OPENING OF THE ST. CLAIR RIVER RAILWAY TUNNEL BETWEEN THE UNITED STATES AND CANADA.

The festivities which took place at Sarnia, in Canada, and Port Huron, in Michigan, on the 19th inst., in celebration of the opening of the St. Clair river tunnel, mark an event of much interest and importance, as well from a scientific as from an international point of view.

In the methods of construction the great work represents a new departure in engineering science, whereby many noble projects of similar class, in all parts of the world, hitherto regarded as too difficult and costly for execution may now be realized with ease and economy.

Internationally considered, the new tunnel stands as a bond of union and amity between the Dominion of Canada and the United States; it forms an open highway for commerce between the two grandest empires of the new world.

The St. Clair tunnel is one of the most finished and solid engineering structures on this continent. From commencement to end of construction, it has borne evidence of the control of a master mind. Every branch of the work went forward with the utmost harmony, skill and precision. The architect, desginer and builder was Joseph Hobson, of Guelph, Ontario, of whom it may be said, without flattery, he stands in the front rank of the best engineers.

The question of tunneling the St. Clair river was under discussion with the officers of the Grand Trunk Railway for several years, but most of the engineering advice was against the project, on account of the great length of time, the immense costs and extraordinary difficulties attending the execution of the work. The only exception was Mr. Hobson, who did not share in these gloomy reports and prognostications. Mr. Hobson's plans were at first disregarded, but on closer examination were sanctioned by the directors and he was placed in absolute charge of the construction. His knowledge of the Beach tunneling shield as used in tunneling under Broadway in this city in 1869-70 satisfied him that similar machines, of greater dimensions, would enable him to execute the proposed work rapidly and economically.

In this he was not disappointed. He designed and constructed two gigantic shields of metal on substantially the same plan as the Beach shield. He employed for the production of the hydraulic work the same makers who had fitted up the Beach shield, and who knew exactly what was wanted, namely, Messrs. Watson & Stillman, of this city, who enjoy a wide reputation for strong and excellent workmanship.

Mr. Hobson's shields were each 21 feet 7 inches in

CHIEF ENGINEER HOBSON BREAKING THROUGH FROM CANADA TO THE UNITED STATES UNDER THE ST. CLAIR RIVER.

diameter and 16 feet long, of plate steel 1 inch thick. To design and construct for the first time two such giant machines, to set them in place, and put them in successful operation under the river, was in itself an undertaking which evinces superior judgment and accurate skill. But Mr. Hobson was equal to every emergency, and his success shows that he foresaw all the requirements of his novel proceeding. In conjunction with the Beach shield he brought to his aid the admirable system of using compressed air in tunnel work, the invention of Mr. Dewitt C. Haskin, of this city, who first used it in the Hudson River tunnel. This air pressure system is a necessity in helping to uphold the soft earth of the tunnel heading.

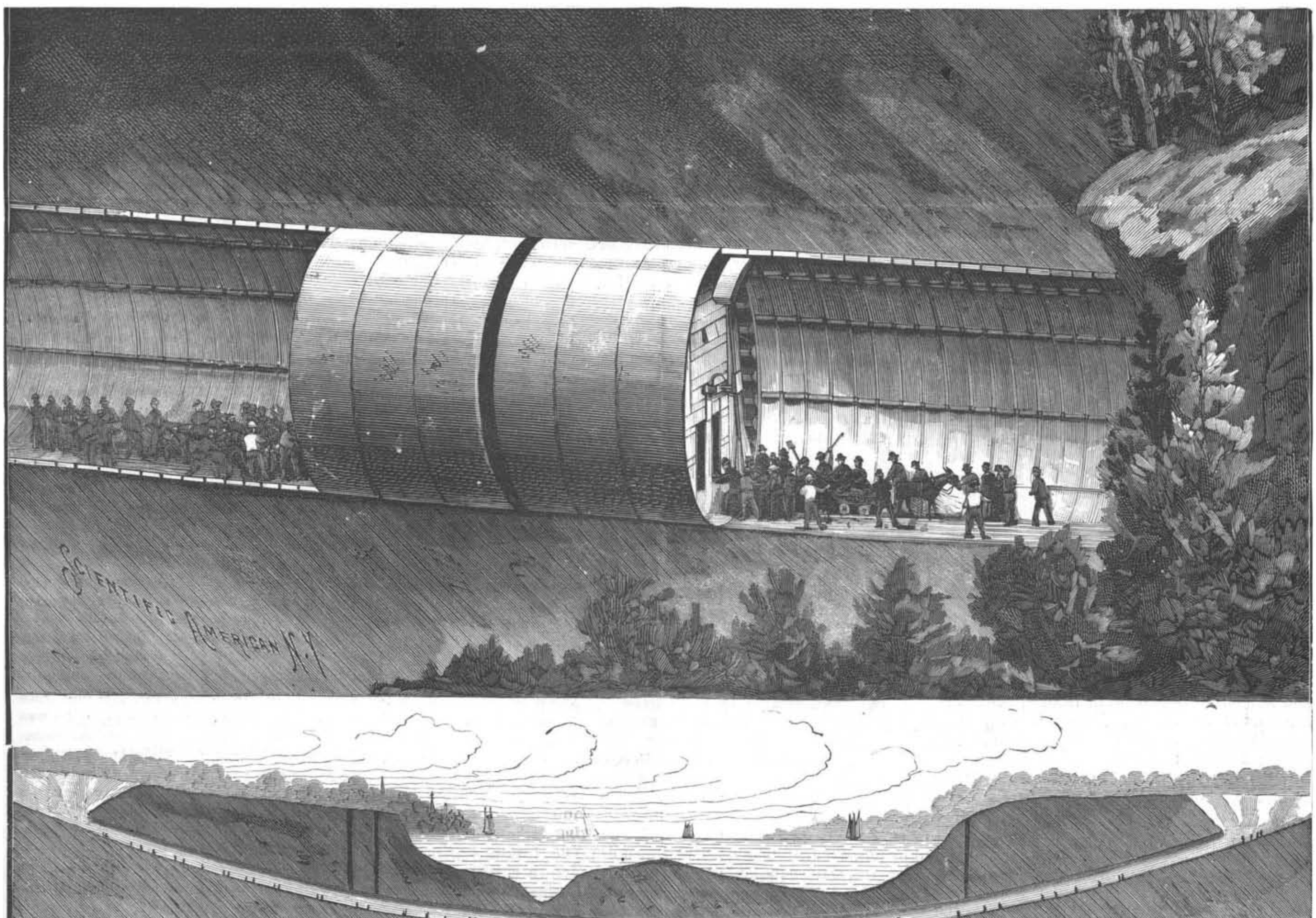
The St. Clair Tunnel Company was formed in the year 1886. Work upon the great cuttings was begun in January, 1889.

Work upon the tunnel portion was begun in August, 1889, and in one year, to wit, on Monday, August 25, 1890, Mr. Hobson enjoyed the supreme satisfaction of breaking through the headings, being the first man to pass through the tunnel. The last stones on the portals, thereby fully completing the tunnels, were laid Dec. 24, 1890. Since that time a great amount of work has been done in preparing and finishing the approaches to the tunnels, a work of great difficulty, owing to the treacherous and slippery nature of the ground.

Referring to our engravings: On the first page the upper sketch shows the approach to the great tunnel at Sarnia, on the Canadian side of the river, with the inaugural train advancing to enter the tunnel. This train was composed of splendid cars, occupied by Sir Henry Tyler, president, with the directors of the Grand Trunk Railway and many distinguished guests. Near the head of the approach to the tunnel Sir Henry was presented with an address by the Sarnia council, after which the inaugural train, amid the cheers and rejoicings of the people, steamed down the incline into the tunnel and disappeared from view under the depths of the St. Clair river, emerging therefrom in Port Huron, Michigan, where an address was presented to Sir Henry from the council of that town. At a later hour a grand banquet was given in Sarnia, when several eloquent speeches were delivered. Such, in brief, were the ceremonies attendant upon the formal opening to public traffic of this new roadway between Canada and the United States. Our lower engraving, first page, shows a bird's eye view of the St. Clair river and adjacent country, with the approach on the Sarnia side. The dotted line indicates the course of the tunnel under the river.

The approaches and portals to the tunnel are much the same on both sides of the river. One of our views, taken from the roof of the Sarnia portal, will give some idea of the magnitude of the cuttings required to complete the approaches.

The walls of the tunnel are composed of segmental



THE GREAT RAILWAY TUNNEL UNDER THE ST. CLAIR RIVER, BETWEEN THE UNITED STATES AND CANADA—THE MEETING OF THE SHIELDS.

flanged iron plates, connected by bolts. One of the plates is shown in our engraving. Thirteen of these plates and a key compose a ring of the tunnel. The lower half of the tunnel is lined with massive brickwork. The tunnel is ventilated by means of two tubes, 20 inches in diameter, arranged in the roof of the tunnel, as shown in our engraving. These tubes extend to the center of the tunnel and pass to the entrances, thence underground to a side building, where they connect with two large Root blowers, by which the required ventilation is obtained.

On page 196 we give sectional elevations, showing the interior of the tunnel and the meeting place of the great shields, by means of which the work was excavated.

The tunnel is 6,050 ft. in length from cutting to cutting, and is divided as follows: From the American cutting to the river edge, 1,800 ft.; from the Canadian cutting to the river edge, 1,950 ft.; and distance across the St. Clair River, 2,300 ft.

The original estimate of cost was $3,000,000. But it is understood the actual expenditure will be less than this amount.

In the construction of the St. Clair River tunnel, two deep cuttings were made, one on each side of the river; that on the American side had a depth of 53 feet, and that on the Canadian side 58 feet deep. Upon the floor of each cutting, against the head thereof, one of the great shields was placed, and the work of tunneling began.

Each shield was circular, 21 feet 7 inches in diameter, 16 feet long, and is built of plate steel, one inch thick, divided into twelve compartments by means of two horizontal and three vertical stays.

The front or heading end of each shield was made with sharp cutting edges. Arranged around against the walls of the rear end of the shield were twenty-four hydraulic rams, each eight inches in diameter and a stroke of 24 inches. By their means the shield was forced forward enough to admit of the building up of a section of tunnel rings within the shield. The power supplied by a Worthington pump was capable of producing a pressure of 5,000 pounds per square inch, or 3,000 tons on the 24 rams. The greatest pressure used was 1,700 pounds per square inch, which is 40 tons per ram and 1,060 tons on the shield.

Each ram had a separate stop cock, so that its pressure could be let on or shut off at will. Thus all of the rams could be operated simultaneously or a portion of them, or singly as required. Thus by letting on or shutting off pressure the shield could be guided and directed in any direction desired, up, down, or laterally, and made to traverse the exact grade required.

The shields weighed eighty tons each, and were built from the designs of Mr. Hobson, by the Tool Manfacturing Company, of Hamilton, Canada, the hydraulic work being supplied, as before stated, by Watson & Stillman, of this city. This form of hydraulic shield is the invention of Mr. Alfred E. Beach, one of the editors and proprietors of the SCIENTIFIC AMERICAN, and was first made and used by him in 1868-69, in constructing a section of railway tunnel under Broadway, New York. The invention was subsequently copied by Greathead and used by him in London in 1886-89, in constructing the two subway tunnels, each three miles in length, from the Monument, passing under the Thames River, Kennington Park Road, etc., to Clapham. The cars in these tunnels are worked by electricity. The Beach hydraulic shield is also now being used in the Hudson River tunnel, in process of construction under the Hudson River between New York and Jersey City.

Joseph Hobson, the chief engineer who planned and built the St. Clair tunnel, is a native of Guelph, Ontario, born March 4, 1834. He served an engineer apprenticeship at Toronto, was engaged in private practice as civil engineer, was for several years employed on location and construction of railways in the United States, Ontario, Nova Scotia. He was resident engineer of the International Bridge, Buffalo. In 1873 he took a position as chief assistant engineer of the Great Western Railway. He was appointed chief two years later, and still holds that office. He is a member of the Institute of Civil Engineers, England, of the American Society of Civil Engineers, of the Canadian Institute of Civil Engineers. He is a tireless worker. In person he is fine looking, six feet high, full gray beard and mustache, bright and genial. Mr. Hobson's efforts in the St. Clair tunnel were from first to last heartily seconded by Sir Henry Tyler, president of the Grand Trunk Railway, who is himself an engineer of rare ability. Further illustrations and particulars of the St. Clair tunnel may be found in the SCIENTIFIC AMERICAN for August 9, 1890, and September 13, 1890.

PROFESSOR THURSTON says: "The assumption seems fair that the locomotive engine will have been superseded when we double our speeds, and that we must find ways to utilize the weights of the cars themselves for adhesion and to make each to carry its own motor."

New Process for Toning Blue Prints.

W. P. JENNEY, E.M., PH.D.

The intense blue color of the ordinary blue print gives unnatural effects in prints from photographic negatives; also in architectural drawings where views and elevations of buildings are reproduced. The following method of toning such blue prints has been found to be easy of application and to give tones varying from a brilliant blue through violet blue to neutral tint and warm shades of gray, according to the intensity of the action of the bath.

The paper employed may be common blue print paper, sold ready for use in rolls, or the specially made paper sold in packages of cut sheets by the dealers in photographic supplies. The solar printing is carried out in the usual manner. The best results are obtained with dark prints, as the intensity of the color is somewhat reduced by the toning process. The following baths are employed:

BATH A.

Muriatic (hydrochloric) acid	3 to 4 drops.
Water	16 oz. (1 pint).

BATH B.

Aqua ammonia	5 to 10 drops.
Water	16 oz. (1 pint).

BATH C.

	Apoth. weight.
Alum	2 oz.
Tannic acid	1 drachm.
Water	16 oz. (1 pint).

The prints are immersed face downward in bath A until all the soluble salts contained in the paper are dissolved and removed, then dipped into bath B until the negative turns a violet blue and the whites are clear, care being taken that the immersion in the ammonia be not continued too long, as the definition of the picture may be injured. The prints are transferred from the ammonia bath, placed face upward in a tray filled with bath C, and exposed to bright sunshine for from 5 to 10 minutes, until no increase in the strength of the picture can be noticed. The pictures are finished by toning in bath B until the desired shade of color is obtained, the picture becoming first a brilliant blue, then violet, and finally, by prolonged action, bluish gray or neutral tint. The toning may be varied by a second immersion in the tannic acid bath C, followed by a second toning in bath B. After toning, the prints are dried in the sunlight in the usual manner.

The above process is specially applicable to prints from photographic negatives, enabling the amateur in the field, provided with a printing frame, some sheets of prepared blue print paper, and the above easily procured chemicals, to test the printing quality of his negatives with results only slightly inferior in detail and definition to those obtained by the complicated process of silver printing.

The Proposed Tubular Railway under the Channel between England and France.

Sir Edward J. Reed, at the late meeting of the British Association, Cardiff, read a paper on "The Channel Tubular Railway." Among the earlier railroad proposals were several, he said, for constructing metallic tubes upon the bed of the channel. The sea in the channel is everywhere of very moderate depth, and where the bottom is not practically level, its departures from the level are surprisingly small and gradual. The depth of the channel nowhere reaches 200 feet upon the selected line from England to France. For several miles out from the English coast it is not 100 feet deep; and the greatest depth is, roughly speaking, about two-thirds of the way across to France, and there its maximum is 186 feet. A railway across this piece of submarine ground is as good as any other railway. The fact that it is a railroad within a perfectly watertight and durable tube—or a pair of tubes, for there would be a tube for each line of railroad—completely renders the presence of the sea water outside of it of no consequence. The securing of these tubes in place, and the ventilation of them, led on to the details of the system. The necessity which enforces the use of water tight tubes for the purpose is attended incidentally by great advantages. The author stated that the tubes would be "of iron or steel in so far as the primary and essential elements of their structure are concerned; and this at once, and obviously, relieves us almost entirely, if not altogether, of the cost, the difficulty, the delay, and the danger of doing our construction work at the bottom of the sea. These tubes can be perfectly well built by our shipbuilders and engineers, and partly by those of France, just as ships are built, but with much greater economy. The tubes thus made will be towed by steamers from the building ports to the channel as they are required for being laid in place, and the operation of laying them is one which has been very carefully studied and worked out in order to make it safe and certain. To this end had been devised the system of making the length of tube which has last been laid the means and the instrument of bringing the next length into its position with unerring accuracy. It is difficult to explain in words alone the operation of laying the tubes. But, obviously, if one end only of a buoyant tube is forcibly taken down from the surface of the water to the bottom, or nearly to the bottom, the other end will float and rise somewhat above the surface. This being so, a pier wholly afloat at the time is brought up to the emerged end of the tube, and coupled up to it by enormous hinge joints. The next length of floating tube is then brought up to the other side of the floating pier, and similarly jointed to it. The pier is now sunk by suitable means and under proper control, and as it goes down carries with it the second end—so to speak—of the first named tube, and the first end of the last named tube. The other end of this latter tube floats, of course, and the operation is repeated. In this manner tube after tube is laid, with piers between the successive lengths, until the whole is accomplished. The lines of railway, of course, pass continuously through the piers as well as the tubes. The whole operation is like the paying out of a huge cable, link by link; tubes and piers alike forming, as it were, the links of the cable. The approximate cost will be between 12 and 15 millions sterling."

The author then dealt with the question of national security, which many suppose the channel tunnel to infringe. In the case of the channel tunnel, were that carried out, it would undoubtedly afford a subterranean military road, which, were it once secured by an enemy, might, in the opinion of many, be held in spite of us, because this subterranean road, being deeply situated below the channel bed, would be completely preserved from attack by the British navy. The channel tubular railway, on the contrary, is everywhere situated above the bed of the channel, and could, therefore, be attacked at every point by dynamite. At the same time, it is so constructed and brought up along the foreshore—at a gradient of 1 in 80—as to be exposed for a length of no less than 3,160 feet to the direct fire of the guns of ships between the high water and low water limit. Any breach or hole made in it below high water mark would, of course, admit the sea at the next tide to the whole interior of the tube. The trains in each tube will always pass through it in the same direction. The trains themselves will, consequently, act to some extent as ventilating pistons, forcing air out at one end of the tube and drawing it in at the other. By fitting wings to the engines or carriages, and throwing them out when necessary, the train may be made to fit the tube more nearly, so to speak, and thus to add to the efficiency of this source of ventilation. If other ventilation should be thought necessary—which was very doubtful if electric engines were employed—one or more of the piers could be fitted up as a ventilating station, with steam engines, air pumps, etc., the foul air of the tubes being forced into suitable chambers, and thence by non-return valves into the sea.

Two Cylinders in One.

A new departure in compounding locomotives, which is almost as radical as the idea of compounding itself was, has been put into practical and successful operation by F. W. Johnstone, superintendent of the motive power of the Mexican Central Railway. Coal costs about $11 per ton on the Mexican Central, and Mr. Johnstone undertook to reduce fuel consumption by the introduction of a compound system of his own, in which the high-pressure cylinder is encircled by the low-pressure cylinder.

The high-pressure cylinder is 14 inches in diameter, and the low-pressure cylinder has a diameter of 30¾ inches, which is equal to a cylinder 24¼ inches in diameter. The stroke is 24 inches, and the two rods of the low-pressure piston are coupled with the single high-pressure rod to one crosshead. In a competitive test of 12 trips with a single engine, the compound locomotive showed economy in fuel of about 25 per cent, which means a great deal on a road where the fuel account is the largest item of operating expenses, being 22 per cent of the total.—*Chicago Journal of Commerce.*

One Hundred and Eight Years Old.

Mr. Jacob Steel died at a small town near Pittsburg, Pa., on August 24. He was born in Fayette County, in that State, on October 19, 1783, and would, consequently, have been one hundred and eight years old had he lived eight weeks longer. He used to say that he remembered distinctly the day of Washington's second election to the presidency, and his first vote was cast for Jefferson. His habits were simple, he was rather careful in his diet, drank a little whisky occasionally, but never used tobacco. What probably contributed as much as anything else to the prolongation of his life was a cheerful disposition and a remarkable evenness of temper.

Artificial Asphalt.

By heating resin with sulphur to about 250° C., a reaction takes place, attended by the evolution of sulphureted hydrogen, and leading to the formation of an almost black pitchy substance containing sulphur and resembling Syrian asphalt in many of its properties. Thus it is insoluble in alcohol, but dissolves readily in chloroform and benzene, and is sensitive to light in the same way as Syrian asphalt, for which it can be substituted for photographic purposes.

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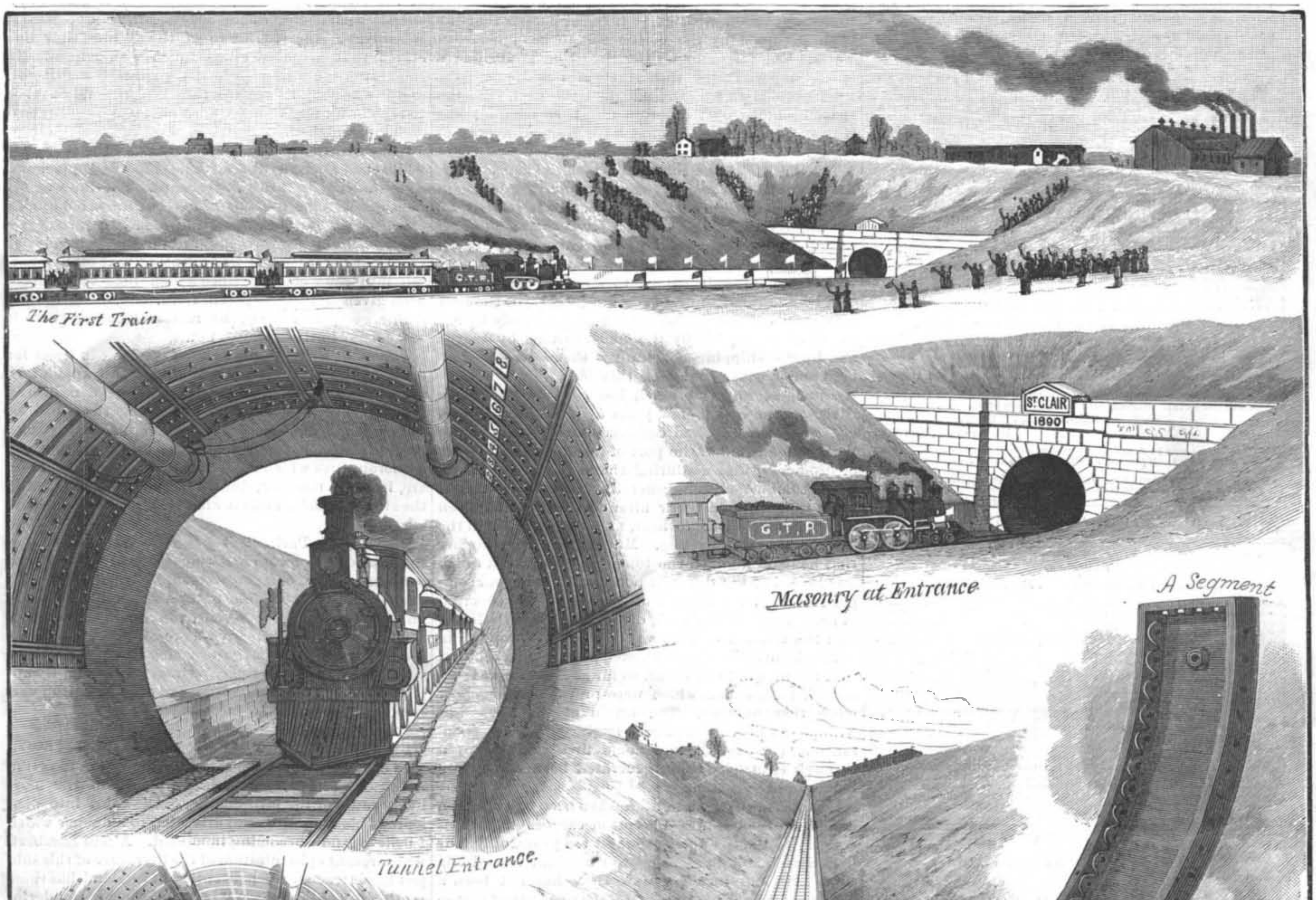

THE GREAT RAILWAY TUNNEL UNDER THE ST. CLAIR RIVER, BETWEEN THE UNITED STATES AND CANADA.—[See page 196.]