

The Mont Cenis Tunnel is intended to connect Savoy with Piedmont; and in the district chosen for the future railway, the chain of the Alps extends about due east and west between two nearly parallel valleys. According to the plan which has been adopted, the northern entrance will be below Modane, about 18 miles west of Mont Cenis. On the south side the railway will emerge near the Alpine village of Bardonnèche, at a level considerably higher than the Modane entrance. Beyond the preliminary surveys required to lay out the line, nothing has yet been done towards the construction of the 25 miles of railway over an extremely difficult line of country, required to connect Bardonnèche with Susa; and we cannot consider the decision of deferring for the present the commencement of this portion of the line, as other than prudent, as it permits the concentration of the energies of all connected with the undertaking, on the vastly more important work of the tunnel. The greatest recommendation to the line from Bardonnèche to Modane, lies in the fact that it is much shorter than any other suggested for traversing the Alps between Savoy and Piedmont.

The lowest pass of this chain on the Italian side is about 2,100 metres (a metre is 39.37 in., or a little over 34 feet) above the sea level; and the tunnel will enable the railway trains to cross the mountain at a height of about 1,333.8—i.e., 766.2 metres below the present pass. Its southern opening at Bardonnèche, in the valley of Susa, is 1,335.38 metres above the sea level; from this point it rises 0.5 per 1,000 metres up to a distance of 6,100 metres—that is, to about the middle of the gallery, when it again slopes down at a declivity of 22.2 per 1,000 to its northern opening near Modane in Maurienne, which lies at a height of 1,202.82 metres above the sea: so that the actual difference of level between the two extremities is about 320 ft.; the Italian end being so much the highest. The steepest gradient within the tunnel equals about 1 in 45, rising to the middle from the French side, descending then towards the Italian extremity, at the rate of 1 in 2000. One-half the tunnel thus having a stiff gradient, while the remainder is, practically speaking, a level.

When we consider that the total distance to be excavated through hard rock is about 7½ miles, at such a depth that the sinking of shafts is impossible, the magnitude of the difficulties to be surmounted may be realized. Under the first idea, that manual labour alone, employed at each end was available; the termination of the work could not be calculated on under twenty-five years; hence its promoters, reflecting on the vast annual outlay, necessarily extending over that period; so brought their influence to bear on the French Government, that they succeeded in procuring a convention—not, however, until last year—with France, by the virtue of which the latter State undertook to pay the sum necessary for the construction of 6,110 metres of the tunnel—half its length—at the rate of 3,000f. per metre, or 3,000,000f. per kilometre, on condition that this compensation should not, taken altogether, exceed 19,000,000f.; reckoning the work upon the understanding that it should be executed by ordinary means, and allowing a period of twenty-five years, as necessary for its completion; but they stipulated that, in the event of the tunnel being accomplished in less than twenty-five years beginning with the

1st of January, 1862, the capital of 19,000,000f. would be increased at the rate of 500,000f. for every entire year that might be deducted from the maximum of twenty-five years. If the works were to last less than fifteen years, the premium would be raised to 600,000f. for every entire year's reduction; so that, if the work were actually achieved in twelve and a-half years, the Italians would gain a premium of more than 16,000,000f. Moreover, as the French Government does not reimburse the Italians immediately, but pays the interest of the sums due, and these interests may be reckoned at 6,500,000f. France will, at the end of the work, be indebted to Italy to the amount of about 31,700,000f.

The tunnel was begun in 1857, with ordinary means. But that year and the two following were spent chiefly in preliminary operations, such as the construction of houses, workshops, &c.; and up to the end of the year 1860 not much over 800 yards had been executed. The extremely slow progress of the works, by mere manual labour, stimulated the ingenuity of the engineers employed in their execution, MM. Grandis, Grattoui, and Sommeillier, who had already tried a boring machine designed by an English engineer, Mr. Bartlett, without success. Mr. Bartlett's contrivance was wrought by steam, and could not be applied to a tunnel where air could not be had for combustion. The Italian engineers proposed to substitute compressed air instead of steam; and, notwithstanding long opposition on the part of foreign scientific men, their method is now in full operation, and exceeds in success the most sanguine expectations. At the Bardonnèche end of the tunnel these gentlemen have availed themselves of a fall of water about 86 ft. high to force air to a pressure of about 90 lbs. on the square inch, within wrought-iron cylindrical egg-ended receivers.

The machinery employed for this purpose is extremely simple, the principle involved being very similar to that of the hydraulic ram. The compressed air, is conveyed from the receivers by a cast-iron main, about a foot in diameter, to the face of the working, where it puts the boring apparatus in action. This machine, nearly 8 ft. high and 10 ft. wide, occupies the drift-way, or heading, which precedes the finished tunnel, enlarged from the heading by manual labour. Eight or ten jumpers are put in motion by suitable pistons, reciprocating within cylinders, which admit of such a motion from time to time as will expose every portion of the rock face to the action of the jumpers. Varying with the hardness of the rock, the average time required by the machine for boring a hole 32 in. deep is rather less than an hour. As soon as about 80 holes have been bored into the rock the machine is disconnected from the main tube conveying the compressed air, and is then withdrawn on rails to a distance of 80 or 100 yards, behind massive wooden folding doors, designed to protect the machine and the workmen from the effects of the explosion. Miners then enter the gallery and charge the holes with powder, light the fuses, and then retire behind the doors, which are closed. After the explosion, another gang of workmen enter the gallery, and set to work to remove the rubbish in waggons running upon narrow rails laid beside the main track; and in about six hours the way is clear for the return