

navigation by altering the natural form of the bar. The first attempt at introducing steam navigation on the river ended disastrously. The Alma, a small paddle boat, after running a short time, took the ground on the bar on the 6th January, 1856. The attempts to raise her ended in breaking her back, and her bones rest in the quicksand at the present moment. Some little time after this the course of the river was staked out by the Government, and leading marks put at the entrance. In the early part of 1853 the steamer *Planet* commenced to run round to the river, and from that time the number of coasting steamers has steadily increased. The sailing craft employed on the river were in the first instance confined to vessels of 15 or 20 tons, but in later years vessels of nearly 100 tons register have entered the river and discharged cargo alongside some of the various wharves which have sprung up on the Heathcote.

From the earliest period it seems to have been considered by the Government of the Province and the public that the combined traffic facilities afforded by the road and the river were insufficient, and that the construction of a more available and efficient means of communication between the Port and Plains was merely a question of time and money. The public mind was impressed with the idea that the best means of over-coming the hill difficulty was by tunnelling through it, and connecting the capital city with the port by railway. Accordingly we find that a second Commission was appointed by Government in November, 1858, to consider the subject, consisting of Messrs. Bray, Cass, Harman, Whitcombe, Wyld, Dobson, and Ollivier. A short time before this Mr. Dobson had reported to the Government that the tunnel would pass entirely through volcanic rock, and that the term of construction would be from five to seven years. The Commissioners in their report considered two leading schemes. One, that now executed, advocated by Mr. Bray, the other *via* Sumner to Gollan's bay, proposed by Mr. Dobson on account of the greater depth of water at that place as compared with Lyttelton. At the same time a Commission was appointed in London, consisting of Messrs. Cummins, Selge, and FitzGerald, with instructions to refer the question of route between Lyttelton and Christchurch to Mr. R. Stephenson. The latter referred it in question to Mr. G. R. Stephenson, who decided, on the 10th August, 1859, in favour of the present direct route. Previously to this decision, Mr. FitzGerald, while in England, had urged very strongly upon the Government the propriety of carrying a line of railway with sharp curves and steep gradients along the Sumner road. This proposal was entirely negatived by the Commission as well as by Mr. G. R. Stephenson.

Shortly after this, the English Commissioners entered into a contract with Messrs. Smith and Knight, of London, to execute the works for the sum of £235,000 (exclusive of stations), the work to be completed in five years. The contract was subject to determination either by the Government or the contractors at any time within four months after the arrival of the contractors in Canterbury, if either the Government should be unable to provide the money, or the contractors should find on examination that the work could not be done for the money. In either case the Government had to pay the cost of making trial shafts to the extent of £3000, and to relieve the contractors from their engagements with the workmen sent out by them.

Messrs. M'Candlish and Baines, agents for Smith and Knight, arrived in Canterbury, Dec. 24, 1859, and proceeded at once to sink the shafts. In consequence of the first Railway Bill passed by the Council having been disallowed by the Governor on the 26th January, 1860, the Provincial Government was not able to give an answer to the contractors on the 24th April following, as to whether the money could be obtained for the line, and it was therefore agreed between the contracting parties that an extension of time should be allowed, the Government agreeing to pay the cost of carrying on the works. In November the Government having obtained the necessary powers for constructing the line and raising the requisite funds, signified to the contractors their readiness to proceed, but Messrs. Smith and Knight, through their agents, declined to ratify the contract, and Messrs. M'Candlish and Baines shortly after left New Zealand.

Mr. Dobson then proposed to open out the ends of the tunnel with the labour available in the colony, and to advertise for tenders for the remainder of the work. But the Council declined to accept the proposal, and a long delay occurred, during which the trial headings were slowly carried on by the working party sent out by Messrs. Smith and Knight.

In May, 1861, the Government accepted a tender from Messrs. George Holmes and Co., of Melbourne, to complete the line from Lyttelton to Christchurch, a distance of six miles, with the exception of the stations, in five years, ending June 1, 1866, for £240,500, the cost of the tunnel, 2838 yards long, being fixed at £195,000. The first sod was cut in the Heathcote Valley, on the 17th July, 1861, and this may be said to have been the date of the commencement of the tunnel works, as up to this time nothing had been accomplished beyond sinking the trial shafts, and driving 96 yards of heading, viz., 30 at the south, and 66 at the north end of the tunnel.

The plan adopted by the contractors was to mine the whole work from a wide bottom heading. To expedite the work three additional shafts were sunk, one close to each front, and one in the clay cutting at the north end of the tunnel, whilst at the same time a gullet was driven up the cutting to meet the heading. Although the ground proved very wet in places, rendering it necessary to close pole a length of seven chains through clay and sand, this plan was perfectly successful, and the timbering remained in good order until the commencement of the brick lining, at the end of the following year.

On the 29th September, 1862, Mrs. Moorhouse laid the first stone at the north end of the tunnel, that of the south being laid by Mr. John Hall, in April, 1864.

The works were at first carried on under great disadvantages. The Otago gold fever broke out soon after the commencement, and a great number of the men employed left for the new goldfield. The profitable nature of the trade between Melbourne and Dunedin made it for a time difficult to induce ship-owners to take freight to Canterbury from Melbourne, whence all the plant and material for the work had to be procured, whilst the wreck of one of the mail steamers deranged the postal communications, and lastly, the amount of water met with at the Lyttelton end of the tunnel was so great that the inner heading had to be abandoned until the completion of the drive from the beach gave a natural drainage for the work.

The ventilation, which many people once thought would prove a great difficulty, has been most admirably arranged. In the first instance, air was driven in by fans worked by horse-power, but this soon proved quite insufficient, and when the works had extended some distance much time was lost owing to the difficulty of getting rid of the smoke. To obviate this on the Lyttelton side, the upper portion of the tunnel was partitioned off by a floor or brattice, about 9 feet above rail level, forming a smoke flue connected with one of the shafts, at the bottom of which was placed a furnace which, by rarifying the air, caused a steady current up the shaft and drew the smoke away from the face of the workings. A similar plan was adopted at the north end, the chimney of a forge being led into the shaft and answering the purpose of a furnace, but the brattice was only continued for a short distance beyond the upcast shaft.

On the Lyttelton side this system answered perfectly well, and the ventilation has continued good ever since; but on the Heathcote side, where the work for the last quarter of a mile has been driven by a top heading (the temporary floor being left above the permanent rail-level for drainage purposes), the ventilation at the close of the work became sluggish, and recourse was had to driving air on to the face by means of four fans driven by an eight horse steam-engine. This proved perfectly successful.

From a comparatively early period more or less difficulty has been experienced from the quantity of water which has poured down from the roof and sides of the tunnel. But the difficulties have invariably been promptly met and overcome by the ingenuity of the engineer and contractors. At the Heathcote end inconvenience was caused solely by the difficulty of getting rid of the accumulation of water. On this side there were no springs rising from the floor, as at the Lyttelton end, and what fell from the roof was in the first instance easily pumped out. Afterwards, as the level of the workings was raised, it was found necessary to adopt other means for keeping them from being flooded. A syphon was employed for this purpose, which discharged the water into the railway ditches in the Heathcote valley, at a distance of more than six hundred yards. This simple contrivance drew the water from a pump or well, to which the drainage from the inner workings was carried by a deep gutter. From the time the syphon was first introduced, it has worked successfully, and discharged without cost or labour many millions of gallons of water.

On the Port side no difficulty was experienced in getting rid of the water after the drives had once been opened out, as the drainage simply ran along the floor into the sea. The real difficulty here lay in protecting the men from the constant downpour, which at times extinguished the lights and rendered it almost impossible to continue the work. So wet was the ground for a long period that it became necessary to use waterproof cartridges, and even then misfires were continually occurring. For a long time the work was carried on under an iron shield, which was supported on runners on each side of the drive, and in some measure protected the men from the water which fell continually from the roof. After a short time the water ceased to fall, and both roof and sides are now perfectly dry, whilst the springs rising on the floor continue to run freely. This would seem to prove satisfactorily that the springs must be artesian, because soon after they were tapped and diverted, the water which had accumulated above the workings ceased to fall. This view of the matter is further confirmed by the fact that no water has been met with in the shafts at more than forty feet above high water level. It is worthy of remark that the principal spring tapped on the Port side was of the temperature of 70 deg. Fah.

On the Port side a good deal of curiosity was at one time excited by the appearance of large numbers of eels and shoals of whitebait in the drains far up the tunnel. These have, however, disappeared, being unable probably to live in the water when it became fouled with smoke, grease, and other abominations. A fine specimen of the eels has been preserved, and is now in the possession of Dr. Haast. Rats abounded in the work, breeding in the cavities, and picking up an ample living from the workmen's meals, the candles and the horse feed. A number of white rats have long been residents in the tunnel.

Ever since Messrs. Holmes and Co. undertook the contract, the work has proceeded without interruption and without pause, except for the proper observance of Sunday. The public has not, as a matter of course, been allowed to visit the works at their pleasure, otherwise we should not have been able to chronicle such a remarkable freedom from accidents; but Christmas and New Year's Days have always been kept as holidays, and on the latter the tunnel has been illuminated and thrown open to visitors. When the resources and population of Canterbury are considered, and it is remembered that for a period of six years the work of the tunnel has gone on day and night without ceasing, we think that, apart from scientific and engineering considerations, it must be considered a very remarkable work, and command the admiration of the outer world.

In a scientific point of view, and as an example of engineering successfully overcome, the work may fairly claim the attention of the profession. The present tunnel affords, we believe, the first instance where a complete section of an extinct volcano has been opened out. The elaborate drawings prepared by Dr. Haast for exhibition in Paris will draw the attention of geologists to the fact, and doubtless