banks continues…"
***The New York Times*, September 16, 1990**

1448

Leading From the Front

1449

SIR Alastair Morton, the charismatic driver of the Channel Tunnel project who has died at the age of 66, was a good friend of Kent.

He was a controversial chief executive of Eurotunnel with a combative personality. But it was that style that helped him overcome some of his biggest difficulties.

Without his persistence - some called it bullying - it is doubtful whether the project would have happened at all.

He fought constant battles with construction companies in the TransManche Link (TML) consortium.

Constantly besieged by sceptical journalists pursuing more stories about the project's financial woes, he defused their hostility with a mix of wit and blunt-speaking.

But there was no escaping the £9bn debt mountain that hampered Sir Alastair's claim to total success. His financial forecasts proved over-optimistic.

The opening of the Channel Tunnel, by the Queen and French president Francois Mitterand, was a great day for Sir Alastair, the culmination of years of 70-hour days.

But it did not signal the end of strife. There was repeated talk of crisis as he tried to keep some angry bankers on side when they feared they would never get their money back…
***kentonline.co.uk*, September 3, 2004**

1450

…He was a supreme exponent of private enterprise whose time came when Margaret Thatcher was Prime Minister. But he was a fierce critic of her failure to sanction a Channel Tunnel Rail Link on the Kent side of the Channel

He admired the French love of "le grand projet" and their investment in the high-speed TGV rail network across France, including the link between Paris and the Channel Tunnel.

He was clearly delighted last year when Prime Minister Tony Blair opened the first section of CTRL - the 46-mile stretch between Cheriton and Fawkham Junction - at Waterloo International.

But he remained characteristically critical of delays in sorting out a domestic service to benefit passengers in Kent. "I would have thought they would have been a lot further forward than they are," he said. "They've had plenty of time to think about it."

Sir Alastair played a key part in the regeneration of East Kent as the first chairman of the East Kent Initiative, based in Dover.

Its efforts, and his lobbying in the corridors of Whitehall, sometimes against the wishes of local politicians who wanted to play down East Kent's economic problems, helped Thanet, Dover, Shepway and Swale win assisted area status…

1451

…He foresaw the economic benefits of the Tunnel and the rail link to the county, doing his best to impress on county officials and business leaders the importance of capitalising on this once-in-a-lifetime opportunity.

After leaving Eurotunnel, Sir Alastair, a South African, later went on to chair the Strategic Rail Authority, but his time there was neither as happy or successful as it had been at Eurotunnel.

He was less comfortable with Labour ministers and the range of organisations he had to deal with at the SRA, including the politically-sensitive issue of RailTrack. The Government found his plain-speaking less to its taste than someone with a softer spot for the public sector.

He quit in 2001 after failing to establish his authority among the competing bodies.

He accused the industry of "drifting" and the SRA of being "powerless"…

1452

…Robert Alastair Newton Morton was born in Johannesburg and educated at Witwatersrand University.

In 1976, he became the first executive to join the British National Oil Corporation. In 1982, he joined the merchant banking group Guinness Peat.

Sir Alastair was knighted in 1991 and, a measure of the respect given him by his French counterparts, a Commandeur de la Legion d'Honneur in 1994.

Above: caption: "Sir Alastair on Dover sea front in July 1993"

1453

A Splendid Investment

1454

"…Meanwhile, the project is in limbo, technically in default, but racing ahead on all eight cylinders. The betting is that either the British will win over the Japanese banks (prominent among the naysayers) through discreet governmental pressure and close the $1.6 billion gap, or the banks will relax the rules and allow the project to go forward with something less than full financing…"
The New York Times, **September 16, 1990**

1455

"…Morton insists that Eurotunnel remains a splendid investment. The company has sole right to operate the tunnel until 2042 (the British and French Governments then take it over), with no competition from another fixed link until 2020. Cross-channel traffic has more than doubled since 1976, and most forecasts predict nearly double today's traffic by 2003. And no underwater link has ever operated at less than full capacity…"
The New York Times, **September 16, 1990**

1456

To Infinity and Beyond!

1457

"…Reaching for a sheet of paper, Morton whips out a pen and draws a diagram comparing revenues from an oil well, a power station and the Channel Tunnel. The revenue lines for the oil well and the power station go sharply up and just as sharply down. The line for Eurotunnel taxis along the runway, gains a little altitude, then flies straight up and out of sight. Morton looks up from the paper and smiles broadly: 'This is one of the very few projects in the world that, at least on a 50-year view, which is long enough for most bankers to think about, doesn't have this up and down characteristic. And that's what keeps the bankers going.' It's that simple. The tunnel has always been simple. It's building the thing that's proven complicated…"
The New York Times, **September 16, 1990**
RE: *Andre Benard* was accused by investors of misleading them about prospects for the project. However, in 2007, a French court cleared him of those charges. Benard died on March 15, 2016 at the age of 93.

1458

Very Continental

1459

"…In the salon of the Clifton Hotel, a handsome old building looking out over the Channel, a group of elderly women huddle for a chat. Travel is on the agenda, specifically how much more of it there seems to be these days. All of a sudden, Europe feels very close. 'Oh, in my time a week at Margate - that was the thing,' says one woman to the group. Heads bob in agreement, and there's a chorus of 'Mmmm, yes.' 'All this running off to Spain and places like that - why, that was something millionaires did'…"
***The New York Times,* September 16, 1990**

1460

"…The heads stop bobbing as the wonder of it all seizes the group for a moment. Europe was always a mirage. You could see it - right there, out the hotel window - but in some ways, it didn't really exist. Now, a couple of holes in the ground are changing everything, forever, letting Europe in with a whoo-sh…"
***The New York Times,* September 16, 1990**

1461

"…Lunch in Paris? *With journey times from London to Paris taking a soupcon over two hours, the Channel Tunnel opened up the possibility of day trips to the French capital. Perhaps even just for a bite to eat. Eurostar admits it has no idea of the numbers who make the journey from the UK just to have lunch in Paris. But there is anecdotal evidence. 'I know a few people who have been to Paris for lunch,' says Roscrow. 'It is an amazing idea still, I think, that you get a train from London and go to Paris…"*
***bbc.com,* May 5, 2014**

1462

"…*Before the Channel Tunnel, we never had the destination 'Paris' up there on the timetable board. This is something the rest of Europe is used to - you can board a train in say, Milan, and go to Moscow. But in Britain, this was all new.' Roscrow has himself lunched in Paris, but says people tend to make slightly more of their day trips, usually leaving as early as possible and coming back as late as possible. 'If you're going to Paris,' he said, 'there's a tendency to spend a little long-er'…"*
***bbc.com,* May 5, 2014**

1463

Getting On With It

1464

"…For the older generation, it's almost too much to handle. But for the British baby boomers, Europe has been a fact of life for 20 years. For them, Paris will be a short hop for lunch and an afternoon of shopping; their Margate will be Vienna or Berlin or Prague. The Channel is no longer a kind of sacred guarantor of Britishness, but an annoying barrier, a two-hour delay on the drive to France. 'What's coming through with the younger people is a belief that we're in, so we might as well get on with it,' says Morton. 'If we don't get on with it, we're going to get done by the other lot.'"
***The New York Times,* September 16, 1990**

1465

Darkest Days

1466

"Plagued by conflict and delays, the $14.7 billion English Ch-annel tunnel project has degenerated from a grand symbol of European business integration to a financial morass, with one of the leading contractors suggesting this week that the project could face bankruptcy…"
***The New York Times,* May 28, 19922**

1467

"…The 'chunnel,' as the 24-mile-long underwater link bet-ween Britain and France is sometimes called, was once sch-eduled to open on June 15 next year. That has been post-poned to the last quarter of 1993 at the earliest and may well be put off until 1994 because of financial disagreements and construction delays…"
***The New York Times,* May 28, 1992**

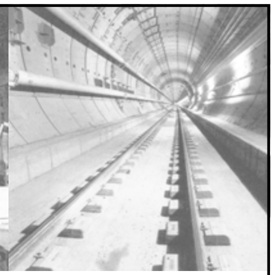
1468

"…A bitter dispute with contractors over payments and a breach of the loan agreement with the banks that have com-mitted $12.3 billion to the venture have undermined Euro-tunnel, the British and French company that will operate the tunnel…"
***The New York Times,* May 28, 1992**

1469

"…Shares in Eurotunnel fell 3.7 percent today on the Paris Bourse after Martin Bouygues, the chairman of the Bouygues construction company of France, said at a news conference on Tuesday that 'one cannot completely exclude the hypo-thesis that Eurotunnel will go bankrupt.' He added that 'the project has skidded off course, and the situation is bad'…"
***The New York Times,* May 28, 1992**

1470



"…The chunnel's two rail tunnels were completed in May and June of last year, but they still have to be equipped with power systems, signals, air-conditioning and other equipment in what remains a highly complex engineering operation. On completion, the shuttle service between Sangatte, France, and Folkestone, England, should take 37 minutes…"
***The New York Times*, May 28, 1992**
Left: caption: "Equipment installation in one of the running tunnels"
Right: caption: "A general view of a running tunnel with the tracks awaiting the final concreting"

1471

1472

"…Mr. Bouygues was the first executive involved with the tunnel to mention a possible bankruptcy. In reaction, Annabel Salmon, a Eurotunnel spokeswoman, said, 'We were astonished by this unfounded outburst.' While a bankruptcy could cause large financial losses for investors and creditors of the project, it is unlikely that it would permanently halt the tunnel's completion…"
***The New York Times*, May 28, 1992**

1473

"…Bouygues, France's largest construction firm, is part of a consortium of five French and five British companies known as Transmanche Link. Transmanche is seeking $2.6 billion in extra payments from Eurotunnel for work already done. The construction companies say Eurotunnel owes them the money because of its ongoing demands for more complex and expensive work…"
***The New York Times*, May 28, 1992**

1474

"…Eurotunnel is contesting that claim, and company officials suggested that Mr. Bouygues's angry statement might have amounted to posturing. The Bouygues company did not return telephone calls seeking elaboration. But analysts, while generally describing Mr. Bouygues's warning as exaggerated, said the plight of Europe's largest construction project was disturbing…"
***The New York Times*, May 28, 1992**

1475

"…'It was originally budgeted at $8.7 billion,' said Mark McVicar, an analyst at County NatWest Wood Mackenzie. 'Now it's budgeted at $14.7 billion, and we still don't know what the final cost will be. We don't know when the tunnel will open, whether the conflict with contractors will be resolved or what revenue to expect. It's all very vague.' An analyst at UBS Phillips & Drew, who insisted on anonymity, said that 'the risk of investing in Eurotunnel is now enormous, and the possibility of bankruptcy cannot be ruled out'…"
***The New York Times*, May 28, 1992**

1476

"…Eurotunnel, whose shares were floated in 1987, was ordered by an independent aribitration panel in March to begin paying $91 million a month to contractors toward a disputed $2.6 billion claim. The order was described by Eurotunnel's chief executive, Sir Alastair Morton, as 'a hand grenade' tossed into midst of negotiations with contractors, and the company has appealed to the International Chamber of Commerce in Brussels. Ms. Salmon said negotiations were continuing with contractors on a settlement because arbitration in Brussels could take years…"
The New York Times, **May 28, 1992**

1477

"…The two sides are still believed to be about $900 million apart, with Eurotunnel insisting that the contractors had agreed to a fixed payment and the contractors countering that the payment from Eurotunnel must reflect their sharply increased costs…"
The New York Times, **May 28, 1992**
Left: caption: "Jack K. Lemley is the chief executive officer of Transmanche-Link and currently presides over the construction of the Channel Tunnel between Great Britain and France"

1478

"…The dispute appears to be slowing progress on the tunnel. Philippe Montagner, a Bouygues director responsible for the group's tunnel operations, said this week that the tunnel was unlikely to open before March 1994. 'Under the best scenario, with everyone working hand in hand, I don't see completion before early 1994,' he said. Every time the completion date is put off, so is the start of much-needed cash flow for the highly indebted Eurotunnel operating company, which has estimated that its first-year revenue will be $1.15 billion.…"
The New York Times, **May 28, 1992**

1479

"…At least partly because of the delay, the company has defaulted on its loan covenants with the 206-bank syndicate backing the project and is urgently seeking a waiver from the banks to tap into the next vein of their $12.3 billion loan. Eurotunnel has already used about $7.3 billion of that total financing…"
The New York Times, **May 28, 1992**

1480

"…Colin Comery, the National Westminster Bank executive heading the team of lead banks, said the whole syndicate would vote on Friday on granting the waiver. He declined to comment on the likely outcome. The agent banks for the syndicate are National Westminster and Midland from Britain and Credit Lyonnais and Banque Nationale de Paris of France. Asked about Mr. Bouygues's suggestion of a possible Eurotunnel bankruptcy, Mr. Comery said, 'I certainly hope it does not come to that'…"
The New York Times, **May 28, 1992**

1481

"…Analysts said it was almost certain that the banks would approve the waiver to keep Eurotunnel operating. 'Having already paid out $7.28 billion, you don't just pull the plug,' said Mr. McVicar of County NatWest Wood Mackenzie…"
The New York Times, **May 28, 1992**

1482

"…In all, Eurotunnel has about $16.2 billion of equity and loans. Given the postponements and the disputes with contractors, analysts say the company may be forced to try to raise more money to survive amid skepticism from banks and the stock market."
The New York Times, **May 28, 1992**

1483

Part 21

Open for Business

1484

The Stuff of History

1485

"'It's only a transport link, after all,' said Angus Willson somewhat disingenuously, pondering the construction site across the road. As director of education at the Channel Tunnel he was more than well aware of the symbolic significance of Britain's greatest engineering project of the century. If all goes to plan, the tunnel will open in December, joining Britain to Europe by a fixed link in the year of the Single Market and the parliamentary battles of Maastricht. Like the map-bending projects that built the Suez and Panama Canals, this is the stuff of history…"
Times Educational Supplement, **April 2, 1993**

1486

"…Since Napoleon first gave the order to drill down into the chalk floor of the English Channel in 1802, the prospect of connecting Britain to continental Europe has been the tantalising and hitherto elusive goal of successive generations of engineers. While such engineers have long pronounced that a tunnel was a practical possibility, British politicians and public in the past 200 years have been less than enthusiastic about the symbolic link with Europe. A tunnel begun in the 1880s reached a mile in length before being stopped on the unlikely premise that the French army might use it for a surprise attack. And a more substantial Anglo-French initiative begun in the 1960s withered away when the cost outgrew the political will to complete it…"
Times Educational Supplement, **April 2, 1993**

1487

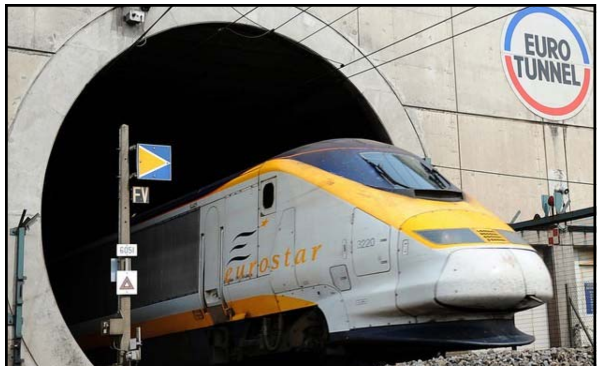
"…With so many failed attempts at crossing the narrow stretch, there were certainly plenty of cynics who thought that the Eurotunnel plan, begun in 1987, would fizzle out in the way of its predecessors. But the tunnel is now in place and peering down this square hole on the Kent coast, it is difficult not to feel a buzz of excitement when one thinks that at the other end of this modest little entrance is the Pas de Calais, France and the whole European continent…"
Times Educational Supplement, **April 2, 1993**
Above L&R: aerial view/s of Folkestone (left) and Coquelles (right) portal/s

1488

"…All around work goes on, preparing a passenger terminal, approach roads, rail lines and completing the tunnel itself, 49 kilometres long, laid between 25 and 45 metres beneath the bed of the English Channel. When the tunnel opens to the public in December, it will offer a rail shuttle carrying cars and lorries on the 35 minute journey between Folkestone and Beussingue, near Calais. Cars and their passengers will be transported in double-decker carriages, divided into four-vehicle compartments, in which passengers will remain for the duration of the journey…"
Times Educational Supplement, **April 2, 1993**
RE: intercontinental mainline trains share tunnel passage slots with shuttle trains
Left: caption: "January 11, 1994: loading trials on a Eurotunnel shuttle train" 1489
Right: caption: "Automobiles exiting Eurotunnel shuttle train"

"…And from June 1994 Britain's first international inter-city line will carry passengers through the 140 hectare site, on the three-hour run between London Waterloo and Paris Gare du Nord…"
RE: on both sides of the Channel, TML had responsibility for the design and construction of terminals. Both London (*Waterloo*) and French (*Gare du Nord*) terminal/s allow shuttle trains to exit from the tunnel and loop around to stand at platforms facing the direction from which they came.
Times Educational Supplement, **April 2, 1993**
Left: caption: "Waterloo International Eurostar terminal" 1490
Right: caption: "Eurostar at Gare du Nord, Paris"

1491



Above: caption: "The journey through the Tunnel on board Eurotunnel Shuttles at a speed of 140 km/h, takes just 35 minutes, of which 26 minutes is beneath the Channel" 1492

"…To make the most of the educational potential of the tunnel, Kent County Council and Eurotunnel in 1987 established the Channel Tunnel Curriculum Development Project. Angus Willson, a local teacher, was seconded as project director, and local authority advisers, advisory teachers and classroom teachers were involved in the preparation of materials. The intention of these, Angus Willson says, has not been to teach about the tunnel, but to use it as an imaginative and topical context for aspects of the curriculum…"
Times Educational Supplement, **April 2, 1993**

1493

"…As a Kent-based project, interest initially focused on the impact of the Folkestone terminal on the local environment. And the education materials reflected this with packs addressing questions of planning and the siting of roads. But as the tunnel developed the question of Britain's place in Europe emerged as an issue of growing importance…"
Times Educational Supplement, **April 2, 1993**
Left: caption: "Model of the Channel Tunnel Terminal, Folkestone" 1494
Right: caption: "Model of Folkestone, Kent Terminal"

Above: caption: "AN ARTIST'S impression of the proposed terminal for the Channel Tunnel in Folkestone, with railway line enclosed in a loop providing a continuous route for trains without the need to reverse" 1495

"…Although in terms of time, the tunnel will bring east Kent closer to the Pas de Calais than London, a massive cultural gulf still exists between the British and their European neighbours. Despite Kent being part of a European Community economic development region that includes parts of France and Belgium. Angus Willson still sees a reluctance among young Britons to consider themselves Europeans…"
Times Educational Supplement, **April 2, 1993**

1496

"…Among the 65,000 school children who visit the Eurotunnel Exhibition Centre each year. Angus Willson has regularly encountered junior Europhobes, who see the tunnel as more of a threat than an opportunity. Rather than looking forward to finding out what lies at the other end of the tunnel, they worry instead about the foreigners who might come out at this end, In an attempt to dissolve this insularity, the Curriculum Development Project has recently produced Breaking Barriers, a video pack which shows how a young man's finely tuned xenophobia becomes a hindrance to his love life…"
Times Educational Supplement, **April 2, 1993** 1497
Above L&R: caption: "Eurotunnel Exhibition Centre, Folkestone"

1498

"…The need for this message of tolerance is more than a liberal nicety. Assaults on foreign language students have become a depressingly regular aspect of the south coast summer, with seafront thuggery threatening an important contribution to the local economy. But the ambivalence of the British to their foreign visitors is presented on arrival at Folkestone train station. Platform announcements are made in both French and English, but the graffiti on the wall facing the station baldly states 'No more French'…"
Times Educational Supplement, **April 2, 1993**

1499

"…Encouraging much more French and German is an aim of the Curriculum Development Project. 'Infos d'aujourd'hui' and 'Nachrichten zum Kanaltunnel' are modern language bulletins for GCSE that report on the development of the tunnel of the tunnel and 'Infos en direct' offers French exercises on audiotape for key stage 4. Angus Willson believes that such materials and the building of the tunnel have contributed to the increasing take-up of the post-16 modern languages courses in Kent…"
Times Educational Supplement, **April 2, 1993**

1500

"…The building of the world's longest undersea tunnel has also been used as the basis for technology materials - 'Primary Practical Investigations,' 'Rail Link Technology' and 'Travel, Terminals and Technology.' Outside the exhibition centre which houses the Curriculum Development Project, is a digging machine that bored through the chalk marl in which the tunnel is set. Its head alone weighs 800 tonnes and when its tungsten carbide teeth were in full 24-hours-a-day operation crawled forward at 200 metres a week…"

Times Educational Supplement, **April 2, 1993**

Above L&R: caption: "Channel Tunnel Exhibition Centre, Folkestone 1992: a Tunnel Boring Machine. One of the 11 TBMs (25 ft. diameter) after employment for boring the two separate rail tunnels with a service tunnel between them, for 31 miles (24 miles under the sea)."

1501

(iii) Tunnel Progress

	Distances driven in 6 months periods	Total	No of TBMs in operation
Jan - June 1988	1782	1782	2 - MST (UK/France)
July - Dec 1988	6734	8516	4 - MST/LST/MST/LST (UK/France)
Jan - June 1989	17149	25665	7 - MST/MRTN/LST (UK) MST/MRTN/MRTS/LST/LRTS (France)
July - Dec 1989	25166	50813	9 - MST/MRTN/MRTS/LST/LRTN (UK) MST/MRTN/MRTS/LRTS (France)
Jan - June 1990	41883	92714	9 - MST/MRTN/MRTS/LRTN/LRTS (UK) MST/MRTN/MRTS/LRTN (France)
July - Dec 1990	34966	127680	8 - MST/MRTN/MRTS/LRTN/LRTS (UK) MST/MRTN/MRTS/LRTN (France)
Jan - June 1991	23617*	151297*	4 - MRTN/MRTS (UK) MRTN/MRTS (France)

*as at 24 June 1991.

MST = Marine Service Tunnel LST = Land Service Tunnel
MRTN = Marine Rail Tunnel North MRTS = Marine Rail Tunnel South
LRTN = Land Rail Tunnel North LRTS = Land Rail Tunnel South

2. Tunnel Boring Machines

There were 12 drives originating from Shakespeare Cliff in the UK and Sangatte in France. There were 11 TBMs in total.

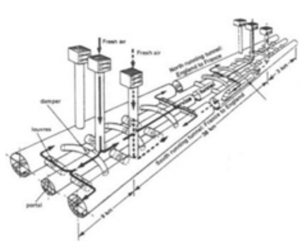
The TBMs were designed around the concept of continuous excavation independent of the ring-erection process. All are equipped with laser guidance system which provide the shield operators with constant information on the position and alignment of the TBM for steering purposes.

The basic TBM is a conventional unit with a telescopic shield built around it to provide support to and protection from the soft and possibly wet rock through which the machines tunnel. The cutterhead is designed to carry picks, and is able to rotate in either direction. Different types of picks are used depending on ground conditions. Disks, picks and cutters can be fitted from the rear of the cutterhead access being gained through a special bulkhead.

On the UK side, the lining consists of unbolted expanded segmented concrete rings, and on the French side of bolted segments through most of the length of the Tunnel.

While the TBMs hewed-out the two large bore running tunnels and the smaller bore service tunnel, a vast amount of other tunneling work was taking place elsewhere under the term "Wend tunneling." For example, the piston relief ducts were dug-out by "hand tunnellers." At 250-meter intervals, they loop over the service tunnel to connect the running tunnels, relieving air pressure from the "piston effect' of the trains traveling at high-speed through the tunnel/s. At 375-meter intervals, passages connect the service tunnel to the running tunnel/s. They too were dug by hand tunneling methods.

1502



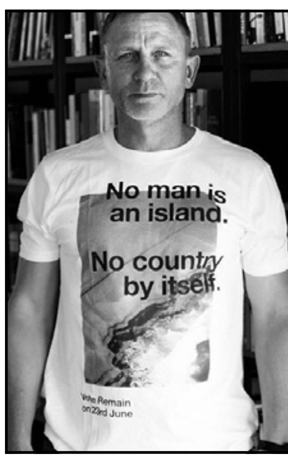
1503

Above: caption: "TBM completes the French Land Service Tunnel"

1504

No Country by Itself

1505



"…All the project's publications are designed to use aspects of the tunnel as an introduction to areas of the curriculum. So looking at the tunnel-boring machine for example, could lead to hydraulics, pulley systems and gears. And for modern languages, the education rooms could be used for role play. But beyond the formal education contained in these packs, perhaps the most vital aspect of the project is the underlying message that in times of ever-growing transport links and economic integration, no country is an island and the garden of England has a land border with France."

Times Educational Supplement,
April 2, 1993

Left: actor *Daniel Craig* wearing a white T-shirt with the slogan: "No man is an island. No Country by itself."

1506

On Track

1507

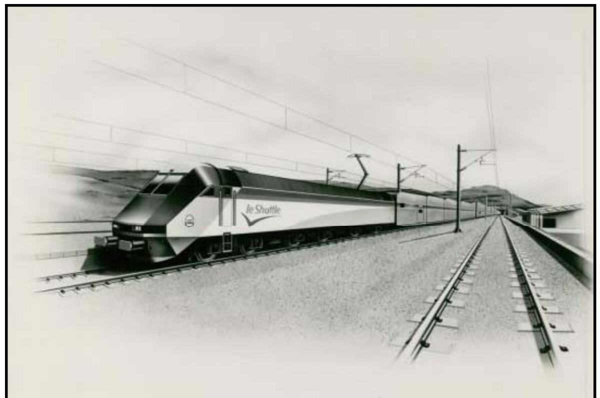
Chunnel On Track For Debut

DOVER, ENGLAND – As we go to press, the Channel Tunnel is still due to open this month, as British and French railroad authorities scramble to meet the deadline. The shuttle trains that will ferry cars and trucks under the English Channel will debut first. Eventually a fleet of 38 trains will run between Folkestone, England, and Calais, France. Later this summer, the 18-car Eurostar trains – based on France's TGVs – will inaugurate 3-hour London-Paris passenger service. British instructors are preparing engineers for the unfamiliar journey with a simulator that can reproduce fog, track obstacles and signal failure. (*Popular Mechanics,* May 1994)

Caption: "Shutle-train power unit undergoes final checkout (top) while Eurostar engineer goes through paces on simulator (bottom)"

1508

1509



Above: caption: "Le Shuttle – the car and passenger service will offer a completely new concept in cross channel transportation"

1510

Light at the End of the Chunnel

1511

Europe's engineering project of the century opens for smooth rides under the English Channel

***Popular Science,* May 1994**

RE: introduction to an article written by *Judith Anne Gunther* entitled: "Greetings from the Chunnel"

1512

Above: caption: "Calais: May 6, 1994. The Queen and the Duke of Edinburgh traveling on the new Eurostar train today (Friday)"

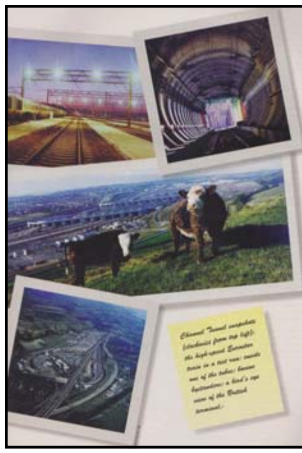
1513

This is the Chunnel

1514

"The traffic is light, as Londoners James and Allison Whitby turn off the M20 motorway at Folkestone. They're headed for Paris, where they hope to find bargains on French antiques, and the simplest way to get there is to catch Le Shuttle. Their $420 ticket will buy them a roundtrip ride on a rail system that transports them and their car beneath the English Channel to Coquelles, a village in Normandy. What neither realizes is that – behind the shiny new trains, pristine buildings, and duty-free shopping opportunities – a technological behemoth exists that operates this 20th century engineering trophy…"
Popular Science, **May 1994**

1515



"…This is the Channel Tunnel. Dreamed of by Napoleon, futilely attempted 100 years ago, and built at a cost greater than most countries' gross national product, the 31-mile underwater rail link between England and continental Europe is finally in place…"
Popular Science, **May 1994**
Caption: "Channel Tunnel snapshots (clockwise from top left): the high-speed Eurostar train in a test run; inside one of the tubes; bovine bystanders; a bird's eye view of the British terminal"

1516

By the Numbers

1517

"…By 1996, the system will transport some 8 million car passengers and 4.5 million bus passengers each year. The largest privately financed infrastructure project ever, the Chunnel created more than 70,000 man-years of employment in Britain alone, estimates the contractor. Estimates from late 1992 presume that as much as 8.5 million metric tons of freight will also pass through the tunnels each year. This staggering capacity and the oversized trains give the system's terminals the aura of a 'Jurassic Park' for train enthusiasts…"
Popular Science, **May 1994**

1518

The Big Picture

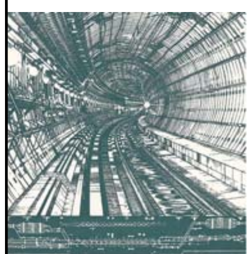
1519

"…The owner, Eurotunnel, hopes to entice a large chunk of the tourist traffic that currently uses hovercrafts and ferries to cross the choppy waters of the English Channel. But it also possesses a larger vision: The Channel Tunnel opens direct passenger train service from London to major cities on the continent and facilitates the movement of freight to and from Britain…"
***Popular Science*, May 1994**

1520

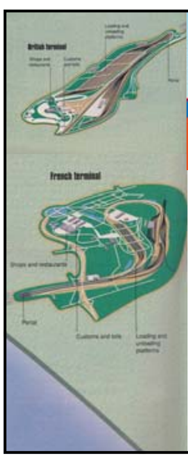
Tour de Force

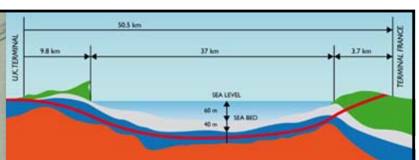
1521



"…Eurotunnel says travel and transport between Britain and France will now be simple, dependable, and competitively priced. But to provide these services requires as mega-operation that few passengers will ever see. The Channel Tunnel is an engineering tour de force, ingeniously encompassing advanced safety equipment, state-of-the-art control rooms and a gigantic air-conditioning system…"
***Popular Science*, May 1994**
RE: presently, the Chunnel is the longest subaqueous tunnel in the world, with its undersea section 38km in length. The three tunnels; each 50km long, were bored at an average of 40m below the bed of the *Straits of Dover.*

1522



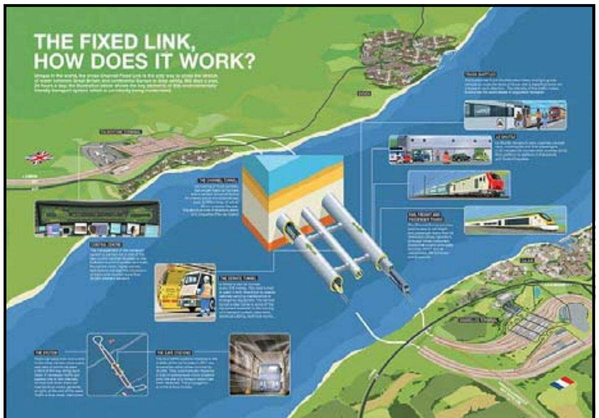


"…Commonly referred to as 'The Chunnel,' the Channel Tunnel is actually a complex of three parallel passageways, dipping as far as 148 feet below the seabed of the English Channel. On the French side, the tunnel surfaces at Coquelles, near Calais, after first passing beneath two miles of coastline. On the British side, the tunnel emerges near Folkestone, at the base of Castle Hill, a knoll five miles inland from the famous chalky white cliffs of Dover. At both portals, the loading platforms, the toll booths, the orderly stretches of new track, and the webs of catenary wire spread out like silt at the mouth of a river…"
***Popular Science*, May 1994**

1523

__Above__: caption: "Line drawing of the Channel Tunnel (50km long) connecting England and France, of the Folkestone and Coquelles terminals and connections to motorway and (high-speed) rail networks"

1524



1525

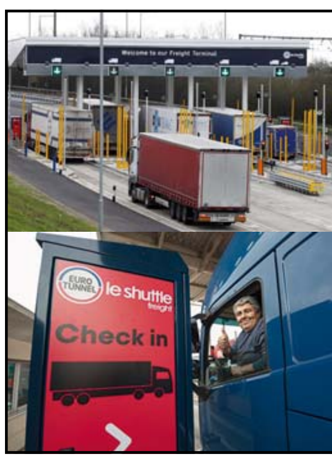
<u>Left</u>: caption: “Covering an area of 650-hectare and 23-km long perimeter, the Coquelles terminal, near Calais, is one of the largest land-travel complexes in Europe (the equivalent in size to an international airport). As a result of the marshy nature of the soil, the whole area had to be covered with a 50-cm thick layer of sand before construction could begin in order to ensure a good base for the foundations.”
<u>Right</u>: caption: “The Folkestone terminal, located at 8 km from the under-sea tunnels at Shakespeare Cliff, covers a 150-hectare area, i.e. about one third of the area of the French terminal. Its construction required first to stabilize the site in order to prevent the sides of the adjacent escarpment from subsiding. The level of the whole site was then raised to level out the soil and eliminate steep slopes.” 1526

Both the French and British terminals are easily reached th-rough their direct access to their respective national motor-way network/s in (M20, in the UK and A16, in France). As well, they both represent the loading/un-loading points for vehicles traveling on *Eurotunnel* shuttle trains. Access to the termin-als is made through a toll plaza for both passenger vehicles and trucks.

1527

Once check-in operations are completed, travelers must go through border controls carried out by British and French police and customs. All controls are carried out before de-parture in order to enable customers to continue their journey directly on the motorway network on the other side of the Channel. 1528

<u>Above</u>: caption: “French customs officers and their dogs wait beside the Eurostar ready for the return journey” 1529



Once past security and cus-toms, passengers have the op-portunity to take shop (duty-free), eat, play etc. at the *Victor Hugo Terminal* in Folkestone and/or the *Charles Dickens Ter-minal* in Coquelles or to drive towards the allocation areas before reaching the platforms area (twelve, each at 1-km long). There, vehicles can drive on *Le Shuttle* for passengers (cars, coaches, camper-vans, caravans, motorcycles, etc.) or on the *Truck Shuttle* (heavy goods vehicles, left T&B).

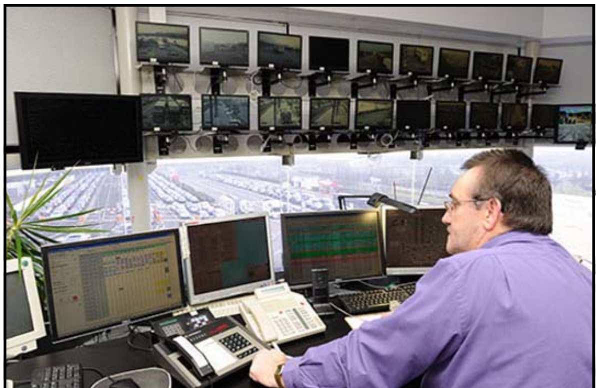
1530

Left: caption: "Cheriton, UK. May 19, 1994: British truck driver Roy Clementson (right), the first heavy goods vehicle driver to make the undersea channel crossing with the Eurotunnel freight service, about to enjoy some champagne"

1531

There are several different areas on each terminal (passenger, freight, control centers, administration and maintenance buildings). Traffic control on the terminals is managed by a road *Terminal Control Centre* (TCC). On top of the many IT systems enabling vehicles to be recognized upon arrival at the self check-in tolls and the many screens linked to about one-hundred cameras, the TCC has a direct view over the allocation lanes for vehicles.

1532



Above: caption: "The two TCCs on the Folkestone and Coquelles terminals manage road traffic flows from check-in to the loading of vehicles onto a Shuttle, as well as the unloading process once the Channel Tunnel crossing is completed"

1533

Above: caption: "Eurotunnel head office in Coquelles"

Upper Left: caption: "Aerial view of the platform area at Eurotunnel Terminal in Coquelles. Every day, Eurotunnel Shuttles transport on average 7,000 cars, 160 coaches and 4,000 trucks carrying more than 55,000 tonnes of goods."

Lower Left: caption: "Aerial view of the maintenance yard on Eurotunnel Terminal in Coquelles (France). At the Coquelles yard, Eurotunnel has the longest rail maintenance building in the world, 838m long, allowing technicians to work on a complete Shuttle."

1534

Above: caption: "The Victor Hugo Passenger Terminal building in Folkestone. Once through border controls, Eurotunnel customers can shop at the Passengers Victor-Hugo building in Folkestone, change currency or stop for refreshments."

Upper Left: caption: "This building houses the rail and road control centres on the Folkestone Terminal"

Lower Left: caption: "This building houses the rail (RCC) and road (TCC) control centres for the Coquelles Terminal"

1535

All Aboard!

1536

"…After James purchases a single ticket, good for his car and any number of passengers, the Whitbys go through customs. Then James directs the car up a ramp and onto a loading bridge. Allison glances at her watch: 11:15 a.m. As the car idles while in line for the next shuttle train, the Whitbys command a good view of the terminal. To their left, a Brussels-bound passenger train slips into the gloom of the north tunnel entrance. Far ahead, a heavy fence conceals a cargo train churning down the Continental Main Line toward London…"
Popular Science, **May 1994**

1537

"…With its brakes hissing, a silvery shuttle train slides up to the platform. The roadway barrier lifts, the light turns green, and, one by one, the cars roll down the loading ramp, onto the platform, and into the gaping hole in the shuttle's side. James dutifully maneuvers through three tubular train cars and comes to a halt behind a green Volvo. He switches off the ignition. A moment later a buzzer sounds, and clacking metal dividers descend from the ceiling at each end of the train car sealing the Whitbys' Opel and four other vehicles onto one long, low-ceilinged rectangular compartment 12 feet wide, with gray ribbed floors and bare white walls…"
Popular Science, **May 1994**

1538

1539

Part 22

Wonder of the World

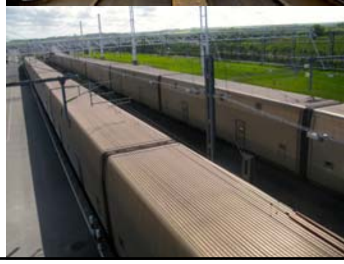
1540

The Steel Wheel

1541

"…The shuttle trains look inordinately large – and they are. At 13.5 feet across, Eurotunnel's shuttle cars are the widest train cars ever built. These rolling stock, each carrying ten vehicles, cost $3,200,000. Each shuttle is a half-mile long: 12 double-decker cars for automobiles, 12 single-deck cars for buses, plus a pair of engines and the loading and unloading cars. …"
Popular Science, **May 1994**

1542

1543

1544

"…Each electric locomotive is capable of hauling a 2,100-ton load at nearly 100 mph and has been fitted with a rarely used bogie arrangement: three sets of wheels, with twin, independently driven axles. This design improves the adhesion of the steel wheels to the track as the train negotiates sharp curves – important for the tight turnaround loops at each terminal…"

Popular Science, **May 1994**

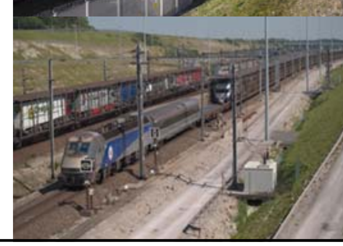
1545

1546

Eurotunnel expects to load a shuttle in approximately eight minutes. The state-of-the-art shuttle cars are equipped with onboard computer to control functions like air conditioning and opening doors, a hydraulic stabilizing system, and a purging system to expel automobile fumes. Larger than most railroad cars, empty shuttle cars would be in danger of tipping over in high winds; tail wind fences were erected at the terminals to prevent such an event.

1. A typical Le Shuttle train includes 12 double-decker cars for automobiles, 12 cars for buses and campers, loading and unloading cars, plus a locomotive at each end. A full shuttle carries about 800 passengers. 2. Passenger cars simultaneously fill both the upper and lower decks via a ramp equipped loading car. 3. Buses and campers enter the shuttle via a loading car with telescoping walls that seal shut when the train is in motion. Hydraulically powered plates bridge the gap between the pavement and the train. 4. Trucks are transported in lattice-walled cars, the drivers travel in a club car at one end of the shuttle.

1547

1548

1549

Eurostar

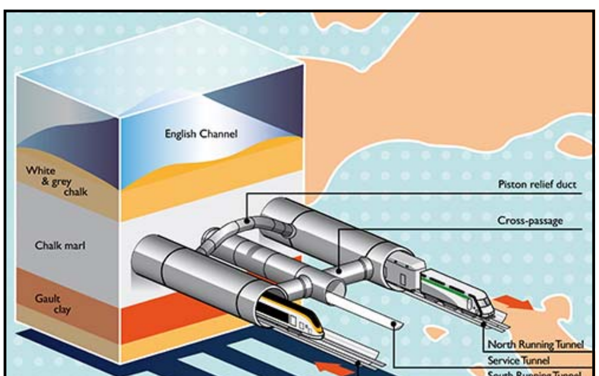
1550

"…Between shuttle trains, Eurotunnel schedules runs for Eurostar passenger trains, which provide non-stop, and, where rail quality allows, high-speed, rail trips between London and destinations on the continent…"
Popular Science, **May 1994**
__Above__: caption: "Passengers ride in comfort on Eurostar trains"

1551

"…The locomotives used for these passenger trains are unique by any standard. Each must accommodate different electrical power pickup mechanisms, signaling systems, and voltages used by the British, French, and Belgian railways. To avoid the need to standardize three countries' entire rail systems, these trains can run on all three – not an easy task…"
Popular Science, **May 1994**
RE: after travelling through the Channel Tunnel, through-trains operated by railway companies continue their journey on the UK and/or French rail networks, which are connected to the tunnel tracks at Dollands Moor and Frethun, respectively. The shuttles operated by *Eurotunnel* remain within the Eurotunnel system. They travel on a rail loop between the Folkestone and Coquelles terminal/s, using the south tunnel when going from France to the UK and the north tunnel, when going from the UK to France.

1552

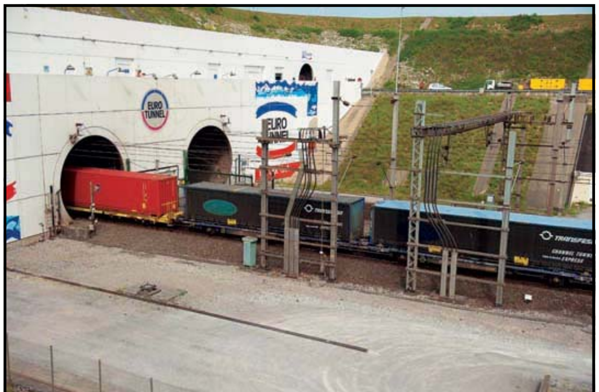


__Above__: caption: "The Channel Tunnel provides passage to Eurotunnel Shuttles carrying cars and coaches or trucks, and also to passenger high-speed trains and rail freight trains from railway operators"

1553

__Above__: caption: "A Eurostar passenger train at the Channel Tunnel portal"

1554



Above: caption: "A rail freight train at the Channel Tunnel portal" 1555

"…'To do that,' explains Eurotunnel official Bill Coleman, 'the Eurostar locomotives need three separate engines – one for each voltage. Also, the Channel Tunnel's intergovernmental commission specifies that all trains using the tunnel must be twin-engine,' a safety precaution in the event of a breakdown. 'That means,' he continues, 'each Eurostar locomotive has six engines. And that's not all – there is a locomotive at each end of the train. Altogether there are twelve engines on each Eurostar train'…"
***Popular Science*, May 1994**

1556

The Journey Begins

1557

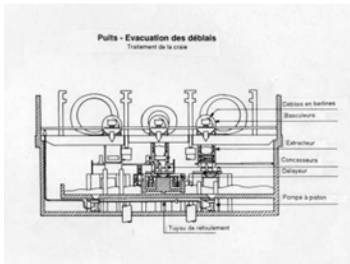
"…With a gentle lurch, the train eases forward. Allison pulls several postcards out of her purse and begins to address them. James opens his car door and stands up, feeling the easy tremble of the moving train. To his right, a stairway leads to the upper level of the train car. To his left, sunlight pours through a small, square window; he walks over and peers out. Fences and a forest of catenary poles roll by. Then the glass goes black, and James realizes they've entered the tunnel…"
***Popular Science*, May 1994**

1558

The Tubes

1559

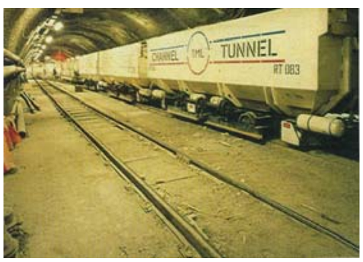
"…Eleven massive tunneling machines - some as long as two football fields - bored the three tunnels that make up the Channel Tunnel complex. The gargantuan cutters gnawed perfectly round tubes through the semi-soft cheese-like substrate of the English Channel, then used conveyors to expel the soggy spoil to the rear of the machines. Conveyor belt systems and other machinery helped remove the spoil to locations outside the tunnels…"
***Popular Science*, May 1994**
RE: excavated material (a/k/a "spoil") removed by TBMs was loaded onto 20-ton muck wagons on the narrow gauge rail network. These wagons (usually eleven per train) transported the spoil between the TBMs and the yard area (two sloping tunnels provided access between the lower *Shakespeare Cliff* site and the underground tunnel yard area). Located alongside the track, the muck wagons discharged laterally into a hopper. The spoil was taken up by a chain conveyor which transferred the spoil to the main conveyor belt which brought it to the surface through a portal. The main conveyor belt had a capacity of 2,400-tons-per-hour, making it capable of accepting the excavated material of five TBMs 1560



1561

"I first became aware of the Mühlhäuser company in the late '70s when I worked on the Kielder water transfer tunnels for the Anglo German JV. Some of the tunnels were equipped with Mühlhäuser muck wagons and some with others of European manufacture. These other units gave constant maintenance problems. They didn't have the large, strong bearings and good suspension of the Mühlhäusers. At the end of the contract, the Mühlhäuser cars were quickly sold on - the others were eventually sent to scrap."
Mike Duggan
RE: Duggan, an employee of TML's UK <u>J</u>oint <u>V</u>enture (JV) partner *Taylor Woodrow,* was instrumental in mobilizing the UK Channel Tunnel operation. More than 350 units of *Mühlhäuser* equipment were used on the project. Rail-running concreting equipment was supplied to the French side (to supplement a slurry pumped mucking system) and a full-range of rolling stock was supplied to the UK operation, including 15 cubic-meter self-tipping muck cars with tipping stations, segment cars, flatcars, man-riders, concrete remixers and cement and aggregate cars feeding rail-running concrete mixers.

1562



1563

"…In all, the machines excavated roughly 245 million cubic feet of spoil to create the passages. Some of that was used to build an outcropping at the base of the famous white Shakespeare Cliff near Dover…"
***Popular Science,* May 1994**
<u>Left</u>: caption: "Dover Colliery opened on the site of the first Channel Tunnel now Samphire Hoe"
<u>Right</u>: caption: "Samphire Hoe, Eurotunnel's nature reserve in Kent, was created using the chalk marl extracted during the boring of the tunnels, is today a model for biodiversity and home to many animal and plant species"

1564

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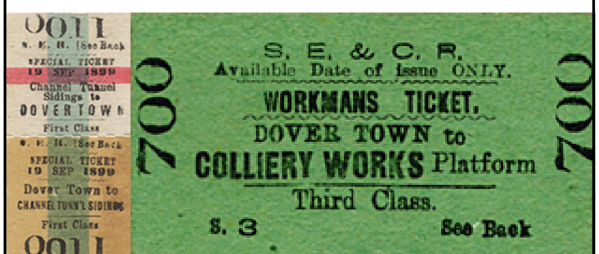
Left: caption: "1898 1:2,500 OS map shows the first stage of development of Shakespeare colliery. The three shafts shown are from left to right Brady, Simpson and the Channel Tunnel construction shaft with Channel Tunnel siding alongside. This is where visitors to the Channel Tunnel alighted from special trains from Dover town."
Right: caption: "A late nineteenth century view of Shakespeare colliery before any major buildings were constructed on the site"

1568



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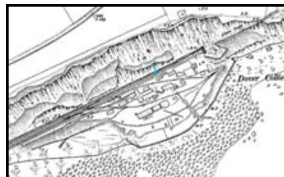
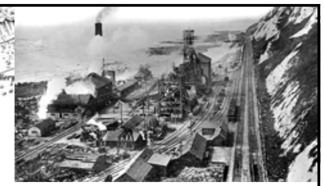
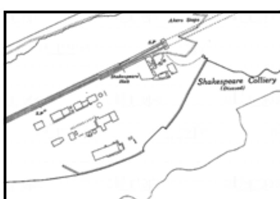




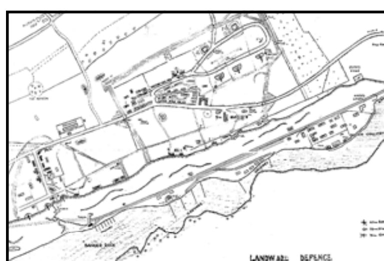
Left: caption: "1907 1:2,500 OS map shows Shakespeare Colliery during development of the site. The boiler house, one of the largest buildings on the site, has not yet been built. The miners' halt officially opened in 1913 although it is known that the miners' trains ran from at least 1900 as one is shown in a working timetable. The blue arrow shows the position of the halt in 1913. Earlier trains might have stopped elsewhere and without a purpose-built platform. Only Borehole shaft is shown. Brady shaft had been abandoned by this date."
Right: caption: "Shakespeare colliery looking south-west from Akers steps in 1910. The headframe of Borehole shaft is seen closest to the camera with the recently (1906) renewed headframe from Simpson shaft to the rear. The boiler house, also a later addition to the site is seen on the left. This view shows no evidence of a platform."

1570



Left: caption: "1938 OS map. The only Ordnance Survey (OS) maps that show and name the halt are from the 1930s. By this date many of the smaller mine buildings had been cleared but most of the larger buildings are still standing. A large building on the south side of the site is the boiler house. Also standing are the railway cottages which are seen just to the south of the tunnel portal."
Right: caption: "By 1940 all the colliery buildings had been removed and the land had been taken over by the War Office to site two coastal artillery searchlights (CASL) fo Hougham Battery which was on the cliff top above. The other buildings to the rear include engine houses (generators) for the light and accommodation for the searchlight crew plus some surviving colliery buildings."

1571



Left: caption: "Plan of Hougham Battery which was one of a number of coastal defence batteries established during WW2 along the Kent Coast. The Dover colliery site has now been taken over by the War Office. Two coast artillery searchlights (CASL) are seen at the southern edge of the site. The colliery boiler house which remained standing into the 1950s is not shown, presumably because it had no military use."
Right: caption: "In 1941 Hougham Battery was built close to the cliff-edge between Abbot's Cliff and Shakespeare Cliff, equipped with three 8-inch Mark VIII naval guns and manned by men of 520 Coastal Regiment Royal Artillery (No. 1 gun is seen here)."

1572

<u>Left</u>: caption: "1957 1:2,500 OS map. All the colliery have now gone and the mine shafts have been infilled and covered over. A number of new sidings have been laid. The two platforms are still shown but not named. The railway cottages were still occupied at this time (omitted on map)."
<u>Right</u>: caption: "The up platform at Shakespeare Cliff seen from a passing eastbound train in June 1958. The only access to the cottages was by rail or the steep climb using Akers 333 steps which are seen between the cottages and the tunnel."

1573

1574

<u>Left</u>: caption: "Channel Tunnel work site seen from Shakespeare Cliff in January 1989. Channel Tunnel works begin. The first step is to greatly enlarge the land area by driving steel sheets into the sea bed to make a coffer dam. This was subsequently filled with concrete. Then the enclosed area pumped out and filled with sand."
<u>Right</u>: caption: "Channel Tunnel work site seen from Shakespeare Cliff in August 1989. The dams are nearly completed. The nearer one is almost pumped out and filled in. Horizontal rail-based cranes are seen on the right."

1575

1576

<u>Left</u>: caption: "The Channel Tunnel construction site in June 1991. The site required for the Channel Tunnel construction was considerably more than the former colliery site. This required land to be reclaimed from the sea. To do this, steel sheets were driven into the sea bed to make a coffer dam; this was subsequently filled with concrete. The enclosed area was then pumped out and filled with sand."
<u>Right</u>: caption: "Shakespeare Cliff Halt seen from Shakespeare Cliff in June 1996. Once construction works were completed in 1994 the Channel Tunnel work site was quickly dismantled, including the footbridge linking the platforms. Although not officially closed, the Halt saw no further rail traffic."

1577

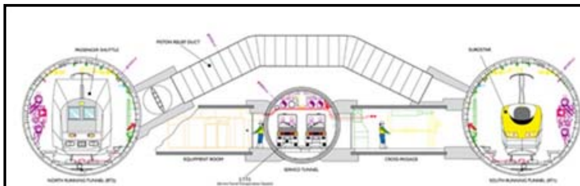
<u>Above</u>: caption: "Once construction works for the Channel Tunnel were completed, the site was landscaped to provide an undulating topography including some low-lying wetlands. The Samphire Hoe country park opened on 17 July 1997. This view from Shakespeare Cliff dates from March 2014 The building on the left is part of the ventilation system for the Channel Tunnel. Air is supplied to the Channel Tunnel from here and a similar plant at Sangatte. Either of the two buildings is capable of supplying all the air required to ventilate the tunnel. Supplementary ventilation also exists on either side of the tunnel. In the event of a fire, ventilation is used to keep smoke out of the service tunnel and move smoke in one direction in the main tunnel to give passengers clean air."

1578

1579

__Above__: caption: "The chalk cliffs, seen here in the early evening sunshine." Once the Channel Tunnel's excavation stage was complete and the lining sections in-place, the site was extensively landscaped. The process included laying geotextile fabric to consolidate the newly formed land which was then hydro-seeded with a mixture of grasses and wild flower seed. Five different seed mixtures were used on different areas to suit the conditions. On the remaining areas, *Rye Grass* was sown but this has gradually died-out to allow plants that grow locally to colonize naturally. 1580

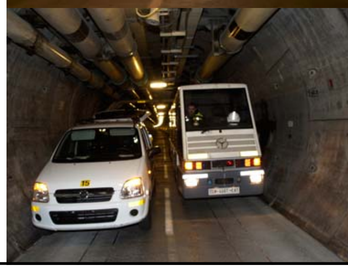
"…On the French end, the spoil was mixed with water, then this slurry was pumped out and dumped behind a 132-foot-tall dike. This mountainous, soggy heap should finally solidify in 1995; it will then be landscaped as a park…"
Popular Science, **May 1994**
__Above__: caption: "The Fond Pignon valley was dammed to contain a lake containing five-million cubic-meters of thin chalk. An extension of the Cape Blanc-Nez cliff, Mount Hubert rises 120-meters southwest of Sangatte." 1581



"…The tunnels themselves are exceptionally sturdy. They are lined with arch-shaped, five-foot-thick concrete segments. To make the concrete extremely strong, granite aggregate mined from the heart of a Scottish mountain was used…"
Popular Science, **May 1994**
__Above__: caption: "Eurostar and national freight trains run on the two single track and single direction tunnels. These "running tunnels" are connected to a central service tunnel by cross-passages located every 375-meters. The service tunnel allows access to maintenance and emergency rescue teams and serves as a safe haven if passengers need to be evacuated in an emergency. The service tunnel is a road tunnel used by electric and/or diesel-powered vehicles. Air pressure is higher in the service tunnel to prevent the ingress of smoke in case of a fire in one of the rail tunnels." 1582

The two rail (a/k/a "running") tunnels are 7.6-meters in diameter and 30-meters apart. Each rail tunnel has a single track, overhead line equipment (catenary) and two walkways (one for maintenance purposes and the other for use in the event of an emergency evacuation and on the side nearest the service tunnel). The walkways are also designed to maintain a shuttle upright and in a straight line of travel in the event of a derailment. The track in each rail tunnel has two continuously welded rails laid on pre-cast concrete supports embedded in the concrete track bed. 1583

The service tunnel is 4.8-meters in diameter and lies between the two rail tunnels (15-meters away from each of them). In normal operations, shuttles use the south tunnel in the France-to-UK direction and the north tunnel when travelling from the UK-to-France. A vehicle was specifically designed for travel in the service tunnel. It's multi-functional and is used for maintenance operations and in case of incidents, with the aim of reaching the scene of an incident in minimum time. 1584



1585

Fixed equipment in the tunnels comes under four categories:

- electricity and catenary;
- rail track and signaling;
- mechanical systems, and;
- control and communications.

Cooling pipes, fire mains, signaling equipment and cables are fixed to the sides of the tunnels and are fed by cooling plants at Samphire Hoe (UK) and Sangatte (France). The overhead catenary supplies traction power to the shuttles as well as to other trains using the tunnel (i.e. *Eurostar* and/or international rail freight trains). The catenary is divided into sections, so that maintenance work can be carried out in stages. Electrical power supplying the tunnels, drainage pumps, lighting and the trains is provided by substations on each side of the Channel. The fixed lighting installations can be switched on from the control center or manually from within the tunnels. Various fire-protection and detection systems are installed at points along the length of the tunnels. In the event of loss of power from one side, the entire system can be supplied from the other side.

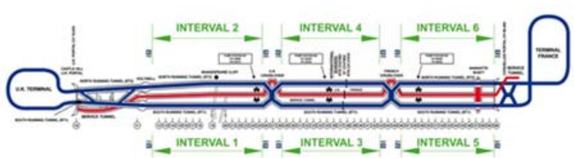
1586

Above: caption: "The communication gates between the service and rail tunnel can be controlled manually within the tunnels or from the Railway Control Centre (RCC)"

1587

The Crossover

1588

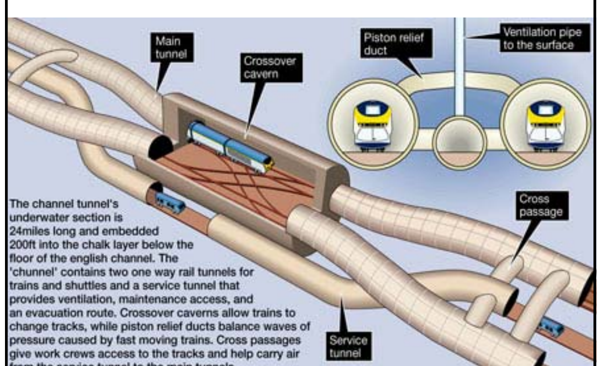


"…For the most part, the three tunnels lie parallel. But twice along their 31-mile paths, the service tunnel veers deeper and northward, and the two traffic-bearing tunnels converge in a cavernous crossover – 515 feet long, 60 feet wide, and approximately 30 feet high. Separated by huge, 99-foot-long sliding metal doors, the crossover stations enable trains to switch from one tunnel to the other…"

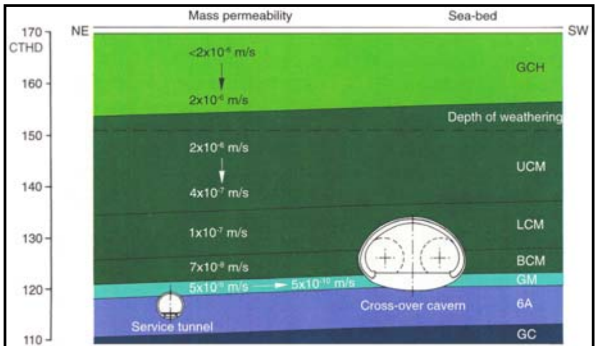
Popular Science, **May 1994**

Above: caption: "Two undersea crossovers bring flexibility of operation as trains can pass from one tunnel to the other during night maintenance periods to isolate a section of tunnel"

1589



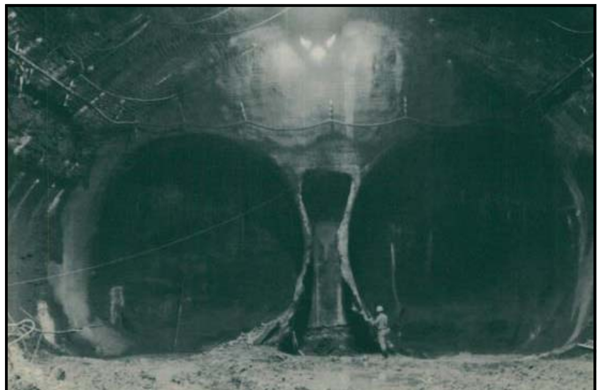
1590



Crossing facilities between the two running tunnels are needed in the undersea section to facilitate maintenance and for operational reasons. The UK offshore Crossover cavern is situated approximately 7km off the coast in an area of favorable geology with its invert in the *Glauconitic Marl*. The crown of the cavern is 35-meterrs below the seabed and it has a squashed elliptical shape; 15-meters high, 22-meters wide and 165-meters long.

Above: caption: "Cross-section of UK Crossover with geology"

1591



Above: caption: "August 1990. File picture of the UK undersea Crossover cavern of the Channel Tunnel. The two 'eyes' are where the UK seaward running tunnel boring machines will break through into the cavern."

1592

The cavern was formed in stages with side headings, crown, bench and invert sections using sprayed concrete temporary and permanent linings. At the time of excavation, this was the largest undersea cavern ever built, representing a major technological *tour-de-force*.

Left: caption: "Excavating the French Crossover to reveal the already-built tunnel"

Right: caption: "Running tunnel TBM in Crossover"

1593

1594

The French crossover is located 12km off the French coast in less favorable ground conditions. The chamber was constructed using a series of contiguous small diameter tunnels with a minimum height of 2-meters and has overall dimensions of; 180-meters-long, 19-meters-high and 25-meters wide.

Above: caption: "Channel Tunnel Project – December 18, 1992: the development of the French Crossover is complete. An equivalent structure was built on the British side."

1595

Like Clockwork

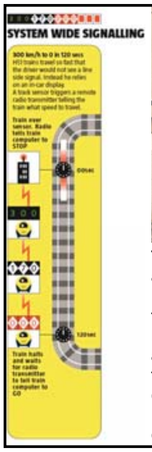
1596

"…That, however, is not standard practice. Except in emergencies or during tunnel maintenance, trains run straight through; during peak demand, the system can run 20 trains per hour in each direction. Doing so requires clockwork coordination, since the trains may be separated by as little as three minutes…"
Popular Science, **May 1994**

1597

"…The handful of people who oversee this delicate operation work in a boxy building at the Folkestone terminal, sitting in front of an 80-foot-long screen that depicts the entire Channel Tunnel system. One controller monitors a computer that keeps tabs on each train's speed commands and orchestrates the movements of all trains against a master timetable. These commands are sent electrically to each shuttle engineer's cab. Should an engineer fail to respond to a command, a computerized safety system called Automatic Train Protection kicks in, wresting control of the train and bringing it to a halt…"
Popular Science, **May 1994**

1598

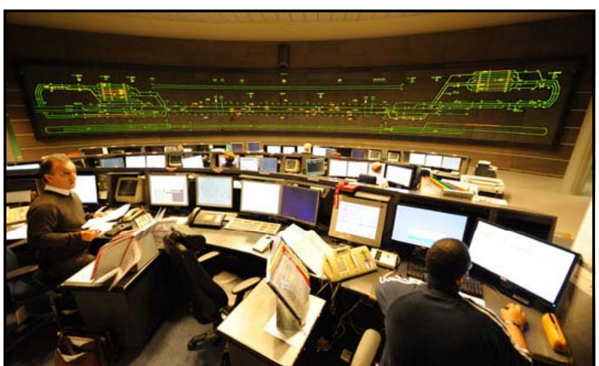


The signaling system in the Channel Tunnel is known as "TVM 430." It functions by means of data transmission from track-to-train and is almost identical to the system used on the high-speed *TGV Nord-Europe*. Instructions and data are transmitted along the track and then to the locomotive driver by indicator lights in the cab. All *Eurotunnel* trains are fitted with vigilance devices and full automatic train protection which minimizes the risk of collision in the event of a human error.

1599

<u>Above</u>: caption: "Train driver Willy Crooks, at the controls while transiting the Channel Tunnel"

1600



<u>Above</u>: the entire *<u>E</u>urotunnel <u>T</u>ransport <u>S</u>ystem* (ETS) is controlled from the *<u>R</u>ail <u>C</u>ontrol <u>C</u>entre* (RCC). There are two RCCs, one in each terminal and each can take turns taking over control of the system. The RCC manages all rail traffic (trains and shuttles) in the tunnels and in the terminals. Although the Eurotunnel transport system is automated, controllers are in attendance 24/7/365, ready to take manual control in the event of technical failure.

1601

"…While one computer dictates the flow of trains, another equally powerful computer system oversees the operation of the bulk of mechanical and electrical systems that are the nerves, veins, and lungs of the Channel Tunnel. Both computers work symbiotically, sharing three fiber-optic cables that span the length of the tunnel and link the control center in Folkestone to a backup center in France…"
Popular Science, **May 1994**
RE: the ETS is divided into two parts:
• *<u>R</u>ail <u>T</u>raffic <u>M</u>anagement* (RTM), which controls the rail traffic system, and;
• *<u>E</u>ngineering <u>M</u>anagement <u>S</u>ystem* (EMS) which controls the fixed equipment such as ventilation, lighting, power for the catenary, etc.

1602

Above: caption: "Two rail control centres, one on each terminal, manage all of the rail traffic (Shuttles and trains) and the remote control of electromechanical equipment for the entire Eurotunnel Concession" 1603

Aerodynamic Heating

1604

"…Ten minutes into the trip, James glances up to read the red-lettered dot-matrix sign suspended from the ceiling: It announces the shuttle is more than a third of the way to France. He sighs and fiddles with his car's radio dials, but it only receives Eurotunnel's broadcast programs (one in English, one in French). He reminds himself to bring a book for the return trip. James gets out of his car again and walks back to the small window, Rhythmic bursts of white illuminate the window, as the train swooshes by the low-level tunnel lights. He places one hand on the pane. It feels warm. That strikes James as counterintuitive. He envisions the shuttle barreling through damp, chilly air, loosely wrapped in a chute of frosty chalk marl. He heads back to his car…"
***Popular Science,* May 1994**

1605

"…When a train speeds through the tunnel, friction heats the air. Left unchecked, this phenomenon could eventually elevate the temperature inside the tunnels to a brutal 122-degrees F. The solution for this is a $200 million air-conditioning system that pumps an astounding 18.5 million gallons of 38-degree F. water through a 300-mile network of 24-inch-diameter pipes. The eight centrifugal chillers used in the process – four at Folkestone and four at Calais – have the capacity to air condition approximately 6,000 homes…"
***Popular Science,* May 1994**

1606

A River (of Air) Runs Through It

1607

"…Fresh air also circulates through the tunnels. Fans with variable-pitch blades blow air into the service tunnel from shafts at each end. This keeps the air flowing like an invisible river through each tunnel. Moreover, the computer-controlled ventilation system can react quickly to emergencies: One fan can push while the next one pulls, flushing smoke out within minutes…"
***Popular Science,* May 1994**
Above L&R: caption: "Samphire Hoe Channel Tunnel spoil remains and ventilation works Viewed From Shakespeare Cliff" 1608

Spreading Rumours

1609

"…The balding man in the red Vauxhall parked behind James looks anxious. Trying to appear casual, he saunters up to James' car and knocks on the window: Has James taken the Chunnel before? He asks. Without waiting for an answer, the man relates a rumor that a leak can flood the tunnels in a matter of minutes. Before James can respond, a man dressed in a blue-and-green Eurotunnel uniform appears through the folding door at the end of the shuttle car. Briefly, he checks to see if passengers are smoking or otherwise misbehaving. The Vauxhall driver turns to the official for a bit of reassurance…"
Popular Science, **May 1994**

1610

Over the Top

1611

"…From the moment an underwater tunnel was proposed, safety was a key issue. Throughout the construction phase, Eurotunnel endured the sharp tongues of critics who predicted the tunnel would be dangerous. 'We've gone over the top, really,' in provisions for safety, Eurotunnel official John Noulton responds. 'But when you're starting from scratch, you get hit with every criticism'…"
Popular Science, **May 1994**

1612

"…To stymie a subterranean flood, says Richard Morris, Eurotunnel director of safety, the Channel Tunnel relies on a drainage and pumping system that 'would certainly cover most situations.' Water that enters the tunnels due to a leak or condensation will drain into a conduit between the two rails. This pours into one of three holding and pumping stations buried beneath the tunnels. Together, the stations' sumps can normally hold up to 158,400 gallons of water, although they can contain seven times that amount when necessary. This capacity is provided by emergency backup systems. Also, there are separate facilities and sump systems assigned to dangerous material spills, even though many chemicals and solvents will not be allowed to be transported within the tunnels…"
Popular Science, **May 1994**

1613

"…Flooding doesn't worry Eurotunnel officials. Fire does. This underwater setting would make excellent fodder for a TV movie-of-the-week: 20,000 persons might be trapped in the Channel Tunnel at one time, with cargo vehicles filled with tanks of gasoline, in a location more than 100 feet below the sea floor. 'The first line of defense,' explains Morris, 'is the built-in sensors in the train cars that detect flame and smoke.' The plan is to evacuate a burning shuttle car and rush the train out of the tunnel. 'Each coach has a 30-minute fire barrier; that was chosen because it takes about 24 minutes for a train to travel from one end of the tunnel to the other'…"
Popular Science, **May 1994**

1614

"…If the train must stop inside the tunnel, passengers would be led through one of 130 connecting passageways that lead to the service tunnel. Air pressure within the service tunnel is maintained at a slightly higher level than the main tunnels, effectively keeping smoke out. …"
Popular Science, **May 1994**
Left: caption: "An example of the many items that must be duplicated to comply with both nation's systems, this tunnel fire hydrant has both French and British outlets"

1615

"…Meanwhile, specially designed vehicles in the service tunnel would race to the burning train to extinguish the flames and provide medical help for any injured passengers. These narrow, rubber-tired vehicles use wires embedded in the ground to stay on course. The small diesel cars carry modular units outfitted with firefighting equipment, for example, or first-aid supplies…"
Popular Science, **May 1994**
Left: caption: "Service Tunnel Transport System (STTS) vehicles"

1616

Above: caption: "The service tunnel, maintained at all times at a higher air pressure, remains protected from any possible presence of smoke in the rail tunnels and allows response teams to intervene using specialized vehicles"

1617

Inferno

1618

"Thousands of Eurostar passengers are still stranded today after an inferno in the Channel Tunnel halted services. All of today's services through the tunnel were cancelled as 300 firefighters battled all night to bring the blaze under control. It is the worst fire on the 31-mile rail link since 1996 and only the third in its history…"
dailymail.co.uk, **September 12, 2008**
Above: caption: "Eurostar passengers sit stranded in London's St. Pancras international rail terminal as firefighters tackle the blaze in the Channel Tunnel"

1619

"…The blaze, thought to have been started by an overheating brake, caused 14 minor injuries and the cost is likely to run to hundreds of millions of pounds. Three hundred firefighters - 100 British and 200 French - fought the fire overnight and brought it under control early this morning…"
dailymail.co.uk, **September 12, 2008**
Above: caption: "Emergency vehicles on standby at the Calais entrance after the fire broke out in the Channel Tunnel"

1620

"…All 32 passengers on board, many of them British, were led to safety through a service tunnel. Twelve were taken to hospital suffering from smoke inhalation and minor injuries but none is said to be critically ill. A spokesman for the Pas de Calais fire brigade said: 'The tunnel is in a very bad way, and it could be a long time before it re-opens. The fight against the fire has been hugely difficult. We have been operating in 1,000-degree heat'…"
dailymail.co.uk, **September 12, 2008**

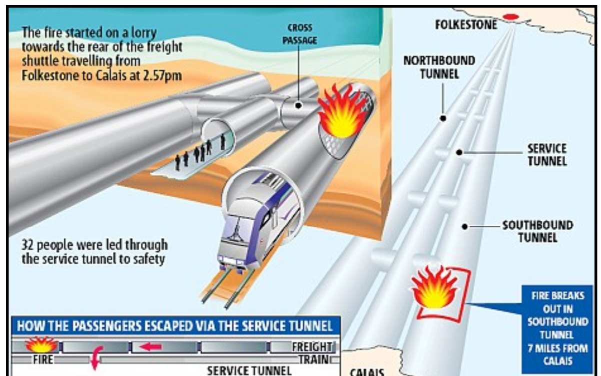
1621

"…Some 40,000 passengers due to travel today have had their journeys cancelled. At least 15,000 were also left in limbo yesterday as the fire forced the company to cancel 25 train services. Disgruntled commuters and families on weekend breaks were offered refunds or exchanges on their tickets. A similar blaze in the tunnel 12 years ago caused £200 million of damage and it was six months before services returned to normal…"
dailymail.co.uk, **September 12, 2008**
Above L&R: Caption: "Queues of passengers build up at St. Pancras station in London, left, and Paris' Gare du Nord, right, after services were cancelled"

1622

"…French Interior Minister Michelle Alliot-Marie, who visited the drivers in Calais said that death and more serious injuries were only averted because the blast was in a 'lorry cut off' from the others, and not a nearby one carrying highly flammable carbolic acid, or phenol…"
dailymail.co.uk, **September 12, 2008**

1623



"…Early reports from evacuees suggest that a faulty brake on a lorry overheated, causing a tyre to explode, which in turn set light to the cab…"
dailymail.co.uk, **September 12, 2008**

1624

"…A French police spokesman said: 'It is a very serious fire, which appears to have broken out at around 2.55 pm on a toxic chemical lorry. 'The truck caught light with disastrous consequences. All of the tunnels have been shut. There will be no more services for the foreseeable future.' The truck was carrying 220 lb. of phenol - also known as carbolic acid - a very toxic and flammable product used in medicines and cosmetics…"
dailymail.co.uk, **September 12, 2008**

1625

"…The circumstances of the latest blaze, which started seven miles from the French side, were almost identical to the fire which engulfed the Tunnel in November 1996, which caused £200 million worth of damage. Then six people received hospital treatment for smoke inhalation when a fire broke out in a wagon containing 10 heavy good vehicles, as well as 34 passengers and crew, eventually closing the tunnel for weeks.…"
dailymail.co.uk, **September 12, 2008**
RE: fires are not the only problem. In 2009, four trains broke down while inside the Channel Tunnel due to cold weather, affecting a total of 2K passengers. Some passengers were evacuated to shuttle trains while others were stranded in the tunnels overnight without power, food or water.

1626

In 1996, 2006 and 2008, trains carrying both vehicles and passengers caught fire. The original plan was to keep moving in the event of a fire; passengers would move into the undamaged part of the train, which could then be detached and driven out of the tunnel safely. After the 1996 fire (above) this policy was changed to evacuate passengers as quickly as possible, moving them into the service tunnel which runs between the two train tunnels.

1627

"…This time, 32 people, many of them British lorry drivers, were evacuated from the freight train via a service tunnel as the fire spread to two other vehicles. Six had to be treated for smoke inhalation and another eight suffered minor injuries.…"

dailymail.co.uk, **September 12, 2008**

Left: caption: "Truckers get off a special emergency train after they were evacuated from the tunnel at the Calais entrance"

Right: caption: "The fire lasted for 16 hours and reached temperatures of 1000 C, yet swift action by the Calais fire-fighters meant only 14 people out of 32 on the train suffered minor injuries"

1628

Above: caption: "Coquelles, France. October 1, 2008: A Eurotunnel freight shuttle train transporting the burnt remains of a lorry. A blaze in the tunnel on September 12, 2008 halted traffic and caused chaos for travelers and freight."

1629

"…Kent Fire and Rescue Service dispatched seven fire engines to assist their French counterparts. Police closed traffic between two junctions of the M20 for several hours because of the backlog of lorries which had to turn back from the Eurotunnel. Kent Police this morning advised motorists to avoid the area…"

dailymail.co.uk, **Sept. 12, 2008**

Left: caption: "Lorries back up on the M20 in Kent after the tunnel closed"

1630

"…More than 200 French and 100 British firefighters tackled the blaze overnight and have just 'mastered' it, Gerard Gavory, the sub-prefect of Calais said this morning. 'The fire has been brought under control - it is not entirely out but we have mastered it,' he said. 'But we have to do more investigations and these will take a few hours'…"

dailymail.co.uk, **September 12, 2008**

1631

"…The freight service under the Channel, which opened in 1994, transports cars and trucks along a 31-mile stretch of track and is operated by Eurotunnel. It runs alongside Eurostar's passengers trains from London to Paris which travel along two larger tunnels on either side of it…"

dailymail.co.uk, **September 12, 2008**

1632

"…Eurostar was forced to cancel 12 of its services bound for France and 13 trains bound for England on its second busiest weekday. Five trains had to be halted en route to the crossing - three on the English side and two on the French side - and the passengers transported back to their departure points…Passengers returning from the aborted journeys to the Continent said they were unimpressed by the service they had received…"

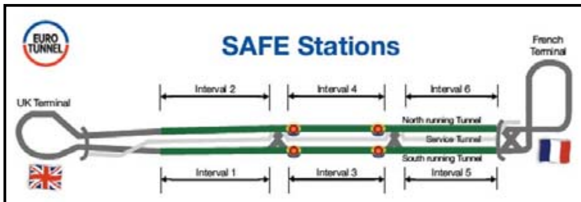
dailymail.co.uk, **Sept. 12, 2008**

Left: caption: "Stranded passengers wait for news in Paris" 1633

Above: caption: "Folkestone, Kent. February 9, 2009: The Eurotunnel control room after the tunnel re-opened. It was closed for five months after the fire." 1634

SAFE

1635

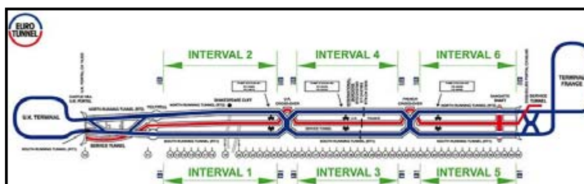


An investigation into a January 17, 2015 freight train fire inside the Channel Tunnel determined that an over-height aerial on a lorry triggered an electrical arc near the tunnel's overhead wires. A delay of 23 minutes in activating the fire alarms meant that by the time the train was halted, it had overshot by 1K-meters the last of two "SAFE" stations where specialist and automatic fixed fire-fighting equipment is installed. Instead it was 3.5 hours until French firefighters arrived on the scene to start subduing the fire. The SAFE stations were retrofitted into the Channel Tunnel after previous fire incidents caused damage to the tunnel lining. The Channel Tunnel has a total of four SAFE stations; two in each running tunnel, located at about the third-way points along each alignment. The SAFE stations were designed to improve overall fire safety in the Channel Tunnel and prevent major infrastructure damage, as was experienced in previous serious fires. 1636

Above: caption: "Locations of the SAFE stations"


As a result of the incident, six key recommendations for improvements were made to *Eurotunnel*, chief among them was a call to ensure trains that are on fire stop inside the purpose-built *Fixed Fire Fighting Stations* (FFFS). Completed in 2010 at a cost of €20 million, each SAFE Station's FFFS can hold an entire truck shuttle train and automatically extinguish any fire with a high pressure "micro-mist."

Above L&R: caption: "The installation of four SAFE stations in the Channel Tunnel makes it possible to contain any fire" 1637



During the January 2015 incident, the France-bound freight shuttle finally stopped in the French section of the Channel Tunnel. The official investigation was led by the French Government's *Bureau d'Enquetes sur les Accidents de Transport Terrestre* (BEA-TT), supported by the UK's *Rail Accident Investigation Branch* (RAIB). Investigations revealed there were two separate arcing incidents, both of which caused the train to stop. The first, at the UK portal, was caused by the over-height aerial which appears to have led to smoldering and smoke inside the lorry's cab. 1638

Above: caption: "Channel Tunnel track layout"

The report also recommended ongoing monitoring of advances in fire detection technology and systems. Additionally, the report called for *Eurotunnel* to optimize the use of the ***E**mergency **T**ransport **S**ystem* (ETS) in the service tunnel.

Above: caption: "The FLOR (First Line of Response) is trained to the specific environment of the tunnel and patrols the service tunnel 24 hours a day in order to provide immediate assistance to passengers"

1639

An Uneventful Ride

1640

"…James' ears pop; the air pressure is changing. He feels the force of inertia pull him forward a bit, as the train decelerates. Sunlight bursts through the windows now. The nervous Vauxhall driver sighs. Farther back in the train, an automobile starts. The train draws to a halt, and the metal fire doors retract into the ceiling. Allison unfolds a map and reminds her husband to drive on the right side of the road, rather than on the left. Now automobiles begin to creep forward, through eight shuttle cars, through the unloading car, and out onto the pavement. Signs ahead point to the A26 motorway, and James accelerates past the stream of cars that crowds the loading ramps leading to an England-bound shuttle. Allison checks her watch again: 12;10 p.m. She glances back at the sprawling terminal and remarks offhandedly, 'A rather uneventful ride, don't you think?'"

Popular Science, **May 1994**

1641

An Enticing Target

1642

"FROM a terrorist's point of view, the Channel Tunnel presents an enticing target: It will handle large numbers of travelers, operate around the clock, and, above all, stand as a symbol of the growing cohesion of European nations. 'Terrorism is an area where we've had to be scrupulously careful from the word 'go,' remarks Eurotunnel's John Noulton. 'Our philosophy has been to make this as tough a nut to crack as possible'…"

Popular Science, **May 1994**

1643

"…There are two types of shuttle trains – one for cars and buses, the other for trucks – and the Channel Tunnel security must prevent a bomb-laden vehicle from slipping aboard either type. The car-and-bus shuttles, says Noulton, are less of a concern, because passengers must stay with their vehicles during the entire trip. That arrangement should dis-courage anyone from setting off an incendiary device – unless the terrorist is suicidal. One looming threat, explains Noulton, is a bomb on a truck shuttle, because truck drivers park their rigs on an open-air shuttle and then ride in a separate club car. Theoretically, a terrorist could place a bomb-laden truck aboard the shuttle and sneak off before the train leaves the station…"

Popular Science, **May 1994**

1644

1645

Euroscan

1646

"…To counter that threat, Eurotunnel installed 'the most sophisticated scanning device for trucks in the world,' says Noulton. Called Euroscan, the system looks for bombs and other contraband, including drugs. While Noulton declined to elaborate, the system probably includes a bomb 'sniffer,' an electronic device that can detect telltale traces of explosive molecules in parts per billion. Euroscan likely uses some form of radiation to search for the organic compounds that constitute most bombs…"
Popular Science, **May 1994**

1647

"…Both terminals are equipped with the Euroscan system, housed in flat-roofed beige structures set far back from the bustle of the toll booths and rest-stop buildings. The idea is to catch terrorists before they reach the loading platforms…"
Popular Science, **May 1994**

1648

They'll Never Know

1649

"…It is also possible, says one Eurotunnel source, that 'private vehicles will be scanned without the passengers knowing it.' The covert screening – again, possibly performed by sniffers – could take place at one of the several stops before boarding, such as at a toll booth or customs check-point. According to the source, the plan is being discussed by the intergovernmental commission that overseas the Channel Tunnel System."
Popular Science, **May 1994**
Above: caption: "Dover, UK. December 22, 1994: A Citroen 2CV leaving Le Shuttle on the first operational day"

1650

1651

Semper Vigilant

1652

Above: caption: "The safety on the Coquelles site is granted by an automated and innovative anti-intrusion system including infra-red control equipment, electrified fencing, Passive Millimetric Wave (PMMW) control system, Euroscan buildings, video surveillance system"

1653

Above: caption: "Two military drones are dedicated to the surveillance of the 650-hectare terminal in Coquelles, in order to further reinforce the security level of the Eurotunnel site"

1654

Above: caption: "With some 43km of high security fences encircling the site, the increasing number of cameras to over 500 and a very important security workforce, the Coquelles site ensures to its customers a maximal level of security"

1655

1656

Seven Wonders

1657

Channel Tunnel

It cost nearly twice as much as anticipated and ran more than a year behind schedule. But you won't hear a civil engineer speak an uncivil word about the Channel Tunnel. Like the Panama Canal, the 31-mile link between France and England fulfilled a centuries-old dream. It's more than just a tunnel – it rolls infrastructure and immense machinery into a transportation system of unprecedented ambition. Three concrete tubes, their walls 5 ft. thick, plunge into the earth at Coquelles, France. Burrowing through the chalky basement of the English Channel, they emerge at Folkestone, behind the white cliffs of Dover. Through two of them rush the broadest trains ever built – double-decker behemoths 14 ft. across – traveling close to 100 mph. the passengers board not on foot but in automobiles and buses. Trucks laden with freight also ride. Maintenance and emergency vehicles ply the third tunnel, between the rail tubes. Meanwhile, machines are always at work, turning the Channel Tunnel into a living, intelligent structure. Huge pistons open and close ducts, relieving the pressure that builds ahead of the trains' noses. Cold-water piping, 300 miles of it in total, snakes alongside the rail tracks to drain off the heat raised by air friction. Fans breathe air into the service tunnel. Pumps siphon water away from rain or condensation. Twice, the tracks race through great man-made caverns where emergency crossover switches are located. And fiber-optic cables make up the tunnel's nervous system, relaying signals from controllers to engineers. The newest of our Seven Wonders, the Channel Tunnel caused no dissent among nominators. Not only does it join two nations, but it links civil, mechanical and electrical engineering in one masterwork. (*Popular Mechanics,* December 1995 – excerpt from an article entitled: "The Seven Wonders of the Modern World – Celebrating the 20th Century's Greatest Civil Engineering Achievements")

1658

A Fundamental Change

1659

The Chunnel facilitates trade worth £91.4bn per year, representing a quarter of all UK trade in goods with the *European Union,* according to a November 2016 report from *Ernst & Young*. The report, entitled: "Economic footprint of the Channel Tunnel Fixed Link," assessed the economic contribution of the Chunnel to trade and tourism and its role in the UK's economic growth. It found that 30% of UK exports (£43.6bn) to the EU and 22% of imports (£47.8bn) from the EU depended upon the speed, ease and reliability of the Chunnel, with exports through the Chunnel alone supporting 220K jobs in the UK. The Chunnel fundamentally changed the way the UK does business, enabling integrated manufacturing across the continent and opening up new markets. Industrial sectors which depend on the Chunnel's speed and reliability of service, include "just-in-time" production for sectors such as the automotive industry, "express delivery" for logistics companies and the rapid transportation of essential fresh food products. As well as goods transported on freight shuttles and trains, the Chunnel also transports 21 million passengers per year via Eurotunnel's *Le Shuttle* service and *Eurostar* trains. This facilitates inbound tourism via the Chunnel worth £1.7bn to the economy, supporting a further 45K jobs in the UK and 840K business trips, which keep the UK's services sector competitive.

1660

Best Yet

1661

Eurotunnel has reported the best annual result in its 20-year history, tripling its profit on rising numbers of vehicles carried on its truck shuttle service under the Channel between Britain and France

***dw.com,* January 3, 2017**

RE: introduction to an article entitled: "Eurotunnel Reports 'Best Year Ever'"

1662

"The owner of the rail link under the Channel logged a net profit of 200 million euros ($211 million) in 2016, up sharply from the 2015 earnings of 75 million euros. The growth had been driven by transports of 2.66 million tourist vehicles and 1.64 million trucks, the company said Wednesday, offsetting falls in cargo services and Eurostar passenger numbers by three percent and four percent respectively due to terrorism fears…"
dw.com, **January 3, 2017**

1663

"…'It's the best year we've ever had at the Eurotunnel group since the opening of the tunnel,' chief executive Jacques Gounon told reporters…"
dw.com, **January 3, 2017**

1664

"…All of the company's three core businesses - the Eurotunnel shuttle services, the ElecLink electricity connector purchased in the previous year and the Europorte rail freight business - had outperformed their sectors, he added…"
dw.com, **January 3, 2017**

1665

"…Opened in 1994, the Channel Tunnel carries passenger vehicles and freight trucks on trains under the sea linking England and France, as well as Eurostar passenger trains connecting London with Paris, Brussels and other points in Europe. Since its opening, the Eurotunnel business has been struggling as traffic and financial assumptions proved over-optimistic…"
dw.com, **January 3, 2017**
RE: in 1987, the high-speed rail link was expected to cost £4.7 billion. By 1998, its total cost was actually closer to £10 billion. Original predictions were that the link would serve 21.4 million passengers annually by 2004. The figure actually reached was 7.3 million. In 2006, *Eurotunnel* was nearing bankruptcy, but it was saved at the last minute by funding from several large banks.

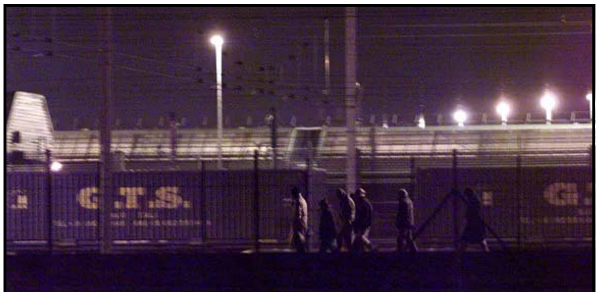
1666

Above: caption: "Villepinte, Paris. April 7, 2004: Nicolas Miguet, a French investment adviser who led a shareholder rebellion, flashing the victory sign at a Eurotunnel general meeting"

1667

Stowing Away

1668



"…In 2007 it was forced to restructure its business, but was dealt additional blows in the years later by the economic downturn and traffic disruptions from migrants seeking to cross the Channel on its trains…"
dw.com, **January 3, 2017**
Above: caption: "Frethun, France. March 13, 2002: Would-be immigrants attempting to find a way into the UK by stowing away on Eurotunnel freight trains. Security breaches at the rail freight yard forced the suspension of practically all freight services to Britain through the Channel Tunnel" 1669

Above: caption: "Calais, France. September 1, 2002: Illegal immigrants coming off a truck after being caught" 1670

In 2008, nine people, including a three-year-old and two pregnant women were found underneath a train in *Waterloo Station*. The refugees were able to climb inside a three-foot gap in an aerodynamic section between the wheels of the train.

Left: caption: "Coquelles, France. February 20, 2001: The grave of an asylum seeker near the entrance of the Channel tunnel. A would-be asylum seeker was crushed to death as he and four others tried to sneak into Britain from France on a Channel tunnel freight train." 1671

"…At least 10 migrants have died trying to sneak through the Channel Tunnel to Britain since June; an unknown number have slipped through undetected. About 3,000 refugees remain encamped outside the busy terminal waiting to cross the English Channel…Authorities at the port have been watching for signs of migrants seeking new routes to Britain as a result of the crackdown in Calais terminal, a major rail and ferry hub that connect the European continent with Britain."
dw.com, **August 21, 2015** 1672

"Eurotunnel has intentionally flooded the area near the tunnel entrance in northern France to keep refugees who try to break into the Channel Tunnel out. This is yet another step in a series of radical decisions taken by the tunnel's bosses in their fight with illegal migration. In September, 103 hectares of vegetation were destroyed to open up a clear view for CCTV and eradicate any potential hiding spots and infrared cameras were installed. Even though the tracks are hidden behind a high 29 km long security fence, a new measure was introduced to tighten security even more – deliberate flooding…"
rt.com, **January 13, 2016**

1673

…The water is not deep, but it covers large stretches of land along the fence line creating additional difficulties for refugees, most of them living in the Jungle camp in Calais, who want to cross the channel to seek asylum in the UK. In summer 2015 the number of people storming the area at once reached 1,500 people at its peak. The Tunnel's security guards used tear gas to fend the crowds off…"
rt.com, **January 13, 2016** 1674

1675

"…Rail freight tonnage through the tunnel, for example, fell 27 percent in 2016, with Eurotunnel attributing that partly to operators' rerouting some services because of the migrant incursions. Improved security around the group's Coquelles terminal in France since late 2015 had eliminated disruptions, the company added…"
***dw.com*, January 3, 2017**

1676

"…Looking ahead, CEO Gounon said the firm was 'extremely confident' for 2017 and 2018. The company plans to pay a dividend of 26 euro cents for 2016, up from 22 cents the previous year. Gounon said the company was planning continued increases in dividends and was targeting a 35-cent dividend for 2018."
***dw.com*, January 3, 2017**
<u>Left</u>: caption: "Paris, France. March 3, 2009: Eurotunnel CEO Jacques Gounon posing before presenting the group's 2008 full-year results. Eurotunnel said it would pay long-suffering shareholders their first dividend as it reported a 2008 net profit of £35m."

1677

GROUPE EUROTUNNEL

1678

<u>Part 23</u>

High-Speed Rail Link

1679

End of an Era

1680

"The last domestic passenger train left St. Pancras last night as the Victorian High Gothic station was prepared for a £310 million reconstruction in readiness for Eurostar services in 2007. The 23.40 Midland Mainline express headed north from beneath the train shed's massive Grade I listed single-span roof, closing a chapter on more than 130 years of railway history. From today, the old building will close. On Easter Monday, Midland Mainline will begin services from an interim station 300 yards to the north, before transferring to a permanent site on the west side of St. Pancras in 2006. The dislocation will affect more than eight million passengers a year, who travel to and from Manchester, Sheffield, Derby, Leicester, Nottingham and Bedford. …"

telegraph.co.uk, **April 10, 2004**

RE: 130-years of British rail history ended when the last train pulled out of north London's Victorian-era *St. Pancras* station on April 9, 2004. The historic structure underwent a £310m retrofit in order to offer faster journeys to both Paris and Brussels from London. *Eurostar* expected the renovated station to reopen in less than three years.

1681

Above: caption: "The Midland Grand originally opened in 1873. It was designed by Victorian architect Sir George Gilbert Scott at a cost of nearly £500,000"

1682

Grossly Underused

1683

"It was 'grossly underused,' says John Prideaux, the rail executive whom many credit with pushing through its choice as Britain's continental rail hub. Railway competition made St. Pancras magnificent, as in the 19th Century the Midland Railway's directors strove to build a finer terminus than its rivals had already established at Euston and King's Cross. But competition also made it redundant when rationalisation set in. Merged first into the London Midland and Scottish (LMS) company based at Euston, then into British Railways, it went into decline…"

bbc.co.uk, **November 14, 2007**

Left: caption: "The Gothic revival masterpiece hotel that form the front of St. Pancras station in central London"

Right: caption: caption: "The hotel's Grand Staircase (the hotel closed in 1935)"

1684

The Facelift

1685

"…The dislocation will affect more than eight million passengers a year, who travel to and from Manchester, Sheffield, Derby, Leicester, Nottingham and Bedford. Refurbishment, which is being scrutinised by English Heritage, will centre on the train shed, which was built in 1868 by the Midland Railway's chief engineer, William Barlow. The glass and cast iron roof, measuring 700-feet-long, 245-feet-wide and rising 100-feet above the platforms, was the largest clear-span enclosure in the world at the time. The roof will be restored, re-glazed and repainted. The grimy yellow iron trusses will be returned to their original striking sky blue…"

telegraph.co.uk, **April 10, 2004**

Above: caption: "View of St. Pancras' train shed, showing the 700-foot-long, 245-foot-wide and 100-foot-high glass and cast iron roof"

1686

1687

Eurostar’s New Home

1688

“…The new Eurostar departure hall will be created in the station undercroft, beneath platform level, which for decades was used to store beer brought by rail to the capital from Burton-on-Trent. The station’s imperious former Grand Hotel frontage will be converted into penthouse flats, while a new hotel is constructed round the corner opposite the British Library…”
telegraph.co.uk, **April 10, 2004**
RE: commencing in September 2004, a concrete enclosure was constructed underground, between the existing King’s Cross *Thameslink* station and *St. Pancras* station. This enclosure ultimately housed the new Thameslink station known as “St. Pancras - Midland Road.”

1689

“…Eurostar expects the station to reopen in less than three years, offering faster journeys to Paris and Brussels. The company is toying with the idea of changing the station’s name to increase understanding of its location among Continental travelers.”
telegraph.co.uk, **April 10, 2004**
RE: *Eurostar* considered changing *St. Pancras* station’s name to “London Central,” “London International,” “London Grand Central” and/or “Union Station”

1690

Pros, Cons and Results

1691

“…Richard Hope, consulting editor of Railway Gazette, thinks there were two reasons why St. Pancras was chosen. ‘First, it was seen as potentially redundant, or at least seriously underused,’ he says. As well as moving its suburban services underground to Thameslink, British Rail had a plan to divert St. Pancras’ main line services into Euston via Market Harborough and Northampton. Second, engineers initially thought ‘relatively cheap access’ could be available using the North London Line through north-east London, Mr. Hope adds. The North London Line idea held out the prospect of avoiding ‘a lot of expensive tunneling’ says Terry Gourvish - but the prospects soon proved illusory…”
bbc.co.uk, **November 14, 2007**

1692

"…In January 1994 the then Transport Secretary, John MacGregor, told MPs that Union Railways - the company set up to construct the Channel Tunnel link - had concluded that 'St. Pancras is preferable to King's Cross as the terminus on environmental, operational and commercial grounds.' The North London Line route, said Mr. MacGregor, had been rejected as 'difficult to construct and environmentally damaging.' John Prideaux was the first head of Union Railways, set up by British Rail to push through the Channel Tunnel rail link…"

bbc.co.uk, **November 14, 2007**

RE: although the idea of using the *North London Line* was rejected in 1994 by transport secretary *John MacGregor*, the idea of using *St. Pancras* station (to replace *Waterloo* station as Eurostar's London terminus for the high-speed *Channel Tunnel Rail Link* (CTRL), was retained. In 1996, *London and Continental Railways* (LCR) was selected by the British government to reconstruct St. Pancras, build the CTRL and take over the UK share of the *Eurostar* operation.

1693

"…The alternative to St. Pancras would have stretched under the main King's Cross building, the carriage entrance on its north-west side, and a gasworks to the north, he says. It would have been very big because of the length of the Eurostar trains. It would have involved excavation under listed buildings, under a medieval fever and smallpox hospital and the gasworks, creating huge constructional and pollution problems…"

bbc.co.uk, **November 14, 2007**

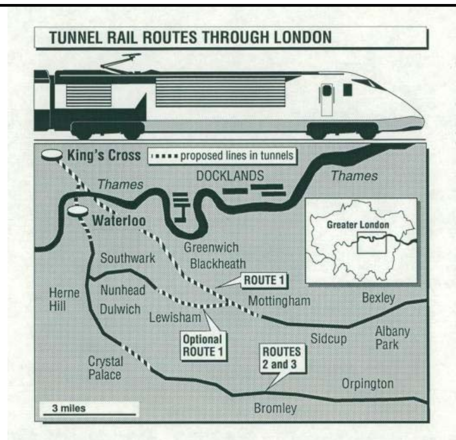
1694

"…Nevertheless, its rejection was not inevitable, says Mr. Prideaux. A bill providing for the south-east London-King's Cross plan had been before Parliament for more than three years. British Rail executives had been making a case for the route for five years, and buying property in preparation for the King's Cross route. So it was understandable that the change was very unpopular among his colleagues, Mr. Prideaux says…"

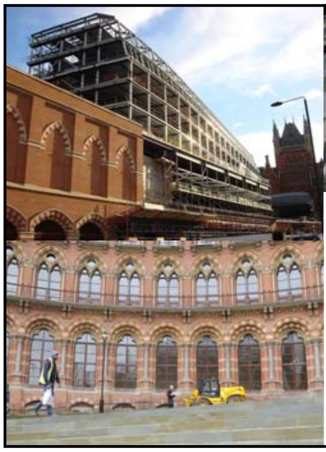
bbc.co.uk, **November 14, 2007**

RE: the original plan for the CTRL included a tunnel from south-east of London to an underground terminus in the vicinity of *King's Cross* station. However, a late change of plan led to a change of route, with the new line approaching London from the east. This opened up the possibility of reusing *St. Pancras* station as the CTRL's terminus, with access via the *North London Line.*

1695



1696



Above: caption: "Model of the extended St. Pancras station (left) and King's Cross station (right), seen before restoration, ca. 2012"
Upper Left: caption: "St. Pancras Renaissance London Hotel extension under construction"
Lower Left: caption: "The St. Pancras Renaissance Hotel will open to guests on 21 March 2007. Its public Grand Opening will take place on 5 May, exactly 138 years after it first opened as a luxury hotel for Victorians."

1697

"…He does not say it was entirely due to him that King's Cross was rejected - but adds that the change led to his own departure from British Rail. In the eyes of John Prideaux the reborn St. Pancras station is 'absolutely fantastic - a monument to modern British railways.' And after attending the Royal opening, he stressed: 'How pleased I am now to see it happen. It makes things seem quite worthwhile, really.'"

bbc.co.uk, **November 14, 2007**

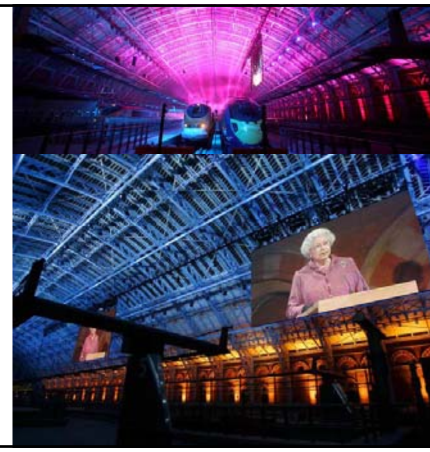
1698

HM the Queen Opens St. Pancras International Station

The Queen, accompanied by The Duke of Edinburgh, today launched High Speed 1, the UK's first section of high speed railway and officially opened St. Pancras International Station, the magnificently restored Victorian train station in the centre of London. Eurostar High Speed 1 services commence from St. Pancras International on 14 November 2007. Her Majesty and His Royal Highness arrived by car at the Hotel Arch beneath the Gothic facade of the Grand Midland Hotel before being greeted by Sir David Cooksey, Chairman, London & Continental Railways, the company behind the project. The Royal Party sat on specially built platforms beneath the Barlow Trainshed roof and delivered an address to an invited audience of over 1,000 guests including senior political figures from London, the UK and Europe. A state of the art light, sound and film show was accompanied by music from the Royal Philharmonic Concert Orchestra, performing with chart topper Lemar and Katherine Jenkins. The finale consisted of a film about the £10.5bn of regeneration that forms the legacy of High Speed 1 while The Queen met drivers from Eurostar and a Southeastern Hitachi "bullet" train. Her Majesty was also introduced to those involved with the construction of the station before receiving a specially commissioned commemorative replica of the grand Station Clock, unveiling an official plaque and receiving a posy of flowers. Rob Holden, chief executive of London & Continental Railways said: "The completion of High Speed 1 and the opening of St. Pancras International, on time and within budget, is a great source of pride for the thousands of men and women who have been involved in one of the most significant projects in UK railway history. For Her Majesty to have been here to officially declare the new high speed line and station open is a fitting tribute." Preparations will now continue for St. Pancras International to open to the public when the Eurostar service completes its move from Waterloo to St. Pancras International on 14 November.

RE: press release regarding the opening of "St. Pancras International Station"

1699



1700

1701

1702

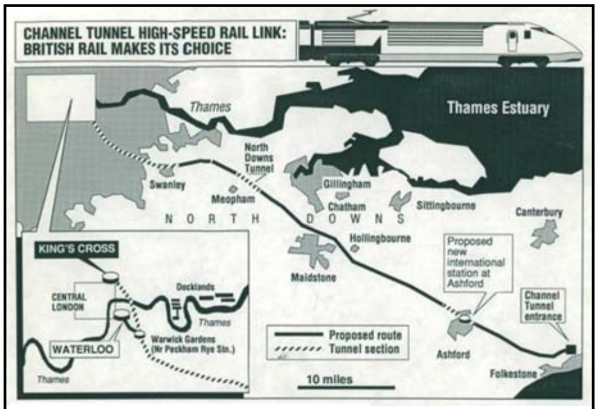
CTRL

1703

"The Channel Tunnel Rail Link, now rebranded High Speed 1, connects Paris, Lille and Brussels to London's extended and refurbished St. Pancras station. High Speed 1 is 109km (68 miles) long. It was built in two parts by London & Continental Railways, chosen by the UK government in 1996 to construct and run the Channel Tunnel Rail Link (CTRL)…"

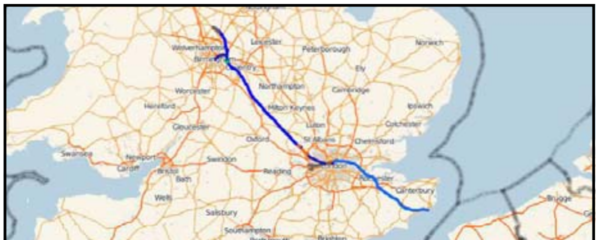
***bbc.co.uk*, November 15, 2007**

1704

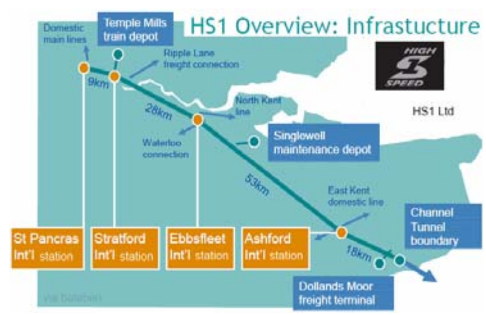


Caption: "London: March 7, 1989. The route for the Channel Tunnel High-Speed Rail Link between London and Folkestone chosen by British Rail." 1705


Above: caption: "March 6, 1989. Residents of Hitherfield Estate, Charing, which would be bisected by BR's routes one and two options"
Upper Left: caption: March 6, 1989. Houses on the Oakhive Estate, Sandling, Maidstone, 'blighted" by the rail line proposals. BR is buying 30 homes the builder cannot sell and has already bought ten houses from existing owners. If Route One is approved, the estate will be demolished.
Lower Left: caption: "March 6, 1989. Hollingbourne village which could be sandwiched between the M20 and the High-Speed Rail Link" 1706



Known as "HS1" and operated by LCR (under the control of the *Department for Transport*), the 68-mile (109km) high-speed *Channel Tunnel Rail-Link* (built at a cost of £5bn) runs from London's *St. Pancras* station to Folkestone, with stations at Stratford, East London and, in Kent, Ebbsfleet and Ashford. *Eurostar* trains to Paris and Brussels and the Southeastern Railway's Japanese-built Javelin trains operate on the track. In June 2010, the British government placed HS1 Ltd. up for sale, with the intention of linking it to "HS2," the north-south high-speed line the government hoped to begin in 2015. 1707
Above: caption: "Routes of HS1 (light blue) and HS2 (dark blue)"



1708

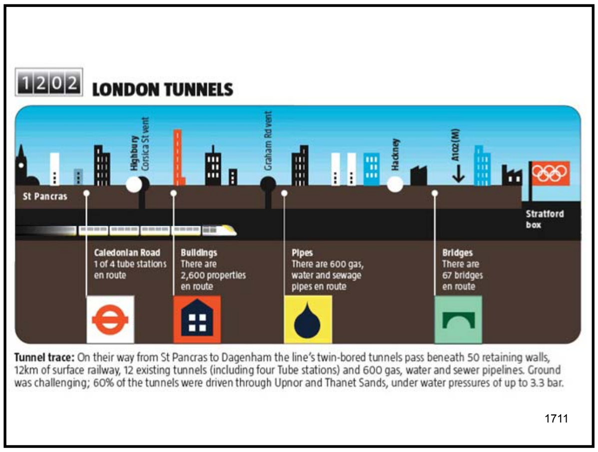
THE JOURNEY

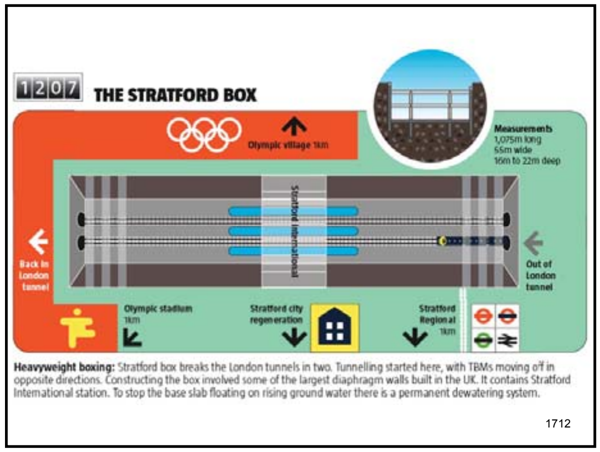
From 14 November it will take just two hours 15 minutes to get from London to Paris by train, after the second section of High Speed 1, opens. It will take a Eurostar train only 31 minutes to reach Folkestone from St Pancras, shaving 15 minutes off the journey time. Here you can travel through this remarkable project.

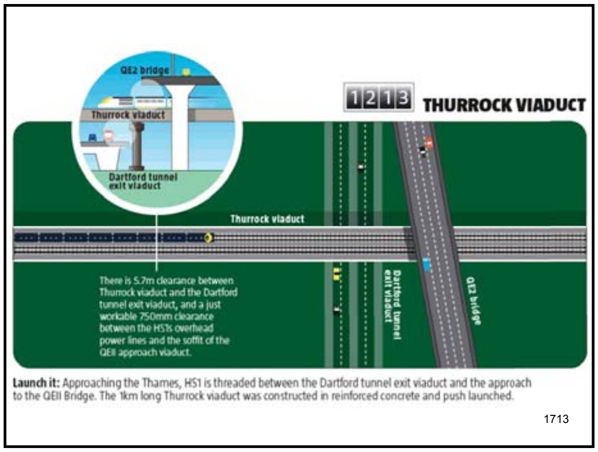
Fast through London and Kent: HS1 is Britain's first dedicated high-speed line. It will carry Eurostar trains between London St Pancras and the Channel Tunnel at speeds of up to 300km/h.

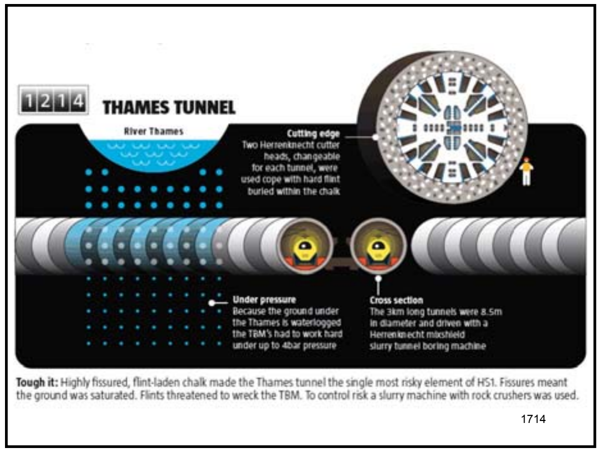
1709

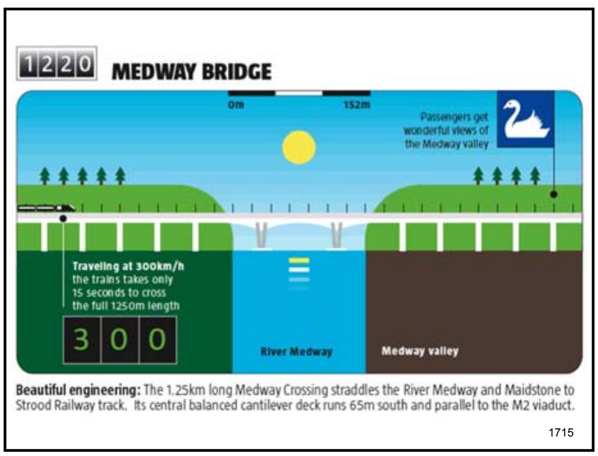
London launch pad: The station was built on top of a vast undercroft, originally used to store beer barrels, which has been opened up for use as a concourse. A steel and glass extension was added to the Victorian train shed to cover the entire length of an 18 car Eurostar train. 1710

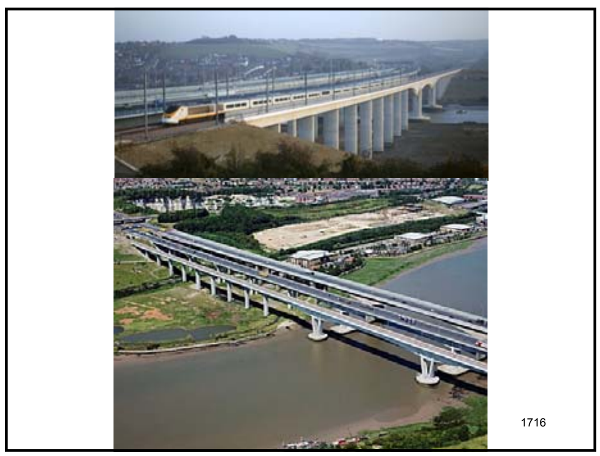

1202
LONDON TUNNELS
Highbury Corsica St vent
Graham Rd vent
Hackney
A102(M)
St Pancras
Stratford box
Caledonian Road
1 of 4 tube stations en route
Buildings
There are 2,600 properties en route
Pipes
There are 600 gas, water and sewage pipes en route
Bridges
There are 67 bridges en route
Tunnel trace: On their way from St Pancras to Dagenham the line's twin-bored tunnels pass beneath 50 retaining walls, 12km of surface railway, 12 existing tunnels (including four Tube stations) and 600 gas, water and sewer pipelines. Ground was challenging; 60% of the tunnels were driven through Upnor and Thanet Sands, under water pressures of up to 3.3 bar.
1711


1207
THE STRATFORD BOX
Olympic village 1km
Measurements
1,075m long
55m wide
16m to 22m deep
Stratford International
Back in London tunnel
Out of London tunnel
Olympic stadium 1km
Stratford city regeneration
Stratford Regional 1km
Heavyweight boxing: Stratford box breaks the London tunnels in two. Tunnelling started here, with TBMs moving off in opposite directions. Constructing the box involved some of the largest diaphragm walls built in the UK. It contains Stratford International station. To stop the base slab floating on rising ground water there is a permanent dewatering system.
1712


QE2 bridge
Thurrock viaduct
Dartford tunnel exit viaduct
1213
THURROCK VIADUCT
Thurrock viaduct
There is 5.7m clearance between Thurrock viaduct and the Dartford tunnel exit viaduct, and a just workable 750mm clearance between the HS1's overhead power lines and the soffit of the QEII approach viaduct.
Dartford tunnel exit viaduct
QE2 bridge
Launch it: Approaching the Thames, HS1 is threaded between the Dartford tunnel exit viaduct and the approach to the QEII Bridge. The 1km long Thurrock viaduct was constructed in reinforced concrete and push launched.
1713

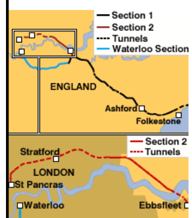

1214
THAMES TUNNEL
River Thames
Cutting edge
Two Herrenknecht cutter heads, changeable for each tunnel, were used cope with hard flint buried within the chalk
Under pressure
Because the ground under the Thames is waterlogged the TBM's had to work hard under up to 4bar pressure
Cross section
The 3km long tunnels were 8.5m in diameter and driven with a Herrenknecht mixshield slurry tunnel boring machine
Tough it: Highly fissured, flint-laden chalk made the Thames tunnel the single most risky element of HS1. Fissures meant the ground was saturated. Flints threatened to wreck the TBM. To control risk a slurry machine with rock crushers was used.
1714


1220
MEDWAY BRIDGE
0m
152m
Passengers get wonderful views of the Medway valley
Traveling at 300km/h the trains takes only 15 seconds to cross the full 1250m length
300
River Medway
Medway valley
Beautiful engineering: The 1.25km long Medway Crossing straddles the River Medway and Maidstone to Strood Railway track. Its central balanced cantilever deck runs 65m south and parallel to the M2 viaduct.
1715


1716

For +11 years and +100 million man-hours, 530 million cubic-feet of earth was removed, five-million sleepers were placed, 310 miles of rail and 185 miles of communication cables were laid. The tunnels run under 2,600 properties and 600 gas, water and sewage pipes and ten pumps were used to remove millions of gallons of water. *Eurostar* trains thread between the *QE2 Bridge* and the *Dartford Tunnel* with a distance of just 75-cm between the train and the road.

1717

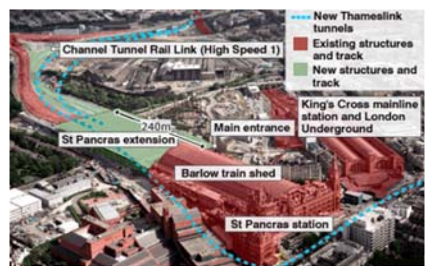


"…Section 1, from Folkestone to Fawkham Junction in Kent, was finished in 2003 allowing trains on the British side of the Channel to run as fast as those on the French side, at a maximum of 300 km/h (186 mph). But speeds in tunnels will be limited to 270 km/h (168 mph) for safety reasons. Section 2 links Section 1 to St. Pancras via a series of new tracks, bridges and tunnels constructed in one of the UK's most ambitious civil engineering projects to date…"
***bbc.co.uk*, November 15, 2007**

1718

"…St. Pancras was chosen as an international terminus in part because it is a few minutes' walk from King's Cross station which has connections to Edinburgh, Newcastle and the east coast as well as six London Underground lines. Thameslink, a major commuter line between Bedford and Brighton, has a station opposite King's Cross. This will close on 8 December 2007 and a new underground station will open at St. Pancras to accommodate longer trains. Thameslink trains continue to arrive at St. Pancras on existing track from the north but new tunnels have been built alongside the HS1 approach as part of the ongoing £3.5bn Thameslink Programme to upgrade and enlarge the whole line…"
***bbc.co.uk*, November 15, 2007**

1719



1720

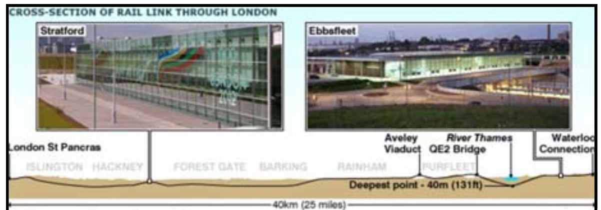
"…The new rail link to the Channel Tunnel was as much about regeneration as speeding up journey times, a proviso made by the government in return for grants and financial backing…"
***bbc.co.uk*, November 15, 2007**

1721

"…In addition to a modern extension designed to accommodate the 400 metre-long (1,300 ft.) Eurostar trains, the existing building at St. Pancras, will be refurbished. The Barlow train shed with its single span roof, a marvelous feat of Victorian engineering, is being restored. Its distinctive gothic frontage, now housing St. Pancras Chambers and once the Midland Grand Hotel, will re-open as a hotel in 2009. The area between St. Pancras and King's Cross is also being redeveloped…"
***bbc.co.uk*, Nov. 15, 2007**

1722

1723



"…New stations have been built at Ebbsfleet in Kent and Stratford in East London, as well as a massive regeneration project known as Stratford City. It's all good news for London and Kent but the project seems to have left two 'white elephants' in its wake. Stratford International was finished in 2006 but will not actually open to the public until 2009, when High Speed 1 Southeastern domestic services are due to start. The new station is surrounded by the construction of the Olympic Park and Stratford City…"
bbc.co.uk, November 15, 2007

1724

"…There is also a question mark over the future of the current Eurostar terminus, Waterloo International, which closed on 13 November. The Department of Transport says it will provide domestic services from the award-winning terminals. But it's far from certain how long it will take to convert the platforms and how much that will cost."
bbc.co.uk, November 15, 2007

1725

1726

Part 24

Spanning the Silver Streak

1727

Very Impressive

1728

"On 6 May 1994, Queen Elizabeth II and French President Francois Mitterand performed the official inauguration ceremony for the Channel Tunnel, a two-bore rail tunnel connecting Britain with France under the English Channel..."
cbrd.co.uk

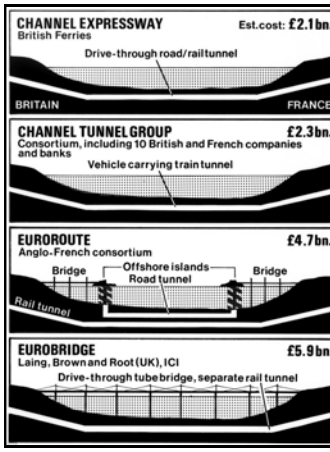
1729

"…Since then, passenger trains have run high speed services between London, Paris and Brussels, and motorists have been able to use a motorail service to transfer cars, buses and HGVs through the tunnel in 30 minutes. All very impressive. But what does all this have to do with roads?..."
cbrd.co.uk

1730

What Might Have Been

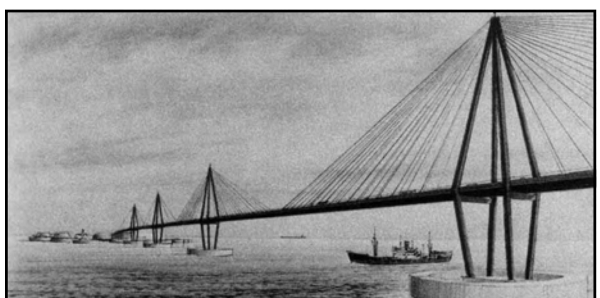
1731



"…The answer lies in the Channel Tunnel being a private enterprise, selected to provide a fixed link across the Channel by the French and British governments. Before the Euro Tunnel consortium was selected there were a number of other bids, all promising a different form of crossing. Some offered routes across for road and rail - one of them providing four parallel tunnels. One, EuroRoute, proposed something so unbelievably grand that its architectural drawings could be easily mistaken for posters for a long-forgotten fifties sci-fi movie…"
cbrd.co.uk

1732

1733



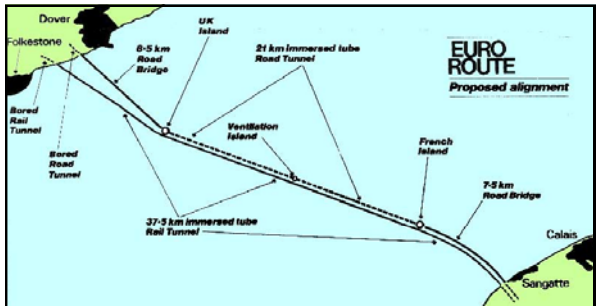
"…EuroRoute was one of about four leading consortia that submitted a proposal to the British and French governments to build the fixed link across the Channel. It was composed of some of the most high-profile institutions of any of the consortia, including big names like Alsthom, Associated British Ports, Barclays Bank, British Steel, BT, GEC and Trafalgar House, among others. Its plan was valued at around £6bn in 1985 prices, and by the deadline of October 30th had secured some £7.2bn in funding - giving a substantial contingency fund and making construction of the link possible…"
cbrd.co.uk

Above: caption: "Sketch of one of EuroRoute's bridge structures"

1734

"…The plan included a fixed link for both road and rail across the channel, with a two-track railway and dual-two-lane motorway connecting to the existing transport networks at either side of the channel. The rail link was very similar in design to the one in existence today, running in a tunnel between depots at Folkestone and Sangatte…"
cbrd.co.uk

1735



"…However, the idea of a road tunnel the length of the Channel was unappealing (despite one bid proposing it) - traffic emissions and the sheer length were thought to make twenty miles an uncomfortable distance. To solve the problem, EuroRoute proposed the crossing be made in three stages, with a central tunnel 21km long and two cable stayed bridges at each side, the three structures connected by two artificial islands…"
cbrd.co.uk
Above: caption: "Map of the EuroRoute proposals"

1736

"…EuroRoute proposed that almost all the crossing be built in pre-fabricated sections, to be built at locations around the UK and France, regenerating many of the run-down industrial areas and not coincidentally providing plenty of work for steelworks and shipyards owned by companies like Alsthom, British Steel and ABP…"
cbrd.co.uk

1737

How EURO ROUTE will create new jobs

The construction and operation of EURO ROUTE will lead to the creation of thousands of new jobs, both locally and throughout the country. More employment will be generated by EURO ROUTE than by any other known cross-Channel link proposal.

The five year construction phase will require skilled workforces to build tunnel and bridge sections to modular designs. There will be a massive volume of work placed with offshore and steel fabrication sites in the North of England and Scotland.

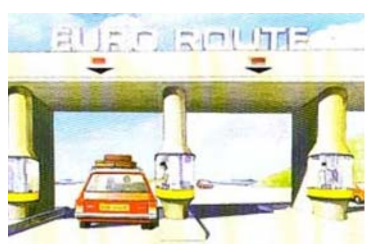
Later, once EURO ROUTE opens its gates to passengers and freight, many more permanent staff will be needed to operate the crossing and its support services – and yet more employment will arise from related activities such as tourism.

EURO ROUTE is a short *and* long term creator of jobs – nationally *and* locally in Kent.

1738

"…EuroRoute's publicity describes a drive across the Channel in detail. The journey would begin on the M20 (then under construction), with motorists exiting the motorway and passing through toll facilities ('speeded up by computer') at Farthingloe. There would be the opportunity to pre-pay for your journey at service areas on the approach…"
cbrd.co.uk

1739



1740

"…A dual-two lane motorway (with full hard shoulders from here to Calais) would then descend into a conventional bored tunnel, emerging from the cliffside onto a spectacular cable-stayed bridge about 8.5km (5 miles) in length and fifty metres above sea level. Of course, motorists driving in the opposite direction would literally enter Britain through the White Cliffs of Dover, traveling from the bridge directly into a tunnel through the chalk…"
cbrd.co.uk

1741

Above: caption: "Artist's impression of one of the five-mile bridges"

1742

The great vertical supports and cable-stays of EURO ROUTE's bridge sections.

How EURO ROUTE will be built

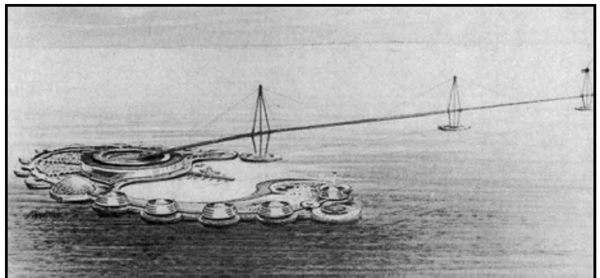
Nothing in the EURO ROUTE design calls for new or risky construction methods. Yet the concept is breath-taking. The road viaducts will be composed of bridge sections each spanning 500 metres and supported by cables from vertical pylons which will tower some 150 metres (nearly 500 feet) above sea level. Stayed cable bridges have a notable safety record.

The twin tunnel will be prefabricated on shore in 125 metre sections which will be towed out, lowered into a prepared trench and joined together. The completed tunnel will then be protected by rock and concrete overlay.

This method of construction has been successfully carried out in many parts of the world, recent examples being Chesapeake Bay, Baltimore Harbour Tunnel, San Francisco Bay, and elsewhere.

Its immensely strong construction makes EURO ROUTE an all-weather, 24 hour a day facility.

1743



"…The bridge would end at an artificial island, where the motorway would widen to dual-three lanes and descend in a spiral beneath sea level at a gradient of 3.5%. The island, and therefore the spiral, are said to be over 200 metres across, and therefore 'somewhat wider than Trafalgar Square'…"
cbrd.co.uk

1744

Above: caption: "Sketch of one of EuroRoute's artificial islands"

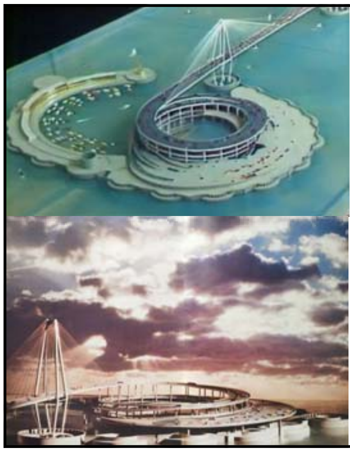
"…The next section would be a 21km (13 mile) tunnel, carrying dual-two lane carriageways in parallel. The tunnel would be of immersed tube construction - prefabricated sections being placed in a trench on the sea floor and then covered over…"
cbrd.co.uk

1745

Above: caption: "Laying prefabricated tunnel sections in their prepared trench"

"…The tunnel would carry traffic safely beneath the main shipping lanes through the Channel, the islands at each end marking out the edge of the lanes, and a third artificial island in the centre for a ventilation shaft which would improve lane discipline among sea vessels…"
cbrd.co.uk

1746



"…The tunnel would end at another artificial island, virtually identical to the first, where the motorway would widen again to dual-three lanes and climb in a spiral to a height of 50 metres above sea level. Both islands would hve unused space around the spirals, as they would be protected by a ring of concrete caissons, and so exiting the motorway would be possible at both. EuroRoute proposed not just parking, fuel and refreshment facilities, but also leisure facilities, duty free shopping, hotel complexes and marinas…"
cbrd.co.uk
Left T&B: model (T) and rendering (B) of artificial island

1747

"…From the island, another identical cable-stayed bridge would travel the remaining 7.5km (4.5 miles) to the French shore, with the road connecting to Autoroutes in the vicinity of Sangatte. Customs formalities would be streamlined to only occur in the country you are entering - meaning you could mingle with French citizens who have never left France without having to leave the UK…"
cbrd.co.uk

1748

Rail Link

1749

"…EuroRoute's rail link is surprisingly similar to Euro Tunnel's existing route. It travels in a tunnel between the current terminals at Cheriton and Sangatte, linking directly with UK and French rail networks. It too was to be twin-tube with a central maintenance shaft. However, in construction, it has several vital differences. A bored tunnel would carry the twin-track line from Cheriton to the foot of Shakespeare Cliffs, and from that point the route would be in an immersed tube, built in the same way as the road link from pre-fabricated concrete sections. It would run parallel to the road link across the full width of the Channel, with access to the ventilation shaft midway. At Sangatte, the line would run in cut-and-cover for several more miles before connecting to the existing French rail lines…"
cbrd.co.uk

1750

"…However, the plan makes no mention of rail investment on the British side - suggesting that non-stop passenger trains have the ability to use both overhead power supply in France and through the tunnel, transferring to BR's third rail system to London. The continental gauge (used for freight) would be able to travel through the tunnels but would have to terminate at Cheriton, with cargo then transferred to British gauge rolling stock there…"
cbrd.co.uk

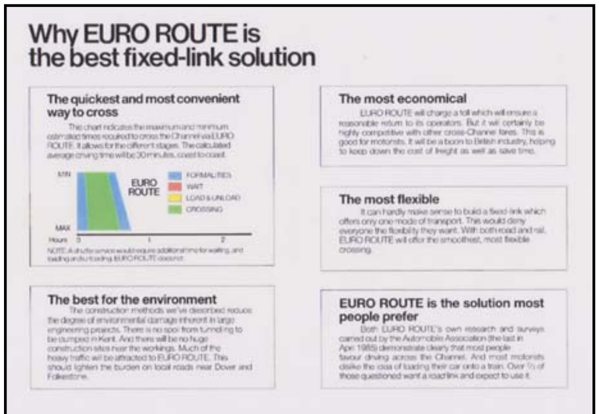
1751

In Hindsight

1752

"…It goes without saying that EuroRoute did not get selected and their Buck Rogers plans did not get beyond the drawing board. But the question must be asked why this is so. In many ways, the crossings promoted by EuroRoute were not only more useful to more people than Euro Tunnel's plan, they were also much more economically friendly. The company estimated that it would create 75,000 jobs for prefabrication and construction work alone. And best of all, it would not cost the taxpayer a penny…"
cbrd.co.uk

1753



1754

"…Wondering whether EuroRoute would have, in hindsight, been a more successful project (considering the debts that Euro Tunnel now suffer) is not as ridiculous as it seems either. Research at the time suggested that 52% of people would prefer to drive across, and that motorists actively disliked the idea of putting their car on a train to cross the Channel. Feelings were even more polarised in France. And of course, EuroRoute was quick to poke fun at its rail-only competitor with the footnote 'A shuttle service would require additional time for waiting, and loading and unloading. Euro-Route does not'…"
cbrd.co.uk

1755

We'll Never Know

1756

"…The reason for the rail-only choice remains unclear. Perhaps the road link costing three times the price of the rail tunnel had something to do with it - making the rail option seem a safer deal. But with hindsight, perhaps a road crossing would now be subsidising the railway. Or perhaps the link would have attracted no additional traffic and would now be struggling with four times Euro Tunnel's debt. Now, we will never know."
cbrd.co.uk

1757

LinkToEurope

1758

In April 1981, a detailed proposal for a 21-mile-long suspension bridge (akin to the *Severn Bridge*) across the *English Channel* was submitted to the *Transport Department* and studied by the Thatcher Government during discussions of the Channel Tunnel project. Starting at either Dover or Folkestone, the bridge would carry a motorway 220-feet above the Channel. The engineers of the bridge (who dismissed the idea of a tunnel as "impractical") stated that private financiers were willing to fund the £3 billion project. They estimated that automobiles would pay a toll of £5.60 (per occupant) while lorries (trucks) would be charged a flat fee of £8. Calling itself "LinktoEurope," the group admitted the huge pylons on which the bridge would rest could make navigation of the Channel difficult for shipping. However, they insisted the structure would be resilient enough to withstand a ship collision without affecting the roadway high above. It was not one of the "final four" proposals examined in 1985.

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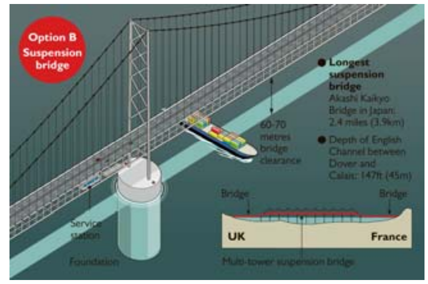

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1761

Boris' Folly

1762

The British Foreign Secretary has floated the idea of building a giant bridge between France and Britain after Brexit. French Economy Minister Bruno Le Maire said the plan should at least be considered.
***dw.com,* January 19, 2018**

1763

Let's Do It

1764

"UK Foreign Secretary Boris Johnson reportedly mentioned his radical idea for an English Channel bridge during a meeting with French President Emmanuel Macron at the recent Anglo-French summit. According to the UK's Daily Telegraph, Johnson told Macron it was 'ridiculous' that two of the world's largest economies were only 'linked by a single railway,' referring to the Channel Tunnel link, which opened in 1994. Macron replied by saying 'I agree, let's do it,' according to the daily…"
***dw.com*, January 19, 2018**

1765

"…Johnson on Thursday tweeted that France's and Britain's success depended on 'good infrastructure and good connections.' He then asked 'Should the Channel Tunnel be just a first step?,' without giving any more detail. He has not discussed the idea in public…"
***dw.com*, January 19, 2018**

1766

Why Not?

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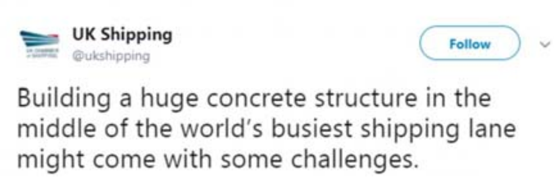

"…Speaking on Friday on French radio station Europe 1, French Economy Minister Bruno Le Maire said 'Why Not?' He went on to say that 'all ideas, even the most eccentric ones, should be considered.' Meanwhile, Shipping UK, which represents nearly 200 shipping firms, pointed out that building a 22-mile (35-kilometer) bridge 'in the middle of the world's busiest shipping lane might come with some challenges,' referring to the Dover Strait…"
***dw.com*, January 19, 2018**

1768

The Debate

1769

"…UK Shadow Foreign Secretary Emily Thornberry rubbished the idea and accused Johnson of 'running out of ideas to improve international relations.' She also called Johnson a clown. Johnson has previously promoted the idea of a second Channel Tunnel but is now said to be favoring a bridge instead…"
***dw.com*, January 19, 2018**

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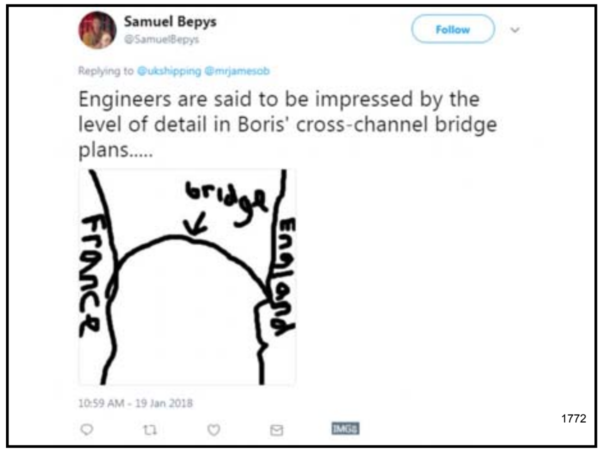

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"…He is known to have a soft spot for large infrastructure projects. As mayor of London he backed a 'garden bridge' over the River Thames, a project that was scrapped by his successor, Sadiq Khan. He also once wanted to build an airport on the Thames Estuary dubbed 'Boris Island'…"
***dw.com*, January 19, 2018**

1774

Above: caption: "Mr. Johnson has backed a bridge project before, promoting the ill-fated Garden Bridge across the Thames. The project was scrapped as a waste of money."

1775

Above: caption: "As Mayor, Mr. Johnson also promoted the idea of closing Heathrow and replacing it with a brand new four-runway airport in the middle of the Thames estuary"

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1777

"It's certainly one way to beat the predicted chaos of the capital's public transport during the summer's Games. And at least if you do get stuck, there are the dramatic views of London's skyline - not to mention a glimpse of the Olympic stadium - to enjoy. The cable car across the River Thames was officially launched by Boris Johnson today with just under a month to go to the Olympics. The London Mayor was the first passenger on the £44 million Emirates Air Line which offers 360-degree views of the city…The Mayor said: 'Get on this cable car immediately. It's beautiful, worth every penny and a stunning piece of engineering.' He added that the new system would provide a much-needed connection across the Thames and become 'a must-see destination in its own right.' The system is sponsored by Dubai-based airline Emirates, which has contributed £36 million to the project in a 10-year deal…Although it has been completed in time for the Olympics, it will also help cut commute times and stay in place after the games…"
***dailymail.co.uk*, June 28, 2012**
Left: *Boris Johnson* with EAL hostesses

1778

In 2012, as mayor of London, *Boris Johnson* backed the £60 million *Emirates Air Line* cable car over the *River Thames,* which he hoped would be used by commuters after the *2012 London Summer Olympics* concluded. In its first year, just sixteen passengers were regular users of the service.

1779

"I certainly believe this is a feasible project. Certainly this is something that can happen within three to five years from the day that the designer puts the first line on the paper. The main challenge is usually the local soil conditions, and then someone needs to think about the problems along the deck, which is the horizontal part of the bridge. Having a bridge as long as 22 miles means that someone has to provide certain design considerations, such as expansion joints every 500m. So its a combination of a very expensive foundation under the sea bed, and obviously certain considerations for the design and construction of the deck. But there are techniques that can support very long decks…"
***Dr. Stergios Mitoulis,* Lecturer on Bridge and Structural Engineering at the *University of Surrey* (January 2018)**

1780

"It has been looked at before. Before the tunnel was built there were bridge options being looked at and of course it is doable. There is no real issue particularly nowadays with modern technologies. We can design relatively long spans. This would be a multiple span structure. This has not got to be one big span of course. The economics may lean towards something like getting on for a kilometre spans or something, 800 metre to a kilometre span, that sort of size I would imagine. Multiple spans. It would be a huge undertaking but it would be absolutely possible and the shipping impact issues could be dealt with."
***Ian Firth,* Director at the Engineering Firm *COWI A/S* (January 2018)**

1781

"Dangerous for container ships and useless when the wind blows (which is often)!"
***Nigel Farage,* former UKIP leader**

1782

"…That's something that has been tackled in the past. There are ways and designs that can be used to avoid such occurrences – it's a matter of designing certain protective barriers before and after the bridge pylons."
Dr. Stergios Mitoulis, **Lecturer on Bridge and Structural Engineering at the *University of Surrey* (January 2018)**
RE: concerns about the potential for ships colliding with bridge piers

1783

"The technology is there now. I think it will be done one day. Technically, the problem would be the fact that the Channel is very busy. You'd need less supports because you need less obstruction to the ships. So, you would need a very big span (between the supports) to allow ships to cross."
Dr. Alfredo Camara, **Department of Civil Engineering - *City University London* (January 2018)**
Re: the *Dover Strait* is the world's busiest shipping lane. Not only would there need to be enough distance between the supports to minimize hazards to navigation, the bridge would also need to be high enough to allow the tallest ships to pass beneath it unhindered. At present, the longest span between supports is 2K-meters.

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"It's good to have vision, particularly with respect to infrastructure projects, but the Dover Strait is the world's busiest shipping lane with many, many hundreds of vessel transits per day. Building a 22-mile-long bridge across the Channel would therefore not be without its challenges, especially as the largest ships currently transiting the Strait have a height above the water line in excess of 60 metres."
Guy Platten, **CEO of the *UK Chamber of Shipping***

1786

"In principle it is feasible, in the sense that there are nominally similar projects in other parts of the world. But based on my experience, the cost will be huge. So if you ask my personal opinion, I don't think this will be a good idea."
Andreas Kappos, **Professor of Civil Engineering and Director of the Research Centre for Civil Engineering Structures – *City University London***
RE: at eleven miles, Europe's longest bridge is the *Vasco da Gama Bridge*. The world's longest bridge is in China. It crosses a body of water 103 miles wide.
Above: caption: "The Vasco da Gama Bridge is a cable-stayed bridge that traverses the River Tagus, near Lisbon in Portugal"

1787

Above: caption: "The Danyang-Kunshan Grand Bridge is 102.4 miles long – making it the world's longest bridge. It hosts the Beijing-Shanghai High-Speed Railway. Its construction took four years, employing 10,000 people, and cost more than £6 billion."

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Above: caption: "Jiaozhou Bay Bridge (a/k/a "Qingdao Haiwan Bridge") is a 26.7 km (16.6 mi) long roadway bridge in eastern China's Shandong province. The longest continuous over-water segment of the bridge is 25.9 km, making it the world's longest bridge over water."

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"We're better off spending smaller amounts of money on improving our crumbling roads and opening more lorry parks. The Channel Tunnel and the ferry routes are working well within capacity, so it makes no sense to commit huge amounts of taxpayers' money in an uncertain economic climate to a costly bridge project that we don't need."
Richard Burnett, **Chief Executive -** ***Road Haulage Association*** **(January 2018)**

1795

"I haven't seen any plans on that. We are going to have very close ties with France economically, culturally and in areas such as defence and security for many many decades to come. What was agreed yesterday (Thursday) and what the foreign secretary tweeted about as well is a panel of experts who will look at major projects together, including infrastructure. And we want to work very closely with our French colleagues on building a shared, prosperous future."
RE: UK Prime Minister Theresa May's spokesman commenting upon UK Foreign Minister Boris Johnson's comments made while meeting with French President ***Emanuel Macron*** **in January 2018**

1796

A Most Fundamental Way

1797

"If you wanted to show your commitment to Europe, is it not time for us to have further and better economic integration with a road tunnel? That's what we need…You could come out of the EU but join Europe in the most fundamental way."
Boris Johnson, **UK Foreign Minister**
RE: reported excerpt from a private conversation at the ***2016 Tory Party Conference*** **which was held in Birmingham, England**

1798

One Step Closer

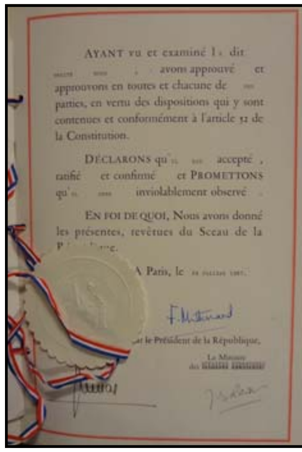
1799

Whether it's a bridge or a tunnel, which would be decided on environmental grounds, Eurotunnel would be part of the process
independent.co.uk, **February 12, 2018**
RE: introduction to an article entitled: "Boris Johnson's plans for second link to Europe one step closer as Eurotunnel expresses interest in project"

1800

"Boris Johnson's plans for a new link between the UK and Europe could be coming closer to reality after Eurotunnel, which manages the Channel Tunnel, said it had contacted the Government to discuss the proposals. Speaking to The Independent, Eurotunnel spokesman John Keefe, said: 'As part of the Treaty of Canterbury and the Concession Agreement which established the Channel Tunnel, Eurotunnel has the right to build the next fixed link. Because of this we have written to the Government and said 'let's have a chat.' There's no more to it than that.' Eurotunnel added: 'Mr. Johnson's comments are a good endorsement for a fixed link across the English Channel. Whether it's a bridge or a tunnel, which would be decided on environmental grounds, Eurotunnel would be part of the process'…"
***independent.co.uk*, February 12, 2018**

1801



"…The Treaty of Canterbury was signed by British Prime Minister Margaret Thatcher and French President Francois Mitterrand in 1986 and is the original document providing for the construction of the undersea tunnel between the UK and France. The Concession Agreement, which was also signed in 1986, entrusts Eurotunnel with the design, financing, construction and operation of the Channel Tunnel for a period of 55 years. The concession was later extended to 2086…"
***independent.co.uk*, February 12, 201**

1802

"…The comments come after a report by The Telegraph, detailing a letter to the Prime Minister from Eurotunnel, which included comments from the company's French chief executive, Jacques Gounon, who said he is 'very interested' in a second fixed link and would be 'delighted to start discussions.' The note from Mr. Gounon states: 'The idea of a second fixed link is something that we regularly consider in our long term plans and we would be delighted to engage with your officials to explore the possibility further'…"
***independent.co.uk*, February 12, 2018**

1803

"…The idea was first put forward by Foreign Secretary Boris Johnson. Mr Johnson said the link, which could function as a bridge between Britain and France, would consolidate the relationship between the countries after Brexit. Mr. Johnson spoke about the project with French President Emmanuel Macron at a summit earlier this year, but his proposal was later criticised by No. 10…"
***independent.co.uk*, February 12, 2018**

1804

En Marche!

1805

"…At the time, he tweeted: 'En marche! Great meetings with French counterparts today' and added: 'I'm especially pleased we are establishing a panel of experts to look at major projects together. Our economic success depends on good infrastructure and good connections. Should the Channel Tunnel be just a first step?'"
***independent.co.uk*, February 12, 2018**

1806

The Brexit Bridge

1807

The Foreign Secretary told MPs it was reaching capacity - and a bridge should be built to ease pressure
***www.mirror.co.uk,* February 21, 2018**
RE: introduction top an article entitled: "Channel Tunnel 'will be full in seven years,' claims Boris Johnson as he steps up bid for Brexit bridge to France"

1808

"The Channel Tunnel will be full within seven years, Boris Johnson claimed today as he defended his call for a Brexit bridge to France. The Foreign Secretary wants a 22-mile cro-ssing over the Strait of Dover - the world's busiest shipping lane - and insisted French President Emmanuel Macron backs the scheme. Mr. Johnson first floated the plan at last month's UK-France Sandhurst summit…"
***www.mirror.co.uk,* February 21, 2018**

1809

1810

"…Answering Commons questions today, he said: 'It was indeed agreed that a committee of wise people should be established to look at reviving the great tradition of UK Fra-nce collaboration in such matters as security, defence, sp-ace, genomics and infrastructure projects, such as the idea of a new connection between our two countries - an idea that was warmly welcomed by President Macron himself.' The Cabinet Minister added: 'Most people will appreciate that the existing Channel Tunnel is likely, at the present rate, to be full within the next seven years'…"
***www.mirror.co.uk,* February 21, 2018**

1811

"…'That's a very short time in the life of a great infrastructure project. It is a curiosity that two of the most powerful econ-omies in the world, separated by barely 21 miles of water, are connected by only one railway line. I think it is a matter for legitimate reflection by our two countries on the way for-ward.' Figures from Eurolink, which operates the Tunnel, show that last year (2017) it was used by 1,637,280 trucks carrying 21.3 million tonnes of freight. A total of 2,595,247 cars and 51,229 coaches used the link, along with 10,300,622 Eurostar passengers…"
***www.mirror.co.uk,* February 21, 2018**

1812

"…In 2008, just 1,254,282 lorries used the tunnel, carrying half as much freight as a decade later. The number of cars was 1,907,484, but the number of coaches on the Eurotunnel was higher at 55,751. Mr. Johnson even wants private firms to foot the estimated £120 billion bill - as companies did for the Channel Tunnel in the 1980s. 'There's no reason why we shouldn't have the same ambition this time,' he said…"
***www.mirror.co.uk*, February 21, 2018**

1813

Who Dares Wins

1814

"…Lib Dem deputy leader Jo Swinson attacked his 'fantasy engineering projects.' And SNP frontbencher Patrick Grady highlighted feared 'gridlock' of vehicles trying to travel between Britain and France if they have to undergo customs checks following Brexit in March 2019. He said: 'What's the point of a 20-mile bridge if there is going to be a 20-mile queue waiting to get on to it?' But Tory backbencher James Duddridge called for 'more visionary and less mockery.'"
***www.mirror.co.uk*, February 21, 2018**

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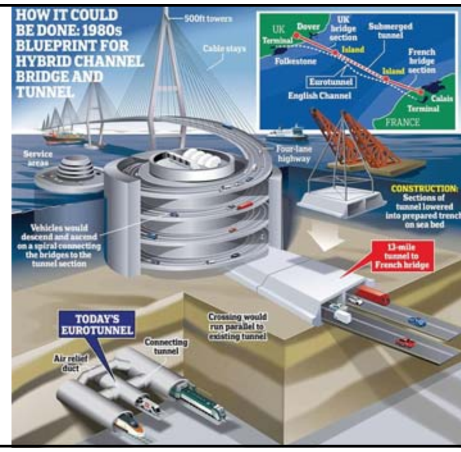

1816

Part 25

The Future is Now

1817

Future Vision

1818

"Boris Johnson is not a details-oriented politician. He's a man with a vision…In his current role as Foreign Secretary, it appears that he hasn't stopped thinking big. He's in the news today because he's proposed a new bridge across the English Channel - providing a second fixed link between Britain and France after the Channel Tunnel…new bridges and tunnels have the potential to bring the world that little bit closer together. And we think there should be more of them. So here's some of the biggest, most exciting proposals that are currently on the drawing board - or at least inside the deranged brains of eccentric engineers…"
***gizmodo.co.uk*, January 19, 2018**

1819

Fehmarn Belt Fixed Link

1820

"…In 2015 construction began on a new tunnel linking the Danish island of Lolland (yes that's a real island) with the German island of Fehmarn, which is then connected to the German mainland. It's a bit of a no-brainer, as it replaces either a time consuming ferry link, or a very long round trip via Denmark's Jutland Peninsula…"
***gizmodo.co.uk*, January 19, 2018**

1821

1822

"…At 18 km long, the tunnel will use the equivalent amount of steel to 50 Eiffel Towers - and will employ 3000 people across 8.5 years to build. But what's most interesting is the way it is being constructed. Unlike our Channel Tunnel, which is bored beneath the seabed, the Fehmarn link will be constructed as 79 separate 217m long prefabricated elements, which will be floated out into the sea on a barge, and then submerged and placed in a trench that has been dug at the bottom of the sea. Once complete, you'll be able to drive between the two countries in ten minutes, or take the train in seven minutes…"
***gizmodo.co.uk*, January 19, 2018**

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Helsinki-Tallinn Tunnel

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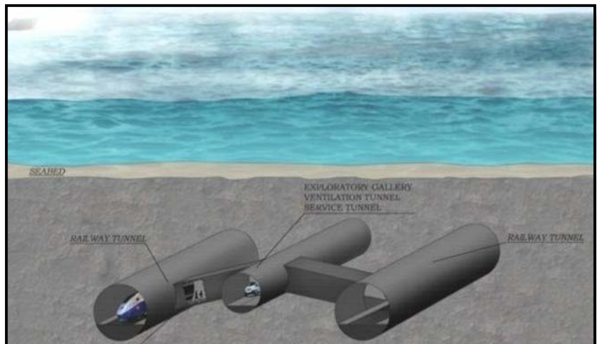

"…Finnish capital Helsinki and Estonian capital Tallinn are just 80 km apart, but have historically felt a lot further, as during the Cold War Finland became one of the richest countries in Europe, while Estonia remained poor and oppressed by the Soviet Union…"
gizmodo.co.uk, **January 19, 2018**

1826

"…But soon a new 92 km tunnel could restore some balance, as plans are afoot to build a tunnel under the Gulf of Finland. The plans are supported by the Mayors of both cities, and now the hope is the European Union will stump up the cash for the proposed rail tunnel. A feasibility study was concluded in 2015 which sounded promising, suggesting that the tunnel could pay for itself within 40 years. It would also for the first time create a land-link between Finland and the Baltics that does not require travelers to pass through Russia, with all of the associated customs-hassle that would entail (as Finland and Estonia are both in the Schengen Zone, it might not even need a passport check). A new tunnel would also provide a bonus stop on the proposed new Rail Baltica railway which, when construction begins in 2020, will create faster rail links between Berlin, Warsaw, and major cities in the three Baltic states…"
gizmodo.co.uk, **January 19, 2018**

1827

1828

Sri Lanka-India Bridge or Tunnel

1829

"…The island nation of Sri Lanka and India are divided by the Palk Strait - which is just 32 km wide at it's shortest point. In fact, just beneath the surface of the sea there are hidden islands known as Adam's Bridge, which were supposedly once navigable on foot, before a cyclone in 1480 permanently shook things up and left them underwater. So ever since, travel between the two countries has required a boat or a plane. There are, however, plans to restore this historic link. At the end of last year 'The Hindu' reported that the Asian Development Bank was willing to pay for a bridge, though as of April this year, the Indian government hasn't committed to anything just yet…"
gizmodo.co.uk, **January 19, 2018**

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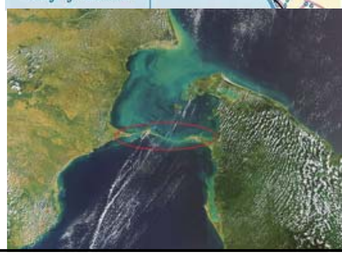

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Gibraltar-Morocco Bridge or Tunnel

1832

"…The British outpost of Gibraltar, on the southern tip of Spain, and Morocco in North Africa sit just 14 km - or 9 miles - from each other. And the conceivable benefits are obvious and huge: For the first time Africa would have a fixed link with Europe, and trade between the two continents could be hugely enhanced. Finally, the Romans' former Mediterranean Empire would be one again - but this time not united by Roman domination, but by the spirit of cooperation. What a great idea - and hey, 9 miles isn't much . . . So building a bridge between the two should be trivial, right? Not quite…"
***gizmodo.co.uk*, January 19, 2018**

1833

"…The problem is that the Gibraltar Strait between the two continents sits at the entrance to the Mediterranean Sea. This is a sea passage that needs to remain navigable to the most enormous of container ships and oil tankers, which (thanks to the Suez Canal in Egypt) deliver the fuel and goods we rely on from the Middle East and China respectively. So any bridge needs to be careful not to screw this up. So far there have been proposals for both a bridge and a tunnel…"
***gizmodo.co.uk*, January 19, 2018**
Above: caption: "Strait of Gibraltar perspective (the Rif on the right and Andalusia on the left)"

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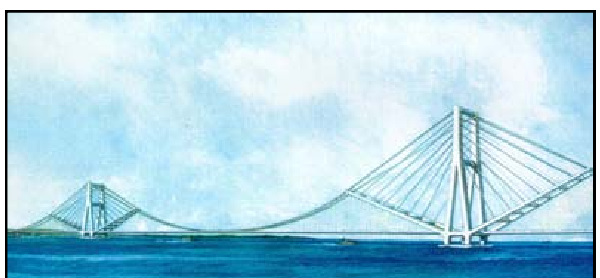

"…In 1996, Prof. TY Lin conducted a feasibility study into building a bridge, and concluded that the best way to do it would be to have two 910m tall piers in the middle of the sea - a tall order given that now 20 years later humans are only just managing to construct buildings on land around that height (the Burj Khalifa, the current tallest building is 830m high). Design-wise, it would need to be a hybrid cable-stayed suspension bridge, with road decks of 5km - longer than any ever constructed. And it would have to be built in deep water. Oh . . . and don't forget that it would sit on top of a tectonic fault, making it prone to earthquakes…"
***gizmodo.co.uk*, January 19, 2018**

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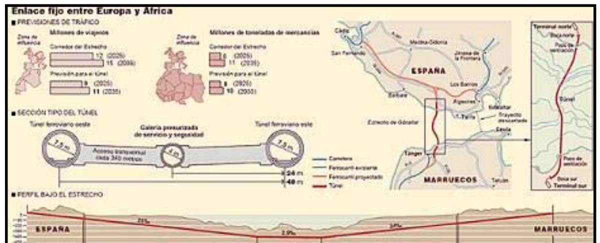


"…The tunnel proposals have hit roadblocks too, after geological surveys revealed the rock is much harder to bore through than, say, that found beneath the English Channel. According to The Guardian, in order to simply carry out the surveys of the rocks to find this, the engineers had to invent new boring techniques to handle the sea currents. Engineers have also concluded that the tunnel wouldn't simply be able to take the shortest possible route, but would need to take a longer 37.7km route, so that the tunnels have the correct gradients to enable trains the required 300m.

***gizmodo.co.uk,* January 19, 2018**

1838

1839

The Darien Gap

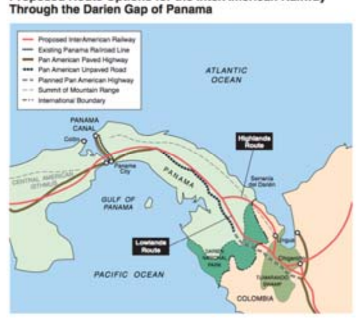
1840

"…The Pan-American highway is a 30,000 km long network of roads spanning the entire American continent, from Northern Alaska to Southern Chile. It's theoretically capable to drive the whole way - apart from one tiny gap. Annoyingly for perfectionists, on the border between Panama and Columbia, when the continent is at its most narrow, there is the Darién Gap - a 160 km long break in the road due to marshland, swamp and rainforest. The reason no one has thought to spray tarmac all over it is partially due to the difficulty of building, but also because of the completely reasonable explanation that it would be environmentally disastrous, as the area is known for its biodiversity. There's also indigenous people who live there, and fears about drug trafficking and violence…"

***gizmodo.co.uk,* January 19, 2018**

1841

Proposed Route Options for the InterAmerican Railway Through the Darien Gap of Panama



1842

1843

Bering Strait Bridge or Tunnel

1844

"…Vice-Presidential Candidate Sarah Palin once famously claimed that she could see Russia from her house which, even if not strictly true, does underscore that despite America and Russia being worlds apart ideologically, they are really only separated by around 50 miles of Ocean. And bridging this ocean - the Bering Strait - has long been talked about with varying degrees of seriousness. Prof. Lin, who also pitched the Gibraltar bridge proposed a crossing in 1958 as an 'Intercontinental Peace Bridge'…"

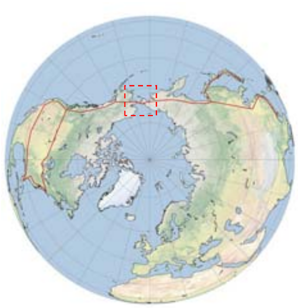
***gizmodo.co.uk*, January 19, 2018**

1845

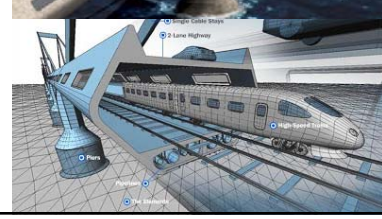
"…Amazingly, despite the strait being just on the edge of the Arctic Circle, conditions might not be too bad - the tidal currents aren't outrageous, and the sea is only 55m deep - much less than, say, Gibraltar. The sticking point, of course, is the temperatures which typically hit -20. Which would make construction a nightmare. The other big problem, as identified by the American Society of Mechanical Engineers is that the location of the bridge is very remote, with no towns for 100 miles on either side. This means that there's very little existing infrastructure from where to build a bridge. Simply reaching the construction site would no doubt involve new roads, tunnels and bridges too - let alone the cost of infrastructure to connect up existing railways and roads with the bridge…"

***gizmodo.co.uk*, January 19, 2018**

1846



1847

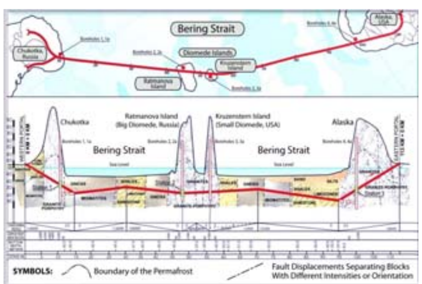


1848

1849

"…Since Prof. Lin's call for a bridge in 1958, these days campaigners appear to be instead lobbying for a tunnel, which they reckon would cost only $35bn. But perhaps it all could be worth it - not because Russia offers a great economic prize to the United States, but because of another country that would stand to gain from such a connection: China…"
***gizmodo.co.uk*, January 19, 2018**

1850



1851

Japan-Korea Tunnel

1852

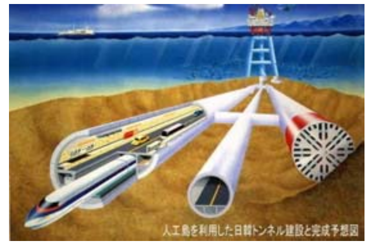
"…Another proposed tunnel that could unite former enemies is the proposed link between Japan and South Korea, which are 128 km from each other at their shortest point. The tunnel would still be the longest undersea tunnel in the world by quite some distance, but it would seemingly make a lot of sense given that both are wealthy democracies that have deep economic ties with each other. In 2009, the then South Korean President Lee Myung Bak ordered a feasibility study, but such a connection isn't expected to be cheap, at over £50bn…"
***gizmodo.co.uk*, January 19, 2018**

1853

1854

"…There are also a number of other obstacles standing in the way, such as the fact that unlike Britain and France, Japan sits on the edge of a tectonic plate - and there are still arguably cultural factors at play, as though the two countries are now friendly they still haven't buried the hatchet over their historical grievances to quite the same extent we have with France (and to be fair, Korea's grievance with Japan is much more recent - up until the end of WWII). And if they can ever build a tunnel, there's just the small matter of getting their rail systems to play nicely: Whereas South Korea uses 1435mm gauge tracks (same as Britain and much of the rest of the world), Japan uses narrower 1067mm tracks…"
gizmodo.co.uk, **January 19, 2018**

1855



1856

Irish Sea Crossing/s

1857

"…Closer to home now and over the years there have been a number of proposals to connect Ireland with Great Britain. In 2007, the Centre for Cross Border Studies proposed a bridge from Northern Ireland to Galloway in Scotland. It'd have to stretch for 21 miles, and the idea is that it would connect up with trains heading towards Glasgow (and then, presumably, on to London). The cost was estimated at £3.5bn…"
gizmodo.co.uk, **January 19, 2018**

1858

"…In 2004 meanwhile, the Irish Academy of Engineers proposed a 50 mile tunnel this time going under a much wider stretch of the Irish sea - linking Rossiare in Ireland with Pembrokeshire in Wales. It reckoned the journey would take one hour and ten minutes. Perhaps where both plans fall down is in the economic question of . . . why? The Channel Tunnel arguably makes sense because it links London - the capital of Britain - with Brussels and Paris, the capitals of Belgium and France. And once the trains get to Kent, it is a relatively short hop to St. Pancras. If you were to catch a train from Belfast to London via Glasgow, or Dublin to London via Pembrokeshire, by the time your train had made the hop under or over the sea, there would still be several hours of sitting on a train to go…"
gizmodo.co.uk, **January 19, 2018**

1859

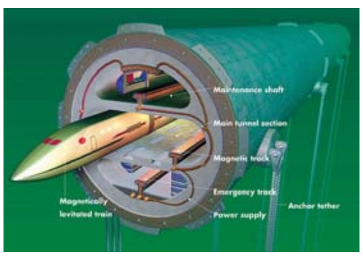
1860

Transatlantic Tunnel

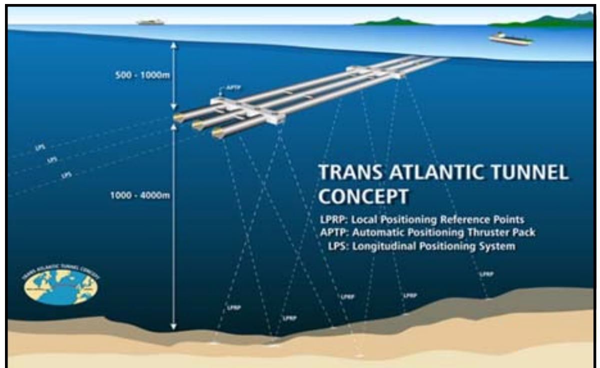
1861

"…And finally, perhaps the craziest proposal of all: If you have a $12tn - yes, TRILLION, dollars to spare then not only would you control 15% of the world's entire GDP, but you'd also be able to build this completely crazy transatlantic tunnel. The idea is that rather than tunnel under the Atlantic Ocean, or sit on the seabed (the volcanic Mid-Atlantic Ridge would cause problems), the tunnel would instead float in the water, held in place by a series of cables anchored to the sea floor…"
gizmodo.co.uk, **January 19, 2018**

1862



1863



"…In order to handle collisions with submarines and whales, these cables would be controlled dynamically, giving the tunnel some flexibility - and they would ultimately be positioned by GPS to keep the tunnel in the right place…"
gizmodo.co.uk, **January 19, 2018**

1864

"…As for the sort of trains you'd need, well, conventional trains are simply too slow for such a long journey. So instead we'd have to use Maglev trains, which float above the tracks using magnets . . . and we'd need to make them capable of travel at 5000 mph in order to be viable. And to achieve these speeds? The massive underwater tunnel would have to be a perfect vacuum…"
gizmodo.co.uk, **January 19, 2018**

1865

"…Well, it's ambitious to say the least - but perhaps don't bank on taking a trip on it in your lifetime."
gizmodo.co.uk, **January 19, 2018**

<u>Left</u>: caption: "MOVIE FORECASTS TRAVEL UNDER ATLANTIC. What travel between America and Europe may be like, a half-century or more hence, is forecast in one of the latest motion-picture productions, which envisions the construction of a 3,000-mile submarine vehicular tube linking New York and London. To offset the objection that such a project would be fantastic under engineering methods developed up to the present time, the movie, 'Transatlantic Tunnel,' provides the builders with an imaginary new tool – a 'radium drill,' supposedly capable of liquefying rock. Streamline, hermetically sealed cars, impelled by electromagnets and traveling in a vacuum, according to the story, would whiz through the completed tube at such terrific speed that a passenger could breakfast in New York, keep a luncheon engagement in London, and get back to America for dinner." (*Transatlantic Tunnel* was released in 1935) 1866

1867

1868

The Mother of All Tunnels

1869

"Deep beneath the Bohai Sea, Chinese engineers may soon begin boring the longest submarine tunnel on the planet. At an estimated 76 miles (123km) long, it would surpass the combined length of world's two longest underwater tunnels - Japan's Seikan Tunnel and the Channel Tunnel between the UK and France. To connect the bustling northern ports of Dalian and Yantai, the engineers will have to tunnel through two fault zones that have cau-ed a slew of deadly earthquakes in the last cen-tury. And the project will cost a whopping $42.4 billion, nearly three times as expensive as Boston's Big Dig…"
***qz.com,* July 12, 2013**

1870

As the Crow Flies

1871

"…Though only 105 miles apart as the crow flies, the drive between Dalian and Yantai takes around seven to eight hours. The Bohai Tunnel would shorten that to an hour. The State Council will begin reviewing the completed blueprint for the tunnel as early as next week…"
***qz.com,* July 12, 2013**

1872

1873

Magnificent Ambition

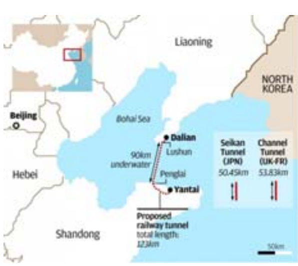
1874

"…Provincial leaders of Shandong and Liaoning hope the tunnel will stimulate economic growth by connecting China's northern rustbelt region with the upper reaches of the wealthy eastern coast. A member of the Chinese Academy of Engineering projected annual revenue of $3.7 billion, largely from freight, meaning the project would potentially pay for itself in 12 years. And if that's not rationale enough, there's bonus of claiming another world record (the government seems to have a fondness for superlative infrastructure). Compared with the world's other undersea tunnels, though, this one is massively ambitious. Here's why…"
***qz.com*, July 12, 2013**

1875

"…The Bohai Tunnel's 76 miles would make it twice as long as both the current record-holder, Japan's Seikan Tunnel, between Hokkaido and Honshu, and the Channel Tunnel, sometimes called the 'Chunnel.' That's a lot of ground that the geographical survey has to cover to make sure the tunnel is feasible…"
***qz.com*, July 12, 2013**

1876



1877

"…As it happens, Chinese engineers already have some experience with underwater tunnels. The 3.8 mile-long Jiaozhou Bay Tunnel connecting Qingdao and Huangdao, was completed back in 2011, and the Xiamen tunnel was completed in 2010…"
***qz.com*, July 12, 2013**
Left: caption: "Record-setting bridge and Jiaozhou Bay tunnel crossings"

1878

"…Those projects used one of the more common ways to build an underwater tunnel, the 'cut-and-cover' method. This entails dredging a trench in the ocean floor and embedding sealed tube sections made of steel or concrete. After divers connect and seal the tube sections, the water is pumped out of the resulting passage and the upper half of the tube is covered with rock. This is how one of the Big Dig tunnels beneath Boston Harbor was constructed…"
qz.com, **July 12, 2013**

1879

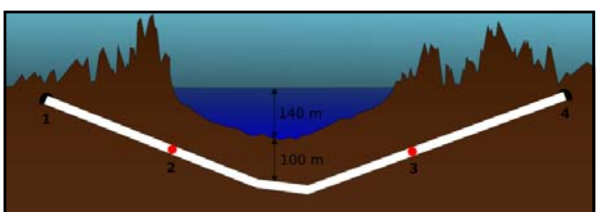
1880

"…Given that the Bohai Bay is roughly the same depth the Jiaozhou Bay, the 'cut-and-cover' approach might work. However, the Bohai Tunnel is 20 times longer than the Jiaozhou Tunnel. That means the Bohai Tunnel will likely require more sophisticated - and expensive - technology than that used for the earlier Chinese submarine tunnels. If the seabed is sufficiently soft, the tunnel can be made the way land-based ones often are, using massive drills called tunnel-boring machines (TBMs)…"
qz.com, **July 12, 2013**

1881

"…These things are huge. The TBMs used on the Channel Tunnel - or 'Channel,' as it's known - were two football fields long and could drill 250 feet a day…"
qz.com, **July 12, 2013**
Above: caption: "A TBM like this one is an option for tunneling under Bohai Bay"

1882



"…The way it works is that two TBMs on opposite sides of the waterway gouge through the sea floor until they meet in the middle. While the Channel Tunnel's deepest point is 75 meters beneath the surface of the ocean, the Seikan Tunnel is 240 meters down - beneath 140 meters of water and another 100 meters of seabed, which made things tougher for Japanese engineers…"
qz.com, **July 12, 2013**
Above: the geology of the undersea portion of the *Seikan Tunnel* consisted of volcanic rock, pyroclastic and sedimentary rock

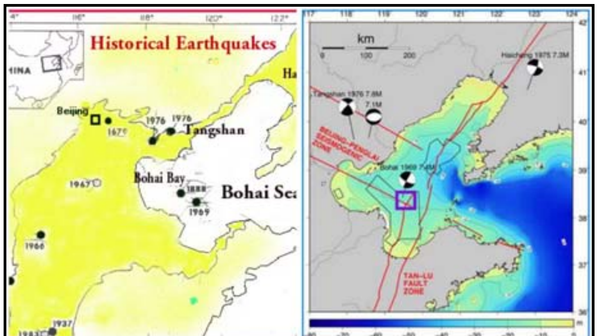
1883

"…But it's not just depth per se that matters. In conditions in which the rock hardness varies a lot, TBMs can be dangerous and ineffective. Though the Japanese first tried using TBMs, the variable type of rock in the seabed caused them to abandon this method in favor of 2,800 tons of dynamite. This is called the 'drill-and-blast' method…"
qz.com, **July 12, 2013**
Above: caption: "A TBM boring through the Alps"

1884

"…This method may be somewhat riskier than the other two, on balance. For instance, a slew of leaks during construction on the Seikan Tunnel led to financial losses and killed four workers. At one point, workers blasted into an area with softer rock, causing water to flood the tunnel at a force of 80 tons per minute. For what it's worth, both of the two previous Chinese underwater tunnels used the drill-and-blast method…"
***qz.com*, July 12, 2013** 1885
Above: caption: "Each three-lane tunnel spans 28-meters"

"…But depth and length are only part of the challenge - the Bohai Tunnel also will need to plan around two major fault zones. Throughout modern Chinese history, the Tanlu and Zhangjiakou Penglai fault zones have been the source of chronic seismic activity. The 1976 Tangshan earthquake, which killed between 250,000 and 650,000 people, is the most notorious..."
***qz.com*, July 12, 2013** 1886
Above: caption: "Aftermath of the 1976 Tangshan Earthquake"



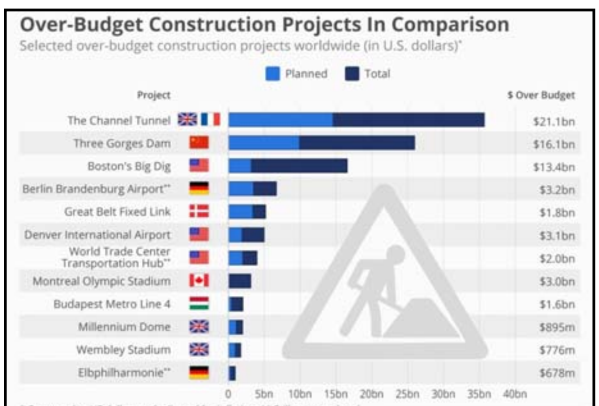
"…as you can see in the map above, there have been others. Perhaps the most concerning historical earthquake for the tunnel engineers to consider is the 7.4-magnitude quake of 1969 that occurred under the bay itself..."
***qz.com*, July 12, 2013** 1887

The Price of Progress

1888

"…What exactly is there to do about it? Li Sangzhong, a maritime geology professor at Ocean University of China, told Caixin that the solution was simply to reinforce the strength of the tunnels walls so that it could 'withstand at least a magnitude eight earthquake.' Fortifying a huge underwater tunnel against the kinds of earthquakes that fell whole skylines will be pricey. The provincial governments of Shandong and Liaoning are reportedly kicking in a combined $16.3 billion. But the price is already beyond what they can afford. Worse, these tunnels almost always go over-budget - the Chunnel, Seikan and the Big Dig are just a few examples…"
***qz.com*, July 12, 2013**

1889



1890

"…The tunnel's enormous price tag makes the timing a little awkward. Vexed by mushrooming sums of local government debt, the central government has been making noise about reining in stimulus spending. But the Bohai Tunnel isn't necessarily a wasteful vanity project of a local government official (though it certainly could be). Despite the desperate need to hit GDP targets, local officials - particularly those of struggling provinces like Liaoning - have increasingly limited options for developing their economies. Linking up China's isolated rust belt to the rest of the country's trade and logistics channels could flush wealth beyond China's affluent eastern coast. But the unfortunate thing about boring a long, gigantic hole under a bay and through two fault zones is that there aren't really any precedents to go by."
***qz.com*, July 12, 2013**

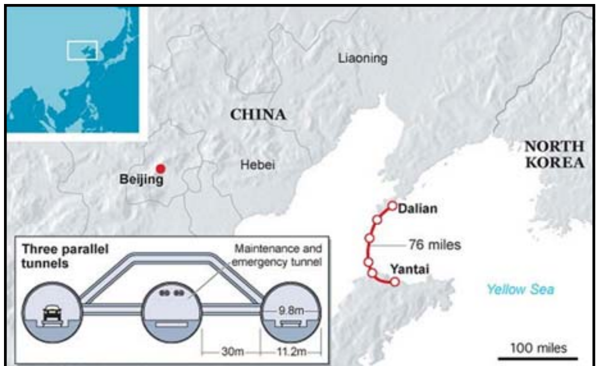
1891

A Vital Link

1892

"At more than twice the length of the Channel Tunnel, China's latest mega project is not short of ambition. A 76-mile-long tunnel will run between the northern city of Dalian with Yantai, on the east coast. 'Work could begin as early as 2015 or 2016,' said Wang Mengshu, an expert at the Chinese academy of Engineering, to the China Daily. He added that the new tunnel will knock 800 miles off the current route between the two cities. It will also form a vital link in a high-speed rail line from China's frozen north to the tropical island of Hainan, in the south…"
***independent.ie*, February 15, 2014**
RE: estimated to cost 200 billion yuan (US$32 billion), in August 2014, it was reported that work on the *Dalian-Yantai Tunnel* project (a/k/a "Bohai Strait Tunnel") was likely to commence during the 13th Five-year plan and construction would take ten years to complete

1893



Above: caption: "China is planning another engineering marvel: a tunnel more than twice the length of the Channel Tunnel underneath Bohai Bay"

1894

"…China has a history of epic engineering projects stretching back to the Great Wall. More recently it has built the world's largest high-speed railway network, longest bridges, and several of its tallest skyscrapers. Even so, the new £22 billion sea tunnel will present several challenges. Engineers will attempt to bore three tunnels - one for cars, one for trains and one for maintenance - through the hard rock, 100 ft. below the sea bed. Vertical shafts will be dug on islands along the route to provide ventilation.…"
***independent.ie*, February 15, 2014**

1895

"…But the area is prone to earthquakes and the tunnel will traverse two major fault lines. In 1976, a 7.5 magnitude earthquake in the nearby city of Tangshan killed hundreds of thousands. Experts warned that excavation work through an active fault needs special attention…"
***independent.ie*, February 15, 2014**
Left: caption: "Remains of the Tangshan Hotel after the 1976 earthquake"

1896

Setting a Prescedent

1897

"…'The government is being cautious about the project,' said a leading researcher on the tunnel at East Shandong University, who asked not to be named. We proposed this idea of a tunnel 20 years ago and many research teams have been looking at it since. We set up a special group to study the Channel Tunnel. In fact, every undersea tunnel engineer in the world has learned from the Channel Tunnel because it is the best example in the world. We learned some construction techniques and also some ways of financing our tunnel'…"
independent.ie, **February 15, 2014**

1898

"…The Channel Tunnel, dug between 1987 and 1991 showed that bores could excavate undersea at high pressure. But technology has improved to such an extent that much more ambitious projects are possible.

Longest transport tunnels in the world *

1. Gotthard Base Tunnel, Switzerland – land railway tunnel beneath Alps connecting Uri and Ticino, opens 2016 – 35.5 miles

2. Seikan Tunnel, Japan – undersea railway tunnel connecting islands of Honshu and Hokkaido, opened 1988 – 33.5 miles

3. Channel Tunnel, UK/France – undersea railway tunnel connecting Folkestone and Coquelles, opened 1994 – 31.4 miles

4. Lötschberg Base Tunnel, Switzerland – land railway tunnel beneath Alps connecting Berne and Valais, opened 2007 – 21.5 miles

5. New Guanjiao Tunnel, China – land railway tunnel beneath Guanjiao Mountains connecting Xining and Golmud, opens 2014 – 20.3 miles."
*** excludes urban metro tunnels**
independent.ie, **February 15, 2014**

1899

1900