A Working Artifact: Restoration of a 1908 Manually Controlled Elevator in Toronto

Romas Bubelis

The restoration of this Otis-Fensom elevator revealed the ingenuity of early twentieth-century electro-mechanical engineering.

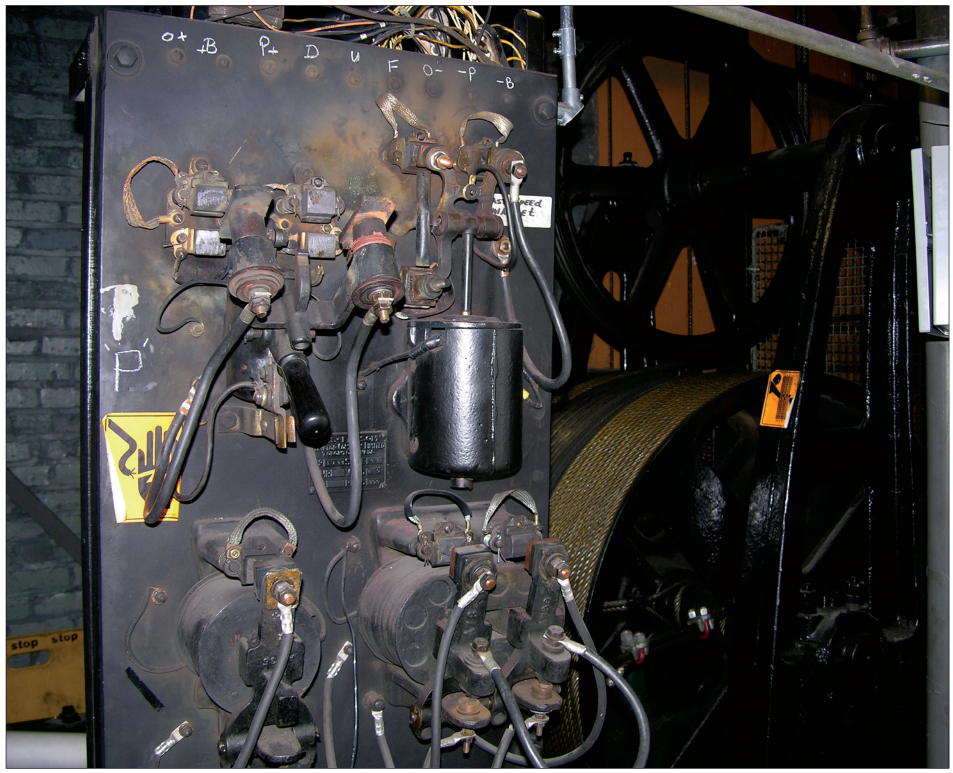

Fig. 1. Birkbeck Building, 10 Adelaide Street East, Toronto, Ontario, center, in the late 1920s. All images courtesy of Romas Bubelis/ Ontario Heritage Trust.

Fig. 2. The electrical controller in as-found condition in 2006, with electro-mechanical devices mounted to the front face. The cable drum and traveling sheave can be seen to the right.

The manually controlled Otis-Fensom elevator in the Birkbeck Building in Toronto was installed when the building was constructed in 1908, the same year that the Ford Model T automobile was introduced. A vintage Ford still driven daily is rare, but the Birkbeck elevator still offers visitors a daily lift, as it has for the past 110 years.

The Birkbeck Building is a national historic site located in Toronto's central business district. It is owned and operated by the Ontario Heritage Trust as the organization's headquarters, a venue for special events, a set for films, and as a commercial office building. This four-story block was designed by Toronto architect George W. Gouinlock for the financial-services firm Canadian Birkbeck Investment and Savings Company (Fig. 1).

A defining attribute of the building is the convincing impression it provides of an ordinary turn-of-the-century office structure. The building is itself an artifact but not a museum; it has functioning offices. The principal rooms are preserved, but so are many of the ordinary ancillary spaces, such as corridors, staircases, vaults, washrooms with period fittings, and offices with frosted-glass partitions. Historic appearances have been preserved but so has functionality. A variety of restored operable windows and transom panels still work as originally intended—to provide natural ventilation and light. The fact that these features are still in daily use contributes greatly to the experience of the place.

The elevator is a feature that was once common but is now rare.[1] The original elevator cab was replaced in the 1950s, but the original electro-mechanical equipment has survived in working condition as have the manual controls operated by an attendant, without automation.

Before restoration, reliability was a problem. Key 110-year-old electro-mechanical components were badly worn from usage. The machinery generally worked, but tolerances between moving parts were loose. It was difficult to find, and even more difficult to retain, elevator-service personnel who had an understanding of the archaic technology and experience in sourcing or machining replacement parts. The increasing frequency and duration of breakdowns reinforced an impression of obsolescence that put the heritage elevator at risk of replacement by modern equipment. Replacement would have relegated the original machine components to nonfunctioning status: static objects on display. The essential heritage experience of riding a manually controlled elevator in an open shaft would have been lost.

The Working Artifact

"A working artifact" was the driving concept; a historic machine still doing the work it was designed to do. Inspiration was drawn from automobile enthusiasts who prefer driving their vintage cars and even thrashing them in hill climbs and other race trials, rather than displaying them behind cordons. Much as the essence of a car is the driving experience, the meaning of a machine like this elevator is inseparable from the function it performs.

In 2016 the Ontario Heritage Trust launched a project with three objectives: to restore the original electro-mechanical machinery to "as new" condition without modernization; to recover the early twentieth-century appearance of the elevator cab; and to make the operating machinery of the elevator more visible to the public.[2]

The project approach was unlike a typical architectural-conservation project that might take as its starting point drawings and specifications for treatments to be undertaken by specialist conservators of historic building materials. The elevator process was more akin to restoring a vintage automobile: learning how the drivetrain works, searching for areas of malfunction and deterioration, overhauling salvageable parts, searching for spare parts, and machining replacement parts where spares are unavailable.

The project team included three individuals who had spent their careers in the elevator industry but were eager to postpone imminent retirement to work on the project.[3] All have a mechanic's curiosity about how things work and are able to understand engineering design from first principles (two members of the team, of course, have vintage automobiles that they have restored). They all brought knowledge of old supply chains and sources for obscure parts. A traditional machine shop was engaged, capable of fabricating one-off components from scratch. In this project, the technical skills and knowledge required were found in these dedicated individuals, rather than in a larger commercial elevator firm.

The Electro-Mechanical Machinery

The ingenuity of early twentieth-century electro-mechanical technology is a credit to the engineers of that time who resolved a set of electrical problems using mechanical solutions. It is in their inventive devices that the heritage value lies. Actions that today are accomplished invisibly by transistors and microchips were achieved in 1908 by the interaction of mechanical devices made up of cogs, shafts, springs, magnets, relays, cables, and weights—all in a state of friction, magnetic attraction, or momentum. The logic of the machinery can be understood by careful observation of these devices in action.

The electrical controller is the largest and most complex device of the operating machinery (Fig. 2). It was removed and taken to an elevator retrofit shop for overhaul. It consists of an upright slate slab to which are bolted the electro-mechanical devices that regulate the current flowing to the motor and brakes to control the movement of the cab. The devices are mounted to the front of the slab, and the connecting wires exit from the back of the slab. These devices include up-and-down solenoids, which prevent simultaneous initiation of up-and-down movement; accelerator relays, which initiate acceleration; a stopping magnet, which initiates magnetic resistance in the motor to slow it down; a brake coil, which engages the drum brake; a fast-speed solenoid, which engages at maximum speed; and the potential brake, an emergency-braking system that disengages power for zero potential for movement.[4] All of these devices move in coordinated action during a typical cycle of starting, acceleration, deceleration, braking, and stopping.

A close examination of the accelerator relays reveals the refinement of the mechanical design. There are four separate pairs of relays. They close in sequence when electric current is applied. Each successive pair of relays has a slightly larger gap between the contact surfaces than the previous one. As they clap shut, the extra millisecond longer that it takes to bridge the gap from the first to the fourth pair brings on the electric power in a smooth power curve rather than an abrupt one, a subtle and elegant solution.

The detailing of the restored accelerator relay is typical of the detailed attention applied to the rest of the project (Fig. 3). The original cast-iron armatures of the relay switches were disassembled, cleaned, and coated with a nonconductive paint.[5] New contacts (carbon on one side and copper on the other) were custom-machined. The spring-dampened brass clamp on the inboard side of the relay was reused and fitted with new springs and a cotter-pin retainer. This shock absorber–like device cushions the impact as the contacts clap shut or spring open with a corresponding electrical arc. New copper through-bolts were made, along with new insulating washers reproduced in Delrin, a contemporary plastic material, in place of the original Bakelite.[6] The existing high-tension wires with plastic insulation were replaced with a period-correct wire with braided fabric insulation. In place of twist ties, waxed strips of canvas were tied together to make wire harnesses as would have been the practice in 1908—the stuff of concours d'élégance.

A process of investigation and documentation preceded the conservation of the electric controller panel. Original shop drawings and wiring diagrams for this elevator were discovered in the Otis Elevator Company archives in Farmington, Connecticut. The shop drawings showed the position of the various rolling components and specified the motor's power and capacity and original cab weight. The wiring diagrams were deciphered in order to understand the conceptual electrical layout. These drawings, diagrams, and specifications were supplemented by careful observation of the machinery in action and through disassembly of individual components. Meticulous field notes were made to document the physical layout of the wiring on the back of the controller panel. All circuits, once identified, were coded with stamped brass tags. Extensive photo-documentation of the existing condition ensured that once disassembled, all components could be correctly reconstructed.[7]

The controller is basically a modulating device that manages the action of the elevator's drivetrain components. As a type, the Birkbeck unit is a winding-drum elevator, with the major components located in a basement mechanical room rather than in the penthouse, as is the case with the more common traction-type elevator. The drivetrain components consist of a 1908 Otis electric "pancake" motor, so called because of its low profile. Its driveshaft passes through an adjacent brake used for slowing under normal operating conditions. The brake consists of a friction plate initiated by magnetic force to tighten around the outer surface of a rotating drum. The driveshaft terminates in a reduction drive. A small-diameter worm gear engages a much larger toothed-ring gear attached to the winding drum, thereby converting the relatively high rotating speed of the motor to the slow rotating speed of the drum. As power is applied, the grooved drum rotates to spool out or wind in the hoisting cables. The cables are attached to the head beam of the elevator cab and also to counterweights that reduce effort on the part of the motor to overcome inertia for lifting and the strain on the brakes when a loaded cab is descending.

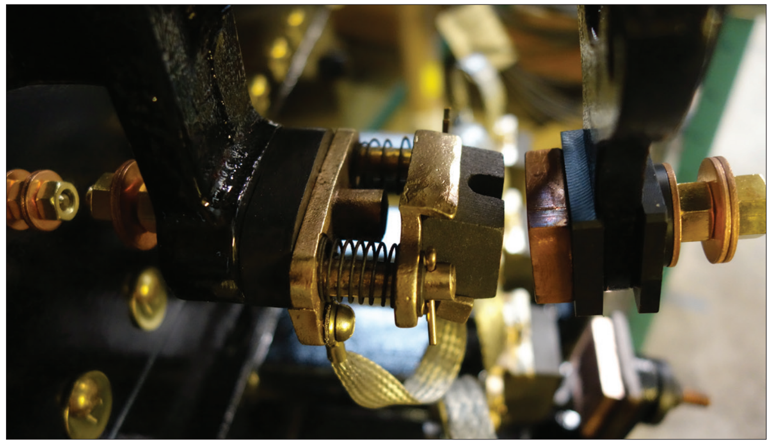

Fig. 3. Detail of a restored accelerator relay with salvaged and conserved components, combined with custom-machined replacement parts.

Fig. 4. Detail of the original 1908 stationary sheave located at the penthouse level, showing an axle with new bearings. The "fly-ball" governor is visible in the background.

Sheaves are large, grooved steel wheels that guide the cables and keep them centered. One traveling sheave is located above the winding drum. It moves horizontally to evenly guide the cables onto the grooves of the drum. An additional four stationary sheaves are located in the penthouse level at the top of the shaft. These keep the cables centered in the shaft. The sheaves and drum were tested for signs of metal fatigue using magnetic particle testing under ultraviolet light.[8] New bearings were installed on the axles of each sheave. New cables were also installed, but the motor, brake, and geared reduction drive needed only minor maintenance.

The centrifugal "fly-ball" governor is an ingenious device that is part of a fail-safe emergency-braking system.

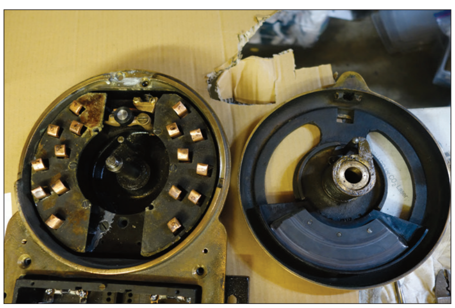

Fig. 5. Faceplate of the antique Otis-Fensom cab switch donated to the project.

Fig. 6. The disassembled switch shows the "finger" accelerator contacts on the stationary side (left) and the corresponding curved carbon contact plate on the inside face of the outer rotating plate.

It consists of two cast-iron spherical weights, each on an arm attached to a central pivot (Fig. 4). The device is attached directly to the cab by a separate set of cables and spins in concert with the movement of the cab up or down. If the speed is too great, centrifugal force causes the weights to rise as they spin until they trip a spring-loaded switch, which mechanically engages a ratchet brake device mounted to the underside of the floor of the cab. This safety brake is an evolution of the ratchet system introduced by Elisha Graves Otis in the 1860s.

The cab switch, located inside the elevator cab, is the interface between the human hand and the machinery. It sends low-voltage signals to the controller, which then initiates motion of the drivetrain to raise, lower, or hold the cab. The cab switch is a circular plate with a projecting handle (Figs. 5 and 6). Top dead center is the stop position. The elevator attendant can rotate the handle counterclockwise to go down and clockwise to go up. If released, the handle returns to the top position to stop movement, similar to a "dead man" safety switch found on early locomotives. The inner workings of the cab switch, as expected, follow electro-mechanical design principles. When disassembled, the device consists of a stationary bottom plate and a rotating outer plate. The fixed bottom plate contains eight spring-loaded "finger" contact points on either side of top dead center. The rotating outer plate contains a curved carbon contact strip. As the outer plate is rotated, the contact strip engages each individual finger contact in sequence, not all at once. The farther the plate is turned away from top dead center, the more contact fingers are engaged and the greater the acceleration. Conversely, the closer the plate is to top dead center, the fewer finger contacts are engaged, resulting in less acceleration. Fortunately, an authentic Otis-Fensom-era cab switch bearing the company logo in a private collection was donated to the project. It was refurbished and adapted for use in the new reproduction elevator cab.

The Replacement Passenger Cab

The replacement of the elevator cab itself presented a different series of challenges. Elevator cabs from the early twentieth century typically consisted of a platform and structural frame provided by the elevator manufacturer with walls, ceiling, and finishes provided separately, depending on requirements. Following the automotive analogy, a manufacturer provides a chassis and engine that is then taken to a specialist fabricator for bespoke coachwork. The walls of the 1950s Birkbeck elevator cab were disassembled, revealing the original 1908 Otis-Fensom-supplied structure, consisting of a head beam and two vertical structural channels with attached diagonal metal straps supporting the original slung wood floor (Fig. 7).

No detailed documentary evidence of the design of the 1908 elevator-cab interior was located. The shop drawings did indicate two gusset plates of curved profile, possibly suggesting a coved ceiling. It was decided to use a surviving 1916 Otis-Fensom cab in the former Masonic temple in Toronto as a precedent upon which to base a replacement design. Emphasis was placed on replicating the utilitarian machine aesthetic and on the selection of lightweight materials so as to not exceed the drivetrain's weight capacity. The walls and ceiling were fabricated and mocked up off-site as a kit of parts that was then assembled on-site within the old Otis-Fensom cab structure (Fig. 8).

The walls of the cab are formed of rolled-steel panels, bolted together and post-painted. The ceiling is made of formed sheet copper with riveted brass straps and coved edges. Three sides of the cab have a fretwork of bars with glass backing at frieze level, providing a visual connection to the open shaft. The fourth wall is formed by the restored original Bostwick gate. This accordion-type brass gate is completely open to the elevator shaft.[9] The floor is finished in hexagonal opaque glass tiles with a contrasting border, similar to 1908 tilework found elsewhere in the building. The floor includes a brass access panel bearing the logo of the Otis-Fensom Company. It was an unexpected donation to the project by a tradesperson installing the floor (Fig. 9).

From the outset, the project had a didactic dimension. The intent was to make the restored machinery visible to building occupants and visitors while also maintaining safety requirements. The elevator mechanical room was fitted with a pair of fire-rated doors with large glass panels through which the controller, motor, winding drum, and sheaves may be viewed while in motion. Dramatic spot lighting was added to highlight individual components. A similar door and similar lighting were installed in the former elevator electrical room, which contains the decommissioned original electrical panel, transformers, and mercury-arc rectifier. The rectifier converted incoming alternating current into the direct current required by the motor. It is a colossal light bulb–like vessel containing mercury vapor that once glowed ultraviolet when current passed through. Even in its decommissioned state, it is an evocative artifact of early twentieth-century electrical technology.

The project also included the restoration or supply of a number of elevator-communications features. An original bronze Otis call-button plate was used to cast five replica plates. On each floor level, the call plates were fitted with electrical circuits, and each plate was fitted with a black call button and a custom-made, translucent, backlit ruby-red button that glows when the elevator is in service. The surviving original call annunciator was restored. This cab-mounted magnetic mechanical device tells the attendant which floor requires service when a call button is pushed. With a push of a call button, a small white flag appears in the appropriate window representing the floor. The trigger is a spring latch and a magnet. After a call is received, the attendant resets the device manually. The original sliding wire-glass frames of the shaft doors at each level were repainted. Each has a contact switch that prevents movement until the door is in the fully closed position. These switches were rewired. In the main-floor lobby, a floor-position indicator was installed. It has a bronze arrow that sweeps across an arc, indicating the current floor position of the elevator.

Fig. 7. Looking down the shaft at the original elevator-cab structure after the walls were dismantled, 2018. Components include the head beam with hoisting cable and vertical channels with diagonal straps supporting the original slung wood floor.

Fig. 8. Mock-up of the reproduction elevator cab in the factory. The walls consist of formed panels of cold-rolled sheet steel bolted together.

The 1908 Otis-Fensom elevator has been restored to life (Fig. 10). Its work is again accompanied by the clapping of electrical contacts, the flash of electrical arcs, the whine of the motor, the whirl of the drum, and the twang of steel cables, as before, all under the control of an attendant's hand. Riding in the cab watching the floors pass by is an elevator experience unlike any other. Press the button; it is always worth the wait.

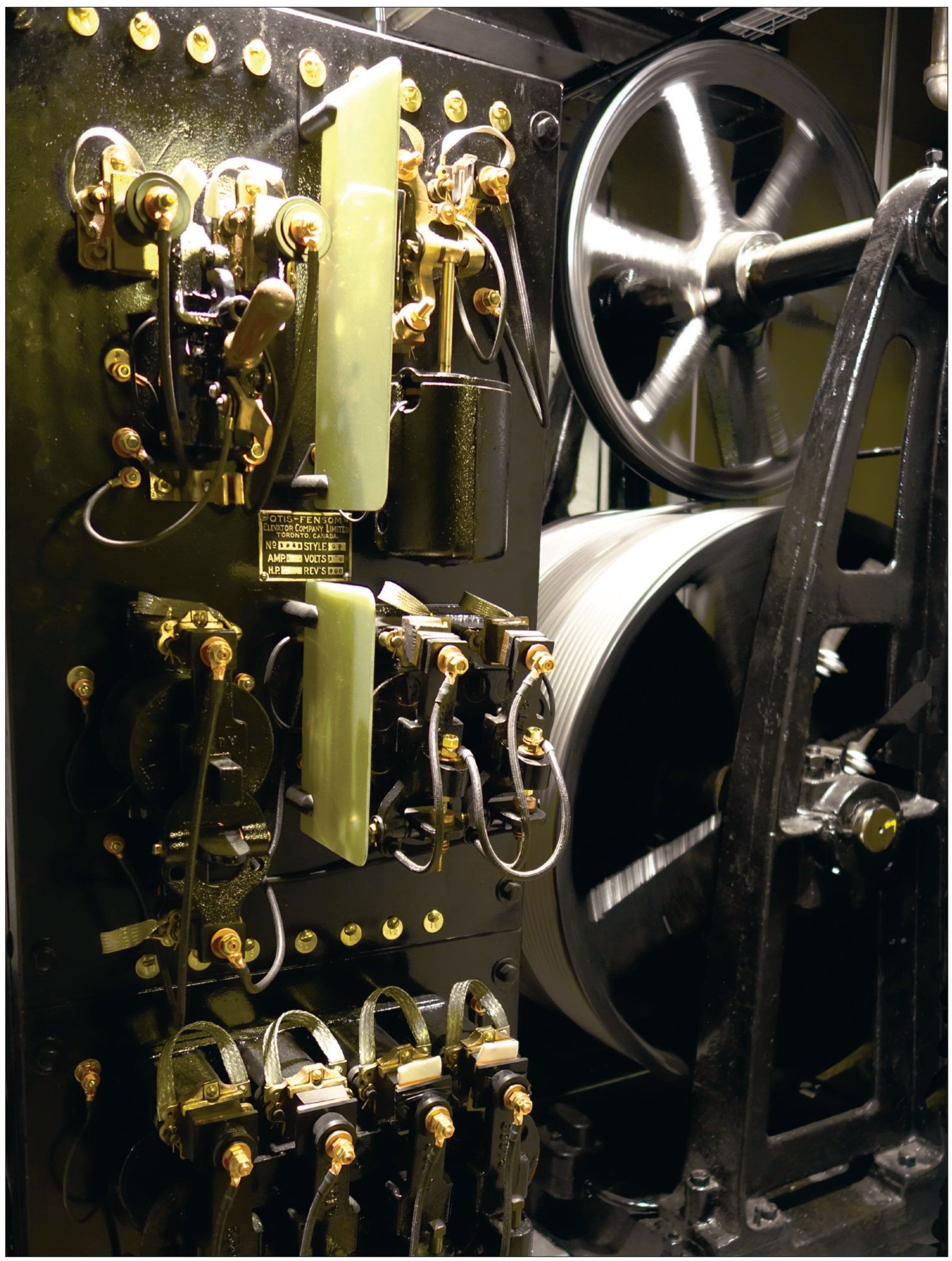

Fig. 9. Interior of the reproduction cab. Walls are post-painted, and the cove ceiling is formed from sheet-copper sections held by brass straps with rivets. The restored brass Bostwick gate appears at right.

Fig. 10. The restored electrical controller with cable drum and traveling sheave in motion.

Notes

1. The Otis-Fensom Company Limited was created in 1905 with the merger of Canadian Otis, a subsidiary of the U.S. parent company, and Canadian Fensom Elevator Company. The Otis-Fensom Company was based in Hamilton, Ontario, and operated through 1949. Detailed discussion of the history, development, and influence of elevators can be found in Andreas Bernard, *Lifted: A Cultural History of the Elevator* (New York: New York Univ. Press, 2014).

2. The project was funded by a cost-share agreement between the Ontario Heritage Trust as the Province of Ontario's lead heritage agency and the Parks Canada National Cost-Sharing Program for Heritage Places. Parks Canada is the Government of Canada department responsible for managing natural and cultural heritage.

3. The owner of the building is Ontario Heritage Trust; the project architect was Romas Bubelis, OAA; the consultant engineer was Rob Isabelle of KJA Consultants Inc.; the project manager was Mark Ockwell, of KJA, now retired; the electro-mechanical specialist was Ernie Cox of Vertex Industries Inc.; the cab fabricator was Jeff Malcom of K-Elevator

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Cab Ltd.; and the elevator contractor was Phil Warne of True Canadian Elevator Maintenance Company Ltd.

4. “A solenoid is a coil of wire usually in cylindrical form that when carrying a current acts like a magnet so that a movable core is drawn into the coil when a current flows and that is used especially as a switch or control for a mechanical device such as a valve”; *Merriam-Webster Dictionary*, s.v. “solenoid,” accessed 2019, https://www.merriam-webster.com/dictionary/solenoid.

5. Nonconductive paint is a specialized coating that limits the transfer of electricity to the metal substrate, in this case, cast-iron armatures holding electrical contact pads. The controller board was also treated with nonconductive paint to help insulate the various attached electrical circuits from each other and the board substrate.

6. Bakelite, an early plastic made from synthetic components, was invented in 1907 by chemist Leo Baekeland. The material was used to manufacture a great variety of products and was favored for its electrical nonconductivity and heat resistance in electrical insulators.

7. Spare parts of cyclical replacement items, such as electrical contacts, were manufactured and stockpiled. Upon completion of the project, copies of archival material from the Otis archives, along with baseline documentation photographs, conservation in-progress photographs, and annotated field notes were filed in the Ontario Heritage Trust archives. The elevator contractor produced an operation manual to guide future maintenance activities.

8. Magnetic particle inspection (MPI) is a magnetic-based, non-destructive testing process for detecting hairline cracks in ferromagnetic materials like iron. In this project, ferrous particles (iron filings) suspended in liquid with fluorescent pigment were brushed onto the sheave while it was magnetized. The particles in liquid coalesce if there is a crack, and that concentration is visible when viewed under ultraviolet light. The testing process was accomplished in situ.

9. Bostwick refers to the original patentees of the device, Bostwick Gate & Shutter Co. Ltd. of London, England.

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