## 1. NAME OF PROPERTY

Historic Name: ST. CLAIR RIVER TUNNEL

Other Name/Site Number: St. Clair Railroad Tunnel

## 2. LOCATION

Street & Number: Between Johnstone & Beard, near 10th Street (Portal Site) Not for publication:___

City/Town: Port Huron Vicinity:___

State: MI County: St. Clair Code: 147 Zip Code: 48060

## 3. CLASSIFICATION

Ownership of Property
Private: X
Public-local:___
Public-State:___
Public-Federal:___

Category of Property
Building(s):___
District:___
Site:___
Structure: X
Object:___

Number of Resources within Property

| Contributing | Noncontributing | |
|---|---|---|
| ___ | 2 | buildings |
| ___ | ___ | sites |
| 3 | 2 | structures |
| ___ | 1 | objects |
| 3 | 5 | Total |

Number of Contributing Resources Previously Listed in the National Register: 1

Name of related multiple property listing:______________________________

## 4. STATE/FEDERAL AGENCY CERTIFICATION

As the designated authority under the National Historic Preservation Act of 1986, as amended, I hereby certify that this ____ nomination ____ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ____ meets ____ does not meet the National Register Criteria.

Signature of Certifying Official Date

State or Federal Agency and Bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria.

Signature of Commenting or Other Official Date

State or Federal Agency and Bureau

## 5. NATIONAL PARK SERVICE CERTIFICATION

I, hereby certify that this property is:

____ Entered in the National Register
____ Determined eligible for the National Register
____ Determined not eligible for the National Register
____ Removed from the National Register
____ Other (explain): ____

Signature of Keeper Date of Action

## 6. FUNCTION OR USE

Historic: Transportation Sub: rail-related

Current: Transportation Sub: rail-related

## 7. DESCRIPTION

Architectural Classification: Other: Subaqueous Tunnel

Materials:
Foundation: N/A
Walls: Cast Iron (Tunnel) -- Limestone (Portals)
Roof: N/A
Other: N/A

**Describe Present and Historic Physical Appearance.**

The St. Clair River Tunnel links Port Huron, Michigan with Sarnia, Ontario by crossing beneath the St. Clair River. Portal to portal, the tunnel is 6,026′ long. In addition to the underground portion of this property, open cut approaches run in a gradual decline from grade level to each portal, at a point approximately 55′ below grade. The length of these approaches, 3500′ on the Canadian side and 2700′ on the U.S. side, brings the total length of this property to 12,226′. The portals are made of rough-cut limestone, and are about 140′ wide and 36′ tall. Low retaining walls flank the tracks along the approaches.[1] The underground portion of the tunnel lies beneath 30′ of water, plus another 15′ to 20′ of clay, gravel, sand and mud. (See figure #1) The tunnel proper is constructed of arched cast iron segments, each weighing more than a 1000 lbs, which measure about 18" long, 12" wide, and 2" thick.[2] (See figure #2) Thirteen of these cast iron segments, plus a smaller arch key segment, are bolted together to form a 20′5" diameter ring of the tunnel lining. A succession of these rings are bolted together to form the more than one mile-long tunnel lining.[3]

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[1]La Moille, Harper's Weekly (February 28, 1891): 158.

[2]Approximately one-third of the "high grade iron" tunnel lining segment pieces were manufactured by the Grand Trunk Railway's shops at Hamilton, Ontario, and the remainder were manufactured by the Detroit Wheel & Foundry Company in Michigan: "The St. Clair Tunnel," Engineering News (December 6, 1890): 499.

[3]Each segment had a grout hole through which portland cement grout was injected to a 3" thickness between the exterior of the lining and the river bed. Special efforts were taken to make all

Upon completion of the cast iron tube, the lower half of the tunnel was lined with brick and mortar to a depth equal to that of the segment flanges. The very bottom of the tunnel was then built up with brick and coated with a 1" coat of concrete, upon which the tracks were installed. This was done to cover and protect the cast iron lining from the corrosive effects of the brine dripped from refrigerator cars. The rails were laid on creosoted pine timbers. Safety platforms and ladders were added. None of the above ground structures associated with the construction of the tunnel remain.[4] Two vertical ventilation shafts were constructed before the tunnel headings passed beneath the river. Their locations are discernable in two places where cables pass through the cast iron tunnel lining segments at the top of the tunnel about one-third of the way in from each portal. These shafts do not contribute in an important way to the nationally significant values of this property.

Immediately outside each portal is a small one-story pumphouse. The pumps prevent the tunnels from being flooded by any rain water which would run into the portals. All major mechanical equipment has been replaced and modified.[5] Replacing earlier pumphouses in 1907, these buildings do not contribute in an important way to the nationally significant values of this property. They do, however, play an important role in helping distinguish one portal from another. (See photographs 1 & 2) The pumphouse at the Canadian portal is constructed of brick, with a gable roof, and the one at the American portal is constructed of stone with a hip roof. An additional pump (non-contributing) at mid-tunnel removes any water which does accumulate in the tunnel out to the portal areas.

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the segment joints watertight. "For the <u>radial</u> joints the abutting surfaces of the segments were planed, and between them was placed a packing piece of seasoned white oak 3/16" thick. These were sawed to the exact size desired, and the bolt holes were bored 1/4 in. larger than the bolt to allow for slight inaccuracies. After bolting in place, this wood packing piece rapidly absorbed water from the surrounding clay and in swelling closed the joint perfectly." The <u>circumferential</u> joints were packed with roofing (coarse canvass covered with asphalt), and additional caulking was applied when needed. See: "The Great Railway Tunnel Under the St. Clair River," <u>Scientific American</u> (August 9, 1890): 87; and "The St. Clair Tunnel," <u>Engineering News</u> (December 6, 1890): 499.

[4]These included: one boiler house with three boilers; one machine shop; one carpenters shop; one smith shop; one electric light room, containing two dynamos and engines, a blower engine and blower, a hoisting engine and a pump. See: "The Great Railway Tunnel Under the St. Clair River, Between the United States and Canada," <u>Scientific American</u> (August 9, 1890): 88.

[5]An early or original pump in the Canadian pumphouse is scheduled to be relocated and preserved.

When electric locomotives replaced the original steam-powered ones, electrical cables were attached to the highest point of the tunnel lining at 12' intervals.[6] Virtually all evidence of these electrical cables and their support structures has been removed from the immediate vicinity of the tunnel and its approach ramps. An important modification to the tunnel was the lowering of the track bed in the late 1940s to provide greater clearance for larger freight cars. The original Root fans at both portals were removed, and when diesel trains replaced the electric locomotives, a different fan system was installed on either side of both portals.

The railroad assembly yards, which are not located within the boundary of this proposed NHL, were leveled using fill from the excavation to produce room for 20 miles of siding. Also outside the boundary of this Landmark nomination is an arch made from six of the 1,100 pound segment pieces left over from tunnel construction. It was erected beside the Sarnia train station to serve as a historic marker.

This proposed NHL is comprised of three contributing elements: the tunnel proper (which includes the cast iron lining and both portals) and the two approach ramps (including retaining walls).

[6]F.E. Sager, Electrification of the St. Clair Tunnel (Montreal: Grand Trunk Railway, 1908), p. 20.

## 8. STATEMENT OF SIGNIFICANCE

Certifying official has considered the significance of this property in relation to other properties: Nationally: X Statewide:___ Locally:___

Applicable National Register Criteria: A X B___ C X D___

Criteria Considerations (Exceptions): A___ B___ C___ D___ E___ F___ G___

NHL Criteria: 1 & 4

NHL Theme(s): XIV.E Transportation: Railroads
XVIII.B Technology: Transportation
XVIII.H Technology: Construction

| Areas of Significance: | Period(s) of Significance | Significant Dates |
|---|---|---|
| Transportation | 1889-1891 | 1891 |
| Technology | 1889-1891 | 1891 |

Significant Person(s): ______________________

Cultural Affiliation: ______________________

Architect/Builder: Joseph Hobson (Engineer)

**State Significance of Property, and Justify Criteria, Criteria Considerations, and Areas and Periods of Significance Noted Above.**

The St. Clair River Tunnel is nationally significant as the first full-size subaqueous tunnel built in North America.[7] Prior to its completion, a railroad had never been able to pass beneath a river. This accomplishment was not possible until engineers learned to combine three elements of tunnel construction (the shield method of excavating, the cast iron tunnel lining, and excavating in a compressed air environment). The St. Clair River Tunnel is important in the history of engineering because it was the world's first true test of the feasibility of constructing railroad (and later vehicular) tunnels through the soft, porous ground commonly found beneath rivers. This engineering advancement had an impact on our Nation's broader historical development by breaking the rail transportation bottleneck which was caused by the difficulty of crossing the wide rivers upon which most of our major population centers were located.

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[7]The term "full-size" refers to the adequacy of the tunnel's diameter and overall design to accommodate trains, and later automobiles.

The popular Harper's Weekly magazine described the St. Clair tunnel as "one of the world's greatest wonders of engineering." One of the major engineering journals of the period described it with more aplomb:

> The most renowned achievements in all departments of human activity owe their importance and fame to the magnitude of the obstacles surmounted. There is now approaching completion near the outlet of Lake Huron, a railway tunnel beneath a river, which, by reason of the difficulties successfully overcome, and the importance of the completed work, is entitled to high rank among the great engineering works of the continent.[8]

While chroniclers of the late 19th century were often overly effusive in their praise for the latest manifestation of human domination over nature, their descriptions of the important technological breakthrough accomplished with the design and construction of the St. Clair River Tunnel were warranted. These century-old assessments were recently endorsed when both the Canadian and American Societies of Civil Engineers designated the tunnel a Civil Engineering Landmark in 1991.

HISTORICAL BACKGROUND

The Demand for Tunnels

Once the vast North American continent had been spanned by thousands of miles of rail, considerable attention began to focus on shorter, often more profitable, connections between various production and transhipment centers, such as Chicago, and the large markets of the rapidly expanding cities back east. Since most major cities were located along rivers, much attention began to center on the best way to cross these final obstacles.

Compounding the technological challenges of crossing such rivers was the fact that legal precedent supported the rights of established maritime interests to unobstructed shipping lanes. The merchant shippers, struggling to compete with the upstart railroads, were frequently successful in challenging the construction of railroad bridges. To be acceptable to these maritime interests, bridges would have to be high enough to allow the tallest ships to pass unhindered, while at the same time, not introduce hazardous bridge piers into the shipping lanes. Even after bridge engineers were able to design tall and wide spans, the bridges proved infeasible because of the costs associated with building the long approach ramps which would have been required for such tall bridges, as well as the difficulty of hauling heavy trains up these ramps.

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[8] T.G. La Moille, "St. Clair River Tunnel," Harper's Weekly (February 28, 1891): 158; and "The St. Clair Tunnel," Engineering News (October 4, 1890): 292.

Most railroad companies addressed this problem by establishing marine railway terminals where railroad cars were uncoupled, ferried across the river on barges, and then recoupled. Not only did this imperfect solution prove costly in time and money, but during the winter, frozen rivers curtailed shipments entirely. Having demonstrated the problems in carrying the railroads on bridges above, or ferries across the river surface, many looked to a third alternative--running the trains in a tunnel beneath the rivers.

The technology for tunneling through hard rock had existed for more than a thousand years. Furthermore, late-19th century advances in hard rock tunnel excavating had significantly increased the pace of such gruelling work. As long as the ground material being tunneled through was solid enough to support the walls and roof from collapsing, tunneling was quite feasible. Such hard ground material, however, is seldom present in river beds. Usually, subaqueous tunnels must pass through clay, sand, gravel, and/or mud. The most obvious problem with tunnelling through such material is that the river tends to filter through the loose material and flood the tunnel. Even if leakage was not a problem, the unstable ground material often collapsed into the tunnel void.

The solution to the dual problems of flooding and caving-in came under great scrutiny during the 19th century. Several notable attempts at subaqueous tunneling were made, a few of which achieved some success. Yet, not until the completion of the St. Clair River Tunnel, connecting Port Huron, Michigan, with Sarnia, Ontario, were the subaqueous tunneling problems overcome. Combining three elements of mid-19th century tunneling technology (the shield method of excavating, the cast iron tunnel lining, and excavating in a compressed air environment), the St. Clair River Tunnel was the first full-size tunnel in North America, if not the world, to conclusively demonstrate the feasibility of subaqueous tunneling.[9]

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[9]The St. Clair tunnel is 21' in diameter. A few small bore subaqueous tunnels in Europe and the United States had been dug utilizing the shield method without compressed air, but such narrow tunnels do not compare to the engineering challenges of a tunnel wide enough to allow a railroad to pass. A closer comparison can be made with London's City & South London Railway tunnel which included the combination of these construction methods two years before the St. Clair River Tunnel. However, the modest size (10' diameter) London tunnel utilized the compressed air for only a few short sections of its excavation through otherwise impervious clay. Strictly speaking, the feasibility of successfully constructing a full-size subaqueous tunnel through more typical unstable river bottoms did not become a proven technology until the completion of the St. Clair tunnel.

Planning to Cross the St. Clair River

The St. Clair River connects Lake Huron with Lake Erie, linking the maritime commerce which ran between the East Coast (via the Erie Canal) and Chicago, and beyond to the Mississippi River (via the Illinois and Michigan Canal). The commercial significance of this narrow channel is suggested in the claim that maritime traffic on the St. Clair River exceeded even that of the port of New York.[10] In the eyes of the railroad companies, however, the half-mile wide St. Clair River was merely an obstacle to be crossed. The prohibition against erecting a low railroad bridge which would obstruct maritime traffic, and the impossibility of building a high bridge which could be climbed by heavily ladened steam locomotives, accounts for the interest in tunneling beneath the St. Clair.

The first plan to build a railroad tunnel in this vicinity was initiated in 1872. That plan called for a brick-lined tunnel between Detroit and Windsor, Ontario, 60 miles south of Port Huron. Shortly after digging began, leakage into the tunnel headings forced the abandonment of the project. During the ensuing decade, the Grand Trunk Railway had consolidated various competitors to a point where it carried one-third of all the traffic between New England and Chicago. As the Grand Trunk Railroad's haulage increased, principally through its subsidiary, the Chicago & Grand Trunk Railway, the car ferry crossing between Port Huron and Sarnia became a tight bottleneck in the railroad's operation. In 1888, for example, the Grand Trunk Railway ferried 297,000 freight cars, 28,000 passenger cars, and 8,000 mail cars across the St. Clair.[11] To accommodate this traffic, the car ferry had to operate around the clock, with crossings at an average rate of one every 48 minutes. Even though no successful full-size subaqueous tunnel had yet been built anywhere in the world, railroad officials demonstrated their intent to replace the rail ferry with a tunnel when they incorporated the St. Clair River Tunnel Company on the Canadian side of the river in 1884, and consolidated that with the Port Huron Tunnel Company on the American side in 1886.

Selected to direct this tunnel project was Joseph Hobson. Hobson was born near Guelph, Ontario on March 4, 1834. As a young man he served his apprenticeship as a provincial land surveyor in Toronto, and after passing his examinations, worked in private practice for several years as a surveyor and engineer on railroads in the United States and Canada. In 1870 Hobson was the engineer of the Grand Trunk Railway's International Bridge, the bridge which crossed the Niagara River at Buffalo. After the completion of this bridge in 1873, he then became the assistant

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[10] "The St. Clair Tunnel," Engineering News (October 4, 1890): 292: and La Moille, Harper's Weekly: 158.

[11] "The St. Clair Tunnel," Engineering News (October 4, 1890): 292.

chief engineer of the Great Western Railway of Canada. Two years later, he was appointed Chief Engineer of the railway. When the Grand Trunk Railway bought the Great Western Railway in 1882, Hobson became the Chief Engineer of the Grand Trunk Railway's Great Western Division. In this capacity, he came to direct the work on the St. Clair tunnel between 1884 and 1891. In 1896 he became the Chief Engineer of the entire Grand Trunk system, until his retirement in 1907. Hobson died on December 19, 1917 at the age of 84.[12]

After conducting test borings of the river bed, and initiating small-bore test tunnels in 1885, work on the tunnel was suspended after a troublesome mixture of loose and wet sand and clay was encountered. Compounding these difficulties, test borings of the river bed revealed that the strata through which the tunnel would have to be excavated was dangerously shallow. Nevertheless, with the encouragement of a $375,000 subsidy from the Canadian government to cover 15% of the tunnel's estimated total cost, the Tunnel Company garnered sufficient confidence to resume the project in 1888. Additional test borings of the river bed conducted in the spring and summer of 1888 provided a more detailed picture of the ground material beneath the river. (See figure #1) Under 30' of river, the first layer of ground was comprised of a thin layer of fine sand and gravel which varied from 5' to 20' in depth. Below that was a 38' to 55' substratum of soft blue clay and quick sand above a hard rock base through which the tunnel would pass. It also contained pockets of dangerous natural gases. This substratum of river bed was so narrow that at one point the tunnel would be only 8' below the bottom of the river, and only 10' from the rock below.

By this point in time, the decision had been made to construct the tunnel using a combination of three elements of tunnel construction: 1) the shield method of excavation, 2) a permanent cast iron tunnel lining, 3) all conducted in a compressed air environment to inhibit the tendency of water flowing from the soft ground material into the tunnel heading.

The first of those elements, the shield method of tunnel excavation, had been developed and improved earlier in the 19th century by Marc I. Brunel and James Greathead in England, and Alfred E. Beach in America. Its principal advantage was that it served as a reinforced housing within which workers could excavate ground material from the face of the tunnel heading. In soft ground, the sharpened leading face of the shield could be

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[12]La Moille, Harper's Weekly: 159; Gerry Elder, ed., Fascinating Facts and Tunnel Treatise: A Collection of Papers on the St. Clair River Tunnel (Sarnia: Sarnia Historical Society, 1990); Dianne Newell and Ralph Greenhill, Survivals: Aspects of Industrial Archaeology in Ontario (Erin, Ontario: The Boston Mills Press, 1989), p. 186; and J.J. Feberwee, C.C. Tattersall and H.R. Laviolette, Early Construction Methods (Sarnia: St. Clair River Tunnel Centennial Committee, 1990).

pushed forward into the heading. In its most successful instances, the shield was combined with a cast iron lining which was assembled in a series of rings in the tail portion of the shield after each forward push into the river bottom. Cast iron linings proved more successful than brick because they were structurally sound immediately after the assembly of each ring, as opposed to the curing required of the mortar in a brick lining. This combination of shield excavation and cast iron tunnel lining had proven successful in tunneling through relatively dry ground, but only a few narrow tunnels (smaller than 10′ in diameter) had been successfully passed through unstable ground by this method.

At the same time that the shield method of excavation was proving successful for small diameter tunnels and for those bored through relatively dry ground, others were experiencing some success with using increased air pressure to prevent water from flooding subaqueous excavations. Compressed air had been particularly helpful in excavating caissons deep into river beds for bridge pier foundations. In the late 1870s, what might have become the first full-size subaqueous tunnel through unstable ground was begun under the Hudson River to link New Jersey and Manhattan. Using compressed air and a thin cast iron tunnel lining (but no shield), the construction of the Hudson & Manhattan railroad tunnel was tragically interrupted several times when the compressed air suddenly rushed out of the tunnel into the river above. The reduction in air pressure within the tunnel resulted in the flooding of the excavated heading with mud and water.[13] Even once the technical problems were overcome, financial difficulties delayed the completion of the Hudson River tunnel for another decade.

A project more comparable to the St. Clair tunnel was the City & South London Railway tunnel in England. A year before these three elements of tunnel construction were combined on the St. Clair project, they were brought together for the first time under the Thames River by James Greathead. However, because the 10′ diameter London tunnel was only half that of the St. Clair,

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[13]The Hudson River tunnel project continued, on and off, for several decades. Several weeks after the successful application of the shield, cast iron lining, and compressed air in the St. Clair tunnel on April 7, 1890, these three construction methods were finally combined in the Hudson & Manhattan tunnel project. While this approach proved successful, the project was again delayed by financial difficulties for more than a decade. The precise date when these three methods were finally implemented on the Hudson River tunnel project has not been conclusively determined. Contemporary engineering journals, however, provide evidence that the St. Clair project preceded the Hudson River project. See: S.D.V. Burr, "The Hudson River Tunnel," The Railroad Gazette (March 14, 1890): 174-6; "Profile of Proposed Tunnel and Cross Section of St. Clair River, July 13, 1889," Miscellaneous Design and Construction Drawings (1991).

and since it utilized compressed air for only a few short sections of its excavation through otherwise impervious hard packed clay, this earlier tunnel did not convincingly demonstrate the success of this construction method.

Therefore, while Chief Engineer Hobson can not be credited with devising an entirely original plan for undertaking the St. Clair project, he did direct the first practical test of this method of tunnel construction.[14]

Constructing the Tunnel

Since there had been so little previous success with subaqueous tunneling, the cost of contracting the work was expected to be very high. For this reason, the St. Clair River Tunnel Company decided to construct the tunnel itself.[15] Revealing some lack of confidence in the feasibility of this undertaking, the Chief Engineer deferred the costly excavation of the approach ramps until the tunnel proper proved successful. Therefore, special vertical shafts were excavated near the future portal sites from which the shields could begin their work at the proper elevation. After gently rolling the two shields down wooden tracks into shafts at their respective starting positions, tunneling was ready to begin. Excavation by the shield method was initiated on July 11, 1889 on the American side, and was begun ten weeks later on the Canadian side.[16]

The cylindrical shields were built by the Tool Manufacturing Company of Hamilton, Canada, and sent in pieces to the excavation sites on either side of the river for final assembly. Each of these 80-ton structures was constructed of 1"-thick steel plate, which, when assembled, was 15'-3" long and 21'-6" in diameter.

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[14]It appears that Hobson had access to simplified drawings of the shields designed by Beach, Greathead and others, and that he would have been aware of Greathead's use of compressed air on short sections of the City and South London Railway tunnel being constructed while the St. Clair tunnel was being planned. See: "Lighting Tunnels and Caissons," Engineering News (November 5, 1887): 328; "The Great Railway Tunnel Under the St. Clair River," Scientific American (August 9, 1890): 87; "The St. Clair Tunnel," Engineering News (November 22, 1890): 467; and "The St. Clair Tunnel," Engineering News (December 6, 1890): 498-499.

[15]"The St. Clair Tunnel," Engineering News (October 4, 1890): 293.

[16]There is some confusion concerning which day the Canadian shield initiated work. "The St. Clair Tunnel," Engineering News (October 4, 1890): 293; and "The St. Clair Tunnel," Engineering News (November 8, 1890): 425, indicate September 24, 1889; while La Moille, Harper's Weekly (February 28, 1891): 158, indicates September 21, 1889.

The front face (the cutting end) of the shield was divided into three horizontal sections and four vertical sections. These internal sections served to reinforce the shield as well as provide work platforms for the laborers at the tunnel headings. The cutting end of the shield featured raked vertical members which plowed into the face of the tunnel heading. Of the twelve compartments formed by these internal divisions, only two opened to the rear. In the event of a rush of water or mud into the shield, heavy doors would block these openings and protect the workers in the rest of the tunnel.[17]

The processes of excavating the river bed, advancing the shield, and assembling the tunnel lining were interconnected. After a few feet of tunnel were excavated, the shield was advanced that much deeper into the tunnel by 24 hydraulic rams, each 8" in diameter. These rams were located along the circumference of the rear of the shield and pushed against the last ring of tunnel lining constructed. By selectively operating some of the rams the direction of the shield's forward movement could be altered. A ring of tunnel lining was then erected in the space created in the wake of the advancing shield. The basic building block of the tunnel lining was a curved, half-ton, 12" x 18" cast iron segment. Thirteen of these segments, plus a smaller arch key segment, were assembled in place to create each ring of the tunnel lining and thousands of these rings were bolted together to form the 6000 foot long tunnel. After being heated to approximately 400 degrees, each segment piece was dipped in melted pitch before being assembled into a ring.[18] A counter-balanced, center-pivot assembly crane, which was vertically attached to the rear of the shield, was hand cranked to grip and move each of the segment pieces into place. (See figure #2) It took about 45 minutes to erect a single ring in place.[19] Once again, the hydraulic rams would then push against the newly erected ring of tunnel lining to advance the shield. The development of the center-pivot assembly crane on the St. Clair tunnel shields is credited with representing the full development of shield tunneling apparatus.[20]

Through some sections of the river bed the excavation work was significantly easier because the forward movement of the shield

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[17]"The Great Railway Under the St. Clair River," Scientific American (August 9, 1890): 87. The doors never required closing, according to: "St. Clair Tunnel," Engineering News (November 22, 1890): 457.

[18]W.M. Patton, A Treatise on Civil Engineering (New York: Wiley & Sons, 1895), p. 828.

[19]"The St. Clair Tunnel," Engineering News (December 6, 1890): 499.

[20]Graham West, Innovation and the Rise of the Tunnelling Industry (Cambridge: Cambridge University Press), p. 124.

was enough to extrude the softer mud through the cutting face and out the rear of the shield where it was loaded onto mule-drawn carts. Otherwise, the workers stationed in the shield's divided sections passed the excavated material out the two openings at the rear of the shield. The average rate of progress was 236 feet per month on the U.S. side and 219 feet per month on the Canadian side.[21]

As figure #3 depicts, a considerable length of shield excavation was undertaken before the tunnel headings began to pass beneath the river. The distance between the shafts dug at the portal sites, where tunneling began, and the point at which the two tunnel headings passed below the river bed was 1,716 feet on the American side, and 1,994 feet on the Canadian side. Since the engineers were little concerned about flooding until the tunnel headings passed beneath the river, compressed air was not introduced until April 7, 1890 on the American side, and May 20, 1890 on the Canadian side.[22] Before initiating the use of compressed air, 8' thick, airtight brick bulkheads were temporarily erected across each tunnel heading to contain the compressed air in the forward portion of the tunnels. Each bulkhead was punctured by two airlocks which were 17' long and 6' in diameter. These were for passing men, mules, construction supplies, and the excavated material between the natural air pressure on one side and the compressed air on the other. Each bulkhead also had a 25' long, 10" diameter airlock for passing the 6" diameter compressed air pipes into the tunnel headings. Workers and material would enter the air lock and wait for the gradual raising or lowering of the air pressure, depending on whether they were coming to, or going from, the compressed air to the natural air (2 to 5 minutes, depending on the leakage of compressed air from the tunnel into the river above). The compressed air was supplied by virtually identical plants on either side of the river. To assure that the required air pressure was maintained 24 hours a day, the pumping plants on each side of the river were established with duplicate systems. At the beginning of construction, air pressure was maintained at 10 psi above normal, but was increased another 18 psi when unstable ground was encountered.

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[21]The record month was July 1890, when the American shield progressed 383.30 feet. In one remarkable 24-hour period in that month the advance on the U.S. side was 15.3 feet, with a total of 10 rings of lining erected. Jerry A. Pinkepank, "A Tale of Two Tunnels: Concerning Blue Clay, Trunk Lines, and Ingenuity: The Story of the St. Clair and Detroit River Tunnels," Trains (September, 1964): 41.

[22]La Moille, Harper's Weekly (February 28, 1891): 158. Some concluded that it would have been wise to utilize compressed air for the entire tunnel excavation work. See: "The St. Clair Tunnel," Engineering News (November 22, 1890): 457.

A large force of primarily unskilled laborers worked in three shifts, seven days a week. Working at each heading during a typical shift would be 26 men excavating in the shield with hand tools, plus fifteen men assembling the tunnel lining immediately behind the shield. Dozens more labored elsewhere in the tunnel and on the surface.[23] Those who labored in the compressed air environment received a supplemental hazardous duty wage of about $1.00 per day, which nearly doubled their pay.[24] During the period in which the highest pressure was used, three workers died from the "bends" when they passed through the airlock without allowing sufficient time for the gradual equalization of the air pressure.[25] The very painful "bends," or "caisson disease," resulted when the body entered a lower atmosphere too rapidly, causing nitrogen bubbles to form in the bloodstream. The victim could suffer temporary or permanent crippling of the joints, or die altogether. On the brighter side, however, the air within the St. Clair tunnel was less harmful to the workers than that of most earlier tunnels because the headings were illuminated with electric incandescent lights, rather than the customary lanterns or torches.[26]

While the tunnel was being dug, a shallow bed of clay was temporarily laid on the floor of the tunnel lining, upon which were set rails and ties for a dual set of narrow gauge track. Along these rails, mules pulled the carts loaded with the excavated material out through the tunnel.[27] On August 30, 1890, after 2,000,000 cubic feet of material had been excavated, the Canadian and American headings met beneath the middle of the river. To the credit of the engineers responsible for maintaining the alignment of the tunnel headings as they worked their way toward each other, the two shields met edge to edge.[28] The two shields were then stripped of their internal dividers and left where they met. The final rings of the tunnel lining were erected immediately inside the abandoned shields. By January 20,

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[23]Pinkepank, Trains: 41.

[24]The 600 to 700 laborers were paid at the following rates: 17.5 cents per hour for diggers; 15 cents per hour for erectors; 12.5 cents per hour for others, plus the additional $1 per day for working in compressed air. See: "St. Clair River Tunnel," Keeping Track (January/February, 1991): 7.

[25]"The St. Clair Tunnel," Engineering News (November 22, 1890): 457.

[26]"The St. Clair Tunnel," Engineering News (December 20, 1890): 548.

[27]"The St. Clair Tunnel," Engineering News (December 6, 1890): 499.

[28]"The St. Clair Tunnel," Engineering News (November 22, 1890): 457.

1891, the last of the bolts holding the segments together were tightened and the tunnel interior was cleaned and treated.[29] While the tunnel proper was then finished, the tunnel approaches were yet to be completed. Twenty-six months after the start of tunneling, and only 17 months after compressed air was initiated, the first train ran through the tunnel on September 19, 1891.[30] The owners and the engineers were very pleased that the entire project was completed for $2,700,000, less than 10% over the original estimate.

Recognized as a great success, the tunnel did, however, include a design flaw relating to its ventilation capabilities. Ventilation was more than adequate during normal operations, thanks to the use of special coke-burning locomotives to pull the trains through the tunnel, and the placement of large Root blower fans at either portal to force fresh air into the tunnel. However, on two occasions when freight cars accidently de-coupled within the tunnel, several workers were killed by the excessive smoke and gases which accumulated during the delay in re-coupling the steam engine to the freight cars. This potential hazard was finally corrected in 1908, when steam-powered locomotives were replaced by electrified ones--the first electric conversion of a railway tunnel in North America.[31] The electric engines were safer, cheaper, and cleaner, and continued in use until they were replaced by diesel locomotives in 1958.[32]

In a curious reversal of the history of carrying rail traffic across the St. Clair River, as special freight cars became larger and taller, the tunnel could no longer be used for all rail traffic. While the tunnel remains in use today, in the 1970s an around the clock railroad car ferry system was reinstituted to carry the taller cars. The railroad plans to construct a new railroad tunnel next to the 1891 tunnel which will be capable of carrying today's larger freight cars. The new tunnel will be constructed using an updated version of the technology pioneered on the St. Clair tunnel--reinforced concrete segments instead of the earlier cast iron tunnel lining.

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[29]La Moille, Harper's Weekly (February 28, 1891): 159.

[30]Feberwee, Tattersall, and Laviolette, Early Construction Methods, p.11.

[31]Electrification had been built into newly constructed railroad tunnels prior to 1908, such as the B&O's 1895 Howard Street Tunnel in Baltimore. The 1908 modification to the St. Clair River Tunnel, however, represents the earliest conversion to electricity of a tunnel. See: Newell and Greenhill, Survivals, p. 192.

[32]Instead of General Electric's direct current, St. Clair used Westinghouse's single-phase alternating current. See: Newell and Greenhill, Survivals, p. 192.

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Previous documentation on file (NPS):

___ Preliminary Determination of Individual Listing (36 CFR 67) has been requested.
_X_ Previously Listed in the National Register.
___ Previously Determined Eligible by the National Register.
___ Designated a National Historic Landmark.
___ Recorded by Historic American Buildings Survey: #__________
___ Recorded by Historic American Engineering Record: #__________

Primary Location of Additional Data:

___ State Historic Preservation Office
___ Other State Agency
___ Federal Agency
___ Local Government
___ University
_X_ Other: Specify Repository: Library of Congress

## 10. GEOGRAPHICAL DATA

Acreage of Property: 16 acres

UTM References:

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| **A:** | 17 | 384280 | 4756920 | **B:** | 17 | 384300 | 4756820 |
| **C:** | 17 | 383440 | 4757160 | **D:** | 17 | 383420 | 4757260 |

Verbal Boundary Description:

The underground portion of this property begins at the western (Port Huron) portal which is located at a point 200′ west of the center line of 10th Street and equidistant between Cedar and Beard Streets. The underground portion of this property is 21′ (outside diameter) in width and continues eastward under ground and water for 6,026′. At this point the tunnel exits the Sarnia portal, where the nominated property (running in a straight line) expands to a width of 50′ until reaching the easternmost end of the retaining walls 2090′ east of the Sarnia portal. This portal is located at a point 405′ east of the center line of Christina Street and 220′ north of the center line of St. Andrew Street. The westernmost point of the nominated property lies in straight line 1655′ west of the Port Huron portal and is marked by the termination of the limestone retaining walls. See attached USGS map.

Boundary Justification:

The boundary includes the full length and width of the underground tunnel, plus that portion of both approach ramps bordered by limestone retaining walls.

## 11. FORM PREPARED BY

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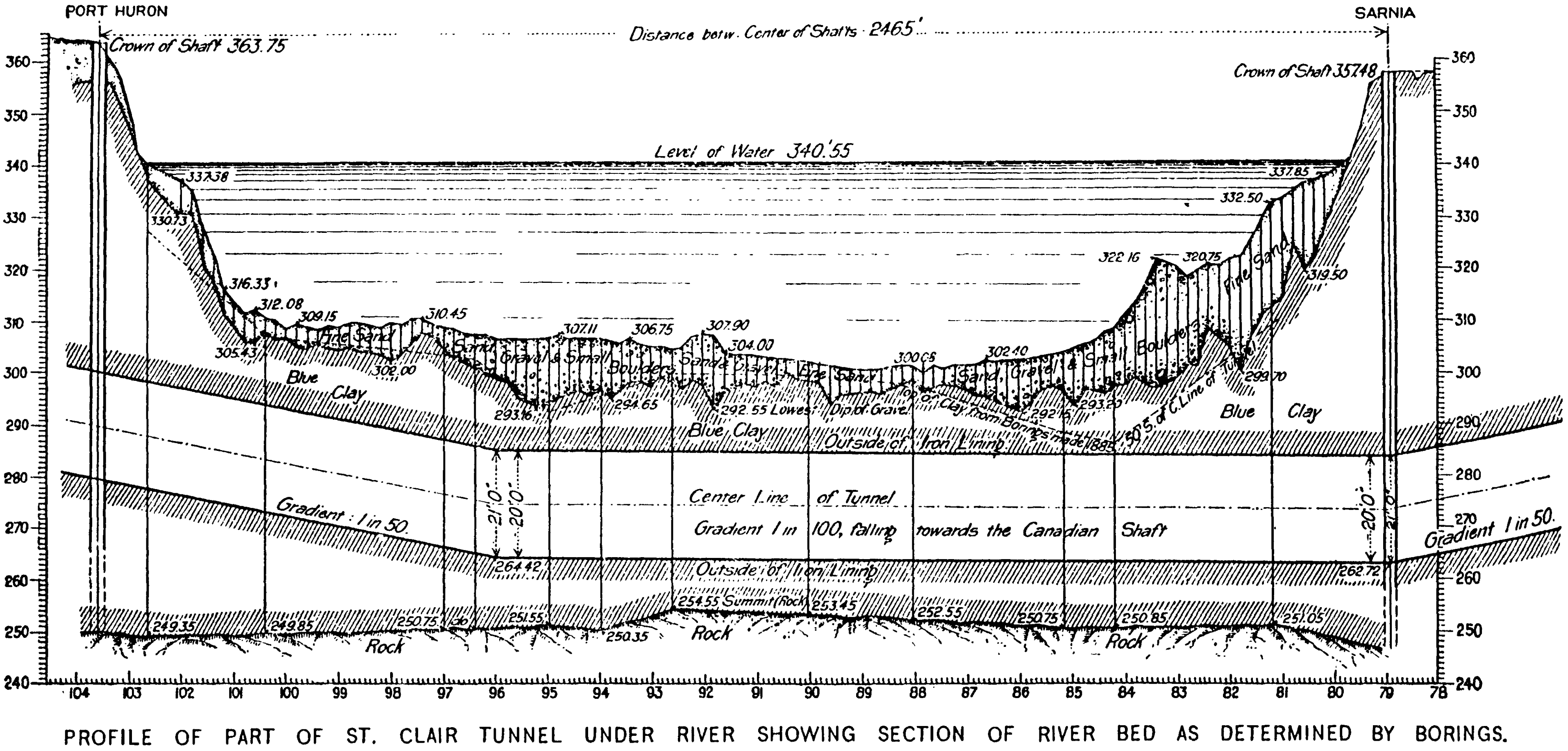


Figure #1
St. Clair Tunnel, River Profile
Engineering News, October 4, 1890, p.292.

# SCIENTIFIC AMERICAN

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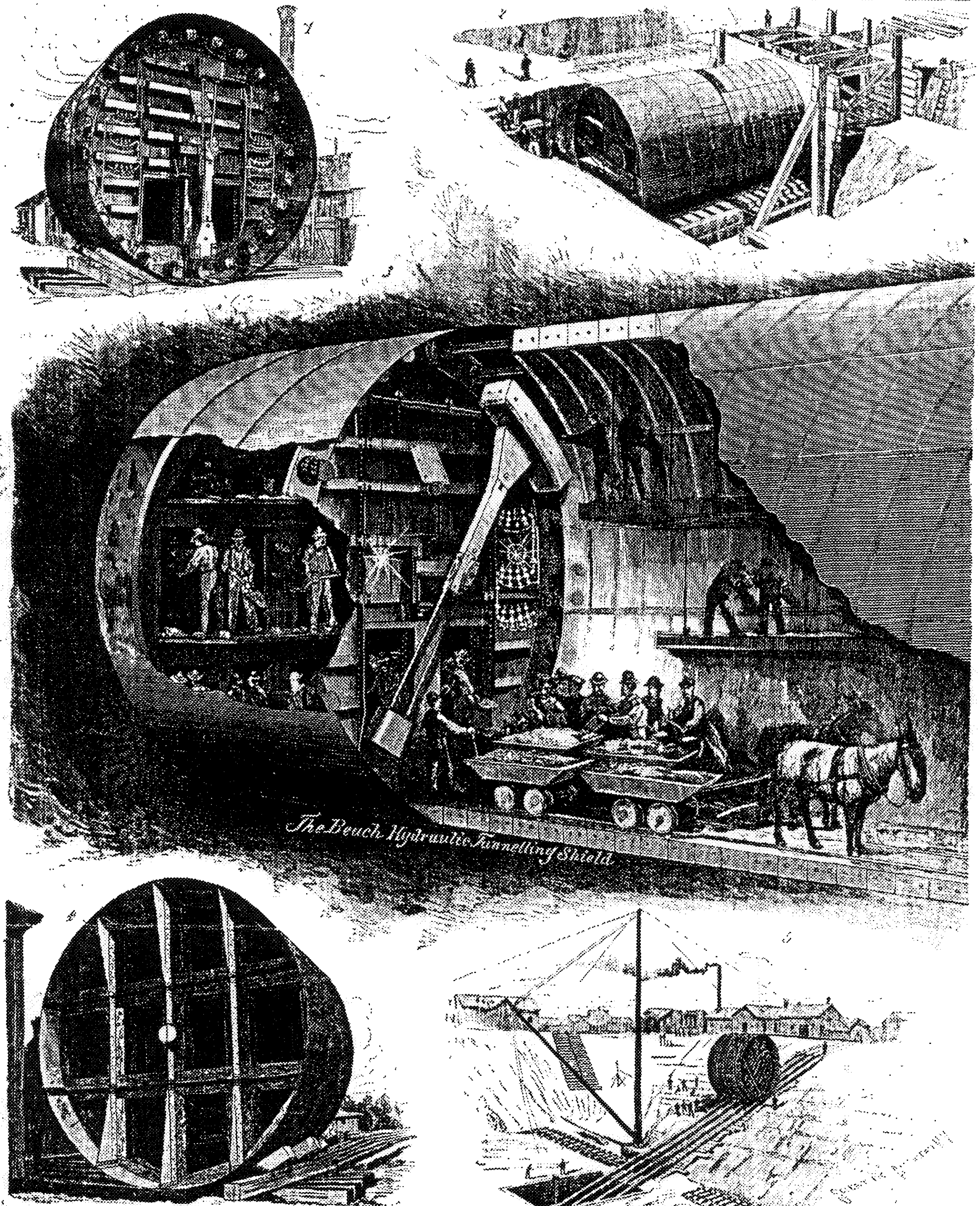


Fig. 1.—Rear view of the shield, showing hood and rams. Fig. 2.—The shield in place on grade. Fig. 3.—Interior view of shield and tunnel. Fig. 4.—Front view of shield. Fig. 5.—Lowering of the shield to the heading.

THE BEACH HYDRAULIC SHIELD AT WORK IN THE GREAT RAILWAY TUNNEL UNDER THE ST. CLAIR RIVER BETWEEN THE UNITED STATES AND CANADA.

Figure #2
St. Clair Tunnel Shield
Scientific American, August 9, 1890

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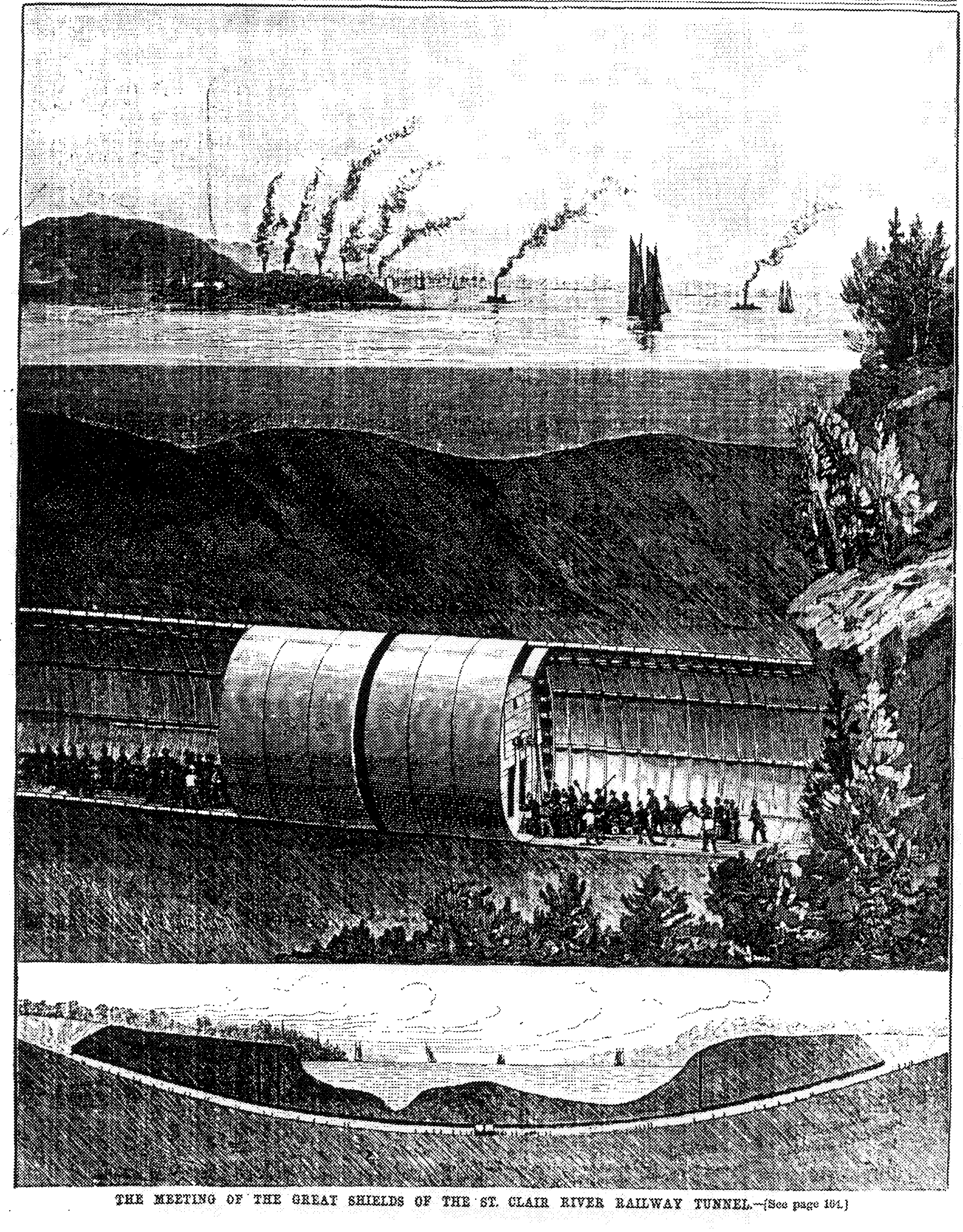

THE MEETING OF THE GREAT SHIELDS OF THE ST. CLAIR RIVER RAILWAY TUNNEL.—[See page 164.]

Figure #3
St. Clair Tunnel, Meeting of the Shields
Scientific American, September 13, 1890.