TRANSPORTATION OF MATERIALS BY ELECTRICITY.

BY A. FREDERICK COLLINS.

The displacement of trucking with teams over long, circuitous routes by automatic electric equipments is one of the methods where the manufacturer is enabled to effect large savings, for with a modern telpherage system one man now does alone what many men and horses have hitherto accomplished.

The earlier telpherage systems comprised a number of buckets or carriers suspended from electric cables, and these were conveyed from one point to another by means of electric motors that received the energy to operate them directly from the supporting conductors. Usually two lines were provided, an up line and a down line, but they were self-acting only to the extent of traversing the circuit.

These systems were usually designed for the carrying of ashes, coal, and earth; but, crude as these devices were, it was evident that with improvements they could be made a hundredfold more useful and that by additional appliances to lift and lower the carriages they could be adapted to the transportation of all kinds of raw and finished materials.

In a recent equipment installed at the works of the Baker Chocolate Company at Milton, Mass., the modern telpherage system has taken on the form of a miniature elevated electric railway, and now, instead of a suspended cable carrying buckets, we find a structure substantially built, and on this overhanging telpher trains are run.

The purpose of this extensive yet simply operated telpherage plant is to convey the cocoa beans and all other material used in the output of the company from the railroad storehouse to the new mill. Formerly all this raw stock was carted by a number of teams around the works by a tortuous route for a long distance, necessitated by the nature of the country; it then had to be transferred manually to elevators, whence it was carried to the third floor of the mill.

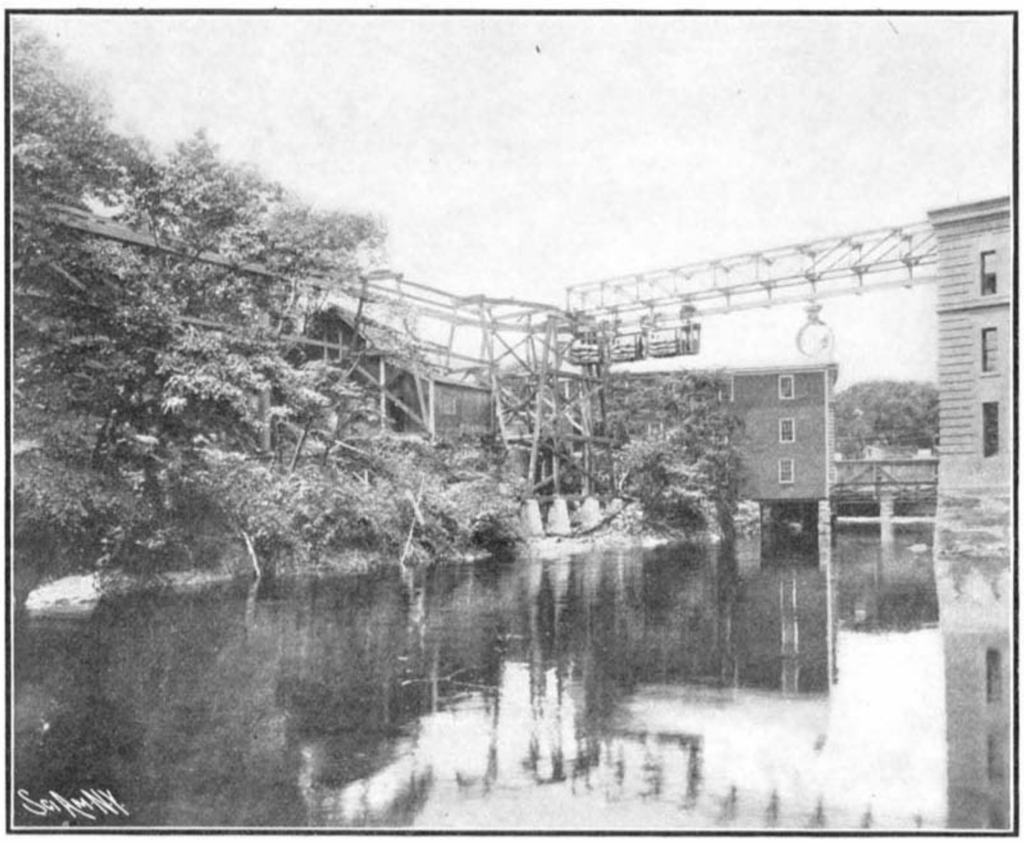
This primitive process not only required time and labor, but, what is more to the point, as seen with a manufacturer's eye, it was exceedingly expensive. Hence the telpherage system under consideration was designed and installed to take the load directly from the top floor of the railroad storehouse and convey it by the shortest possible route to the third floor of the mill, where the manufacture of cocoa and chocolate is commenced, and thus the cost of transportation of the raw stock is reduced to a minimum.

The route presents a most difficult example of telpherage engineering, as the accompanying photographs will indicate. As an instance, one section of the line was built upon the side of a precipitous cliff half-way down, and in some places the track is fifty feet above ground; but finally the road was completed, the distance between the objective points was reduced to the last limits, and as far as time and space entered into the proposition, they were all but annihilated.

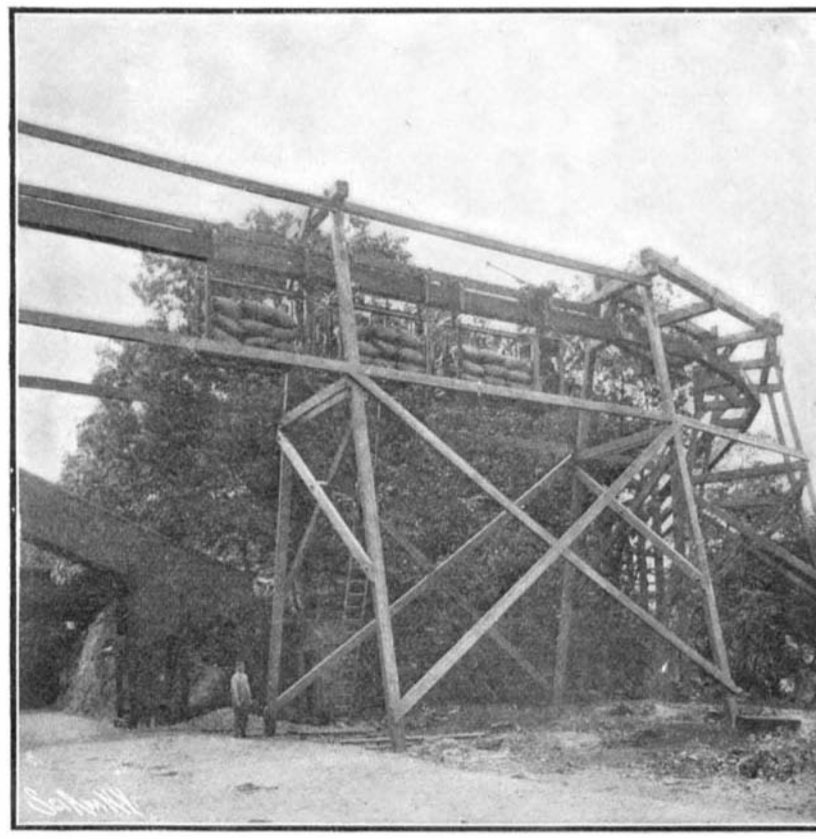
The only piece of level ground that the track follows is for sixty feet beyond the railroad warehouse; it then turns a ninety-degree curve of 40 foot radius and passes along the side of a rocky, precipitous cliff at the base of which is a swift-running river. Another ninety-degree curve of 20 foot radius is then made after passing over the roof of a building, on the rocky ledge of the river bank, and thence the track is carried across the river, on a splendid steel bridge, erected under the most difficult conditions, into the third floor of the new mill.

On the level this portion of the track is supported by A bents 35 feet above the ground, resting on concrete foundations. Along the cliffs the supports consist of huge vertical posts of Georgia pine, 14 inches square, varying in length from 30 to 40 feet. The foundations of these posts are cut out of the slanting side of the solid rock, and they are braced by heavy timbers in the shape of a figure 4, these also being anchored back in the solid rock. When one considers the extreme length and weight of these poles, each of which weighs over a ton and a half, the difficulty of carrying them along the side of the precipice and standing them up on end will be in a measure appreciated.

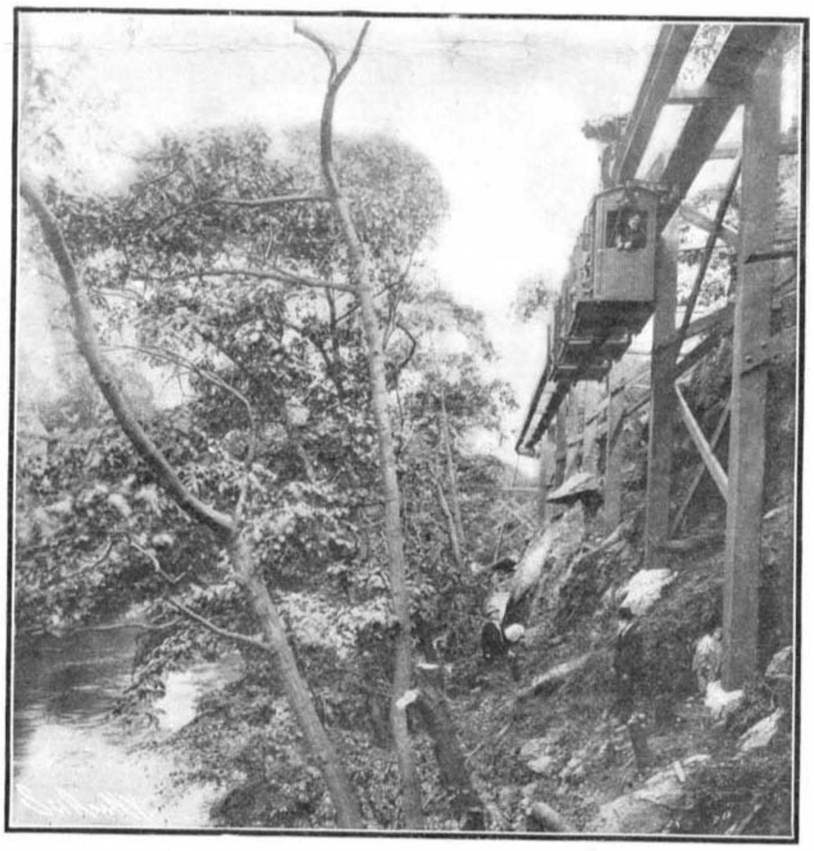
Another feature was the spanning of a building and elevating the track nearly 15 feet over its roof without molesting the building in any way. On the slanting rock of the river bank the foundation piers which support one end of the steel bridge were built up, using many tons of concrete. The top of this tower is 55 feet above the water, and the distance between the



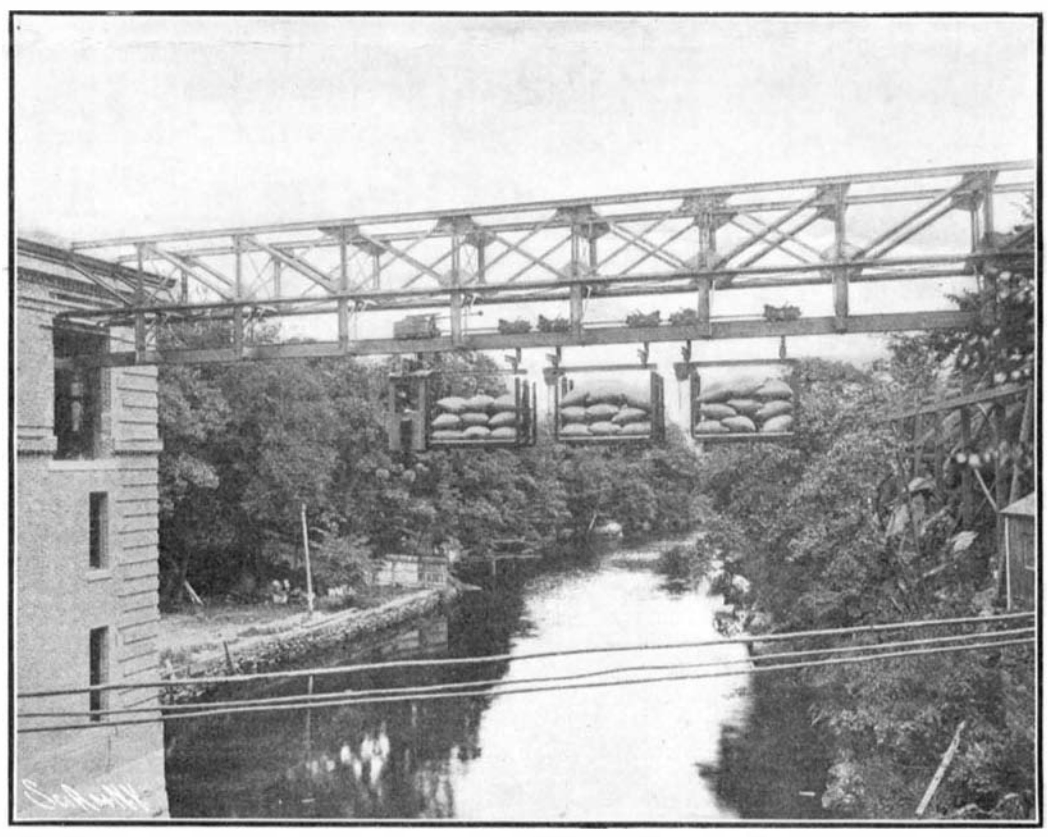
The Concrete Foundations for the Supports of the Steel Bridge Which Spans the River. Telpher with Full Load about to Pass around the Curve.



From the Storehouse, the Telpher Train Crosses the Road, Rounds the Curve, Travels along the Bank of the River, then Crosses the River upon a Steel Bridge and Enters the Mill.

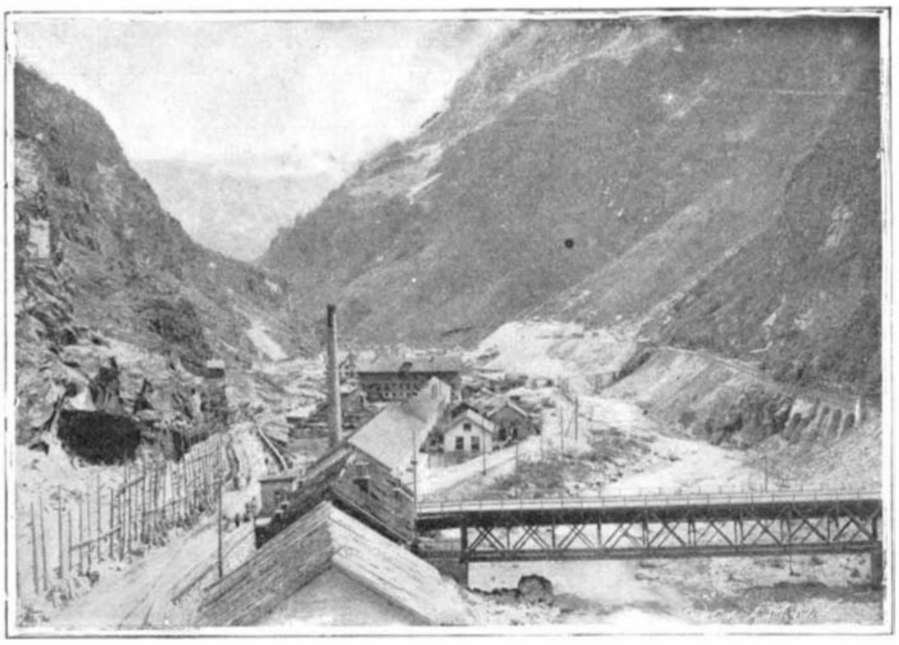


The Line was Built on the Side of a Cliff, in Some Places 50 Feet Above the Ground. The Upright Posts are Supported in Concrete Footings.

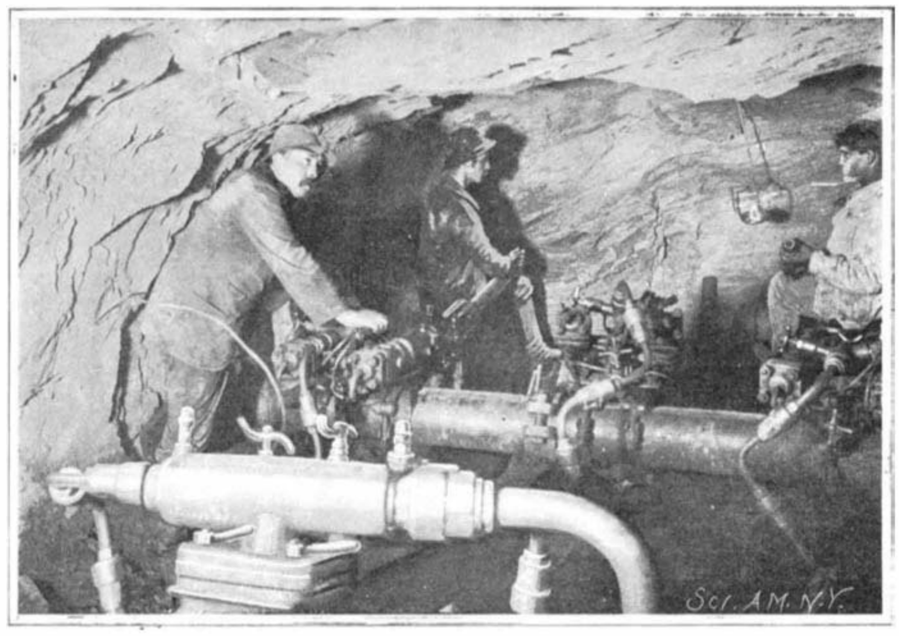


Details of Bridge and Telpherage Machinery. The Capacity is One Ton per Minute in Either Direction or Two Tons per Minute if the Loads are Carried in Both Directions.

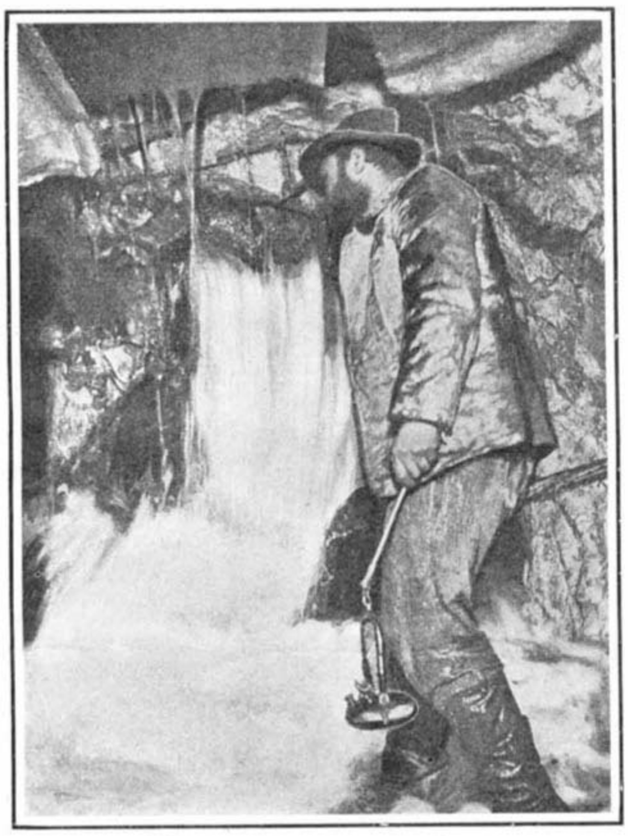
TRANSPORTATION OF MATERIALS BY ELECTRICITY.



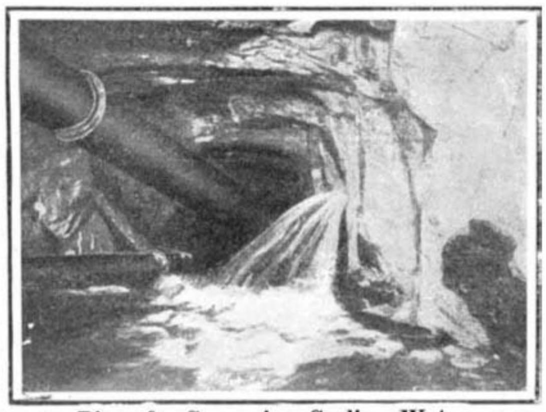
Upper Power House. Iron Bridge Across the Diveria for the Flume. To the Left, a Small Tunnel Leading to the Main Tunnel.



Three Brandt Hydraulic Rock Drills, with Which all the Rock-Drilling Was Done.

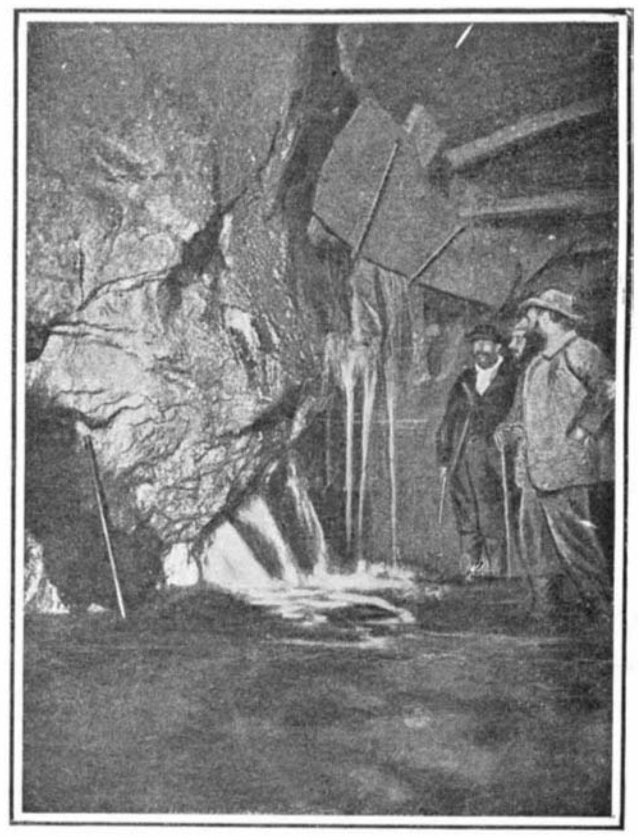


A Large Spring of Hot Water in Side Wall.



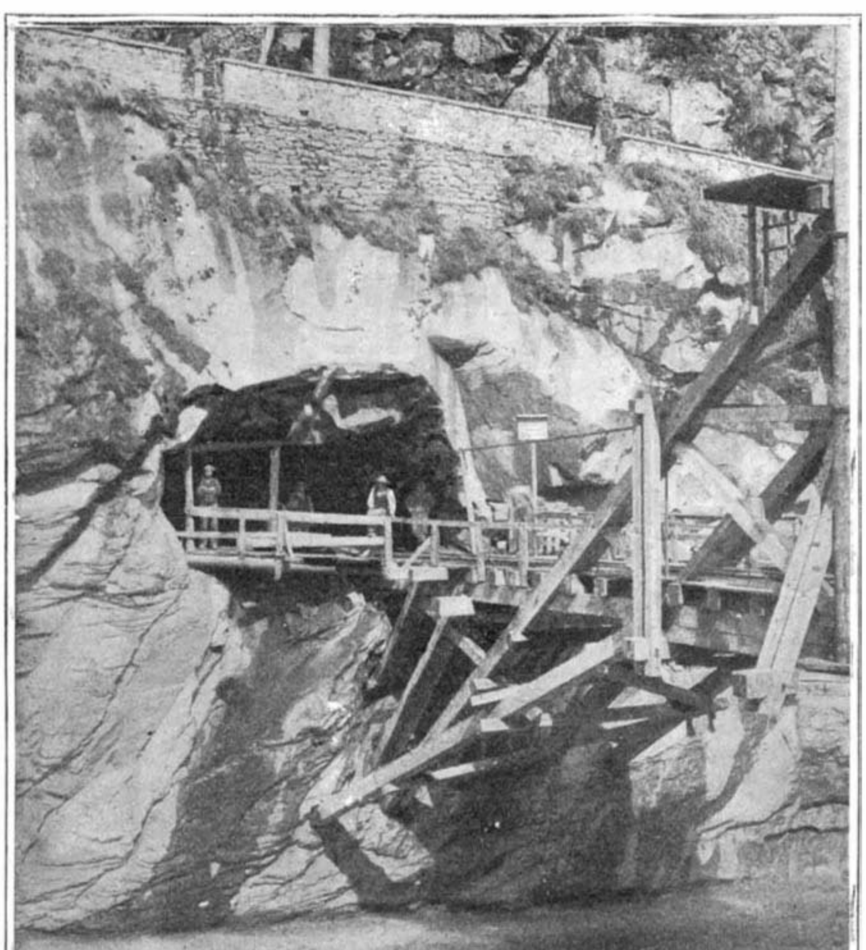
Pipes for Conveying Cooling Water.

Springs Gushing from Tunnel Walls.

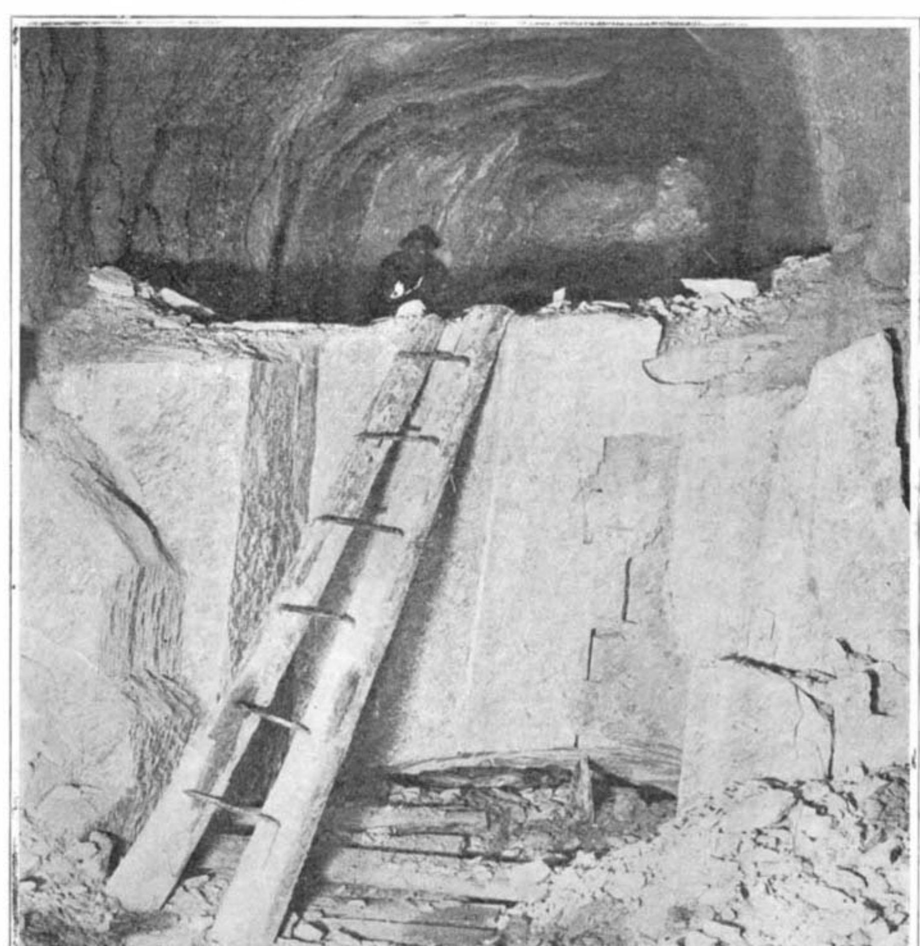


A Spring in Roof Partially Stopped by Boards.

Difficulties from Flooding Met With in Boring the Simplon Tunnel.



Entrance to a Gallery on the South Side, Showing Bridge Across the Diveria.



Cut in the First Tunnel, 4,500 Yards from the Entrance.

THE COMPLETION OF THE SIMPLON TUNNEL.

tower and the wall of the mill, which rises directly up from the water, is 80 feet. This distance is spanned by a heavy steel bridge carrying the track beneath it. The elevation of the track effectually prevents it from being blocked by snow in winter, a serious impediment always to teams or any surface transportation.

The bags of cocoa, each weighing about 300 pounds, are loaded on trucks in the railroad storehouse; each truck has a capacity of 2,000 pounds, and when these are loaded they are pushed underneath the rail and hooks are attached. The operator raises the trucks several inches clear of the floor, then starts the telpher with its load of three trucks of 2,000 pounds each, and in three-quarters of a minute the train has passed by the precipitous cliff, on across the river, and has landed the load of three tons of cocoa beans on the third floor of the mill. The trucks are now unhooked from the machine and pushed out of the way and three empty ones are hooked on in their stead in less than one minute's time and the operator is on his way back to the storehouse, where three more loaded trucks are awaiting him; in this way no time is lost and the entire trip has not taken three minutes.

The telpher, or electric locomotive in this case, runs on top of a single overhead rail and is controlled by an operator seated in an inclosed cab, which is suspended from the telpher directly beneath the truck, the combination really forming a little monorail system. The operator has his controller, which is exactly like an ordinary trolley car controller, at one hand, and at the other hand is a powerful brake-wheel which applies the brakes simultaneously to the telpher as well as to all of the trailers which carry the trucks suspended beneath them, so that the whole train can be stopped within its own length.

The current is supplied to the telpher through trolley wires, being taken off by a trolley pole. The total length of the train is 30 feet and the average speed is at the rate of about 700 feet per minute. The weight of the machine is 4,600 pounds, and with the three loaded trucks the total moving load on the structure is 12,000 pounds suspended from the overhead rail.

This is the system that is eliminating the work of man and beast, and which resolves the carrying of materials, however fragile, however costly, over long and tedious routes, and one telpherman at two dollars per day does the work better than five men and twice as many horses in the old way. The cost of the power consumed by the telpher in running back and forth for ten hours does not amount to more than one dollar for the day's work.

Although this is only one of the many plants designed by the Telpherage Company (there are nearly seventy-five in the Eastern States alone), it is typical of the high degree of efficiency that has been reached in this branch of electrically-operated mechanism.

THE COMPLETION OF THE SIMPLON TUNNEL.

BY CHARLES R. KING.

The boring of the Simplon tunnel has at last been completed, the thin diaphragm of rock that separated the two headings having been finally burst through on February 24, 1905. The success of an enterprise of such magnitude marks this as the greatest event in civil engineering for several years past, during which time the work has been progressing quietly with persevering energy and patience, while the outside world has in the meantime changed with greater ease in its geographical and political bearings, suppressed nations and peoples, and sacrificed millions of lives at the altars of conquest and lawful depredations, as in the remotest ages of barbarism. But the boring of a simple tunnel could not, even with all the wealth of a dozen empires, and all their terrific armaments of blasting machinery, be accomplished faster even to please the rulers of peoples. However, the triumph here is quite different, and will endure hundreds of years, or time sufficient for empires and peoples to change national proprietorship several times over.

It is already known that the Simplon tunnel is 19.729 kilometers, or 12¼ miles, in length, constructed with twin passages, each 16½ feet wide, and separated by a distance of 55.7 feet between their axes; that the tunnel is straight throughout except for a short curve at each of its ends, in order to join its tracks with the outside railroad lines, which have both to follow along narrow valleys or gorges (the Rhone valley in Switzerland and the Val Vedro in Italy) and with the alinements of which the tunnel forms an obtuse angle. The grade of the tunnel is, as is known, 2 per 1,000 from the Swiss portal and 7 per 1,000 from the Italian portal. The summit of the line, 704.3 meters (2,310 feet) altitude, is reached at 9.572 kilometers (5.944 miles) from Brig and is situated in the subsoil of Italy.

The tunnel will bring not only Geneva and southwestern, or French, Switzerland into closer communication with Milan and the Adriatic railways of Italy, but it will shorten the distance from Calais to Milan 80 and 95 miles respectively over the other routes now passing through the Gotthard and Mont Cenis tunnels.

The new Simplon route will eventually not only be a still shorter way to the Adriatic coast from north Switzerland (Basel) and from France (Paris) by means of other connecting lines yet to be constructed, but, most important of all, it will be an express route, practically level, which means fast trains and cheap freights as compared with the expensive operations of traffic over the Gotthard inclines. Had it not been for this, the tunnel might have been driven at a much higher altitude and at an enormous saving in the cost of the work. The Swiss end of the tunnel has an altitude of 2,250 feet, and the Italian end 2,076 feet, while the tunnel summit is 2,310 feet.

The practice of boring mountains at as low a level as possible is likely to become general in the near future. Already plans have been made for piercing the Ligurian Apennines, north of Genova (Italy) with a tunnel about 13 miles long, lying at a comparatively short distance below the surface, merely for the purpose of reducing existing surface gradients and thus facilitating traffic between this port and Milan, the industrial capital of Italy. The Wildstrübel in the Bernese Alps is, according to present plans, to be bored in order to connect the great international railroad center of Basel with the Simplon tunnel, and so effect a great saving of distance as compared with the detour now made by the present Simplon line *via* Lausanne and Lake Geneva.

In driving the Simplon tunnel, one of the great difficulties encountered was the influxes of hot water that occurred; first, on the Swiss side, and, later, on the Italian side. The spring cut into at the southern end of the workings could never have been dealt with from the northern side.

This spring was the most formidable one encountered, and yielded 80 liters (20 gallons) of water per second at a temperature of 46 deg. C. (114.8 deg. F.). It is located at the southernmost fringe of that great tract of subterranean water courses which had so much retarded, during the previous two years, the progress in the northern, or Swiss workings, its exact position being at 9.14 kilometers from the southern portal at Iselle (Italy). This irruption occurred on September 6. Previous to this event, the boring in No. 1 main tunnel was calculated to be finished on October 16, 1904—had it been possible to maintain the previously-existing average of 6 meters per day. Instead, however, all work throughout the various constructional sections in the main tunnel had to be suspended. To combat this inflow, the first step was to enlarge the spring's orifice in the tunnel, in order to reduce the velocity of its inrush, and then cover up the opening with thick lagging boards to keep the water out of the heading, these boards serving besides as non-conductors of heat. The flow was subsequently led off through a special drainage transverse passage between the two tunnels, the work of boring which was rushed through, in order to enable the hot water to be promptly diverted into the main drain in the No. 2 secondary tunnel. This passage, about 125 feet to the rear of the hot spring, is the forty-fifth from Iselle (at 9.1 kilometers). The irruption of this hot-water spring increased the general air temperature in tunnel No. 1 to an average of 35 deg. C. (95 deg. F.) from an average temperature previously existing of only 27.8 deg. C. (82.04 deg. F.).

The ventilating air where delivered at the heading face previous to the inflow of this hot water was only 20.5 deg. C. (68.9 deg. F.), but afterward the temperature rose to 40 and 45 deg. C. (104 and 113 deg. F.) near the springs, though it was reduced to about 28 deg. C. (83.48 deg. F.) by means of batteries of cooling sprays, the water of which had a temperature of 16 deg. C. (60.8 deg. F.). This cooling water was pumped by a centrifugal pump run by hydraulic turbines and by a 100-horse-power steam engine located in the tunnel, the pumps taking their supply from a large spring of cold water, which has been canalized in the tunnel about three miles farther back, where it occurs in cross passage No. 21A at 4.4 kilometers.

The spring mentioned has a temperature of 12 deg. C. (53.6 deg. F.) and a natural pressure at the rock outlet of 80 pounds per square inch. It is tapped by a 253-millimeter (9.96-inch) pipe surrounded with a jacketing of broken charcoal for keeping down its temperature, and this natural head of the water for a long time served all requirements for spraying the atmosphere.

Spraying heads located in each of the rearward transverse passages of tunnel No. 1 were used for cooling the air, and a special plant consisting of long perforated pipes, adjustable to all positions, was used as at the Swiss end, for cooling the rock. In encounters with new hot springs in the northern or Swiss headings, the most efficacious method of preventing the hot water seriously raising the temperature of the air was to project a large volume of cold water right into the aperture from which the hot water issued, thus reducing the heat of the inflowing water from the very first. While this was going on, the aperture was excavated as rapidly as the conditions permitted, in order to reduce the velocity of the inrush, which was often such as to throw the water to a distance of sixty feet, and sometimes cause it to hurl pieces of rock that would occasionally wound a miner. After enlarging the orifice, planks were driven in vertically against the walls, and with other planks lapping their joints, the water was shut in and drained off into a deep channel or well, whence it was pumped to the top of the incline into the large channel drain of tunnel No. 2 of the north heading.

At the Swiss, or north, end of the tunnel, both headings were still full of hot water up to the time the headings were burst through. No. 1 main tunnel was filled for a length of 253 meters (835 feet) and No. 2 auxiliary tunnel for a length of 23½ meters (77½ feet), these distances being measured from the iron safety-gates which were finally erected across the tunnel in March, 1904, in view of the possible encounter with further hot-water springs than those which had been met in the autumn of 1903.

After this time very little advance was made in tunnel No. 2, as it received all the water coming from the two headings; but No. 1, notwithstanding that the atmospheric heat had risen from 23 deg. C. to 31 deg. C. (73.4 deg to 87.8 deg. F.) was still driven on 199 meters (656.7 feet) during the last three months of the work and with an average sectional area of 6.1 square meters (65½ square feet). The progress of boring the main tunnel in the month of May was exceptionally good, varying from 2.20 meters (7.21 feet) to as much as 5 meters (16.4 feet) per day and averaging altogether 3¼ meters (10.66 feet) daily. In the last 200 meters (660 feet) the rocks traversed were exclusively of silicious and micaceous crystalline limestone, of gray and gray-white color, with seams tending uniformly north to west from 15 deg. to 20 deg., the stratifications occurring in regular layers up to the last 90 meters, whence they were tumbled and broken and accompanied by secretions of calcite. Across the strata west to east were fissures which coincided with the great infiltrations of hot water.

Another of these was cut into at advance point 10.376 kilometers. It yielded 35 liters (9¼ gallons) of water per second at a temperature of 44 deg. C. (111.2 deg. F.). At this time (May 18) the hydraulic power for the pumps was found insufficient to deal any longer with all the infiltrations, including also the large quantity of cold water forced into the heading for indispensable cooling purposes. Hence an order was given to shut the flood gates. In order to reduce the pressure, discharge pipes were placed in these doors, through which there was a considerable flow of water. At the north portal this amounted to 146 liters (51¾ gallons) per second.

The chances of success at the southern side of the boring were much greater, for there the whole grade of the tunnel throughout (of 7 per 1,000) rendered drainage pumping unnecessary, and the lesser temperature of the rock, which prevailed up to September 6 last in the Italian headings, enabled the refrigerating water to be brought to the front without the difficulty and need for voluminous non-conducting jackets for the pipe lines, such as were obligatory at the north end of the tunnel for two years past, and, more recently, in the Italian workings.

From this end the work was followed regularly with an average advancement of about five meters per day. Apart from the important springs met at 4.5 kilometers from the Iselle entrance, the springs of water were small and did not seem to form any great obstacle to work. The 6th of September the head of the main southern gallery was 9,110 meters from the southern entrance at Iselle and there were only 244 meters more to be tunneled in order to reach the abandoned north tunnel. At 10 A. M. there appeared in the calcareous schists being traversed a spring supplying 100 liters (26.41 gallons) per second, and whose temperature was 45 deg. C. (113 deg. F.). The temperature of the rock was 42.5 deg. C. (108.5 deg. F.). The work had to be stopped, and a transverse tunnel connecting the two tunnels was then constructed, so as to allow the hot water to flow out through the main tunnel by means of a lateral canal along the walls of this tunnel. The flow of this hot spring was then concentrated at a single point.

In order to diminish the temperature, which stopped the men from working, the tunnel was cooled with jets of cold water. After the two parallel south tunnels had been connected at this point, a delay of three months sufficed to achieve the work of enlargement. When this was accomplished, the heading was pushed forward with all possible speed, with the result that the juncture of the south and north tunnels was finally accomplished on February 24, and the great volume of water accumulated in the headings of the north tunnels was tapped, and allowed to flow down through the south tunnel into the Diveria River. To accomplish this result has taken six and one-half years and the expenditure of $15,700,000. The best rate of advance of a single heading was 500 to 700 feet per month in dense granite rock. A more detailed illustrated description of how the tunnels were bored, and how the many difficulties met were overcome, will be published shortly in the SUPPLEMENT.