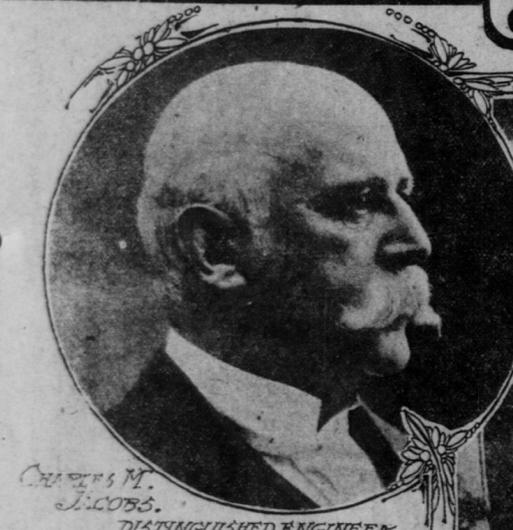
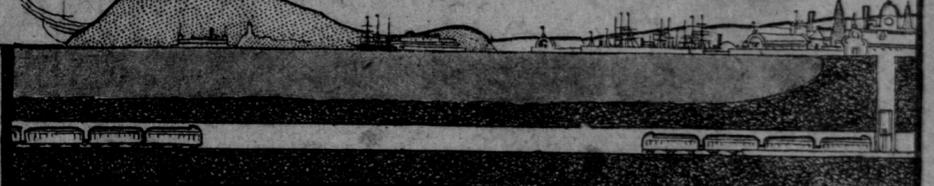
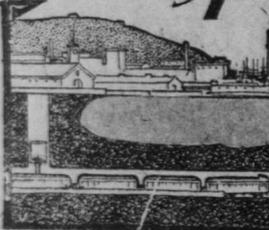


Completing the Tunnels Under the Hudson

SUCCESS OF THE LATEST SUB-AQUEOUS PROJECT IS FURTHER EVIDENCE OF THE FEASIBILITY OF A RAILROAD UNDER SAN FRANCISCO BAY



CHARLES M. JACOBS. DISTINGUISHED ENGINEER WHO BUILT THE TUNNEL.

THIS is the day of running railroads where men please. The gigantic plan of President Cassatt of the Pennsylvania Railroad to enter New York under the Hudson River seems assured of success, for his tunnels from opposite shores have met beneath the stream and the subway now connects two States. The success of this undertaking has given added courage to the promoters of the project to connect the Old World with the New by a tunnel under Bering Straits.

It makes more practical than ever the scheme for an under-the-bay tunnel connecting San Francisco with the mainland at Oakland. With more Eastern railroads planning to cross the California line, the competition to cover the distance between San Francisco and Chicago in briefer time grows keener still. It is beyond doubt that in time—maybe not such a long time—transcontinental railroads will complete their runs in the heart of San Francisco instead of at the Oakland mole. Indeed the trans-bay local traffic has become so enormous as almost by itself to justify a tunnel under the water.

With the matter of subaqueous tunnels bearing so closely upon our own future, the details of the new tunnels under the Hudson into New York will be found of more than passing interest.

AFTER two years and a half of continuous work the eastbound and westbound shields in one of the twenty-three-foot twin tubes, which the Pennsylvania Railroad has been driving under the Hudson River to connect New York and New Jersey, have met. Now men may walk through dry-shod, from one State to the other. The second tube, a few feet to

the south, is expected to join about October 7. The meeting of the shields marks the beginning of the completion of one of the most astonishing engineering feats on record. It means the realization of the long-time dream of the Pennsylvania Railroad—to land its passengers in the heart of Manhattan Island. Probably no feat of railway strategy in the history of the United States has attracted more attention throughout the world than this one. Its completion will mark a triumph over difficulties of tremendous magnitude, as this will be the longest tunnel ever bored entirely under water.

For many years the Pennsylvania Railroad has brought its passengers to Jersey City and then, they have had to stop. The company looked longingly across the Hudson River, but for decades it seemed impossible that this longing could ever be gratified. Engineers wagged their heads doubtfully when the subject of a tunnel was broached, and financially were overcome at the thought of the expense of building a bridge across the river.

Soon after President Cassatt took office, however, at the head of the Pennsylvania system, he determined that the ambition of the railroad should be realized. In his annual report for the year 1899 he modestly stated to the stockholders:

Ferry Conveniences Bettered.
"In order that your company may perform its duty to the public and secure its share of the growing traffic it will be necessary to continue to improve and extend to your property."

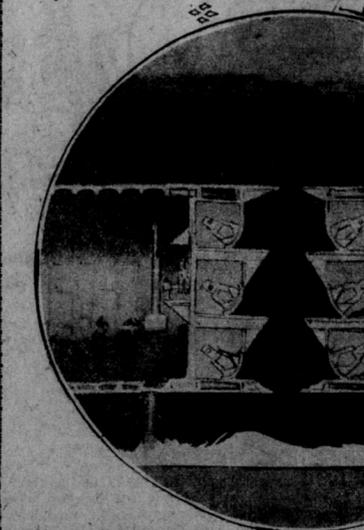
of 190 feet. Its walls of salt rock glitter and flash with exquisitely hued crystals, and there are figures representing "Knowledge," "Labor," "Vulcan" and "Neptune," as well as a special throne of state at one end, of course hewn in the rock of salt and kept for the use of the aged Emperor Franz Joseph or the imperial archdukes.

There is a triumphant archway in salt over the entrance to the great hall, surmounted by a minor saluting, and at his feet is carved in crystals the Polish greeting, "Szczesne Boze!" the equivalent of the German "Gluckauf." Whenever an old working is exhausted and closed or a new one opened in the subterranean city the event is celebrated by a great ball in the Lentow saloon. Then it is that hundreds of Gallician peasant women, wives and friends of the workers below, quaintly clad as a complete opera chorus, take their partners in the vast rough-hewn salt cavern, while shrill pipes and quaint-sounding flutes and sweet violins make merry music as the couples whirl in wild Slavonic dance.

Another vast chamber, about 350 feet from the surface, is the Michalowiec hall, on the second tier of the city. Rock salt was dug out of this for forty-four years. It is about 100 feet long, sixty-five feet wide and 117 feet high. The sides and roof are secured by hundreds of tree trunks placed one above the other as pillars and strutted together. This reminds one of the terrible accidents that have happened in the city of salt. More than once fires have broken out in the workings, and have burned for years, until the wooden props have given out. Or, again, the strange, sullen-looking saline lakes, navigated by boats in these dark depths, may rise suddenly, probably fed by subterranean springs, and drown scores of these patient, hard-working men.

Worst of all, great masses of the rock salt, often weighing hundreds of tons, may fall in avalanches from the domed roofs of the streets or the ceilings of new chambers. One notices the immense saloons, restaurants, churches and other public buildings hewn in salt, are lighted by great chandeliers of salt crystals. There is one in the Michalowiec chamber ten feet in diameter, twenty feet high and containing about 240 candles. The Kaiser Franz chamber, named

ALEXANDER J. CASSATT, PRESIDENT PENNSYLVANIA R.R. CO., WHO ORDERED THE TUNNELS BUILT.



after the present ruler of the dual monarchy, contains two immense pyramids with ornamental bases, commemorating a visit of the Emperor and Empress many years ago. This hall is nearly 200 feet long and about 105 feet high. Leaving this chamber one crosses a wooden bridge over a subterranean river filled with blind fish, and in the dim light of torches one beholds another public monument—an obelisk thirty feet high, carved in rock salt, and recording a visit of the late Crown Prince Rudolph and Princess Stephanie in 1887.

One may but mention in passing the Drozdowice and Archduke Frederick chambers on the way to the Central railroad station, which is named after Count Goluchowski. Here meet all the

IN A WONDERFUL CITY OF SALT

IF THERE is any more surprising monument of human labor than Wieliczka's underground city, hewn in the course of ages in glistening rock salt in the bowels of the earth, one would like to know what it is and where it may be found. An out-of-the-world place this, in the quiet Carpathian valley of the Vistula, some miles off the Cracow-Lemberg Railroad, in Austrian Poland.

For ever since railroads came into the world these peasants refused to permit them near, fearing lest the vibration should cause the upper earth to fall in upon and bury the teeming inhabitants of those strange, crystal, sparkling streets, a thousand feet down in the earth, with their little horse railroads drawn by congenitally blind animals, who may be said never to have been "in the world" at all as we know it.

One thousand years of patient human toil have honeycombed out of the solid salt crust of the earth an entire city at various levels. It consists of an intricate congeries of winding streets and dim, scintillating alleys; of pillared churches, diamond and ruby staircases, restaurants, railroad stations, shrines, statues, monuments and a thousand other wonders—all rough hewn in the hard, sparkling rock crystals, which, lit by electric lights, pine torches, magnesium flashes or thousands of candles, fairly blaze like a world of precious stones.

The salt city is not only difficult of access, but the Austro-Hungarian Government (it is state property) most jealously guards it and all workmen are searched several times a day lest they should be tempted to conceal fragments of rock salt upon their persons. It is not clear why mere salt should be considered so precious, but the fact remains that all workers are searched as jealously as the Kafirs in the diamond mines of Kimberley.

abysses leading to this wondrous city, though many visitors prefer to go down by the long, massive staircase hewn in the solid salt, which flashes emerald and ruby rays at every step.

One naturally asks why an entire city was hewn in the salt, more especially the pillared cathedrals, the altars, statues and the like. And one learns, naturally enough, that all this patient work chiseled out during centuries is in the nature of votive offerings touching prayer services, with weird music, here held in their rock salt churches. Also they have their own band for festive occasions.

The high altar in the salt "cathedral" is cunningly adorned with twisted pillars, and it is flanked by salt-hewn statues of St. Stanislaus and St. Clement. On the altar steps are carved in ruby red rock salt effigies of two kneeling monks, and in the background of the altar is a huge salt crucifix before which stands the Virgin placing the infant Jesus in St. Anthony's arms. This, the most extraordinary church in all the world, contains a salt-hewn pulpit, supported by salt statues of St. Peter and St. Paul, and in a niche below stands a glistening statue of the good King Augustus II.

Emulation must have been the secret of all this gigantic work. It seems that no sooner was the first shrine chiseled in salt, the first statue carved, than succeeding generations of miners, fired with zeal, resolved to see what they also could do in this strange sculpture. Some 300 feet away from the cathedral is a most wonderful rock-hewn salt cavern in this weird city. This is the vast "salle de dansa," the wonderful Lentow ballroom, lit with enormous lustres or chandeliers of wire-hung rock salt crystals of opalescent hues. These last were added in honor of a visit from Russian Czar Alexander I, who visited the city of salt with the Palatine of Hungary. This great ballroom is over 300 feet in length and towers dimly to a height

of 190 feet. Its walls of salt rock glitter and flash with exquisitely hued crystals, and there are figures representing "Knowledge," "Labor," "Vulcan" and "Neptune," as well as a special throne of state at one end, of course hewn in the rock of salt and kept for the use of the aged Emperor Franz Joseph or the imperial archdukes.



THIS IS THE WAY THE TUNNELS LOOK TO-DAY.



WHERE THE TUNNELS BEGIN ON THE JERSEY SIDE.

company secured Charles M. Jacobs, an Englishman, who has probably had to do with the building of more large tunnels than any other living man. He designed iron shields used in the work. The shield is the most important feature of tunneling under water, and it takes an engineer really to appreciate what it means. Four shields have been in use in the Hudson River work, two in each tube, one working from the Jersey side and one from the New York side in each case. The shields are still in perfect condition, and, owing to their peculiarly satisfactory character, this work has been pushed forward with almost unprecedented rapidity.

The chief assistant engineer, James Forgie, a Scotchman, designed the hydraulic sliding platforms with which the shields are equipped. It is on these platforms that the men stand in making the excavation ahead of the tube itself; the platforms slide out as the work advances, and the excavated material is dumped through the shield upon tram cars, which carry it back to the shaft.

Mr. Forgie was the principal assistant to the distinguished tunnel engineer, Greathead, in the construction of the Waterloo and City Railway tunnel under the river Thames in 1894.

The contractors, the O'Rourke Engineering Construction Company, began operations in the subaqueous tunnels on April 18, 1904, the first boring beginning on the Manhattan side. On September 1 operations on the New Jersey side were begun, a deep shaft having been sunk on each side prior to the beginning of the actual boring.

Quietly the work went on, and the public heard of little that was happening. Accidents were remarkably few. There was only one death that could be traced to the effects of compressed air; there were, inevitably, cases of the "bends." Two physicians have been in constant attendance at the work, and everybody who enters one of the tubes has to undergo a rigid examination. Comfortable quarters, well heated and well ventilated, are provided for the workers, and hot coffee is given to them as a stimulant when they emerge from compressed air.

men in the report for the year 1901 Mr. Cassatt stated the determination of the road in the following simple language:

"The Board has long felt that the convenience of the public, require the extension of your line into New York and the establishment of a centrally located passenger station in that city through which the inconvenience and delays of transfer by ferry will be avoided."

The project required capital in unlimited abundance. Above all else, it required extraordinary courage to foresee and to feel sure of the ability of the company to realize from its new improvements sufficient revenue to pay dividends on the largely increased capital. In the report for 1901 Mr. Cassatt stated his views on this subject as follows:

"The cost of the work will be large, but your board is satisfied that the expenditure will be fully justified by the results attained."

To carry through this extremely difficult undertaking, the company designed its third vice president, Mr. Samuel Rea, to take direct charge of the work, to consult with the New York City and State authorities with reference to the rights necessary to the project, and to appoint a commission of five of the most eminent civil engineers in the world to draw up the plans for the work itself. The commission consisted of Colonel Charles W. Raymond, U. S. A., chairman; William H. Brown, chief engineer of the Pennsylvania Railroad Company; Charles M. Jacobs and Alfred Noble. All the work has been done under the direct supervision of Mr. Rea, and through his energy and ability innumerable difficulties of almost every kind have been surmounted. Among the special matters which he had to superintend was the purchase of the necessary real estate—millions of dollars' worth of it. He had also to appear before the Board of Rapid Transit Commissioners in New York City, to obtain the consent of the New York Board of Aldermen, and to superintend the awarding of the enormous contracts for doing the work itself.

The Men Behind the Shields.
To have direct supervision over the work on the Hudson River tunnels the

The tube itself consists of a series of iron rings, and the installation of every ring means a progress of two and a half feet. Eleven plates and a key piece go at the top complete the circumference, and an entire ring weighs about fifteen tons. The cast iron plates, or sections of the ring, have flanges at right angles to the surface, and it is by these that the successive rings are held together with bolts. Hydraulic rams, placed against the flanges every few inches around the tube, push the shield forward at a maximum pressure of 3,000 tons; if the pressure of the air in the tube be taken into account the pressure upon the shield is increased to 4,000 tons.

The shield itself weighs 194 tons. It has nine doors in it, and through these comes the rock, sand, or silt, or whatever the material through which the tube must be driven. Thirty men work in a gang, and there are three shifts in the day of twenty-four hours. The record progress so far is five rings, or twelve and a half feet, in eight hours. Men of all nationalities have built the Pennsylvania tubes under the Hudson, negroes having done a large part of the job. Laziness is something the contractors never had to contend with; they say there must be something about the compressed air which generates energy and enthusiasm, for the "muckers" vie with one another to make the record number of rings.

Perhaps there has never been an engineering project in which theory and practice were so nearly in agreement. The engineers calculated the difficulties closely, and a really remarkable system of reports has been in effect from the first day. Every morning Mr. Jacobs has known the progress made the day before to the very inch and the amount of rock and silt excavated to the cubic foot. The Pennsylvania contractors never had to contend with hold this perfect system and the thoroughness of each day's work chiefly responsible for the promptness of the meeting of the tubes.

Engineers say, too, that no project was ever carried out where the emphasis was so entirely upon the results rather than upon the money it cost to attain them. Records have been kept with unprecedented accuracy and fullness, and they have not been revised and re-revised with bewildering frequency.