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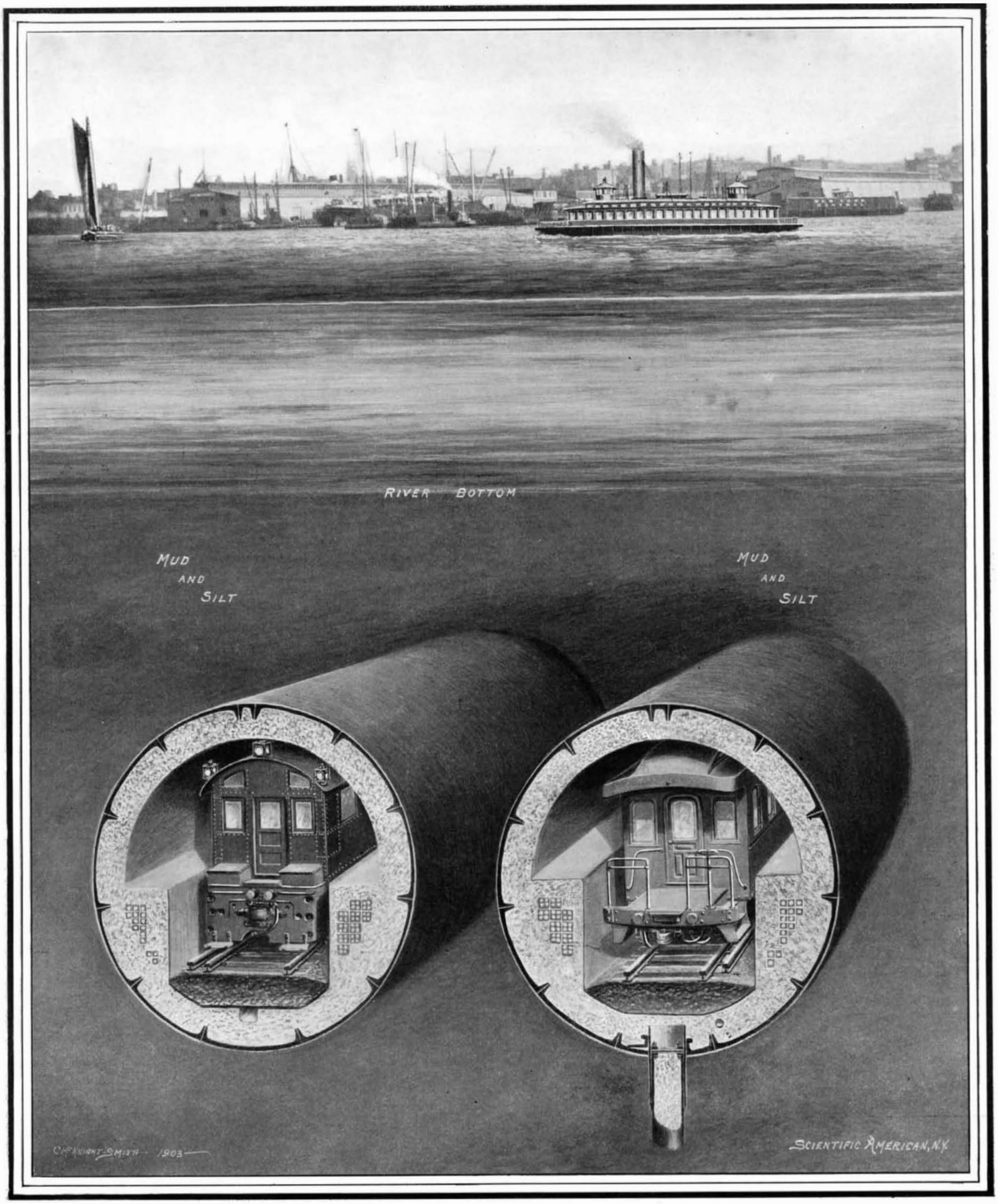

Total length of tunnel from New Jersey to Long Island, six miles. Outside diameter of shell, 23 feet.

SECTIONAL VIEW OF PENNSYLVANIA RAILROAD TUNNEL NOW UNDER CONSTRUCTION BENEATH THE HUDSON RIVER.—[See page 42.]

uring the apparent diameter of the object when the Röntgen bulb is stationary and then ascertaining the actual shape of the body by means of parallel movement of the drawing stylus and the bulb. Now if $a\,l$ is the apparent length of the foreign body, $r\,l$ its real length, D the distance of the anticathode of the tube from the luminous screen, and d the distance of the object from the anticathode, the equation $d = \frac{r\,l \times D}{a\,l}$ will give the true distance of the foreign body from the luminous screen.

THE PENNSYLVANIA TUNNEL AT NEW YORK CITY.

Rapid progress is being made in the initial stages of the great engineering project by which the Pennsylvania Road is to secure a terminal station in Manhattan Island and through connections with the Long Island Railroad system. The work of clearing away the buildings on the four large city blocks that will be occupied by the passenger station is well under way, two of these blocks, over a third of a mile in total length, being ready for excavation. The shafts from which the work of tunneling will be carried through have been sunk; and before many weeks have passed the whole stretch of work from the portal in Jersey to the portal in Long Island will be covered with as big a force as can be crowded upon it.

The location and profile of the tunnel are shown in the accompanying diagrams. Commencing at the western approach to the tunnel, two tracks will enter the western end, known as the Hackensack portal, in the face of Bergen Hill, which runs parallel with the Hudson River. From this point to the portal which marks the exit on Long Island will be a distance of a trifle under six miles. The two tracks will pass through the hill in separate tunnels, which will extend to the Weehawken shaft, a distance of a little over one mile. On this portion of the work the tunneling will be of standard construction, but from the Weehawken shaft to the shaft on the western shore of Manhattan Island, a distance of about 6,000 feet, the two tracks will be carried in separate circular tubes of a construction hereinafter described. The line will descend from the Hackensack portal to its lowest point below the North River on a grade of 1.3 per cent, and at its lowest level the bottom of the tubes will be about 90 feet below mean high water of the North River. From this point, for a distance of 2,000 feet, the line will rise on a grade of 0.53 per cent, and then for another 3,000 feet it will ascend on a grade of a little under 2 per cent to a point between Ninth and Tenth Avenues on Manhattan Island. At the Manhattan shaft, going eastward, the tubular construction ceases, and the two tracks diverge into two triple, parallel tunnels, with three tracks in each—the main line and two sidings. The triple tunnels extend for about 1,100 feet, when they merge into a four-track, single-arched tunnel, which extends for 605 feet to the western end of the terminal station. The new terminal station will be the greatest structure of its kind in existence. It will extend from Seventh to Ninth Avenue, and from 31st to 33d Street, and will cover a great parallelogram measuring about 460 feet north and south by about 1,800 feet east and west. The details of the station and the architectural features have not as yet been made public; but the treatment will probably be a modified classic, or some style agreeable to such a monumental structure.

The portion of the tunnel thus far described is under the charge of Charles M. Jacobs as chief engineer. The portion now to be described, extending from the station to the end of the tunnel in Long Island, is under the charge of Alfred Noble as chief engineer. The latter division, which commences just east of Seventh Avenue, consists of two lines of three-track arched tunnels, one below Thirty-second Street, and the other below Thirty-third Street. This form of construction continues for 1,650 feet, when each set of three tracks merges into a double track carried in a concrete-arched tunnel for a distance of 2,400 feet. At Second Avenue the tracks swing to the left, and are carried in two concrete-lined tubes beneath the East River to East Avenue, a distance of about 6,000 feet; and from East Avenue to the end of the tunnel at Thompson Avenue, a distance of 3,700 feet, the tracks are carried beneath four separate concrete arches. The tracks descend from Seventh to Fifth Avenue on a 0.5 per cent grade, and from Fifth Avenue to the lowest point beneath the East River on a 1.5 per cent grade, from whence they rise on a 1.25 per cent grade to surface.

On the whole of the tunnel work thus outlined, that lies beneath the East River and the land, it is not anticipated that any conditions will be encountered that will call for special construction and present any obstacles to the smooth and uninterrupted prosecution of the work. The borings indicate that beneath the land the tunnels will be driven chiefly through rock, and under the East River through fine to coarse sand and gravel.

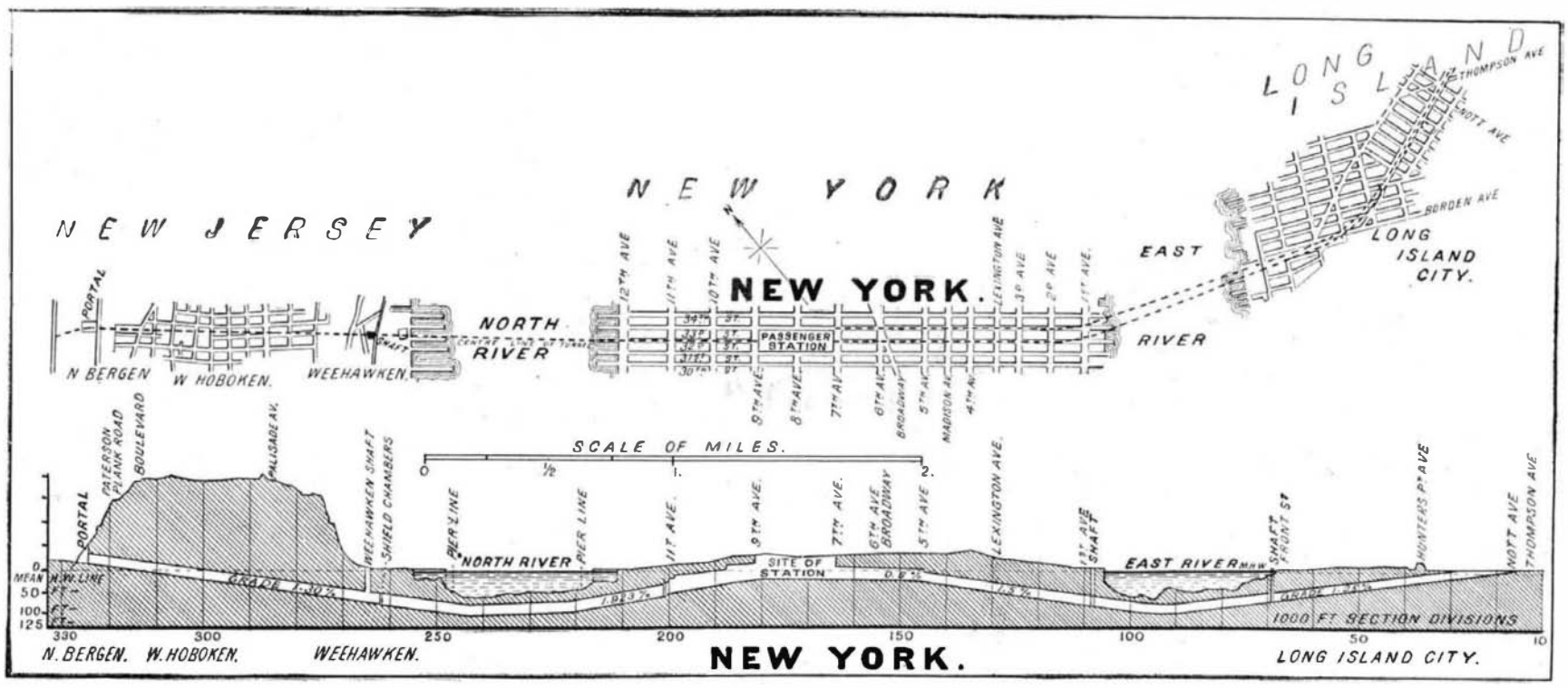

DIAGRAM SHOWING THE LINE OF THE PENNSYLVANIA TUNNELS UNDER THE HUDSON AND EAST RIVERS.

In passing below the North River, however, it will be necessary, in order to avoid going to a depth which would involve heavy grades that would be expensive to operate, to carry the tunnel through a river mud and silt that are of such consistency that the question of the stability and perfect alignment of the tunnel calls for special study. Although the silt is sufficiently firm to preserve the tunnel itself in perfect alignment, it was considered by Mr. Jacobs that provision should be made for carrying the moving train loads independently of the tunnel shell. It was considered that if the heavy Pullman trains, weighing with their locomotives as much as 600 to 700 tons, were allowed to bear directly upon the shell of the tunnel, their weight and impact might produce a settlement and set up bending stresses that would result in fracture and leakage. The problem will be solved by driving a line of very massive cast-iron screw piles through the floor of the tubes, at 15-foot intervals, with their heads projecting within the tubes, and capping the piles with a system of heavy transverse girders and longitudinal stringers, upon which the track rails will be laid. The heavy load and severe impacts of the trains will thus be received by the piles, and should there be any slight settlement of the piles under load, the movement would not affect the tubes, which would serve their proper purpose as an envelope for the protection of the trains. The piles will be driven either to rock or to a bearing capable of sustaining a predetermined load without settlement. Of the 24,049 feet of cast-iron single-track tunnel, 12,174 feet will be reinforced with screw piles.

The cast-iron shell consists of bolted-up segments, each 30 inches in length and containing eleven segments and a key piece in each. The shell is 2 inches in minimum thickness, and the segments are flanged on all sides, the joints being planed and provided with five or six 1½-inch bolts, as the case may be. At stated intervals corresponding to the position of the piles, plates are cast with flanged holes, which are temporarily closed by a cast-iron block. After a certain length of the shell has been driven, it will be bulkheaded off, placed under pneumatic pressure, and the piles will be screwed down from the interior of the shell. The piles are 27 inches in outside diameter, with 1¼-inch thickness of shell, and they are made in 7-foot sections. The lower end of the pile is square, and is provided with one turn of a wide screw cast integrally with the pile, the outside diameter of the screw being 4 feet 8 inches. The pile is screwed down by means of a special hydraulic ratchet arrangement bolted to the head of the pile, and as one section is carried down, another 7-foot section will be bolted to it, the process continuing until rock or impenetrable bottom is reached. The core of mud inside the hollow pile will be excavated for a depth of 12 feet below the tunnel tube, and the space filled in with concrete. After the pile has been driven, the last section will be removed, cut to exact length, to bring it flush with the floor of the tube, and replaced and bolted. The upper end of the pile after it has been filled with concrete will be closed by a bolted disk. Above the cap of each pile will be bolted heavy transverse girders, and upon these girders, bridging the intermediate space of 15 feet, will be a pair of longitudinal girders, upon which the railroad tracks will be laid. By this method the weight and impact of the heavy trains will be borne directly by the piles, and the iron and concrete tube will have no other duty to perform than that of forming, as we have said, a protective envelope for the trains.

The tunnel, particularly that portion of it beneath the rivers, has been planned with a view to the prevention of accidents to trains, or mitigating the dangers, should an accident occur. In the first place, the sides of the tunnel are filled with a mass of concrete up to the level of the car windows. This will reduce the damage due to derailment or collision to a minimum, and will provide a means of egress from the tunnel in case of accident. Should a train be held in the tunnel for any reason, it would be possible for the passengers to climb out upon these footways, and escape by them to either end of the tunnel. Moreover, should a car jump the track, it would be impossible for it to slew out of line, and it is probable that the whole train could be brought to a stop before any more serious injury than the breaking of windows had been done. The electric cables will be carried in conduits and embedded, as shown in our engraving, in the concrete mass of these side benches. At stated intervals there will be refuge niches formed in the concrete for the use of employes, and, lastly, the whole tunnel will be thoroughly lighted from end to end.

Parisian Airship Fund.

The Municipal Council of Paris has appropriated an annual allowance for the encouragement of physiological research in connection with balloon ascents. The studies will especially be directed to the exaggeration of vital activity in high altitudes.