INDUSTRIAL CROSSROADS; BUFFALO AND THE NIAGARA FRONTIER

A GUIDEBOOK
for the

SOCIETY FOR INDUSTRIAL ARCHEOLOGY

21ST ANNUAL CONFERENCE
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Edited by
Thomas E. Leary
Elizabeth C. Sholes

Contributors
Thomas E. Leary
Elizabeth C. Sholes
Duncan Hay
Martha Costello
David Crossland
John Healy
Michelle Greenwald
Ralph Greenhill
Robert Barnett

INDUSTRIAL CROSSROADS; BUFFALO AND THE NIAGARA FRONTIER
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INTRODUCTION

The industrial topography of Buffalo and its environs has been sculpted by several economic cycles and cataclysms that were manifested in the built environment and the transformation of landscapes. While the most significant surviving sites date from the 1890s through the 1920s, the chief stages of growth and decline in Erie and Niagara counties may be summarized through three prominent symbols: intermodal commerce first generated by the Erie Canal and its enlargements (1825-1890s); industrial development catalyzed by the relocation of the Lackawanna Steel Company to the shores of Lake Erie (1900s-1980s); the megalithic state university campus planted on the barren plains of a northern suburb with the hope that knowledge, private capital and public policy would cross-pollinate and flourish (1970s-present). The structures, technologies and jobs that characterized the first two of these distinct, though overlapping, eras are the focus of the pages that follow, particularly with respect to the key themes of grain and iron, bread and steel--the lifeblood of the lakes for many generations.

Construction of the Grand Erie Canal to connect the Hudson River with Lake Erie commenced in 1817 and culminated in 1825, vaulting over the Niagara escarpment via a twin flight of combined locks en route. Governor Clinton's storied Ditch riveted the present pattern of settlement on the upstate region of New York, boosted the fortunes of canal towns at the expenses of turnpike centers or settlements on natural waterways, and established Buffalo, the western terminus, as a major transshipment node--gateway to the midwest, back door to the Atlantic. A century later, the twin replicas of the Statue of Liberty facing east and west atop a downtown bank still celebrated the city's location as inevitably strategic; the Jazz Age was perhaps the last time when it was possible to do so realistically.

On the rudimentary waterfront of the 1820s and 1830s Buffalo's harbor was little more than the mouth of a sluggish creek. Deep-draft schooners and steamers of the growing upper lakes fleet exchanged passengers, package freight and bulk commodities with barges plying the Ditch or (after 1829) vessels transiting the Welland Canal across the border to reach Lake Ontario and the St. Lawrence River, the alternate route from the inland seas to the ocean. In the 1840s and 1850s the tentacles of trunk line railroads began enveloping the city, further enhancing its position in the evolving continental transportation network. By the 1880s roundhouses and car shops, including the facilities of terminal switching lines such as the Buffalo Creek RR, had become the area's largest individual employers as well as focal points for labor unrest during the national strikes of 1877. The maze of yards and tracks crosshatching East Buffalo also foiled Frederick Law Olmsted's plan to string one of his emerald necklaces around the urban perimeter.

Where water and rail transport converged, the 19th-century port of Buffalo accumulated an extensive inventory of structures and equipment for the mechanical handling and storage of bulk commodities such as eastbound grain and iron ore or westbound coal, primarily anthracite from the Wyoming, Lehigh and Schuylkill fields of eastern Pennsylvania. An inner and outer harbor system, embracing both the Buffalo River and protected anchorages in Lake Erie, was organized around artificial slips, basins and coastal protection works. Wooden grain elevators sprouted beside the waterways as did lake-transfer coal trestles that discharged by gravity through pockets and chutes in the manner of Lake Superior ore docks. As the industrialization of the Great Lakes littoral proceeded apace, the elevators in particular came to dominate the waterfront both visually and economically, only to be superseded by larger, more efficient, less combustible successors.

"Over and above the elevators," pronounced Anthony Trollope at the time of the Civil War, "there is nothing specially worthy of remark at Buffalo." Perhaps--though more than one European intellectual experienced the hulking granaries while missing their meaning. In any event, Joseph Dart (1799-1879) is usually credited with fathering the grain elevator as a distinct type of industrial architecture in 1842. Dart was a merchant with {no/little] technical background, and he acknowledged an explicit debt to the bulk-handling methods first devised by Oliver Evans. He described his offspring as "... a warehouse, of large capacity for storage with an adjustable Elevator and Conveyors to be worked by steam; and so arranged as to transfer grain from vessels to boats or bins, with cheapness and dispatch." However, Dart's active involvement in the grain trade was of relatively brief duration.

It was the engineer Robert Dunbar (1812-1890) who devised the characteristic unloading mechanism required for raising grain from a ship's hold on an endless string of buckets: this movable contraption was the "adjustable Elevator" called a marine leg for which Evans' inventions provided no precedent. Dunbar went on to establish a distinguished career in this specialized field of machinery design and construction. In action, the protruding marine leg captivated the imagination of tourists such as Trollope and Kipling who compared the symbiotic link between vessel and elevator to the proboscis of a mosquito or the trunk of an elephant.

Dart and Dunbar's collaborative project could hold 55,000 bushels in its storage areas as of 1842-1843 and could elevate grain at the rate of 1000 bushels per hour. Both figures doubled within three years. By the 1880s there were numerous elevators in the harbor with a wide range of storage and transfer capacities of waterborne grain to barges or rail cars. Dunbar's adaptation of Evans' elevator leg to make it retractable had indeed been the key breakthrough in securing Buffalo's commercial position. As an 1899 newspaper article surveying the state of the waterfront put it with pardonable braggadocio:

> The main purpose of the Buffalo elevators is to take grain from lake vessels and put it into railroad cars or canalboats for transportation to the seaboard...Buffalo stands first in the world in the

> application and use of marine-elevating machinery. No port can rival it in the quantity of grain elevated from vessels, or in its capacity to handle this vessel grain...Here is Buffalo's pre-eminence; it is the greatest port of the world for the transfer of grain from boat to shore.

The first elevators also decimated the ranks of Irish longshoremen and initiated a trend toward injecting capital into the labor-intensive process of unloading grain boats; but they did not entirely eliminate the role of human effort. On the vessels that call at Buffalo's four active marine receiving elevators, gangs of scoopers still descend into the holds to manipulate power shovels and other gear used in moving the grain to within reach of the marine legs. They follow an occupation whose traditions may be exceeded only by its hazards: job-related illness from inhaling grain dust during the course of strenuous exertion was identified by Victorian physicians as "elevator pneumonia." The uneven tenor of labor relations was another constant in the history of the 19th-century waterfront. Taxed by abusive hiring practices, both the grain scoopers and the lumber shovers, the harbor trade least affected by mechanization, struck during the 1890s to eliminate economic intermediaries such as boss scoopers and stevedores who interfered with direct bargaining between employers and employees.

Manufacturing soon augmented commerce. Already enmeshed in an international grain market, local traders were haunted by the spectre of idle shipping that continued to clog the docks following the Panic of 1857. A self-appointed leadership cadre within the business community offered a critique of Buffalo's prospects: one of the most articulate spokesmen was John Wilkeson, whose father had overseen construction of the first privately-funded local harbor improvements. In the view of Wilkeson and others, the maritime economy predicated on the lake-canal interchange now seemed threatened by forces beyond local control. The waterfront no longer provided sufficient steady jobs for a growing population because of labor-displacing technology such as the grain elevators. A few speculators had amassed profits from rising real estate values, but their gains were channeled into ostentatious consumption rather than investment that might benefit the community. Boosters of manufacturing advocated an economic diversification program that would tap the great east-west flow of minerals, grain and forest products to nurture resource-based enterprises.

As would later be the case at the turn of the century, the most spectacular of the new departures resulting from this propaganda campaign involved the smelting and refining of iron ore. Previously remote from raw material sources, Buffalo's intermediate location between western ore and eastern coal became advantageous as water and rail transportation improved, particularly with the opening of the Sault Ste. Marie Canal in 1855. Unfortunately, little physical trace remains to mark the sites of the iron works established during the 1860s. On the peninsula once known as Farmer's Point where Hamburg and Katherine streets meet the Buffalo River, two partnerships began building blast furnaces in 1860-1861. The companies eventually merged and expanded as the Union Iron Works before succumbing to hard times following the Panic of 1873. Another blast furnace was constructed during 1863-1864 in the Black Rock section where what is now Hertel Avenue crossed the Erie Canal and ran down to the Niagara River. Known as

Fletcher's Furnace, this project marked the continued backward integration of Pratt & Co. from hardware merchandising into iron manufacturing. In the late 1850s the same firm had acquired the 1847 iron and nail works at the junction of Scajaquada Creek, Niagara Street and Forest Avenue where the processes of puddling and rolling had been introduced to Buffalo.

All the Civil War-vintage blast furnaces used anthracite for fuel since mines in eastern Pennsylvania were readily accessible via rail and canal. Furnace charges included ore from the upper Great Lakes combined with iron from Lake Champlain and other districts in Ohio and Canada. The stacks featured energy-saving closed tops and vertical hoists to facilitate the constant process of dumping raw materials into the furnace.

State-of-the-art technology alone could not keep Buffalo's first-generation blast furnaces in business, however. The plant at Tonawanda, established in 1873 as another venture by Pascal Paoli Pratt and associates, never really got off the ground. The furnaces at the Union Iron Works were blown out in 1876. Fletcher Furnace hung on a bit longer. It was rebuilt in 1881 to use coke, but the changeover to a more efficient fuel provided little help; the stack was finally dismantled in 1885. Despite Buffalo's strategic geographic position its iron industry did not prosper as automatically as the grain trade.

A key figure in the revival of local pig iron production was Frank B. Baird. After settling in Buffalo in 1888, he swiftly mobilized business and political connections from his native Ohio to rekindle idle blast furnaces on the Niagara Frontier. Tonawanda, dormant for 15 years, resumed operations after a capital transfusion from Rogers, Brown & Co., Cincinatti pig iron dealers. Baird relied on a similar relationship with M.A. Hanna & Co. of Cleveland to bring about the 1900 consolidation of the Buffalo Union Furnace Co., comprising three new stacks on the 1860s site of the Union Iron Works.

Capital drawn from out of state thus helped make Buffalo a major center of low-cost pig iron production in the early 20th century. Howver, such investments also isolated plants and jobs from the context of community development that John Wilkeson had advocated. Many decisions concerning expansion or contraction would henceforth depend on cost and profit calculations by corporations without siginificant local ties. Frank Baird, who had disposed of his share in Buffalo Union Furnace to the Hanna interests in 1920, warned of the dangers inherent in the loss of local control before his death in 1939.

The consequences of Baird's initial successes extended beyond his own enterprises. The resuscitation of rusting sites dispelled the investment community's lingering doubts about the potential profitability of iron and steel in Buffalo. As the area became a magnet for heavy industry after 1900, established lines of production such as merchant pig iron grew even stronger. In 1904-1905 the Buffalo & Susquehanna Iron Co. blew in new blast furnaces at South Buffalo on the Union Ship Canal. Other plants, though, undertook something new to the area--the making and shaping of steel.

Buffalo's relatively late entry into this field at the turn of the century was actually an advantage. In the narrow river valleys of Pennsylvania where iron mills had flourished in profusion, congested sites limited potential expansion; it proved difficult to integrate new technologies into existing works. Not only did the lakeshore districts offer large tracts unencumbered by previous construction, they were becoming even more desirable points for assembling raw materials and distributing finished products to eastern and western markets. The opening of the Mesabi iron range in 1892 accelerated what would become an early 20th-century trend toward building greenfield plants on the Great Lakes.

The company that decided it would eventually be better off in Buffalo came from Scranton, Pennsylvania. Lackawanna Iron & Steel could trace its history back to 1840 and had rolled Bessemer steel rails since 1875. President Walter Scranton observed that relocation had been considered for several years preceding the final decision in 1899 to build anew at Buffalo from whence the company was already shipping its rails by lake to Chicago and Duluth. The Niagara Frontier thereby gained a major new industry as the initial phase of construction was carried out between 1900 and 1903; Scranton suffered the same job and revenue losses that would hit home here when plants subsequently closed.

It would be difficult to exaggerate the significance of Lackawanna Steel's arrival. Easily the most visible of the many plants that got started or moved to the region during the heady years of the early 20th century, steelmaking sparked a burst of industrial expansion that would have dazzled John Wilkeson. Even the Buffalo newspapers eventually perceived that the Lackawanna development represented a watershed, shifting the community's economic center of gravity from the commercial transhipments of the past to the heavy industries of the second Industrial Revolution. Other steel companies soon followed Lackawanna's lead. In Blasdell Seneca Iron and Steel began rolling sheets near the Lackawanna works in 1907. During the same year New York State Steel (later known as Donner Steel and subsequently a Republic plant) started its open hearths at South Park Avenue and the Buffalo River. Shortly thereafter Wickwire Steel commenced building a blast furnace at Rattlesnake Island in the Town of Tonawanda on the Niagara River, achieving fully-integrated operations by the First World War.

While steel production geared up around the turn of the century, a major transition in building construction and power sources reshaped the form and functions of many Niagara Frontier industrial landmarks. Reinforced concrete began displacing wood and load-bearing masonry, permitting greater areas of glazing to flood daylight over larger factory floors and hordes of newly-mobilized workers. Electricity generated at central stations and delivered over long distances through an increasingly-dense power grid superseded reciprocating steam engines and mechanical transmission systems at individual sites. Expressed in such classic developments as the Pierce-Arrow and Larkin complexes, the engineering and technology of this era may be seen most dramatically in the descendants of Dart and Dunbar's grain elevator.

As spiraling insurance rates rang down the curtain on the half-century run of the wooden elevator, three types of fireproof storage stood waiting in the wings: round or square steel bins; round tile bins; and reinforced concrete bins. After extensive North American auditions the concrete cylinder was cast for the lead and quickly took center stage. In Buffalo, the first steel elevators on the waterfront, the Great Northern and the

Electric, appeared in 1897 while the last of the breed, the Monarch, was completed in [1905]; the first example of concrete construction at the inner harbor, the American Malting storage house, opened the following year.

The triumph of concrete over steel and tile was founded on its suitability for the requirements of storing grain and its relatively economical construction costs. Reinforcing steel embedded in the walls handled tensile stress that concrete alone could not tolerate. Circular bins called for proportionally more concrete than other configurations, but could get away with using less steel. The round silo was also well-suited to novel construction methods such as using "slip-forms" (also known as "moving shutters") to permit continuous pouring of concrete rather than relying on a series of fixed lifts. Various eminent elevators builders including John S. Metcalf, Macdonald Engineering and Barnett & Record have claimed or been given credit for introducing early versions of slip-forming.

However, in order to fully capitalize on the advantages offered by this new medium, a shift from empiricism to science had to occur in the field of grain elevator design. This development was summarized concisely by Canadian elevator engineer James Spelman as he reflected on the evolution of his profession in 1914:

> The [wooden] elevator builder in most cases developed from a good carpenter. Not much technical engineering talent was employed, the ingenuity being that of the natural mechanic. These men knew very little about grain pressures, but they soon discovered what thicknesses of walls were required for bins of various sizes and that if the bins were built too high the timber below would crush. The construction was gradually developed so that the minimum amount of material was used to carry the loads safely. The result was that, in wooden elevators, loads were used that would not be tolerated by other engineers.
>
> About the time that the building of fireproof elevators was proposed, those who were in the business of constructing elevators realized that they knew very little about grain pressures. It was all very well to build in wood, in connection with which experience had been gained, but in order to make a proper design for a building in steel, or tile, or concrete, it was necessary to know what the side pressure, and the down pressure and all pressures amounted to, at least approximately.

In 1895 the German, H.A. Janssen, derived certain formulas to help unravel some of these riddles; other investigations were conducted by Wilfred Airy of Britain, J.A. Jamieson and H.T. Bovey of Canada, and J. Pleissner of Germany. Janssen's work confirmed, for example, that circular bins were well suited to accommodating loads where lateral pressure on the walls was uniform. Armed with the insights of mathematics and the lessons of history (the interstitial bins of the first large concrete elevator, F.H. Peavey's at Duluth, had ruptured in 1900 and again in 1903), engineers were eventually able to design wall thicknesses and reinforcement spacings that reflected the characteristics of grain at rest and in motion.

Some venerable elevator builders proved unable to manage the transition from rule-of-thumb to textbook formulas. For example, early in 1898 the Buffalo Elevating Association--an arm of the Lehigh Valley RR--engaged R. Dunbar & Sons to plan a steel replacement for the recently-incinerated Sturges Elevator; the specification for fireproof construction was presumably inspired by the local success of the Great Northern and the Electric. However, despite a distinguished lineage, the firm's current principal, George H. Dunbar--son of the late Robert--was not involved in the culmination of the project, the construction of the new Dakota Elevator [in 1901/1902]. Though he was a West Point graduate, George Dunbar may have found himself unable to transcend the ingrained traditions of wooden elevator construction; by 1900 he abandoned the business in which his father had distinguished himself. Perhaps this hasty exit from the field was motivated by personal preference rather than professional obsolescence; long an ornament of Buffalo's highest social circles, George opted for a new career in investments and, eventually, a new home in Hollywood. In any event, the void was quickly filled by the homegrown and outside engineering companies that would be responsible for the fireproof elevators of the new century: Steel Storage and Elevator Construction which gained a toehold in Buffalo with the Electric and whose chief talent, Harry R. Wait, would later found Monarch Engineering in 1909; Alfred E. Baxter (1860-1926) whose first major local commissions included cereal, flour and feed milling plants rather than waterfront terminal elevators; the Chicago outfit of James Stewart & Co. which assigned its newest stars, R.H. Folwell and W.R. Sinks (both lured away from Barnett & Record) to the job of designing and building the American Elevator in 1905-1906.

As reinforced concrete transformed the appearance of grain elevators, electrification modified their materials handling functions. The spectrum of change may be most fully appreciated by glancing back at the arrangements inside the vanished Richmond Elevator. This was a timber crib affair: 72 bins (the largest being 50' high x 10' square) with a total storage capacity of 280,000 bushels; powered by steam; designed by Robert Dunbar and Bradford Clark; built in 1863. To summarize its mode of operations briefly, at this stage of materials handling development the vertical elevating systems were powered but horizontal transfers from legs to bins and vice versa were accomplished through gravity. Grain was raised from vessels via the marine leg which slid up and down between braced vertical guides, being lowered and raised by means of block and tackle; tension pulleys took up the slack in the driving belt as the position of the leg shifted. From the head pulley of the marine leg grain discharged through an instore scale to the boot of a interior lofter leg. There were three of these inside legs, each equipped with buckets on an endless belt revolving around head and boot pulleys similar to those of the marine leg. Grain re-elevated to the top of the house could be spouted from the lofters either to the storage bins or to a cleaner for removing dust and chaff. The Richmond was also equipped with a drier and cooler for salvaging damp grain. In loading out grain was reclaimed from storage by spouting to the lofter boots for re-elevation and then spouted to the outstore scale for delivery to canal barges.

The most obvious deviations from early 20th-century practice at the Richmond involved the inability of the marine leg to move laterally along the dock (thus requiring the vessel to be shifted if more than one hold was unloaded) and the absence of upper and lower conveyor belts to facilitate horizontal transfer. Both lacunae were filled later in the 19th century. Dunbar mentioned a marine tower moved by steam at the Connecting Terminal Elevator, built in 1882. As elevators grew larger it became impossible to reach all the bins by direct spouting from the lofter heads so conveyors were introduced for intramural and intermural handling. Mechanized horizontal transfer played a key role in the Chase plan of elevator design with its long, parallel ranks of bins; by the mid-1880s Duluth elevators featured an extensive system of belts, running at 600-775'/min. and carrying up to 13,000 bu./hr.--capacities not markedly inferior to the equipment later installed in fireproof granaries.

While these materials handling innovations preceded electrification, the new power source certainly contributed to incremental improvements in design and performance. Freed from the constraints of mechanical power transmission, mobile marine towers could patrol much more extensive stretches of dock (the 1882 version at Connecting Terminal could travel only 18'), thus servicing longer vessels more rapidly. For functions dispersed on different levels throughout a structure as large as a grain elevator individual motor drive provided an obvious boost in operating efficiency while also contributing to reduction of some fire hazards. In many late 19th-century wooden elevators the machinery up in the cupola over the bins was often driven through long lines of shafting with pulleys and belting to countershafts. Some elevator engineers were not satisfied with this situation. Dighton A. Robinson (who would go on to design the machinery in Buffalo's Great Northern) enumerated some of his reservations in an 1891 patent specification:

> The disadvantages of such systems are, first, the impracticability of keeping in line the long shafts in the top of the building, owing to the settling and rocking of the same as the grain-bins are filled and emptied. This motion of the building thus makes necessary constant attention to and changes in the alignment of the cupola-shafts and of the counter- shafts connected therewith; second, great danger of fire in the upper part of the building caused by sparks from the friction devices; third, the necessity for use of high bin-posts on which to set the cupola to give sufficient strength for the proper support of the heavy shafting, etc., and, fourth, the original high cost of construction and expense of maintenance.

Fireproof construction would certainly improve the structural stability of elevators and electrification dispensed with the long shafts. Nevertheless, friction-reducing rope drive transmission systems (the subject of Robinson's 1891 patent) persisted in one form or another through the first decades of the 20th century until a new generation of drive arrangements (including helical reduction gears, silent chains and flexible couplings) came in during the 1920s. However, even concrete elevators remained subject to the threat of grain dust explosions such as the tragedy that devastated the [Santa FE] elevator at Chicago in 1920, leading to additional safety precautions and design modifications.

The juice that originally powered these concrete classics came mainly from hydroelectric plants at Niagara Falls. Direct current for local consumption was generated as early as 1881 by Jacob F. Schoellkopf's Niagara Falls Hydraulic Power and Manufacturing Company; but it was the Niagara Falls Power Company that first harnessed the potential energy of the cataract for long-distance transmission. Backed by substantial financial resources, Edward Dean Adams and his cohorts deployed a galaxy of international engineering wizards who converted alternating current from a theory to a commercial proposition. Adams' Power House #1 began sending part of its output to Buffalo, some 22 miles away, in 1896. The Schoellkopf interests and the Niagara Falls Power Company eventually merged in 1918, forming a predecessor of the modern utility, Niagara Mohawk. By the mid-1920s the united generating stations produced more electricity than any other system in North America. Installed capacity at the expanded Schoellkopf station at the base of the cliffs below the American Falls aggregated 450,000 hp; the Canadian Niagara station across the border accounted for an additional 100,000 hp; the 110,000 hp plant of the pioneering Niagara Falls Power Company, known as the Edward Dean Adams station, had been relegated to standby status since it could utilize less of the head available at the Falls than the Schoellkopf units.

It is unfortunate that so little of the historic fabric once represented by these plants has survived on the U.S. side. The Schoellkopf station was partially crushed by a rockslide in 1956, a casualty of the unstable geology in the Gorge and the erosion associated with earlier hydraulic projects. Loss of power from the Schoellkopf station precipitated construction of the present Niagara Power Project under public auspices. The twin power houses of the Adams station were razed in 1965.

The availability of hydroelectric power also recast the economic base of Niagara Falls as electrochemical and electrometallurgical companies found a desirable location for energy-intensive production processes. The electrolytic cell and the electric arc furnace displaced older, slower and more expensive methods for manufacturing caustic soda and chlorine compounds, reducing metals such as aluminum, or producing novel materials such as the artificial abrasive, carborundum, developed by E.G. Acheson.

Between the gaudy Pan-American Exposition of 1901 and the onset of the Great Depression, major corporations expanded into Buffalo and the Niagara Frontier region, acquiring local businesses and establishing new plants. Key industrial sectors included primary metals, transportation equipment, rubber, lumber, and grain processing. By the end of the 1920s, for example, Buffalo was well on its way toward becoming the nation's largest flour milling center, [a distinction it still retains/has recently relinquished-------]. The diverse work environments and job skills associated with this flowering of larger and smaller industries also affected the lives, fortunes and health of a racially and ethnically heterogeneous population.

Since the era of expansion was capped by the construction of such Art Deco monuments as City Hall and the New York Central station on the East Side, Buffalo's industrial balance sheet has counted more debits than credits. Briefly, the city's loss of prominence in the North American grain trade is traceable to changes in traffic patterns associated with the opening of the fourth Welland Canal (1932) and the St. Lawrence Seaway (1959) as well as navigation improvements on the Mississippi. The rivers of wheat that Trollope thought would remain ever-flowing have been diverted to other channels, leaving the big lake transfer elevators marooned and abandoned in the ox-bow of Buffalo harbor. Political machinations eliminated favorable rail rates that might have compensated for the decline in marine grain shipments. Only elevators serving as adjuncts to local flour mills still receive grain from lakers through the marine legs inspired by Robert Dunbar 150 years ago. The fortunes of other local plants have also remained dependent on decisions taken in board rooms and government offices elsewhere. Concluding a historical survey in 1945, E.P. Entwistle, general manager of the Lackawanna steel plant, observed, "The last page in the history of the development of the iron and steel industry on the Niagara Frontier will only be written when iron and steel are no longer produced." With respect to local pig iron production and integrated steelmaking the words on that last page are now an epitaph. Despite three decades of shutdowns, manufacturing remains a vital component of the region's economy, though employment in that category has declined from [171,000] as of 1965 to under 100,000 today. Factories, both closed and active, are still prominent features on the landscape, but their operations have left a legacy of toxic waste mixed with the memories of a distinguished industrial heritage.

The descriptions in the text that follows include the stops on the Friday process tours, the principal attractions in Niagara Falls and Lockport on the Sunday bus tour, and the main features on the Sunday cruise around Buffalo harbor with particular emphasis on the major visual resources represented by its 14 waterfront grain elevators. Also listed--with profuse apologies to the original authors--are condensed versions of entries covering the fourth Welland Canal (1913-1933) and Niagara Falls hydroelectric sites that were originally printed in the 1984 Ontario Society for Industrial Archeology/SIA guidebook accompanying the Niagara Peninsula fall tour: these places will be the highlights of the Monday post-conference tour. Obviously, even with such an extensive agenda many significant points on various bus routes, as well as elsewhere in the region, could not be included. Conscious of thematic gaps and potential misstatements, the editors can only offer a quotation from the preface to Hamilton Child's 1869 Gazetteer and Business Directory of nearby Orleans County, which seems to illustrate some continuity in the trials of producing prose:

> That errors may have occurred in so great a number of names and dates as are here given, is probable, and that names have been omitted that should have been inserted is quite certain. We can only say that we have exercised more than ordinary diligence and care in this difficult and complicated feature of book-making. To such as feel aggrieved in consequence of error or omission, we beg pardon, and ask the indulgence of the reader.

FRIDAY PROCESS TOUR #1

OUTOKUMPU AMERICAN BRASS CO.
70 Sayre St.
Buffalo

Outokumpu American Brass is Western New York's last hot metal operation. The company began in its current location on Military Road at Sayre Street in 1907 as Buffalo Copper & Brass Co. In 1917 it was purchased by and renamed as American Brass Company. In 1922 the international mining and smelting conglomerate, Anaconda Copper Mining purchased American Brass and ran the Buffalo operation successfully as a subsidiary known as Anaconda American Brass.

In the mind 1970s, however, Anaconda had fallen on hard times. In 1971 their Chilean copper mines had been nationalized by the Allende government. Unlike other companies such as Koppers, Anaconda had failed to negotiate a successful buy-out and lost their holdings outright. In 1977, with its corporate leadership in disarray, Anaconda sold out to Atlantic Richfield [ARCO], a diversified petroleum corporation and was absorbed as an operating division in 1981.

During its first years of ownership, ARCO increased capacity 40% with a $90 million expansion. In 1984, however, ARCO suffered long-term losses with the reduction in oil prices and short-term losses in its metals division. It announced it would either sell or close the six metal plants, including the Buffalo operation. In 1985, however, five local businessmen, with the help of the New York Economic Development Corporation and the Erie County (NY) Industrial Development Agency, negotiated a successful buy-out of both the Buffalo plant and the other five metals operations. From 1985-1990, the local company was known as Buffalo Brass and was enormously successful. It was largely worker managed and went from losses to over $300 million in annual profits. In 1990 the local owners sold the plant to Outokumpu Group of Finland which continues to operate the plant successfully.

Outokumpu American Brass makes both copper and brass products including strip, sheet, tubes, and ammunition casings. All products begin with the copper and brass furnaces where raw metal, scrap, and alloys are melted to customer specifications. The furnaces are located in the 1972 plant addition; the original 1908 cast house is idle. There are two brass stations and two copper stations, although one of the latter is used only for special orders. Each station has two 800kw melters (1600kw/furnace) and one holder. The holder is rated at 85,000 lbs. while the melters hold a total of 80,000 lbs. The melters and holders are electrically fired and are controlled by an operator (caster) through an electronic control panel.

The hot metal is poured continuously into vertical molds submerged in a water-filled quench tank below the casting floor. The final cast is called a "cake" and weighs approximately 20,0000 lbs. Copper cakes are up to 37 1/2" wide, 5" thick and up to 24' long. Brass cakes are up to 27 1/2" wide, 6 3/4" thick, and 25' long. When the cake has cooled sufficiently, the caster station is moved aside to exposed the quench tank and mold. A 50-ton crane with "grabbers" rated at 15 tons is moved overhead to seize the cake at the top and pull it vertically upward from the mold. Cakes are then moved to the side of the cast house and laid on flatbed cars for transfer to the re-roll bay approximately 1/4 mile away.

In the re-roll bay the cakes are placed into the gas-fired reheat furnace via mechanical feed. The cakes are heated at 900-1000° for 3-4 hours. The furnace capacity is 100,000 lbs./shift hour. Hot cakes are then mechanically discharged onto the 300' long, 2-high reversible run-out line. It produces the longest copper and alloy strip in the U.S. industry. The roller sits at a computer-controlled panel inside a recently air-conditioned booth. He controls the passes based on customer specifications established in the cast shop. During rolling, proper weight is assessed along the line. At the end of the runout line is a quench tank and an upcoiler and trimmer. Once rolled, coils are moved to their next destination by a 15-ton overhead crane. The runout line and its related operations is powered by a 5000hp. Toshiba motor installed c.1986. In May of this year, Outokumpu announced it will spend $22 million to purchase and install a new 1986 rolling mill to be moved to Buffalo from a plant in Vasteras, Sweden which has now closed.

Some of the product is transferred to the Torin mechanical milling line to remove oxidated surface material. Only 15/20000 inch is removed, and if imperfections cannot be rectified, the coil is scrapped and returned for recycling.

Other products go to the Pittsburgh 4-stand, 4-high, 44-roll non-reversing breakdown mill. The product passes through the line at 100-fpm to reduce thicknesses further. At the end of the breakdown line, the strip is downcoiled with paper to prevent surface abrasion.

Another line, the 5-stand, 40-roll narrow gauge roll takes the product from 38/1000" to 3/1000" thickness. Radiator and tube brass is processed here. One of the brass company's major customers is Lockport's Harrison Radiator Division of General Motors.

Light gauge products of 10/1000" thickness or less are annealed in bell annealers. Coils are mechanically loaded onto one of three arms on a center post inside the annealing furnace (the design was employee originated). The shell is placed over the coils and the atmosphere is purged, then recharged. Heat from gas-fired jets is directed on the shell where temperatures are brought to 280-400°C over 3-4 hours. When the heating cycle is completed, coils are cooled slowly to below 100° C. before the shell is removed and the coils removed. The entire process takes 24 hours.

Light gauge products up to 26" wide can be further rolled at the #47 Bliss mill, a Z 4-high reversing mill installed in 1981.

Heavier-gauge strip is annealed in one of the five 9-story-high strand annealers. Each annealer has its own elevator for maintenance, and each level has its own gas heating torches. At each end of the annealer is an "accumulator" to receive the product and make a mechanical stitch thereby creating an extended loop which rotates through the entire height of the tower. At the bottom is a water seal that creates the chamber's own atmosphere, and at the exit is a mild acid bath for surface cleaning. Each loop is heated to between 700-800° C., but annealing specifications vary according to time rather than temperature. The strand annealers give the strip a more uniform grain size and make it more uniformly ductile.

Three slitters in the brass mill, #70, #71, and #72 cut strip to customer order. Copper mill slitter mass produce strip to standard size. The brass strip then may be directed to the continuous weld tube line where tubes of various size are curved, formed, and welded seamlessly with a one-step process. Until recently there were two welders, but one has been sent to a companion mill in Spain. Only Line 7986 remains. Tubing still plays an important role in the product line primarily for decorative work in brass beds and the like. The brass bar and lobby decor at the Radisson Hotel near the airport came from Outokumpu American Brass.

American Brass has long had a small line of defense contract work manufacturing cartridge and shell casings for NATO and for Lake City Arsenal, Arkansas. The 84 Press is a continuous-feed, 2-draw press and is one of only 2 contracted by the Department of Defense. The remaining presses stamp a variety of casings . This department was highly unprofitable under ARCO but, after the 1985 buy-out, became entirely worker managed. Under its slogan "Cups R Us," workers set all terms and conditions of production with no supervisors on the floor. Orders are received and processed by the work teams themselves. This was the first quality circle, and in under two years it transformed from a company liability to a highly profitable operation generating $1.5 million in profits the first year.

KITTINGER CO. INC.
1893 Elmwood Ave.
Buffalo

Kittinger Furniture was begun in Buffalo in 1866 as Colie & Sons. In 1900 Irvine J. Kittinger joined the firm then acquired the company in 1913. In 1917 they moved to the Elmwood Avenue location. Until 1965 the company was owned by the Kittinger family, a single-facility operation producing high-quality traditional 18th-Century reproduction furniture both for consumer retail trade and by custom order for businesses.

In 1965 it was spun off to General Interiors Corporation, then beginning in 1985 the company went through a variety of hands including improbable owners such as General Mills, Maytag, and Chicago Pacific, none of which found it sufficiently profitable. In 1990 it was purchased by a single owner, Michael Carlow, who has since run the company profitably and who has preserved the basic production system combining mechanized and hand processes to turn out high-quality furniture efficiently.

The 3-story Elmwood Avenue building was built 1920-1928. It is concrete frame/fenestra with steel sash and brick curtain walls. There is both a concrete floor and roof. Cabinet and assembling departments are on the first floor, storage on the second, and finishing on the third along with upholstering. Behind the main building is the 1920 facility now used for the woodworking machinery department. In front of that building in a separate facility separated by the lumberyard are the drying kilns.

Kittinger furniture involves a five-layer technique that begins with poplar cores plus poplar cross banding above and below the core. Veneers of Brazilian and Honduran mahogany are then added for surface beauty and durability. Veneering is a 200-year-old process that provides a wide range of customized possibilities including grain uniformity and direction unavailable in solid core woods. Wood is seasoned 1 week to 2 months in dry kilns before cutting and shaping.

The production process begins in the mill. Basic shapes are milled using planers, rodding, boring, and joining machines, tenons, and jigsaws. Initial cuts are made on machine saws, then lathes shape circular pieces. All of the machinery dates from the earlier part of the century and has not changed appreciably over the years. Rough-milled pieces are then put in bins according to their destination. Parts are first assembled or glued, then a single cabinet maker fits pieces together and sands them to their basic design. One craftsman follows the piece throughout the process.

If a piece involves carving, the rough outline is first done on a multiple carving machine, replacing individual planes. The machine uses a maple-wood template or model in a center jig. There are 24 arms, 12 on each side, with various cutting heads to cut different styles. Where necessary parts then go to a spindle where designs and shapes are refined. The final detail carving, however, is still done by hand.

After carving is completed, the piece moves to finishing. Some work is done in spray boots, but finishing still remains largely a hand-application process, requiring 20-25 separate operations. After finishing the piece moves to trimming and/or upholstering where hardware, glass, and fabrics are installed, then continues to inspection before being shipped to retail outlets.

Many of Kittinger's employees have been with the company for upwards of 30 years, but there is also a healthy contingent of younger workers learning the trade and keeping the processes alive.

PIERCE-ARROW MOTOR CAR CO.
1685-1695 Elmwood Ave.
Buffalo

George N. Pierce branched out from the manufacture of bird cages through the bicycle craze at the end of the 19th century and into automobile production. In 1906-1907 his firm completed a complex centralizing the operations involved in producing the Great Arrow car. The property, part of the recent Pan-American Exposition's grounds, originally covered 15 acres. Seven major buildings were put up during the first phase of construction, and they remain standing among the 14 structures now on the site. Lockwood, Greene & Co. held the prime contract with Albert Kahn, who had recently completed the Packard factory, as associate architect. However, the large areas of glazing that distinguished this and other pre-WWI daylight factories have largely been filled in. Nevertheless, the Pierce-Arrow works remains a significant example of both reinforced concrete construction and early automotive plant design that has endured longer than the founding company, which eventually expired in 1938. A multitude of commercial and light industrial businesses now occupies the site.

Of the two buildings fronting on Elmwood Ave., the original three-story Administration Building, 252' x 70', with its characteristic barrel-arch roof was designed by George Cary who abandoned the neoclassical vocabulary of his Beaux Arts training so evident at his 1901 New York State Building for the Pan-Am Expo. (now the Buffalo & Erie County Historical Society); the three-story addition to the south dates from 1910. The real Pierce-Arrow factory, however, lies behind this public facade. Production methods were initially predicated on precision machining and static assembly. The Manufacturing Building was 402' x 205', one story with a sawtooth roof; it housed belt-driven machine tools for small parts work. Fabrication of the composite body took place in a U-shaped building, 160' wide; the south wing, fronting on Great Arrow Ave., was originally 401' long, the north wing measuring 327'. All sections of the Body Building were at first two stories high, and they have subsequently been raised and extended to form the current vista. Components from machining operations and the body shop merged in the Assembly Building, situated between the other two areas; this structure was also a single story with a sawtooth roof and dimensions of 402' x 122'. (This mixture of one-floor and multi-story structures was also evident at Ford's Highland Park plant, also designed by Albert Kahn and opened in 1910.) Other Pierce-Arrow buildings completed during the 1906-1907 phase of construction were the Brazing Building, Power House and Garage, all aligned on the New York Central Belt Line.

The Pierce-Arrow factory demonstrated some of the virtues of reinforced concrete when applied to construction of large industrial structures; the seven original buildings were ready for occupancy in a little over six months--according to the Engineering Record, this span represented a significant saving of time over methods involving load-bearing masonry or steel-frame fabrication. However, as an industrial design the complex antedated the assembly line, and later engineers faced a constant struggle with the layout in attempting to rationalize production methods.

CALSPAN
4455 Genesee St.
Cheektowaga

Fueled by the growing role of aerial combat in two world wars, Buffalo once boasted of a substantial aircraft industry, studded with names such as Curtiss, Bell, and Consolidated. The Calspan facility in Cheektowaga began as a small research unit of Curtiss-Wright Corporation which was established during World War II. After the war, Curtiss-Wright decided to move its operations and donated the facility to Cornell University which took over the facility in January, 1946.

At that time the laboratory included a two-story brick building, a large subsonic wind tunnel, and technical equipment valued at $4 million. Cornell attempted to maintain the operations solely on contract research. To assist the operation, six aircraft companies, AVCO, Bell Fairchild, Grumman, Republic, and United, pledged working capital believing that east-coast research operations would benefit their businesses. By the end of 1946 Cornell Aeronautical Laboratory was doing well, with $2 million in recorded business. During the next few years, CAL's research in guided missile technology, controlled aircraft stall and stability, radar, lasers, and general computer applications all emerged from this one facility.

In 1972 CAL became a public corporation but could not generate sufficient income to move from a non-profit operation to become a successful profit-making organization. In 1978 Cornell sold the laboratory and its related operations to Arvin Industries which made the successful transition to profitability and operates the company today.

Calspan retains its headquarters in Cheektowaga but has 14 other locations throughout the country. About 90% of their work is now for the Department of Defense rather than the private-sector aviation and aeronautical industry. Much of their research centers around the wind tunnel first built in the 1940s and continuously upgraded. The transonic tunnel has tested over 1000 models of aircraft since World War II.

The laboratory turned its research efforts to the auto industry's safety efforts in 1949. Much of that research involves crash and stress tests with the Hyge Sled Test Facility.

Dummies are placed in cars then photographed with high-speed, 2000-frames/second cameras to document events and calculate weaknesses. Much of this research is for their National Highway Traffic Safety Administration, although some is performed for individual manufacturers.

Other stops on the tour will include the Hyposonic Shock Tube Facility, the Tire Research Facility, the Low-speed Wind Tunnel, and the Atmospheric Simulation Facility.

FRIDAY PROCESS TOUR #2

POHLMAN FOUNDRY
205 Baitz Ave.
Buffalo

This firm commenced operations at Broadway and Lathrop St. in 1889, but its tenure on this site is traceable back to 1910. A series of expansions have extended the original 10,000 sq. ft. building. Pohlman was the first jobbing foundry in Western New York to covert from cupolas to electric melting; a pair of 6-ton coreless induction furnaces was installed in the back foundry as of 1969. Output from these furnaces now averages 35-45 tons per day.

Pohlman currently has the capability of making precision iron castings ranging from 10,000 lbs. down to ounces. It pours flake graphite irons with high tensile strength, nodular graphite iron having enhanced ductile properties, and special high-alloy grades. Since 1938 the company has been licensed by the Meehanite Metal Corp. to use its patented quality control testing procedures.

Some work is organized on a semi-production basis where the same patterns are used repeatedly; other jobs are custom ordered. There is a considerable variety of equipment and techniques for filling flasks of different sizes with the appropriate type of sand. The molding machinery includes cope and drag lines as well as a Hunter automatic line that has displaced most of the compressed-air squeezers. Flasks may be filled with conventional green sand or chemically-bonded sand in the case of larger castings. Other departments in the foundry include the pattern shop, core making, and heat treating.

Control of the business has continued to descend through several generations of the Pohlman family.

GIBRALTAR STEEL
2555 Walden Ave.
Cheektowaga

The present plant on Walden Ave. originated in 1958 when John W. Lyons, relocated Gibraltar Steel, his four-year-old coil slitting business, into a 20,800 sq. ft. facility. Lyons, formerly a salesman for Seneca Steel on Military Rd., broadened his firm's product line by entering the strip steel market in 1963. During the late 1960s Gibraltar added space to house a 4-high, 3-stand Waterbury-Farrel automated tandem cold reduction mill and a production line for steel strapping. In 1972 Kenneth E. Lipke of American Corporate Consultants bought the Cheektowaga mill. He promptly launched his own expansion program to accommodate additional annealing, coil slitting, and steel strapping apparatus. The company also acquired an adjacent warehouse formerly occupied by Latrobe Steel. In

1975 Gibraltar diversified by acquiring several steel processing firms (including Seneca, its original founder's former employer) whose operations complemented developments in Cheektowaga. The firm now has divisions in Ohio as well. Within this corporate structure the Walden Ave. plant specializes in precision cold-reduced strip and high-tensile steel strapping. Occupying this particular niche, Gibraltar has continued to weather the downturns and downsizing that have disabled larger integrated producers.

Customer for cold-reduced strip include makers of stampings for such end uses as transmission components. Approximately half of sales are automotive-related. The metallurgical lab exercises quality control functions and also works with sales representatives and customers to analyze requirements for specific applications. Gibraltar purchases pickled, hot-rolled coils from such suppliers as LTV Steel, Warren Consolidated Industries, Sharon Steel, and Dofasco. The coils are first slit to 8-10" widths. They are then reduced in thickness (gauge) to customer specification on the tandem mill, which is equipped with automatic gauge controls and can attain tolerances of +/- .00025". The speed of the mill is c700' per minute. After recoiling, the strip is annealed in batches to restore its ductility and then temper rolled under tension on single-stand reversing mills to impart the desired combination of final gauge, surface quality and mechanical properties.

Production of steel strapping begins with a 12-strand oscillating slitter that can handle coiled strip up to 2000 lbs., slicing a 10" package into 1 1/4 - 2" ribbons. The slittings are spooled and loaded onto a six-strand continuous heat-treating and painting line. The strands move through the several stages of this process independently. After passing through the line, bundles of strapping are banded, weighed and tagged for delivery. Gibraltar is one of the major domestic producers of electrotempered strapping in standard finishes or customized colors. This specialty item is used by primary metals producers and forest products industries for packaging their own shipments.

OLIVER GEAR, INC.
1120 Niagara St.
Buffalo

Oliver Gear began production in 1907. Today they are the oldest among Buffalo's gear manufacturers. The shop is equipped to produce gears from 1/2" up to 121" diameter in cast iron, bronze, steel, nylon, and micarta (a fiber-reinforced resin). Specialized shapers, milling machines, and hobbing machines are capable of turning out external and internal spur and helical gears, bevel gears, worms and worm gears, chain sprockets, racks and splined shafts. Products can be flame hardened in-house or sent out for heat treating. Oliver makes original and replacement parts for gasoline pumps, food service equipment, materials handling devices, and construction machinery. They also provide repair and replacement services for a wide variety of customers.

PRATT & LAMBERT INC.
75 Tonawanda St.
Buffalo

Pratt & Lambert was founded on Long Island in 1849; the firm's first product was a liquid drier for the non-ready-mixed paints of that period. In 1902 the company purchased the Tonawanda St. site at a tax foreclosure sale (the previous occupant was a sewer pipe foundry) and began erecting a varnish plant. Their product line has also included paints; the former lacquer facility across Scajaquada Creek is now closed. Existing construction is chiefly steel frame with brick curtain walls and concrete floors and roofs. A number of the three- and four-story buildings in the present complex date from just before, during or after the First World War. The multi-story layout determines the process flow on this site and distinguishes it from the horizontal organization of production at newer, single-story paint factories.

Resin reactors are still operated here on an intermittent basis; this process replaced earlier methods of cooking resins in liquid or lump form by the batch in kettles. Resins are uncrystallizeable substances, soluble in alcohol but not water. Beginning in the 1930s, fossil resins (the dried secretions from certain trees and plants) were displaced by synthetic phenolic and alkyd resins; this development also substituted laboratory analysis for the empirical formulas carried around under their hats by earlier generations of craft practitioners. Current resin production is approximately 800,000 gallons per year, overall capacity being 2,000,000 gallons. Of the three active reactors, the two larger models can each turn out a batch of 2200 gallons in about 12 hours. The procedure involves heating, mixing and agitating certain ingredients including oils and catalysts, the exact composition being varied to provide an range of drying rates. Resins are then canister strained or filter pressed and pumped into drums. Some resins are now purchased from outside suppliers.

Paint production is predicted on gravity flow from floor to floor as materials pass through stages from grinding to filling. On the fourth floor manually-fed dispersers mix pigments, resins and solvents; machines of this type displaced roller mills that had ground pigments and oils into a smooth film. There are also examples of closed-head mills featuring various grinding media such as stones, porcelain rods and steel balls; this equipment is now reserved for cases where pigments are particularly difficult to disperse. Newer examples of the processes in this area would rely on internal pumping techniques between half-floors and a more horizontal alignment.

From the grinding floor the dispersers feed let-down tanks below. The capacities of the storage units range from 600 up to 5000 gallons. The let-down tanks also represent the final point at which the paint mixture can be fine-tuned by adding water, resin, solvent or other substances, based on test sample results from the control lab.

On the second floor there are presently three filling lines for containers of different sizes. One of these lines is actually a converted ketchup processing machine. The filling lines involve both mechanized and manual operations including fitting the container lid, labelling, bending and inserting handles, and packaging. Some batches are still filled by hand. The entire filling department is being redesigned to accommodate new high-speed filling and packaging equipment. Packaged paint containers now descend to the shipping floor on roller conveyors.

Over the past two decades changes in the production process at Pratt & Lambert have been manifested in the shrinking resin department, less processing for pigments, and reduced manual handling due to greater use of pumps and fork lift trucks. Other departments in the present plant include the research and process control labs in addition to the print shop that turns out labels for over 2000 different products, some with bilingual text for shipments to Canada.

Current paint production capacity at the Buffalo plant is 4,000,000 gallons yearly. The proportion of oil and latex-based paint, once divided equally, has now shifted in favor of latex. The Tonawanda Ave. facility serves mainly the trade sales market. Other Pratt & Lambert plants in Kansas, South Carolina, Louisiana, and Tennessee are more oriented toward industrial customers as well as regional distribution.

E. & B. HOLMES MACHINERY CO.
59 Chicago St.
Buffalo

This firm was the first in the U.S. to manufacture a complete line of cooperage machinery. The brothers Edward and Brittain Holmes were originally involved in Buffalo's lumber trade and operated a planing mill on Michigan St. In 1856 they acquired the Swartz Iron Works on Chicago St. and converted it over to production of patented machinery for making barrel components and fitting the parts together.

By the mid-1870s the E. & B. Holmes line included a series of 13 machines: 1) stave dresser; 2) stave joiner; 3) saw for cutting staves to uniform length; 4) machine for setting up barrels; 5) machine for levelling barrels and casks; 6) machine for driving truss hoops by power; 7) machine for chamfering, hollowing and crozing barrels; 8) machine for smoothing barrels; 9) machine for dressing and jointing headings; 10) machine for jointing and dowel-boring heads; 11) machine for dressing heads of all sizes; 12) machine for turning barrel heads; 13) machine for beveling, punching and riveting iron hoops. This equipment was adaptable to barrels of all types, including casks and hogsheads, both dry and wet. In 1887 the firm began offering a line of production tools for general woodworking, including gang edgers, self-feeding ripsaws and shingle planers. Machinery was exported to Germany and Russia. The shop's products won awards at the 1876 Centennial Exposition in Philadelphia, the 1893 World's Columbian exposition at Chicago, and the 1901 Pan-American Exposition in Buffalo.

The former Swartz works on Chicago St. succumbed to fire but was rebuilt on the same site. The main building now features brick load-bearing walls, is four stories high, and measures approximately 150' x 45' with an L at the rear that once housed the forge. In the late 1880s the machine shop shared its premises with a neighboring casket factory. Today E. & B. Holmes remains the oldest business in Buffalo still operating under its original name and at its original location. Owned since 1971 by Andrew S. Krafchak, the company is now run as a general job shop. However, specialty cooperage machines are still occasionally manufactured to order, principally for distillers and the wine industry.

GRAPHIC CONTROLS CORP.
189 Van Rensselaer St.

Graphic Controls has its own corporate history and processes, but Buffalo's interest in the facility has much to do with its location in the historic Larkin Complex. The Larkin Company was both a soap manufacturer and a premium-based mail-order business that operated from this 1902 2-million-square-foot facility. They had subsidiaries in Pittsburgh, Boston, Philadelphia, and Peoria, Illinois and manufacturing operations throughout the eastern states. They produced luxury and laundry soaps, powders, perfume and other household goods. Their mail-order business dispensed a variety of useful and decorative wares including china, decorative paintings, handkerchieves, and the like to induce customers to buy more of the company's basic products.

The company was founded in 1875 by John D. Larkin, whose brother-in-law owned a soapworks in Buffalo then relocated to Chicago where Larkin became senior partner. One of the leading managers of the early company was Elbert Hubbard, later founder of the Roycroft settlement in East Aurora, NY and leader of the arts-and-crafts movement centered there. At Larkin he was first a soap salesman then Larkin's second-in-command in Buffalo. His departure from the company in 1892 created dissension since Hubbard demanded a part of the company value and eventually received $65,000 in settlement. When Larkin reorganized the company, he made sure he alone was firmly in control.

The Larkin complex is most famous for its innovative office building designed by Frank Lloyd Wright and constructed 1903-1904. Its demolition in 1950 (the site is now the parking lot on the north side of Seneca Street) was a dark day for Buffalo and spawned the formal organization of historic preservation in the city. Beyond the Wright contribution, however, lay an industrial complex of genuine significance in its own "right".

Twelve factory buildings of 8 to 10 stories in height were built starting in 1895, and seven other structures, including the facility housing Graphic Controls, were built after the Wright Administration Building was completed. Most of the factory sites were used in Larkin's basic manufacturing to store oils, fats, and other raw materials, boiling and distilling, wrapping, bottling, storage, and the like. There was a boiler house, chemistry laboratory, photography and engraving departments, and office space for the mail-order processing. The site was served by several different railroads (New York Central, Lake Shore & Michigan, the Erie), and a spur line fed raw goods to Larkin and took finished goods to market.

The main complex consisted of essentially one building made up from a warren of additions built between 1895 and 1907. These are buildings B (1903); C (1895); D (1896, rebuilt 1912) and D Annex (1897); E (1898); F (1898): G (1900): H (1901); I (free standing west of main complex, 1902); J (1904); K (1904); L (west of main complex, 1905); M (adjoining L west of main complex, 1905); N (1907); O (1907). Building A, the Wright Administration building was built 1906. The Larkin Warehouse, behind the main complex at Van Rensselaer and Carroll streets, is the current home of Graphic Controls.

Graphic Controls in its current incarnation, succeeded six independent predecessor companies dating back to 1909. A Canadian company, Staebler & Baker, Ltd. made recording instruments and needed charts for those instruments. Other chart-making companies entered the field, and in 1940 George Clarkson moved his small chart making business to 189 Van Rensselaer Street in Buffalo. In 1957 Clarkson and two of his sons consolidated six similar businesses, including Staebler & Baker into what is now Graphic Controls.

The company began producing industrial recording charts, then expanded to data recording and monitoring devices and supplies. It has a diversified product line including a pen company, but its main focus is on advanced industrial charting equipment, computer supplies including pens and media for computer-aided design, medical recording charts and electrodes,and other similar industrial instrumentation.

In 1978 Graphic Controls was taken over by the Los Angeles-based Times-Mirror Corporation, the Chandler-family holding company that publishes the *Los Angeles Times* and is a major property developer. In 1986, officers of the company in conjunction with other investors, promoted a leveraged buyout from Times-Mirror and became independent.

The production processes are part of the high technology revolution of the late 20th Century. Within its 10 floors, the company incorporates engineering and machine-shop operations with computer-controlled development and production methods. It not only manufactures high-tech industrial goods but employs advanced technology in its own production processes.

COL. FRANCIS G. WARD PUMPING STATION
foot of Porter Ave.
Buffalo

The City of Buffalo began construction in 1907 on a new intake crib and tunnel for a pumping station to supplement the existing facility on Massachusetts Ave. The Buffalo Dredging Co. completed the intake project in 1913. The new crib lay in the "Emerald Channel"--the clearest portion of the Niagara River. Twelve ports in a circular brick and steel housing admitted water through sluice gates. The crib itself consisted of 3/4" steel plates, riveted into two concentric rings with concrete infilling. A concrete-lined tunnel, 11'3" x 12', ran 6651' to the new pumping station at the foot of Porter Ave. and then on to the Massachusetts Ave. station.

Work on the new pumping station began in 1909; but the collapse of the roof trusses in 1911 became a political scandal so completion was delayed until 1916. Designed by the local firm of August Carl Eisenwein and James A. Johnson, the handsome building consists of brick curtain walls over a steel frame with reinforced concrete floors and roof, the roof being covered initially by Ludowici-Celini tiles; the ornamentation included terra-cotta trim. The structure was named for the then-Commissioner of Public Works.

As of 1916 intake water was channeled directly into the pumping station via two subterranean canals that forked around the central boiler house wing. River water was chlorinated at the intake but was not otherwise treated. In 1924 a rapid mechanical sand filtration system was installed in buildings adjacent to the pumping station. A raw water conduit from the intake tunnel led to a head house and low-lift pumping station. The low-lift duty was eventually handled by a total of five Dayton-Dowd electric centrifugal pumps; their capacities ranged from 750,000 to 45,000,000 gallons per day. The filtration units installed in 1924 were rated at 240 mgd. They did not occupy all of the filter gallery, and the remaining space was used as clear water reservoir. An underground reservoir extension was constructed in 1936. The filtration plant also included a coagulating basin from which treated water passed through Venturi meters and then to the pumping station via a filtered water conduit.

The 1916 pumping station consists of an engine room and three perpendicular wings. The central wing originally contained eight Babcock & Wilcox 750 hp sectional water-tube boilers. These units were replaced in 1952. Six of the successors were removed in 1963 and the remaining two converted to gas-firing for steam heat. The two 250' chimneys that flanked the boiler house are no longer extant. The north wing contains offices and storage. Located in the south wing are the machine, pipe and meter shops.

The engine room is 364' x 90'. Space was originally provided for eight pumps; five were installed in 1915. Carrying the nameplate of the former Holly works in Lockport, they were manufactured at the Snow Steam Pumps plant on Buffalo's East Side. The vertical triple-expansion engines have cylinder dimensions of 31" & 64" & 98" x 66". The plunger diameter is 37 1/2". Each engine had a capacity of 30 mgd and was rated at 1200 hp. Including two 20' flywheels, the approximate weight of each unit is 1100 tons. Discharge from each pump was measured by a 48" Venturi meter. These engines have not operated regularly since boiler capacity was cut back. The station's high-lift duty is now carried by three 50 mgd DeLaval horizontal centrifugal pumps driven by 2500 hp General Electric motors; these units were installed in 1938. At the time of its completion Col. Ward station's 150 mgd capacity made it the largest municipal pumping plant in the U.S.

Recent upgrading at the station had included a new control room, a bypass for the original 12' conduit, and additional sediment disposal facilities as well as constant skirmishing with the invading zebra mussel.

FRED KOCH BREWERY MALTING DIVISION
100 Childs St.
Buffalo

Fred Koch Malting on Childs Street is a division of the Rochester, NY-based Genesee Brewery. It occupies a grain elevator and malt house whose first incarnation was as Francis Perot's Sons, Inc. Begun in the Northern Liberties of Philadelphia, the company was founded in 1687 by Anthony Morris who operated a small brewery and malting operation. The company endured under Morris family control until 1820 when Francis Perot, Thomas Morris' son-in-law, assumed control and renamed the company in his own lights. In 1850 the Perots eliminated the brewing business to concentrate exclusively on malting.

In 1907, seeking a more satisfactory link to the critical barley deliveries upon which malt is based, the Perot family left Philadelphia to establish operations in Buffalo. They had earlier founded a malting business in Oswego, NY on the Erie Canal, but finding their markets and business conditions in Buffalo to be most profitable, they ceased all other operations elsewhere and concentrated their affairs on the Buffalo River. They did not forsake their roots entirely, however; for whatever reason, the family brought with them the stationary steam engine that Francis Perot had installed in his own brewery in 1819. Widely believed to be one of the oldest in existence, the engine is now at the Franklin Institute.

The Perot family ran the elevator and malthouse until the 1960s when it was finally taken over by American Malting (no links to the 1890s trust). The cessation of the family business also ended the reign of the oldest continually-operating company in America. During the succeeding decades, the facility went through a number of ownership changes until 1986 when Koch assumed control. Today Koch is the only U.S. malthouse east of the Mississippi and only one of two in eastern North America, the other being in Montreal.

The elevator and malthouse today are substantially unchanged since the last renovations in 1936. The complex consists of a 931,000-bushel reinforced concrete grain elevator in 2 sections, A and B each with 9 bins, and two malt houses, A and B. Unlike flour mills, the elevator in a malt plant is not just for grain storage but is part of the malting process.

All grain deliveries today are received by rail. Beginning in 1933, Perot had obtained its barley through a cooperative agreement with the adjoining American Elevator which had the marine leg that Perot lacked. The American Elevator is now owned by Omaha-based ConAgra, and the grain exchange via overhead conveyor gallery has ended. Today rail cars arrive, three at a time, on Track 2 between the elevator and malthouse where they unload over a gravity drop to a single subterranean hopper. Cars empty 3800 bu. of barley per hour.

The grain drops onto 3 30"-wide crossbelts and is carried to the single 6000-bu./hr bucket receiving leg. The bucket leg takes the barley to the workhouse where it goes to the 3000-bu. garner and the 30,000-lb. weigh scale. The scale is still a mechanical balance beam and is believed to be original 1907 equipment. From the scale the grain is dropped either to the 40" wide bin floor belt or is moved via jack leg to cleaning/grading. When it goes to the grading floor (1 story down), it moves first to the Carter Day indent cylinder cleaner (c.1960s). Grading is done on 3 floors each with 3 S. Howes Co. Reel Graders (Silver Creek, NY) introduced c.1949. The barley is separated into A, B, and C grades (7/64, 6/64, 5/64") then is recombined after noting the ratio. From grading a jack leg takes the barley from the bin floor back to the east side bins of the elevator where it is kept until needed in the dry tanks associated with each malt house.

Malthouse A holds 1300 bu. in each of two tanks; B House holds 1350 bu. in each of its two tanks. Screw conveyors transfer the barley from the elevator to the malthouse. The conveyor discharges into a second screw conveyor, then the barley goes onto a belt, and a third screw conveyor then drops into the malt house steep tank.

The barley is steeped, or soaked, in just enough water to cover the grain. In A House the 6 steep tanks are each 11'8" x 17' with a 5'6" cone and hold 1990 cu.ft. of grain. In B House the 6 tanks each are 13'2" x 14'7" with a 6'6" cone. Each of these tanks holds 2343 cu.ft.

After 30 hours of steeping (a reduction from the 72 hours needed in 1950), the resulting slurry is pumped to germinating compartments where it is kept at 56° F. and sprinkled with water to induce sprouting. A House has 4 germinating compartments, 2 up and 2 down. Germinating boxes are 105' x 16'9 1/2" x 52 1/2". B House boxes are the same configuration and are 105' x 16'11" x 54 1/2". Each box has a perforated floor with a false bottom to permit temperature regulation and air flow. Air is circulated via fans. A House has 2 fans each with a 40,000 cfm. capacity while B House has 1 85,000 cfm. fan. Barley stays in germinating for 5 days.

After germination the malt is unloaded in layers with a winch and a board "scraper" that moves mechanically back and forth across the barley, removing it in layers. (This process is not unlike the semi-mechanized shovels used by grain scoopers to unload ships). The "green malt" then is transferred via screw conveyor to the "beer tunnel" (so named because it is cool and was regularly used to store employees' beer bottles) where it is then discharged into a chain-drive bucket leg. The leg raises the green malt to the top of the drying kilns.

Both of the two malt houses use Aladin-design kilns. The kilns each have two levels. In A House they are 89'5" long with the bed levels being 29 1/2" and 23" (top and bottom respectively). In B House they are 105' long with top and bottom levels of 29 3/4" and 24". A House kilns were installed in 1907, but the B House kilns were added c.1936. Both houses have 50,000 cfm. fans to facilitate drying. On both beds in both houses, it takes 15 hours to dry the malt properly.

After drying, the malt drops to a holding bin then is moved via screw conveyor to a bucket leg which raises it to another upper-level screw conveyor. This conveyor takes the malt back over to the elevator on the west side to what are, essentially, the malt bins. Before storage it is re-cleaned and polished at the S. Howes Co. cleaners. The screw conveyor then takes the malt to a chute where it goes to a receiving leg in the malt bins. Malt batches are binned for 5 days and are analyzed during this period by the resident maltster and plant manager, Brian Robins (one of 26 maltsters in North America) who then recommends the proper malt blends.

When malt is ready for shipment, it is dropped from the bins, moved through screw conveyors to the dump scale, then to the jack leg. This elevates the malt to an aspirator from which gravity drops it into waiting trucks. The shipping system processes 1490 bu./hr. Nine trucks per day can be loaded over a 24-hour basis. Although no rail shipping is currently done, the loading capacity could fill 4 rail cars/ day. Once the trucks are filled, the malt is taken to Rochester to be brewed along with other ingredients into Genesee Beer.

FRIDAY PROCESS TOUR #4

SAGINAW/GM BUFFALO GEAR & AXLE PLANT
1001 E. Delevan Ave.
Buffalo

General Motors opened a combined Chevrolet assembly plant and a Fisher body plant at this location in 1923. Initially three separate two-story bays extended southward behind the East Delevan Ave. facade. Fisher Body operations occupied the western prong with assembly and painting operations in the others. The predominant style of construction featured reinforced concrete framing, walls and roofs with 12' brick curtain walls. As designed, the plant was capable of producing 25 cars per hour. During the Second World War, manufacture of parts for aircraft engines and tanks replaced civilian auto output.

Earlier the Delevan plant was involved in a footnote to the turbulent organizing years of the autoworkers union. Amid the CIO organizing drive of the Depression era, a three-day sit-down strike by members of UAW Local 424 in June, 1937 successfully protested the layoff of a female employee without regard to her seniority.

After World War II Chevrolet retooled the Delevan plant to make axles. The product line over the last 47 years has at times included universal ball joints, drab links, body brackets, brake and clutch pedals, truck extensions, shock absorber brackets, differentials, and wheel hub and drum assemblies. The physical plant has expanded accordingly.

In 1984 the Buffalo facility became part of the Saginaw Division with GM. Approximately three-quarters of plant output now consists of rear-wheel-drive axles for models such as the Chevrolet Camaro, Pontiac Firebird, the Astro and Safari vans, and Blazer and Jimmy trucks. Steering linkages are also produced for various GM cars and trucks. A substantial percentage of components is supplied locally from Saginaw's Tonawanda Forge (Tour #5). In 1989 Saginaw-Buffalo was awarded a contract by GM global partner, Isuzu, to build up to 250 axles a day for pickup trucks and utility vehicles assembled in Lafayette, IN. As a result of these developments, employment which had been declining since the mid-1970s, has now stabilized at around 1900.

To visualize the Delevan plant's principal product, imagine a triangle with a stick emerging from two of its sides and a circle at the end of each stick. The triangle represents the differential carrier, containing a precise arrangement of gears for transmitting power from the drive train through the axle to the driving wheels. The sticks are the axle tubes with suitable shock absorber brackets and other appendages. The circles stand for the brake drums.

The production process involves both machines and assembly operations; it is designed to bring various elements of the triangle, sticks, and circles together. Principal sub-assembly operations are organized around producing the differential carrier and case, the axle tubes, and the brake drums. Some of the steps involved in producing the innards of the differential include pinion gear blanking on CNC lathes and case hardening "green" ring gears in heat-treating furnaces. The differential cases also undergo a sequence of machining operations, and the differential carrier and its outer case are then assembled and inspected. Axle tube elements are likewise machined and assembled, and the tube assemblies are then welded to the carrier and case. On the main line, the combination of triangle and stick is then mated to the circles from the brake sub-assembly line where the bearing surfaces for the axle shafts have previously been finish-ground and the brake drums balanced. After sorting by computer, the completed axles are then placed in shipping racks and loaded into boxcars for their journey to the appropriate assembly plant.

GM is now in the midst of installing a second line at the Delevan plant at a cost of $15,000,000. The new line represents the latest investment in the facility since the mid 1960s. It is designed to accommodate the longer rear axles not specified for the restyled Camaros and Firebirds to be produced at Ste. Therese, Quebec. A total of 35 hourly workers on two shifts will train to learn skills required for 12 job classifications, and, as part of a labor-management team concept, they will make decisions regarding production and work scheduling.

BUFFALO WEAVING & BELTING CO.
260 Chandler St.
Buffalo

Buffalo Weaving and Belting began its operations in 1891 in a single brick building on Chandler Street on Buffalo's West Side, adjacent to the New York Central "Belt Line" railroad tracks. The small business began as a manufacturer of web horse harnesses, a specialty textile line of narrow-fabric weaving. The company soon diversified by adding rubber products to its output, and after only 11 years in business, they were ready to expand their physical plant as well.

In 1902 they broke ground for an extension to the plant both east and west of the original building along Chandler Street. After the building improvements were added, BW&B had a distinct rubber mill on the west end for rubberizing canvas belts and manufacturing mechanical rubber goods; a cotton warehouse and pipe shop in the center, and weaving operations on the east side. In between each section were shipping bays.

In the weaving section, part of the upstairs space contains the warp room familiar in all regular textile mills. The only difference is the preponderance of synthetics and industrial-grade yarns rather than cottons and woolens. Downstairs is the weaving room which contains 25-40 looms of various types capable of weaving from 1/2" to 60" widths. Some of the looms are needle looms. The wide-product looms are fly-shuttle types. BW&B's most successful narrow-weave product is arrestor tapes for military aircraft landings. Very early BW&B was producing goods with synthetic yarns and thus found new product lines in things such as car seat belts while maintaining some of their more traditional product lines.

In the rubber end they manufactured mechanical rubber goods such as rolls of sheet rubber and bowling pit carpets for the return ball lane. They manufacture coal mining conveyor belts narrow in width but up to 500' long, tank seals for the floating roof of gasoline tanks to prevent evaporation and pollution, combination rubber and lead X-ray shield aprons and several other products. Natural rubber is sometimes used. It comes in blocks while synthetic rubber ingredients come in powders. These are mixed in 150-170 lb. batches to custom order in Banbury mixers. The rubber then goes to one of two 3-roll calendering machines from which it is turned into sheet or to a press or vulcanizer for curing.

The company was locally owned until the 1940s when it was purchased by a Philadelphia entrepreneur, John Marian who continued to operate the plant in its present location. Over the years the company management adapted to changing markets by developing new product lines in specialty areas. They maintains a rubber/textile product division on a roughly 50-50 basis.

The company has 125 employees and is doing well financially in its product niche.

PIERCE-ARROW MOTOR CAR CO.
1685-1695 Elmwood Ave.
Buffalo

See TOUR #1.

COL. FRANCIS G. WARD PUMPING STATION
foot of Porter Ave.
Buffalo

See TOUR #1.

FRIDAY PROCESS TOUR #5

SAGINAW/GM TONAWANDA FORGE
Kenmore Ave.
Town of Tonawanda

The Tonawanda Forge, as it is popularly known in Buffalo, is a comparatively recent addition to the Chevrolet Engine plant of General Motors. Engine Plant #4 opened in 1937 to produce both automobile engines and axles. During World War II, however, it was retooled to produce military aircraft engines, so that GM moved the axle production to its own location in Buffalo (see Tour #4). In the immediate post-war years, Tonawanda Engine continued to produce aviation engines and, with the Korean War in full swing in 1951, induced the government to build both a forge and a foundry on the Kenmore Avenue side of the property. Thus Tonawanda Forge began its existence as a government facility.

By the 1960s the plant was again manufacturing automobile components for the domestic market. In 1966 the Forge yielded 380 Tons per day of engine forgings, steering knuckles and the like. The plant itself has remained relatively unchanged in overall space, having only a small (170' x 88' x 31') addition built in 1971 to be used for cooling forgings with the space consigned to that process opened up to expand production on the Vega aluminum engine.

The equipment used at the forge includes several die forges and presses of up to 3500 tons in capacity which were installed in 1953 and remain on line today. Before reaching the die forges and presses, forging stock is heated in rotary and induction furnaces where they reach temperatures of 2600° F. Some of the stock is sent to hot formers which yield 80 pieces per minute. These were installed in 1981 and produce various parts for engines, transmissions, and rear-drive axles. About 35% of Tonawanda Forge product in the latter category remains in Buffalo supplying Delevan Axle. The Forge serves also as a kind of merchant mill; while the bulk of production is for General Motors, the Forge also supplies axles and transmission components to Ford Motor Co. for its New Venture operations.

Known as the Chevrolet Forge Plant for the first 30 years, GM changed the name of the operation to New Departures Hyatt in 1984. Workers complained that it sounded like an airport hotel, but it was supposed to reflect the reorganization of GM product groups into internationally-cooperative arrangements with Canada as part of the Chevrolet-Pontiac-Canada group. In 1989, because both Tonawanda Engine and Forge and Delevan axle had product links, all three were reunited as the Saginaw Division of the C-P-C group.

In early 1989 GM announced plans to invest $125 million in the engine plant, expanding the overall capacity with a new line of engines to be assembled on a second production line. The forge was also expanded to keep pace with the heavier demands for component forgings. Despite the downturn later that year, the Tonawanda facility remained a key link in the corporate production plans, surviving and expanding even as other facilities closed.

In late 1991 expansion plans were finalized to build the 3.1 liter engine at a rate, at full capacity, of 9200 units per day. Despite the benefits to GM in expanding the forge along with the engine plant, in April, 1992 there was discussion of selling the forge operations to the Michigan-based Forming Technology Division of Masco Industries. At the present time, no plans have been completed. The Forge currently employs 600 workers.

CHARLES R. HUNTLEY STATION
River Road
Town of Tonawanda

In 1916 the Buffalo General Electric Company opened a coal-fired electric generating station near the Niagara River in the Town of Tonawanda. Conflict and carnage in Europe had created a climate of uncertainty regarding the reliability of hydroelectricity received from Niagara Falls--a potential target for saboteurs; wartime production was also straining the limits of existing generating capacity.

Built by Babcock & Wilcox, the River Station initially contained three 20,000 kw generating units. Additional 25 Hz units were added as follows: 1919--35,000 kw, 1926--60,000 kw, 1928--75,000 kw. Production of 60-cycle current commenced in 1930, and a long series of additional units went on line in 1942, 1948, 1953, 1954, 1957 and 1958. During the 1920s the River Station was renamed for Charles R. Huntley, president of Buffalo General Electric from 1907 to 1926.

The 80,000 kw 1942 turbo-generator was one of the first large condensing units built in a single casing; it also featured hydrogen cooling. The Westinghouse 100,000 kw unit installed in 1954 included the world's first completely inner-cooled generator, hydrogen gas being forced through a hollow copper coil rotor. The addition of the two 200,000 kw 1957-1958 units resulted in removal of the original 1916 generating equipment.

Completion of the 1958 expansion program brought Huntley's overall up to 1,200,000 kw with eight units generating 60 Hz current and three producing 25 Hz. However, not all these units remain in service today. Steam pressures for the latest units registered at 1250 psi as of 1942 and 2700 psi by 1958; during the same years the station carried steam temperatures of 900 degrees and 3000 degrees respectively. Fuel consumption per kilowatt-hour was 3.3 lb. as of 1920, .85 lb by 1942, and .68 lb in 1958. Electrostatic precipitators were fitted to cut stack emissions in 1972-1973. Coal is received by both rail (in unit trains) and by water (in self-unloading lakers). The station's parent, Niagara Mohawk, is the result of a 1949-1950 consolidation among several upstate utilities.

BUFFALO SPECIALTY PRODUCTS SHOP INC.
S-3100 Lakeshore Rd.
Blasdell

Buffalo Specialty Products began in 1983, but the building and the process history are those of Bethlehem Steel. For many years Specialty Products was an independent business operating south of the main Bethlehem plant. Bethlehem bought the company and subsumed the operations as part of the overall Lackawanna production until the plant itself closed in 1983. At that time Specialty Products was purchased by Helm Coal Corporation a holding company based in York, Pennsylvania that began operating the facility one week after the final shutdown of the rest of Bethlehem's Lackawanna operations.

The Specialty Products line includes highway guide and guard rails as its primary output. Under Bethlehem ownership the mill turned out sections for making steel stockyard pens, all-steel cellar doors, storage racks, jigs for auto assembly plants, blanks for auto rear axle housings and universal joints, steel window and screen framing, milk can sections, steel track for overhead garage doors. Other cold roll formed sections included concrete reinforcing bars and rebar mats, and expanded joists and studs Some ornamental railings and gates were also produced there. The mill can produce heavy shapes from coil or plate that are 5/8" thick up to 90' long.

The basic process used both by Bethlehem and Helm Coal is cold forming from coil or plate. The mill is considered a "McKay" mill so named for the big roll former around which other operations are centered. The other principal press is an Alpha Press with Talleyrand controls. Unnecessary stock is also cut off in the Alpha. Automotive blanks are turned out on the 400-ton Niagara Press (Buffalo, NY) which performs the first step in this process. The Niagara has a coil feed and leveler. The 800-ton Bliss Press has a coil box and coil feed to take stock 3/8" thick to 48" wide plus sheets and manual-feed parts. The parts and semi-finished shapes are stored for further work by a Hohl pneumatic stacker.

Specialty Products also has its own machine shop to both manufacture and repair 90% of its equipment. The company also designs its own tools in house with a CAD/CAM system of their own.

Coils to feed the presses and blanking machines comes largely from steel service centers or is bought directly from steel mills. Sources change constantly based on availability and price.

The company currently employs 70 regular workers, but this summer has been able to hire 8 college students to supplement the workforce on a temporary basis.

FRIDAY PROCESS TOUR #6

BETHENERGY LACKAWANNA COKE DIVISION
Hamburg Tpk.
Lackawanna

Technical dictionaries tell us that coke is "the solid residue from the carbonization of coal after the volatile matter has been driven off." Beginning in the 1890s the intramural heat and energy balance of steel plants was changed quite dramatically by new procedures for trapping and refining the aforesaid volatile matter (rather than simply venting it into the atmosphere as was the practice at older beehive ovens). By-product coking was an integral part of operations at the new works of the Lackawanna Steel Co. from its inception. By 1907, seven years after construction of the plant had gotten underway, there were 10 batteries in place, a total of 470 ovens. The first four batteries (188 ovens) used the Otto-Hoffman regenerative heating design; the remaining six batteries consisted of Rothberg ovens. Coke made in these ovens was pushed into pans and quenched manually.the by-product plant recovered ammonia, tar and other substances used in the manufacture of dyes, drugs and other organic compounds. An Otto benzol facility was added in 1915 to process light oils useful in the production of the high explosives then being expended so prodigally and futilely on the Western Front. In 1920, as the Lackawanna Steel era drew toward a close, a new Semet-Solvay battery of 60 ovens became the first at the plant to quench coke in a hot car.

During the decades when Bethlehem Steel oversaw integrated production at Lackawanna (1922-1983), the following types of new batteries were constructed at the coke plant: three Koppers-Becker with 171 vertical gun-flue ovens; two Wilputte with 152 gun-flue ovens; three Wilputte with 228 underjet ovens (including one six-meter battery). In 1953 a major reconstruction of the coal handling system resulted in installation of a belt conveyor, supplemented by mobile stocking and reclaiming equipment, to replace a coal bridge that had collapsed in a windstorm. Coal arriving via rail was unloaded by a dumper rated at 20 cars or 1400 tons per hour. Low-volatile coal moved from the dumper to storage on 54" conveyors running at 500 fpm and was reclaimed from the field west of the coke plant for movement over the same route to the coal preparation facilities. As of 1955 this coal handling system was capable of stocking and reclaiming 25,500 tons over two eight-hour shifts. As of 1973 (the last burst of prosperity at Lackawanna), 3,775,000 tons of metallurgical and thermal coal was received by rail; designated capacity of the coal yard at this time was 1,000,000 tons.

After the shutdown of ironmaking, steelmaking and primary mill operations at Lackawanna in 1983, the coke plant remained active as part of the BethEnergy Division. Three batteries continued in operation, though #9 (the six-meter battery) has since been shut down. Coke is now produced in 152 Wilputte underjet ovens at Battery #7 (1952) and #8 (1962). On a coking cycles of 18 minutes each slot oven turns 14.5 tons of coal into 12 tons of coke. Annual production is approximately 800,000 tons. Facilities at the coal chemical plant as of 1984 included direct primary coolers, direct final coolers, centrifugal exhausters, direct saturators (ammonia absorbers), centrifugal and displacement gas boosters, light oil scrubbers, gas desulphurizing units, and an Otto benzene plant. Coal chemical products at that time included tar, ammonia liquor, ammonium sulphate, light oil, benzene, toluene, xylene, solvent naphtha, naphthalene, pitch, sodium phenolate, tar acid oil, primary oil and sulphur as well as coke oven gas.

A recent emissions abatement program to reduce discharges affecting air and water quality has resulted in a new coke-pushing control system, a closed-loop benzene recovery system, and a pretreatment plant staffed by bacteria with a taste for the phenols, ammonia and thiocyanate present in the weak ammonia liquor previously discharged into the local sewer system. The BethEnergy Lackawanna coke plant is presently up for sale.

BETHLEHEM STEEL GALVANIZED PRODUCTS DIVISION
Hamburg Turnpike
Lackawanna

Operations in this portion of Bethlehem Steel's Lackawanna plant involve cold reduction and coating of coils from the Burns Harbor, Indiana works. The steps in this process include: 1) pickling, the chemical removal of mill scale (iron oxide) from hot-rolled coils by immersion in an acid bath; 2) cold reduction, the flat rolling of pickled coils on tandem (continuous) mills to diminish thickness, provide a smooth surface finish, and enhance physical properties within specified dimensional tolerances; 3) annealing, a heat treatment to restore ductility and remove stresses associated with cold reduction; 4) temper or skin pass rolling, a light reduction after the annealing stage to induce the desired surface finish, mechanical properties, and acceptable flatness without stretcher strain markings; 5) galvanizing, the coating of cold-rolled steel with corrosion-resistant zinc.

The cold mills department dates from 1935-1936, a period of revolutionary change in the basic steel industry associated with the introduction of continuous mills producing the flat-rolled steel increasingly used in consumer durable goods. This line would become the staple of most integrated steel plants after the Second World War, displacing rails, structurals and other kingpins of the capital goods trade. At Lackawanna original cold mill equipment was extensively revamped over the course of successive modernization programs such as the upgrading carried out between 1949 and 1952. As a result, maximum coil weight increased from 12,000 lbs. to 65,000 lbs. over the 20-year interval from 1935 to 1955. The continuous hot-dip galvanizing line, housed in a separate building, became operational in 1962.

Hot-rolled bands from Burns Harbor go first through a continuous pickling line. As of 1950 there were three picklers in service, each rated at 80 tons per hour.

The 4-high, 4-stand tandem cold reduction mill has 20" diameter work rolls and 49: diameter backup rolls; both sets are 75" in width. This mill was extensively reconfigured during the early 1950s. A fourth stand was added at that time; the original 1250 motor drives were replaced by 2500/4000 hp units; and the top speed was increased from 620 to 2200 fpm. By the mid-1950s the 75" tandem mill and its 54" companion were capable of handling 70" diameter coils. The average hourly output of both mills was 125 tons.

Cold-reduced coils are stacked and box-annealed in one of 11 gas-fired radiant-tube furnaces. A substantial tonnage of cold-reduced steel was at one time also annealed in (flat) sheet form. Annealing is useful in preparing a formable substrate for coating.

Temper rolling is conducted on two 4-high, single-stand 75" skin pass mills with 20" and 24" diameter work rolls, respectively.

Based on 20 turns per week (essentially equivalent to round-the-clock operation), the 75" tandem mill has a annual rolling capacity of 1,080,000 tons, approximately equivalent to the nominal output rating of the temper mills.

In the finishing department coils may be slit or cut to sheet length per customer order.

The galvanizing line accommodates coils up to 70,000 lbs. in strip widths of 24" to 72". Maximum line speed is 430 fpm. Annual coating capacity is 500,000 tons. Coatings include zinc-iron alloys with a spangle-free finish (Jetcoat/Galvanneal).

Cold-reduced or coated sheet is sold to customers in the automotive, appliance and construction sectors. Recent investments in the Lackawanna facilities have included computerized speed and shape controls on the 75" tandem mill and a post-anneal alloy furnace in the galvanizing department. Labor-Management teams (LMPTs) are actively involved in solving daily problems that affect overall quality and efficiency.

ORIGINAL AMERICAN KAZOO CO.
8703 Main St.
Eden

In 1907 Harry Richardson opened a sheet metal workshop where he made toy flutes, fishing tackle boxes, metal dog beds, and peanut vending machines. In 1916 Richardson converted his shop over to producing a metal version of a wooden kazoo invented by Emil Sorg and Michael McIntyre. Today, many of the original Niagara Machine & Tool Co. presses are still stamping out kazoos to the tune of 2,500,000 units annually. These machines, however, have been extensively retrofitted to meet current occupational safety standards. Electronic and pneumatic controls have been incorporated into the presses so that only a single stroke is made when the operator hits the foot pedal or hand lever. The small shop in Eden remains the only plant in the U.S. where this musical instrument is manufactured by metalforming methods. It is now owned by Brimms, Inc. of Tonawanda, New York, whose product lines include health and beauty aids, sporting goods and toys.

In making the #19 kazoo no soldering or welding is involved. The process begins with flat sheet metal that is sheared to size in strips. Two dedicated blankers then stamp out the rough forms of the kazoo's top and bottom portions. These machines may also be set up to produce parts for kazoos in the form of other toy instruments. The edges of both blanks are then curled under and the top half is embossed with the maker's name. In machine #2 the top-half blank is curved, the air hole stamped out and the key impressions formed. Machine #4 attaches the round resonator holder to the top half. The resonator holder, part of a two-piece component, had previously been stamped from sheet metal as a round blank and formed into a cup; a hole was then punched out and threaded to receive the replaceable resonator element (usually concocted from portions of sheep anatomy). The cap is also formed separately by blanking and cupping; its circumference is rolled under, and a hole is punched out and threaded. Other forming machines curve the bottom blanks. The top and bottom halves are subsequently mated by being pressed together in a final crimping machine, the resonators are inserted by hand, the cap is screwed on, and the kazoo is ready for packaging. All the presses are driven through line shafting and belting from a single 20 hp motor. Dies are sharpened in the shop, but the work of actually making them is jobbed out.

Production of other kazoos in the form of toy musical instruments involves some soldering as bells are welded onto horns and slide tubes (previously machine-rolled and hand-bent) are married to trombones. An air-static powder coating line, installed in 1989, has replaced older painting techniques. The company also manufactures plastic kazoos by injection molding, though that process is not carried on at the Eden shop.

EDWIN R. WINTER & SONS RAILROAD SALVAGE
Route NY 75 / Shirley Rd.
North Collins

Edwin R. Winter and family earn their livelihood by coping with derailments and by keeping the Buffalo Southern, a short line running over a former Erie RR branch, on track also. However, the avocation of this extraordinary clan involves the salvage and restoration of historic machinery, particularly gas and steam engines. Using much of the same equipment they employ in righting Conrail wrecks, the Winters have amassed a significant collection of large artifacts, now housed or displayed in the open on their property south of the Village of Langford in the Town of North Collins. Many of the machines were once associated with Buffalo manufacturers or industrial sites.

Among the steam traction engines is an operating 1912 Buffalo Pitts, made by the local firm descended from John Pitts' 1851 agricultural machinery works. Originally used to run a cheese factory rather than for road work, this 12 hp model was subsequently rehabilitated by Wallace E. Wood of the Rochester area. He completed the cab, changed the location of the coal bunker from left to right, put on a new tank, reflued the boiler and rebuilt the link motion. After being displayed at fairs for a number of years, the Buffalo Pitts migrated to Canada, but it was later repatriated and restored by the Winters. According to information compiled by Herman Sass, as of 1912 the Buffalo Pitts company offered a line of single traction engines from 10 to 30 hp as well as 14-35 hp double engines. Cylinder dimensions for the single engines ranged between 7" x 10" and 11 1/4" x 12"; the comparable figures for double-cylinder models were 6" x 10" to 7 3/4" x 12". Other working traction engines include a 40 hp Beau Bogart, built in 1902 by the Buffalo shop of Farrar & Trefts, and a 1916 80 hp model by J.I. Case of Racine, Wisconsin.

Large pieces of equipment by other well-known firms include a Snow compressor by the East Buffalo works that had merged with five other companies, including Holly of Lockport as well as Worthington, in 1899; this 100-ton specimen was Ed Winter's first major project in the restoration field. An eight-cylinder, 200 hp product of the former Buffalo Gasoline Motor Co. on Niagara St. dates from the era of WWII. Also on displayed is a 24' flywheel from one of the 1927-1928 Bethlehem gas blowing engines from the former Blowing Engine House #2 at the Lackawanna steel plant.

LOVE CANAL
97-99th Sts.
Niagara Falls

William T. Love came to Niagara Falls in 1892 to build a model community with easy access to markets and abundant inexpensive power. The key to his development was to be a canal that would supply power to nearby industrial sits. By 1896 Love had abandoned his plans. Some 45 years later what remained was a ditch, approximately 75' wide and 3000' long, called Love's Canal. The canal was located just outside the city limits at that time, and the area was sparsely populated.

In 1941 Hooker Electrochemical Company determined that Love Canal was suitable for use as a landfill. The new site was needed to accommodate increased volumes of waste resulting from war-related chemical production. Hooker utilized the canal for disposal from 1942 to early 1954. Disposal was a "dig, bury and cover" operation. At the time it was considered to be an improvement over the usual practices of open dumping or untreated disposal in the most convenient waterway. Over a twelve-year period Hooker filled the northern and southern thirds of the canal with manufacturing residues and plant wastes.

By 1954 residential growth into the area surrounding Love Canal was imminent. The Niagara Falls Board of Education requested that Hooker sell it the canal property for a school. Initially reluctant, Hooker transferred the property to the School Board after a site investigation and with a deed that disclosed the contents of the canal. The 99th St. School was built adjacent to the unfilled central portion of the canal. .Houses were subsequently constructed on properties east and west of the canal property. Roads and sewers were built through the area as well. Eventually, the northern and southern portions of the canal were transferred to the City and to a private developer.

During the ensuing years there were occasional incidents of subsidence and exposure of wastes. Landowners placed and graded additional fill or cover over the residues. Hooker provided assistance and advice when requested. In the late 1970s it became apparent that there were chemical releases from the canal. The City, Niagara County and Hooker began the process of remediation.

The initial focus of the remedial plan was containment of the chemicals through a system of barrier drains, on-site leachate treatment and a clay cap. In 1979 the State of New York took responsibility for the remediation. Through a series of orders the State and Federal governments relocated hundreds of families in the surrounding area and eventually purchased the homes. All but two structures in the two rings of homes closest to the canal itself were demolished and covered under the cap that seals the site today. Other remedial efforts have addressed the clean-up of off-site chemical migration to sewers and creeks. Hooker, now Occidental Chemical Corporation, will incinerate (thermally destroy) contaminated sediments at its Niagara Falls plant.

Love Canal has given rise to numerous legal proceedings, some settled, some now in court, and some pending. At present, the Federal Circuit Court in Buffalo is considering the outcome of a punitive damages trial that lasted eight months. Still to come is a resolution of the apportionment of remedial costs as well a some private suits, though the majority of those cases have been settled. Throughout the litigation industrial historians, both avocational and professional, have provided insight into the social, technical and regulatory context surrounding Love Canal and the chemical industry of Western New York.

NIAGARA FALLS WATER WORKS
5317 Buffalo Ave.
Niagara Falls

In 1912 the city of Niagara Falls completed a municipal water works, comprising a 48" steel pipe intake extending 2200' into the east channel of the Niagara River, a pumping station and a filtration plant. Both the city and the privately-owned Niagara Falls Water Works Company had previously drawn their supplies from portions of the river that were heavily contaminated by sewage from Buffalo and the Tonawandas. The consequences included periodic typhoid fever outbreaks that eventually proved intolerable. The new filter plant combined coagulation, sedimentation, rapid sand filtration and chlorination treatments. A year after the new facility went into service the number of typhoid cases had dropped 1100%.

The original Indiana Limestone ashlar filter building was T-shaped. Filter gallery dimensions were 124' x 66'; two settling and coagulating basins measured 124' x 55' x 21'. Intake water passed through 16 filter units containing 30" of Cape May sand and underwent simultaneous air/water washing. The gallery was extended to the east when 16 additional filters were installed in 1935. A coagulation wing was added in 1956. The adjacent pump house was subsequently converted to a garage and the original Allis-Chalmers 7 mgd electric turbine pumps are no longer extant. A 4700' intake to the Emerald Channel was opened in 1950, relegating the east channel intake to emergency service. A separate 32 mgd pumping and filtration plant was completed in 1953. The Niagara Falls Water Works were the first to use the gaseous chlorination treatment process.

Water is currently drawn from a new 48" intake running 3000' into the East Channel, the Emerald Channel intake having been closed. All treatment and pumping operations have been concentrated in the 1953 facility. Raw water is chlorinated and filtered through 18" of anthracite coal and 14" of sand; there are six filtration units. No aeration techniques are used. The present capacity of the pumping station is 40 mgd.

Under an agreement negotiated among the city, state and federal governments and approved by a U.S. district judge Occidental Chemical Corp. (formerly Hooker) would contribute $64.9 million toward a new municipal drinking water plant. Between 1947 and 1961 Hooker had disposed of 63,000 tons of chemical-processing waste in a eight-acre dump known as S-area. Some of these chemicals have seeped into the soil around the city water plant. Occidental has been under court order since 1983 to control the seepage and undertake remediation measures.

BUFFALO AVENUE INDUSTRIAL DISTRICT
56th St. to Portage Rd.
Niagara Falls

Among the industries spawned by the availability of hydroelectric power were plants producing abrasives, chemicals and ferroalloys via novel processes such as the electrolytic cell and the electric arc furnace. The wall of industry that still lines the south side of Buffalo Avenue between the water works (see above) and the site of the E.D. Adams generating station (see below) includes several descendants of those early ventures. Numbered among the largest consumers of power from the first of Adams' stations were Union Carbide (15,000 hp), the upper aluminum works of the Pittsburgh Reduction Company (3600 hp), Carborundum (1100 hp), Niagara Electro-Chemical (650 hp) and Oldbury Electro-Chemical (500 hp).

One of the earliest electrochemical firms to set up operations based on the availability power from the Falls was the Castner Electrolytic Alkali Company. In 1897 Power House #1 of the Niagara Falls Power Co. began transmitting alternating current to the 550-amp models of Caster's patented electrolytic cell. Each unit was divided into three compartments, two containing brine with an intervening space filled by water. At the bottom of each cell lay a pool of mercury that functioned as a cathode. Metallic sodium, formed by the electrolysis of sodium chloride, amalgamated with the mercury. A rocking motion imparted to the cell carried the metallic sodium from the two outer compartments to the inner compartment where it reacted with the water to form a pure caustic soda (NaOH). Chlorine gas was formed at the anodes in the two outer compartments, and was subsequently passed over lime to produce bleaching powder. This chlor-alkali process constituted the Niagara Falls plant's staple product line during most of its history. The name of the concern was changed to Mathiesen Alkali in 1917, and the complex is now part of Olin Corporation. The last of the Castner cells was removed in 1961 [but the original building that housed them remains extant]. This plant was the first to produce liquid chlorine (1909), synthetic anhydrous ammonia (1923) and the rocket fuel, hydrazene.

The consequences of innovation at a nearby site would prove even more momentous. In 1904 Clinton P. Townsend and Elmer A. Sperry (inventor of the gyroscope) patented an electrolytic cell that proved superior to the LeBlanc and Solvay processes in the production of caustic soda and chlorine. In the Townsend cell an electric current was passed through a salt solution, yielding sodium hydroxide, chlorine gas and hydrogen gas: the equation is 2 NaCl + 2 H20 + electricity = 2 NaOH + Cl2 + H2. The process was put into commercial operation by the Hooker Electro-Chemical Co., using Niagara Falls hydroelectric power. BY 1906 a total of 68 2000-amp Townsend cells were in use at the new plant on Buffalo Avenue. Bleaching powder was also formed by passing chlorine gas over lime. A fire in 1910 destroyed most of the original facilities and initiated a reconstruction with fireproof building materials. As in the case of many other chemical and dye companies, a building boom occurred during the First World War; a noteworthy employee representation plan followed in the postwar turmoil of 1919. The original Townsend cells were eventually superseded by the Marsh, Hooker Type-S and the H4 designs.

In the course of its expansion Hooker also acquired two pioneering electrometallurgical/electrochemical companies, originally located on the south side of Buffalo Avenue. The Oldbury Co. produced white phosphorus in electric furnaces similar to the type originally used by Carborundum. The Niagara Alkali Co. specialized in chlorine and caustic potash (potassium hydroxide or KOH); the last of the Vorce cells originally used in this process was replaced in 1972 by high-amp, stationary mercury cells. Beginning in the 1930s Hooker diversified its product line to include synthetic chemicals, insecticides and fire-resistant plastics.

ECHOTA
A-D Sts, west of Hyde Park Blvd.
Niagara Falls.

During the 1890s the Niagara Falls Power Company created this planned, 84-acre industrial community through its subsidiary, the Niagara Development Company. The Cherokee word, "Echota", was translated as "Town of Refuge." Stanford White designed the housing. The village initially consisted of 67 dwellings with provision for 112 families along with a three-story brick building that functioned as a general store, assembly hall and bachelors' quarters; a school and fire hall were also constructed. Homes featured electric lighting, running water and indoor plumbing. Individual residences were rented at first and eventually sold off by the company, following a pattern of asset calculation evident in New England textile communities and other industrial centers. Structures to the east of Hyde Park Blvd. were removed during construction of the intakes for the Robert Moses generating station (see below).

DOBBIE FOUNDRY & MACHINE COMPANY
150 Portage Road
Niagara Falls

The Dobbie Foundry & Machine Company was incorporated in 1896, succeeding the firm of Dobbie & Stuart, formed in 1892. However, the company had done business in Niagara Falls under other names since the Civil War and also had conducted operations across the border in Thorold. The foundry had cast grave markers for casualties of the Spanish-American War. Following incorporation Dobbie specialized in production of hoisting equipment for a global market. They supplied safety winches to support the suspended light fixtures in New York's Grand Central Terminal and McKim, Mead & White's Penn Station, furnished steel frame winches for the Panama Canal and the DEW Line, and turned out a wide variety of timber or steel stiff-leg, guy, barge and travelling derricks, many of which were used on domestic and overseas projects by the U.S. Army

Corps of Engineers.The last large, custom-order derricks built at this shop were installed at the Snell and Eisenhower locks on the U.S. section of the St, Lawrence Seaway in 1959. The oldest portion of the brick, U-shaped foundry and forge shop dates from approximately 1892; the reinforced concrete machine shop was added in 1923. The foundry and forge ceased operations in the mid-1960s when the business chose to emphasize machine shop work, steel fabrication and warehousing. The company is now out of business.

ADAMS STATION DISCHARGE TUNNEL
Underground, Buffalo Ave. to Lower Niagara River
Niagara Falls

The Niagara Falls Power Company commenced construction of the discharge tunnel for its hydroelectric plant in 1890. During the preliminary phase of exploring ways to utilize the immense energy potential of the cataract, Thomas Evershed of Rochester, a division engineer on the Erie Canal, had proposed a two-mile underground tailrace to receive the discharge of 238 turbines operating under heads of 79-124'. His notion of using the Falls to generate mechanical horsepower at individual mill sites was abandoned by the Niagara Falls power Company in favor of the pioneer AC generating station named for financier Edward Dean Adams. However, the idea of a long tailrace tunnel was retained to convey discharge from the hydroelectric station above the Falls to an outlet portal in the lower river.

The tunnel is horseshoe-shaped in cross section with a maximum height and width of 21.027' x 18.84'. The original lining was 10" of vitrified paving brick laid in rowlock courses with Portland cement mortar. The 4'/1000' grade changed to an ogee 90' from the portal to permit half the flow to discharge below mean low water level. The discharge rate was calculated at 8900 cfs. Overall length of the tunnel was 7438' after its extension to Power House #2 by 1902. George B. Burbank acted as the resident consulting engineer. Along with the Adams Station, the tunnel fell into disuse but was eventually recycled as part of a new municipal waste water treatment plant; only minor repairs to the tunnel lining were found to be necessary at the time. The partially-submerged outlet portal is visible just downstream from the Rainbow Bridge and upstream from the site of the former Schoellkopf Generating Station.

ADAMS STATION TRANSFORMER HOUSE
Buffalo Ave., opposite Portage Rd.
Niagara Falls

The achievements of the Niagara Falls Power Company on this site are a milestone in the development of power generation and transmission. Inauguration of service to Buffalo, 22 miles away, in 1896 marked the debut of commercially-successful alternating current generated at central power stations and transmitted over long distances.

Construction began in 1890 with work on the underground discharge tunnel (see above). The entire development was in operation by 1904.

The complex consisted of two power houses and a transformer house flanking an inlet canal. In 1965 both power houses were razed and the canal filled in; the entry to Power House #1 was reconstructed on Goat Island. The power houses contained a total of 21 turbine-generator units. Water was diverted from the Upper Niagara into the canal, 1700' x 250' x 12', whence it dropped through steel penstocks to the turbines, using 136' of the 216' head nominally available. The original turbines in Power House #1 were double-runner Fourneyron-type, discharging directly into the wheelpit. They were designed by the Swiss firm of Faesch & Piccard and built by I.P. Morris of Philadelphia. Due to frequent thrust bearing burnouts and loss of head associated with the absence of draft tubes, these units were replaced during 1910-1913 by Francis inward-flow turbines, designed by C.G. Egbert of the Niagara Falls Power Co. and built by Bethlehem Steel. The 11 turbines in Power House #2 also featured a Francis-type runner; they were designed by Escher, Wyss & Co. of Zurich and fabricated by I.P. Morris. The original horsepower rating of each turbine was 5000 at 250 rpm. Long vertical shafts connected the individual turbines to their component generators up in the power houses. The generators in Power House #1, designed and built by Westinghouse, were of the umbrella type with an external revolving field. General Electric designed and built the 11 units in Power House #2, five of which featured an internal field that simplified the fabrication process. The current generated was two-phase, 2200 volts. This was stepped up for transmission to three-phase, 11,000-22,000 volts by pairs of GE air-blast transformers or Westinghouse oil-insulated, water-cooled transformers, located originally in the surviving transformer house.

The Adams Station suffered the fate of many landmark innovations: it was initially successful and therefore quickly outmoded. By the time the plant went on standby in 1921 its 110,000 hp capacity was being dwarfed by continued incremental improvements such as the three Allis-Chalmers units then being readied for installation in Schoellkopf Station 3-C: each was designed for 70,000 hp and 65,000 kva at 107 rpm under 213' head. Devoid of original equipment, The Adams Station Transfomer House is now distinguished chiefly by its architectural lineage, having been designed by McKim, Mead & White. The original section of the quarry-faced ashlar building is 90 1/2' long with a subsequent extension to the southwest.

GREEN ISLAND BRIDGE
Over Niagara River from U.S. Shore to Green Island
Niagara Falls

In 1900, mindful of the tourist influx that the impending Pan-American Exposition at Buffalo would bring, the Commissioners of the State Reservation at Niagara Falls elected to replace the "excessively ugly" bowstring truss bridge that had connected Green Island to the mainland. Contracts were let to W.H. Keepers & Co. of New York for two concrete and steel arch bridges with limestone facing. One span would connect the shore to Green

Island, once the site of a large paper mill; the other would continue from Green Island over to Goat Island.

Since the bridges were to cross the Upper Niagara's rapids only 500' above the American Falls, the construction project was both difficult and hazardous. Temporary bridges, composed of 17 sunken stone-filled timber cribs, carried life lines between piers. A 600' cableway transported materials to Green Island. Electric motors powered the centrifugal pumps used to evacuate water from the cofferdam and also operated the concrete mixers. In order to complete the work before winter, a night shift worked above the 30 mph current under arc lights.

The bridge to Green Island is the longer of the two spans, 371' overall. The two end arches measure 103 1/2' x 10'; the center arch is 110' x 11 1/2'. The arches were formed of concrete, mixed one part Portland cement:two parts sand:four parts gravel and passed though a 1 1/4" ring; 13 pairs of 6" x 3/4" steel bars reinforce each arch. The voissoirs are quarry-faced limestone, 36"-42", extending 10-18"into the concrete.The spandrel walls, piers and abutments were given a similar stone treatment. The 13 1/2'-thick piers, each armed with a granite-nosed icebreaker on the upstream side, rested on a concrete base set into the river bottom. The original iron railings and gravel roadway have been replaced, but the bridge has otherwise seen little alteration.

GOAT ISLAND BRIDGE
Over Niagara River from Green Island to Goat Island
Niagara Falls

This bridge is a smaller version of the Green Island span. It is 198' in length. The center arch is 55' x 10' and the shore arches measure 50 1/2' x 9'. The piers are 8' thick. The consulting engineer on both bridges was Richard S. Buck.

FIRST SISTER ISLAND BRIDGE
Over Niagara River inlet from Goat Island to First Sister Island
Niagara Falls

The Commissioners of the New York State Reservation at Niagara Falls authorized the present stone arch bridge in 1898. It replaced a suspension bridge that obstructed the view between Goat Island and the first of three islands commemorating the daughters of a General Whitney. The arch is formed of quarry-faced limestone laid in Giant Portland cement. The voissoirs are 3' thick at the springing line and 2'6" thick at the crown. The 60' span of the arch consumes most of the length of the bridge; the arch's rise is 8.902'. The arch crown and a portion of the abutments have a concrete backing. Quarry-faced limestone also forms the spandrel and wing walls, which curve into projecting bays on either shore. The architects were Vaux & Emery of New York, and the contractor was W.A. Shepard & Co. of Niagara Falls.

RAINBOW BRIDGE
Over Niagara River and Gorge
Niagara Falls, U.S.A.-Niagara Falls, Canada

A total of four bridges have occupied the site of this international crossing just below the Falls where the main trade has always been in tourism. The first two were of the suspension type, opened in 1869 and 1889 respectively. The original construction project by the Niagara Falls and Clifton Bridge Company resulted in a 1268' span with wooden towers that were subsequently replaced in iron. The original cables were fashioned from iron strands. The bridge was designed by Canadian engineer Samuel Keefer. In 1887 Leffert L. Buck undertook the task of widening the deck (two carriages could not pass abreast) and replacing most of the original fabric. On the night of 9-10 January 1889 a windstorm destroyed the renovation shortly after its completion, and Buck replaced the structure on the basis of his recent modifications. However, the need to accommodate a new electric street railway as well as pedestrian traffic soon brought L.L. and R.S.Buck back on the scene with a commission for a heavier structure.

The Bucks' choice for this third bridge was a two-hinged deck arch with a Pratt truss web system. Known as the Falls View Bridge or Upper Steel Arch--as then distinguished from the near-contemporary Grand Trunk crossing downstream (see below) --and also as Honeymoon Bridge, it was the longest steel arch built during the 19th century, spanning 840'. The rise of the arch was 150.' A pair of inverted bowstring truss shore spans, 190' and 210', made the connections with the cliff tops. Construction took nearly three years between 1895 and 1898. The Buck design survived until 1938 when an ice jam in the gorge rose up to the skewbacks, shearing the arch off at its hinges and causing a spectacular collapse that was thoroughly documented by the media.

The engineers of the present Rainbow Bridge, Waddell & Hardesty of New York, took heed from the 1938 disaster, relocating to a site 550' further from the Falls and setting the main arch abutments on solid rock 50' above the surface of the river. It was the first publicly-owned bridge over the Niagara. This fourth crossing is an open-spandrel steel deck arch with a span of 950', the longest hingeless arch in the world at the time of its construction according to David Steinman (though not Carl Condit). The main arch consists of two steel box girder ribs spaced 56' apart. Each arch section is composed of 24 girders 12'in depth. The deck of the bridge is 1450' long with a pair of 22'-wide roadways separated by a central mall. The roadways are carried 202' above normal water level. When the Rainbow Bridge opened during the wartime year of 1941 annual traffic totaled 362,000 vehicles and 1.6 million pedestrians. The comparable figures for the 50th anniversary year of 1991 are 4.5 million vehicles and 590,000 pedestrians. Within the next few years the Niagara Falls Bridge Commission plans to widen the traffic approaches and increase the number of border inspection lanes.

MICHIGAN CENTRAL RR CANTILEVER BRIDGE
Over Lower Niagara River and Gorge
Whirlpool St. / Ontario St., Niagara Falls, U.S.A.

Only a masonry pier on the American side remains from the span constructed in 1883 to carry the double-track line of the Michigan Central Railroad over the Niagara Gorge. Conceived by Charles C. Schneider, this structure has often been identified as the first large North American bridge built on the cantilever principle. However, it was not the first such design to be proposed: W.P. Trowbridge had set the precedent when his plan for the Blackwell's Island Bridge over the East River in New York was accepted in 1874; a cantilever bridge was constructed on the Cincinnati Southern Railroad route over the Kentucky River in 1877.

Claims of priority notwithstanding, the Michigan Central Bridge was certainly a noteworthy structure in its time. Given the difficulty of the site, Schneider resorted to construction procedures similar to the methods employed in erecting the Canadian Pacific's Frazer River span. Both steel and wrought iron members were used in the original structure which consisted of two 195' anchor arms, two 175' cantilever arms and a 120' central span. A high steel bent, comprising four inclined posts resting on masonry footings, rose from each bank to carry deck Whipple and Pratt truss approach spans.The rails crossed 239' above the swirling waters. The total clear span between the towers was 470', and the overall length of the bridge was approximately 900'. Schneider designed the bridge to accommodate 66-ton locomotives and trainloads of 2000 pounds per linear foot. To keep pace with the increasing weight of motive power and rolling stock, a new center truss was incorporated at the turn of the century; the reconstruction permitted the bridge to carry 167-ton locomotives and 4000 lb./ft. rolling loads. In 1925 the cantilever was replaced by the present steel arch immediately downstream (see below) and subsequently dismantled. According to unsubstantiated rumors, some of the metal from Schneider's creation was recycled into a bridge at an undetermined location in Africa.

MICHIGAN CENTRAL RR STEEL ARCH BRIDGE
Over Lower Niagara River and Gorge

Though plans to replace the cantilever bridge were being formulated at the time of the First World War, construction did not get underway until 1923. H. Ibsen of the Michigan Central designed the present structure, a two-hinged spandrel-braced deck arch with a span of 640'. The railway line crosses the gorge just north (downstream) of the cantilever bridge site. The current Michigan Central bridge, which has inherited the Upper Steel Arch nickname from the late Falls View Bridge, opened to traffic in 1925. It is located immediately upstream from the Grand Trunk RR crossing.

GRAND TRUNK RR STEEL ARCH BRIDGE
Over Lower Niagara River and Gorge

The chasm hewn over eons by the Lower Niagara River has furnished one of the great bridge sites in North America. The gorge in the vicinity of the Whirlpool is approximately 800' wide. The perpendicular drop of the cliff walls is in excess of 200', and the swift current of the rapids below has always precluded construction of piers or falsework. The challenge posed by the conditions at this particular location has been met by three exceptional bridge engineers.

Charles Ellet had received a theoretical introduction to cable suspension bridges at the Ecole Polytechnique. In 1847, while designing a crossing over the Ohio River at Wheeling, he also contracted with the American & Canadian Niagara Bridge Company to build the first railway suspension bridge on the continent. By 1848 Ellet had spanned the gorge with a 770' wire-cable suspension footbridge with wooden towers as a preliminary to the railway span. The width of the deck was a precarious 7', and there was no stiffening truss. The iron basket used to ferry workers, materials and thrill-seeking tourists across the river on a tramway during construction now reposes in the collections of the Buffalo & Erie County Historical Society. A dispute with the company directors over apportionment of revenues led to Ellet's departure under a cloud of bad feelings (he subsequently concentrated his attention on Wheeling and acquitted himself nobly).

Responsibility for the railway bridge project passed to John A. Roebling in 1851. Trained at the Royal Polytechnic of Berlin, Roebling had emigrated from Prussia in 1831 to become the American virtuoso of the suspended bridge form. Using Ellet's bridge as the auxiliary for which it was intended, he completed the railway span in 1855. The 821' double deck (providing for a roadway as well as trains) was carried between masonry piers by four 10" iron wire cables with radiating stays. The composite Pratt stiffening trusses, 18' in depth, consisted of wooden posts and diagonal iron rods. Though not the first permanent span across the Niagara (another footbridge had opened further north at Lewiston-Queenston four years earlier), the job of constructing a railway bridge twice the length of any predecessor--and over such a vertiginous site--burnished the luster of Roebling's reputation. In 1880 Leffert L. Buck,the third outstanding engineer to test his talents against the rigors of Niagara, replaced the original stiffening trusses with steel; in 1886 he erected steel towers in place of the original masonry. In neither case was traffic on the bridge interrupted.

However, the constantly increasing live load of locomotives and rolling stock eventually dictated that Roebling's bridge be replaced. In 1897 Buck completed the present steel arch for the Grand Trunk Railway. It was the first arch to span the gorge, nosing out Buck's other creation, the Falls View Bridge (see above), for the honor by 11 months. The two halves of the arch were erected simultaneously from travellers on the suspension bridge which was then removed: once again, traffic continued without interruption. The two-hinged spandrel-braced double-deck arch has a clear span of 550' with a rise of 114'. Two 115' Pratt trusses connect the rail and highway decks with the tops of the cliffs, giving a overall length of 1070' including approaches. The bed plates of the arch rest on masonry abutments on the slopes of the gorge; the Canadian abutment has a concrete foundation. The rails are carried 225' above the river. Buck proportioned the bridge to carry a live load of two 128-ton engines and a trainload of 3500 lb./ft. Early modifications included replacement of the highway deck and reinforcement of the arch in 1919. Also known as the Whirlpool Rapids Bridge or Lower Steel Arch Bridge, the Grand Trunk Bridge presently carries a single track. The Niagara Falls Bridge Commission is currently planning to replace the 1897 span with a new four-lane international bridge on a site 200' further north. Construction is expected to take place between 2001 and 2004 at a cost of $102 million.

NIAGARA POWER PROJECT
5777 Lewiston Rd.
Lewiston

With a total capacity of 2400 megawatts, the state Power Authority's Niagara Project was one of the largest hydroelectric plants in the world when it went on line January 28, 1961. The project is located about four miles north (downstream) from Niagara Falls. It utilizes 176' of head from the Falls, combined with 129' of drop in the rapids above and below the cataract.

Water from the Niagara River is diverted at the head of the upper rapids, 2.5 miles above the Falls, through a pair of four-mile long, buried conduits, 46' x 66', that run underneath the city of Niagara Falls. The conduits empty into a forebay, located on the escarpment above the Niagara River Gorge.

The project includes two power plants: the Robert Moses Plant, a conventional hydroelectric station, and the Lewiston (Tuscarora) Pump-Storage Plant. The Moses station has 13 150 mw units operating under 305' head. Each is equipped with a Francis turbine that receives water through a 24' diameter penstock. The plant combines the forebay dam, headworks, and a semi-outdoor powerhouse in a single structure, 1840' long x 580' wide x 389' tall.

The Lewiston plant has 12 pump-generator units. They are arranged to raise water from the forebay into an upper reservoir, using power from the Moses station, during period of low demand for electricity. As daily demands approach their peak, water is released back into the forebay through the units. In this latter mode each has a generating capacity of 20 mw. Head ranges from 66' to 101' through the course of the cycle.

Average flow of the Niagara River is about 202,000 cfs. In 1950 the U.S. and Canada signed a treaty, agreeing that, for the sake of scenery and commerce, no less than 100,000 cfs should flow over Niagara Falls during daylight hours in the tourist season from April 1 through October 31. At night and during the winter, flow over the Falls can be cut back to 50,000 cfs, the remainder being available for hydroelectric generation.

The Power Authority project is the only remaining hydroelectric plant on the U.S. side of the Niagara River. It superseded the 80 mw Adams plant, built in 1895, and the 360 mw Schoellkopf Station, built in 1907, enlarged 1918 and 1924, and nearly destroyed by a rockslide on June 7, 1956.

The Sir Adam Beck stations of Ontario Hydro are opposite the Moses plant, on the Canadian side.

LEWISTON-QUEENSTON BRIDGE
I-190 over Lower Niagara River and Gorge
Lewiston, U.S.A.-Queenston, Ontario

Downstream from the Niagara Power Project, the present steel arch is the third crossing at this site. The first bridge was a suspended design by Edward W. Serrell that opened in 1851; it survived until an 1864 winter storm left photogenic remnants dangling over the gorge. No replacement was attempted until 1898-1899 when Richard S. Buck produced a second suspension bridge. This design spanned 840' with a tower-to-tower distance of 1040'. It included recycled cables from the recently-dismantled bridge upstream at Clifton, another Buck project (see above, Rainbow Bridge). The second Lewiston-Queenston Bridge originally carried a single track for the International Traction Company plus a roadway and walkway. Hardesty & Hanover designed the steel arch successor that opened in 1962; at 1000' it is the world's longest fixed-end bridge. As enumerated by Carl Condit, the elements consist of two fixed ribs, spandrel posts without diagonal bracing, K-truss bracing between the ribs, and pyramidal skewbacks.

NORTHERN TIER, ERIE CANAL COMBINED LOCKS 67-71
Pine St.
Lockport

The 60+' cliff of the Niagara Escarpment presented a major engineering problem during construction of the original Erie Canal (1817-1825). The puzzle was solved by Nathan S. Roberts who designed a double flight of five locks for ascending and descending traffic. His design, and the labor of Irish construction crews, also created the focal point for the city of Lockport. Each lock measured 90' x 15' with a lift of 12'. An original drawing of the Roberts twin flight survives in the possession of the Lockport Public Library; however, the locks themselves have been replaced by subsequent construction.

The first enlargement of the Erie Canal, carried out in fits and starts between 1836 and 1862, expanded the canal prism from 40' x 28' x 4' to 70' x 52 1/2' or 56' x 7' and the lock dimensions to 110' x 18'. The maximum tonnage of canal boats was thereby increased from 75 to 240. The extant Northern Tier consists of five combined locks, #67-71, built of limestone ashlar. These locks were completed in 1842, just as the Stop Law called a four-year halt to state canal construction. Thomas Evershed, who would later attempt to master Niagara Falls, worked on this project as a young engineer. The locks in the northern flight were not lengthened during the canal upgrading of 1884-1890. Their combined lift during that era was 54.16', the varying height of the lift at Lockport having been determined by changes in the height (or existence) of a dam further west at Tonawanda.

The Erie Barge Canal project of 1909-1918 resulted in replacement of the southern flight by two concrete, electrically-operated locks, 310' x 45' x 12' with a combined lift of 49'. The early 20th-century design was inspired to some extent by the engineering of the Ymuiden locks on the North Sea Canal. The Barge Canal locks' gate and valve operations are powered by vintage GE 7 hp motors. The miter gates of the Northern Tier have been removed, and the flight now functions as a spillway around Locks #34-35. Two of the stone-arch footbridges that once spanned the chambers remain in place.

SOUTH HYDRAULIC RACE
Along Niagara Escarpment
Pine St. to Exchange St.
Lockport

In order to maintain the four-foot depth of the original Erie Canal for the 62-mile stretch from Lockport eastward to Rochester, water was diverted around Nathan Roberts' twin flight of combined locks. This flow of surplus water furnished the power for Lockport's earliest industries. However, because the water was actually the property of the state, interplay between political and manufacturing interests became continuous and, on occasion, rancorous.

In 1826 a surface-level hydraulic race or power canal was chopped out of the escarpment's face, south of the Erie Canal. Water was conveyed from above the locks to Lyman Spaulding's seven-story flour mill and the Pomeroy & Bass carding mill (neither is extant). Subsequent extensions reached the Douglas & Jackson flour mill (not extant) in 1828 and the site of the Lockport Manufacturing Company's cotton mill as of 1832 (extant, see below). Here the waste water was discharged into Eighteen-Mile Creek.

In 1856 the Lockport Hydraulic Company, which included the politicos Washington Hunt, William Marcy and Thomas Flagler, gained control of the surplus water privileges. The new group enlarged the South Race to a bottom width of 12' and a depth of 6'; they subsequently blasted a hydraulic power tunnel through the cliff on the north bank of the canal (see below). The present remains of the South Race, including some masonry retaining walls and earthen embankments, presumably date from these improvements of 1856-1858.

As of 1880 a two-level power canal system was in use. The lower level is no longer visible: it was supplied by the tailrace discharge from the Thornton & Chester flour mill (see below, Dickinson Electric Building). The upper level was about 52' above the level of the canal below the locks. According to the 1880 U.S. Census of water power, a maximum of 500 cfs was diverted around the locks to the South Race and the Hydraulic Tunnel. Assuming 65% efficiency for the turbines at individual sites, approximately 2104 mechanical hp was available of which 1421 hp was then being utilized. Steam furnished 350 auxiliary horsepower. The Lockport Hydraulic Company paid New York State $200 annually for the right to dispose of the surplus canal water which it leased to manufacturers in units of 12 effective horsepower. Eleven industries employing 289 persons operated on the South Race at the turn of the century. Subsequent demolition has cleared away most structural remains except for the Moore Mill, Dickinson Building, Lockport Mfg. Co. and a c.1835 stone building, located between Market St. and the Barge Canal, whose previous incarnations have included a tannery, flour mill and warehouse.

MOORE FLOUR MILL/CITY HALL
2 Pine St.
Lockport

During 1861-1864 N.E. Moore erected a flour mill on Pine Street just south of the twin flight of enlarged locks. The mill was equipped with four run of stone and produced around 100 barrels per day. Water power was furnished by the South Race which curved around the flanks of the building. The subsequent career of the structure has been checquerd. From 1893 to 1974 it served as Lockport's City Hall. The building may also have been connected with the Holly System Water Works which pumped water out of the canal from a site on the north bank beneath the Holly Manufacturing Company (see below). A single-story rear wing and square brick chimney were added prior to 1887, but whether this space initially housed boilers for supplying steam pumps operated in conjunction with the Holly water system is unclear. On an 1887 map the building is shown with its rear wing but is still identified as "W.K. Moore & Co. Flour Mill," whereas an 1898 Sanborn map records the presence of pumping machinery. The second story of the rear wing was added in 1893-1894 to provide City Council chambers. The V-profile of the east gable end may have been shaped by the hillside location: the south gable end of the Richmond factory across the canal is of similar construction (see below). Most traces of the water power system in the 2 1/2-story random ashlar structure have been obliterated by contemporary modifications.

DICKINSON ELECTRIC BUILDING
C. 150' north of Main St., 100' east of Pine St.
Lockport

The building on this site is a descendant of Lyman Spaulding's seven-story stone flour mill which he built on the South Race in 1826; it had eight run of stone. The flour mill succumbed to fire but was rebuilt on the original site in 1840. Another fire occurred in 1858 and the mill was then rebuilt by N.H. Wolf. The reconstruction may have taken place slightly higher up the slope of the Niagara escarpment as the course of the South Race was altered by the Lockport Hydraulic Company at about the same time. The Buffalo millers Thornton & Chester bought Wolf's mill in 1877 and operated it until fire visited for a third time in 1895.

Around 1900 Charles E. Dickinson utilized the charred site for a hydroelectric station. Because the building was set against the steep face of the escarpment the raceway entered it on the seventh floor: semicircular arches in the north and south facades mark its course. Three generating units aggregating 1320 kw were installed prior to 1919 but are no longer extant. Interior flooring and columns presumably date from Dickinson's reconstruction; the extent to which the quarry-faced random ashlar exterior walls survived previous fires is unknown. Viewed from the east, the building does appear to have been constructed in two phases since a line of quoins runs down the center of the facade. Completion of a Niagara Mohawk station in 1942 rendered the Dickinson Building redundant. It is now owned by the City of Lockport which lopped off the top two stories to install an observation platform.

LOCKPORT MANUFACTURING COMPANY MILL
33 Exchange St.
Lockport

Only the first story and truncated tower survive on the oldest extant industrial building in Lockport. In 1833 the Lockport Manufacturing Company erected a cotton factory in Lower Town, which the Albany Land Company had projected as a rival to the settlement around the locks. Power was derived from the South Race (see above) that discharged into the underground Eighteen-Mile Creek in this vicinity. The original mill was five stories in height and 120' x 54' in plan. The Lockport Manufacturing Company and its successor, the Niagara Manufacturing Company, continued to produce textiles until 1854 despite problems with irregular water supply. Work associated with canal enlargement seems to have resulted in a shutdown during 1854-1857 after which Henry Walbridge and Washington Hunt converted the structure into a flour mill with eight run of stone. The Franklin Milling Company, incorporated in 1894, subsequently took over operations until 1907 when a fire reduced the building to its present dimensions. The remnant has smooth-faced random ashlar walls with a concrete-block addition on the northwest corner. The projecting central tower still bear the plaque of the Lockport Manufacturing Company.

LOCKPORT HYDRAULIC COMPANY TUNNEL
Parallel to north bank of Erie Barge Canal above and below locks
Lockport

The tunnel of the Lockport Hydraulic Company is a product of the inventive genius of Birdsall Holly, united with the political connections of former governor Washington Hunt and his cronies. After gaining control of the surplus water rights in 1856, the company had initially confined its efforts to improving the South Race (see above). In 1859 Holly commenced manufacturing sewing machines on the fifth floor of the Boston Block Company; his backers included Hunt and other investors in hydraulic enterprise. By 1864 Holly was in need of additional space to manufacture components for the water works system he was then perfecting. Land was available atop the escarpment north of the Erie Canal, and Holly's friends still controlled the water rights. The problem of how to utilize the 57' available head from a site perched on the edge of a cliff was solved when Holly devised a scheme for blasting a tunnel to carry water from above the locks to the turbines of his proposed machine shop (see below).

The first section of the tunnel was completed in 1865; it was extended to the Richmond Manufacturing Company (see below) in 1869 and to the Lockport Pulp Mill (now ruins in Upson Park) around 1880. Overall length was approximately 2800'. The charter of the Lockport Hydraulic Company was canceled in 1908, and the tunnel was abandoned when construction of the Barge Canal lowered the water level below the intake.

HOLLY MANUFACTURING COMPANY
Lock, Gooding and Caledonia Sts.
Lockport

The history of Lockport is entwined with the inventions of Birdsall Holly. A native of Auburn, New York, Holly collaborated with Henry Silsby of Seneca Falls in designing a rotary pump prior to relocating to Western New York. In 1859 the Holly Manufacturing Company was formed with capital provided by several figures in the Lockport Hydraulic Company, including the ubiquitous Washington Hunt. Works were constructed on the escarpment north of the flight locks, powered by water from the Hydraulic Company's tunnel (see above).

The foundry and machine shops turned out boilers and steam pumps for Holly's patented water supply system that combined domestic service and fire protection (1864); components were also manufactured for his district steam heating system (1876). The Holly shops were the largest industrial employer in Lockport as of the mid-1890s with a payroll of 470; but the decline from that point was rapid. The firm was merged into the International Steam Pump Co., machinists struck for $3.00 a day, and by 1904 all operations had been transferred to the former Snow Steam Pump complex (subsequently Worthington) in Buffalo. A fire in 1909 left the original buildings in ruins that have lingered down to the present, but two later structures on Caledonia St. have survived though with modifications: the former foundry, 100' x 60', and the erecting shop, 160' x 90'. Neither building appears on an 1875 map; both are represented on an 1887 map. Each quarry-faced ashlar building has been reduced to a single story with flat roof.

RICHMOND MANUFACTURING COMPANY
29 Gooding St.
Lockport

The Richmond Manufacturing Company was founded in 1869 by James Richmond and subsequently taken up by his nephew, William. The firm produced grain cleaning machinery for flour mills; 60 were employed at the turn of the century. The present building was constructed in 1881. It is four stories high, 192' x 40' in plan, built of quarry-faced random ashlar with a V-shaped south gable ends similar to the rear wing of City Hall (see above). A small stone wheel house, halfway down the escarpment derived power from the hydraulic tunnel (see above) and, for a time, transmitted it across the canal to other sites via wire rope. Subsequently occupied by a box company and a ceramics manufacturer, this is the best preserved of the industrial structures in the 1975 National Register District along the north bank of the canal.

ERIE BARGE CANAL BRIDGES (passed on lock cruise):

LAKE ST. BRIDGE

ADAMS ST. VERTICAL LIFT BRIDGE

EXCHANGE ST. VERTICAL LIFT BRIDGE

NEW YORK CENTRAL RR NIAGARA FALLS BRANCH BRIDGE

PINE ST. BRIDGE

"THE BIG BRIDGE"

BUFFALO HARBOR CRUISE

Inner Harbor: Buffalo River

BUFFALO NAVAL & SERVICEMEN'S PARK
1 Naval Park Cove
Buffalo

Berthed along the museum's 1300' frontage on the Buffalo River are three specimens of World War II-era technology for warfare at sea: the cruiser USS Little Rock (retrofitted with guided missiles), the destroyer USS The Sullivans, and the submarine USS Croaker. The site was once occupied by the freight house of the Delaware, Lackawanna & Western RR. This road entered Buffalo via the northeastern Pennsylvania anthracite regions and commenced establishing extensive waterfront facilities in 1879-1882.

DELAWARE, LACKAWANNA & WESTERN RR TERMINAL
Foot of Main St. at South Park Ave.
Buffalo

One reason for the failure to build a union railway station in Buffalo was the reluctance of the DL&W to abandon the advantages of its waterfront location. The anthracite carrier completed its new passenger terminal in 1917. It was designed with a double deck, carrying six passenger tracks on the upper level with three lower tracks for express freight shipments. A high-level service track ran past the street facade to the old freight house and coal docks along the north bank of the river. Piles were driven to bedrock at 31-53'. The upper level tracks were carried on a reinforced concrete deck and columns. Of note is the trainshed whose design follows the pattern of shallow vaults devised by Lincoln Bush for the railroad's Hoboken Terminal (1904). Arched steel girders spanned a pair of tracks to carry continuous, reinforced concrete roof slabs. Illumination was provided by skylights, conceived by the railroad's A.E. Deal and composed of a series of 6-7" glass panes--not exactly a daylight factory, but sufficient perhaps for the purpose. Train service ceased in 1962. The neo-classical passenger waiting area and office building has since been demolished. However, the former freight track area has been recycled to accommodate the maintenance shop for MetroRail cars. Both ends of the Bush trainshed on the upper level have now been enclosed, but the space itself remains vacant, several proposals for commercial and cultural use never having reached fruition.

FIREBOAT EDWARD M. COTTER

Recently sent to the sidelines by municipal budget difficulties, the Cotter and its crews battled many waterfront blazes during a long and valiant career. The vessel was launched in 1900 at Elizabeth, NJ and originally carried the name of city fire commissioner

W.S. Grattan. Its firefighting apparatus included three piston pumps capable of delivering 9000 gpm. In 1928 the Grattan was severely damaged by an explosion and fire at what is now the Mobil Oil complex. Rebuilt with new pumps and oil-fired boilers, the fireboat returned to service in 1930. The Grattan was dieselized in 1953 and another generation of pumps boosted firefighting capacity to 15,000 gpm. The following year the modernized vessel was renamed in memory of Edward M. Cotter, late president of Buffalo Fire Fighters Local 282, AFL-CIO. Under both names the Buffalo fireboat was heavily involved in quelling conflagrations at grain storage and processing plants, beginning at the Wells Elevator in 1902 and continuing through the inferno at Pillsbury's Ganson St. complex in 1972. When the Maple Leaf Mills at Port Colborne, Ontario were burning out of control in 1960, the Cotter crossed Lake Erie to become the only U.S. fireboat ever pressed into international service. A National Park Service maritime resources survey has identified the idle vessel as among the seven most historic examples of its type.

GENERAL MILLS PACKAGE FOOD DIVISION
54 S. Michigan Ave.
Buffalo

This nine-story structure opened on October 6, 1941. A major fire on February 15, 1940 had destroyed a similar facility shortly before its debut. There were four items in the initial product line: Wheaties, Bisquick, Kix (corn) and Cheerios (oats). Today the plant and its several adjuncts include production, storage and shipping facilities that turn out a wide variety of cereals and baking mixes, including all of General Mill's domestic output of Cheerios along with half the Total.

MICHIGAN STREET BRIDGE

The Michigan Street Bridge has had an interesting existence both as an engineering structure and as an historical moment in the annals of tort law.

The first bridge at the Michigan Street location was the 1897 Belidor double-leaf bascule. It was torn down in 1932 and replaced with a vertical lift bridge in 1933. This span had a comparatively short existence. In 1959 during an ice jam on the Buffalo River, a steamer improperly secured at an upriver grain elevator dock pulled loose from its moorings and became a dangerous runaway. With no crew aboard and being both pulled by the rapid current and pinned by the ice, the steamer rushed downstream out of control. At the Standard Elevator the maverick steamer hit the Steamer Tewksbury, which also gave way and crashed into the bridge, caving in the South tower which fell into the river.

Needless to say, this hair-raising adventure called for yet a third bridge installation, the one we see today. The current bridge is a span lift bridge with all mechanisms on the center of the bridge. It is powered by 2 100hp. motors still controlled by the 1960 system of controls and relays. The span length is 240'.

KELLOGG ELEVATOR

DATE	1910
DESIGNER	Charles B. Foster
BUILDER	Steel Storage & Elevator Construction
CAPACITY	1,000,000 bu.
Main Bins	10 x 2 rows, 26'8"ID x 85' high
Innerspace Bins	9 x 1
Outerspace Bins	20
Marine Leg	2 x 15,000bu/hr: mobile (1911)

Spencer Kellogg incorporated in Buffalo in 1892 as an outgrowth of a small linseed oil processing company begun in Amsterdam, NY. The firm withstood challenges from the Rockefeller-dominated American Linseed trust to become one of the nation's leading vegetable oil producers. SK Co. built its elevator to take advantage of the anticipated opening of the New York State Barge Canal in 1915, and by 1912 when the company reorganized as Spencer Kellogg & Sons, Inc., the firm was already worth $6 million. Tied to imported raw plant materials and to export markets for worldwide oil sales, the SK&S's oddly bifurcated structure originally spanned a slip which brought ships directly to the elevator. This area is now filled in. The company expanded its product line during the world wars to find alternatives to scarce supplies and to create new foodstuffs such as oleomargarine for the domestic market. By 1940 the company had its own steamship line and research laboratory. After World War II it was a $100 million business. Throughout its history the company relied primarily on linseed oils as the base operation for the company and particularly the Buffalo Elevator and mill. Thus in 1948 when there was a worldwide shortage of flaxseed, the basis of the oil, the Buffalo operation was closed. The company survived in Buffalo as a business concern with operations around the world, but its very success made it a tempting target for other corporations. In 1961 SK&S was acquired by the giant Textron conglomerate based in Providence, RI which shortly thereafter absorbed the Buffalo company and removed all its independent operations. Today the grain elevator is owned and operated by St. Mary's Cement Company.

WHEELER/GLF ELEVATORS

DATE	1909 (Wheeler)
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	700,000 bu.
Main Bins	5 x 3 rows, 25'ID x 80' high
Innerspace Bins	2 x 4
Outerspace Bins	10 (Open topped)
Marine Leg	1 x 15,000 bu/hr: fixed (1909,rebuilt 1953)

DATE	1936 (GLF "C")
DESIGNER	A.E. Baxter Engineering
BUILDER	Unknown
CAPACITY	170,000 bu.
Main Bins	3 x 2 rows, 21'ID x 85' high
Innerspace Bins	2
Outerspace Bins	None
Marine Leg	See above

DATE	1941 (GLF "A")
DESIGNER	A.E. Baxter Engineering
BUILDER	James Stewart Co.
CAPACITY	1,250,000 bu.
Main Bins	12 x 2 rows, 19'8"ID x 92' high
Innerspace Bins	11 x 2
Outerspace Bins	None
Marine Leg	See above

Wheeler Elevator Corporation was a family concern incorporated February, 1909. In September of that year, they assumed a $200,000 mortgage to construct the concrete elevator but abandoned the active business only 8 years later. In 1921 Producers Warehouse assumed operating control of the elevator. They were the property owning and developing arm of the Cooperative Grange League Federation (GLF), a Syracuse-based farmers' co-op. The Wheeler family retained control of the property until they sold it to Transit Forwarding in 1926. Transit was therefore the GLF "landlord" for three years until in 1929 Transit sold the property outright to GLF. In 1931, due to changes in property law, Cooperative GLF Holding replaced Producers Warehouse as the legal owner. GLF's interest in the Wheeler elevator site was to buy supplies for and sell products on behalf of member farmers. In 1936 and in 1941 GLF expanded the elevator and mill, adding a feed mill as well. In 1964 GLF locals throughout New York and Pennsylvania joined with Eastern States Farmers Exchange, the grange organization in Massachusetts. Upon consolidation they adopted the name Agway. Under this corporate identity they continued to operate the Buffalo elevator and mills until 1974 when the organization decided to decentralize all operations and establish more country elevators rather than large urban terminal facilities. When Agway abandoned the elevator, it changed hands several times becoming a county property in 1985. Finally it was sold to a local fishing club, but they have not occupied the property, and it remains derelict.

HURON CEMENT

Huron Cement Elevator was one of the few built expressly to handle cement rather than grain. Constructed in 1927, it has 22 silos each 80' high. It was operated by Huron until the late 1980s when the plant was acquired by LaFarge Cement based in Southfield, Michigan, The ships that bring the cement to LaFarge come from Bath, Ontario. They deliver about 7,000 tons per load to the elevator which can hold 18-20,000 tons total. Cement is blown in from the ships to the silos and is discharged either in bulk through downspouts to fill waiting trucks or is bagged and shipped in package.

OHIO STREET BRIDGE

The Ohio Street Bridge was built in 1962 as a replacement for the original Brown bascule bridge built in 1906. The current bridge is 1000 tons, has a 275' span, and lifts to about 100' above the river. It is tower driven and is unique in the fact that it is PLC computer operated. It recently underwent a three-phase rehabilitation first replacing the steel deck and some steel members; second, electrical and mechanical systems were upgraded at which time the computer drive was added, and third, the east tower was replaced along with river bumpers and the roadway barriers.

STANDARD ELEVATOR

DATE	1928
DESIGNER	A.E. Baxter engineering
BUILDER	James Stewart Co.
CAPACITY	3,000,000 bu.
Main Bins	20 x 3 rows, 25'ID x 112' high
Innerspace Bins	19 x 2
Outerspace Bins	None
Marine Leg	2 x 30,000 bu/hr: mobile (1928)
	2 x 15,000 bu/hr: mobile (active 1990)

DATE	1941
DESIGNER	McKenzie Hague & Co. (Chicago)
BUILDER	McKenzie Hague & Co.
CAPACITY	2,000,000 bu.
Main Bins	8 x 2 rows, 38'1 1/2"ID x 105'6" high
Innerspace Bins	7
Outerspace Bins	14
Marine Leg	See above.

Standard Elevator was built by the New York City grain company, Hecker-Jones-Jewell. At that time Hecker became a subsidiary of Standard Milling Co. of New Jersey. but the Hecker name was already familiar in Buffalo for its control of other milling and elevator properties. In 1929 Hecker and Standard were bought out by a newly-created investment firm, Gold Dust Corporation which was absorbing large grain concerns including the Rockefeller-dominated American Linseed Company. The take-over was poorly timed; the 1928 agricultural bounty turned to disaster the next year. Less than four months after Gold Dust purchased Hecker and Standard it had to divest itself of excess assets. It sold the Hecker Elevator to Nisbet Grammer, a Buffalo grain merchant and elevator operator who headed Eastern Grain Elevator Corporation. He renamed the elevator the Nisbet after his mother's family, but it was an insufficient talisman, for the elevator did not prosper. In 1935 Grammer died, then in 1938 so did his partner John J. Rammacher. Their deaths brought their company into liquidation, and they sold the elevator in 1939. Ironically the new owner was once again the Gold Dust Corporation now renamed Hecker Products with a Standard Milling subsidiary. They rechristened the elevator the Standard. In 1946 Standard Milling spun off from Hecker taking the Buffalo elevator as part of its holdings. Standard continued to operate the elevator until 1981 when it was sold to Pillsbury which continues to use the facility for its primary storage operations.

ELECTRIC ELEVATOR ANNEX

DATE	1940
DESIGNER	H.G. Onstad
BUILDER	Engineering Construction Co.(Chicago)
CAPACITY	6,000,000 bu.
Main Bins	15 x 1 center row, 1 each corner. 6 in various configurations at 4 intersections.
Innerspace Bins	Not applicable
Outerspace Bins	Not applicable
Marine Leg	None

The Electric Elevator was built in 1897. It existed briefly as the Eames Elevator named for its principal owner who was a Buffalo grain merchant and banker. The Electric was the first electrically-powered grain elevator in Buffalo, hence the enduring mane. Its first phase of construction consisted exclusively of steel rather than concrete bins. Even then it had a 2-million-bushel capacity and substantially enhanced the city's grain storage volume. Despite its promise, the Electric did not enrich its owners whose company remained fairly static. In 1925 the Electric was sold to Eastern Grain Mill & Elevator owned by Nisbet Grammer. Shortly after the sale, the Electric Elevator Company was dissolved. Eastern Grain ran the Electric throughout the Depression until the deaths of the primary owners, Grammer and Rammacher (see Standard Elevator). In 1939 the Electric was sold to the giant grain merchant company, Cargill Inc. which was looking for eastern terminal elevators to supplement its extensive midwest country and sub-terminal elevator holdings. In 1940, responding to the early wartime pressures for massive exports and to the glut of grain from Canada pouring from the plains seeking outlets in eastern harbors, Cargill wanted an eastern facility to handle the supplies. The company contracted a 6-million-bushel annex for the Electric, this time a concrete structure with bins 80' high. The addition was built in record time, rising 6-12 feet per day. Despite its appearance there are actually no bins; rather, there are large open chambers surrounded by a semi-cylindrical facade. Construction began in September, 1940, and just before the end of the shipping season, 4 million bushels were already in storage. Cargill had no real commitment to either the elevator or the city; during the post-war years the only incentive for Cargill to retain the Electric lay in its utility for storing government surplus grain through the Commodity Credit Corporation. Proximity to the St. Lawrence and to comparatively nearby New York City ports accessibly via railroad with cheap rates made Buffalo a logical transfer point for CCC grain, especially in winter. In 1964, however, Buffalo lost its preferential rates, and Cargill determined it was no longer profitable to retain the Electric. They did not immediately relinquish the property, however. They merely abandoned it and ceased paying taxes. In June, 1982 the county foreclosed and held an auction for back taxes on the Electric. Cargill interestingly was the winning bidder, buying back its own facility for a mere $40,000, less than they owed. In December, 1983 they finally sold the Electric to a group of Niagara Falls investors who, in March, 1984, demolished the original steel bins along with the sole marine leg, leaving only the annex we see today.

AMERICAN ELEVATOR
RUSSELL-MILLER FLOUR MILL

DATE	1906
DESIGNER	James Stewart & Co.
BUILDER	James Stewart & Co.
CAPACITY	2,250,000 bu.
Main Bins	12 x 4 rows, 24'10"ID x 89'8" high
Innerspace Bins	11 x 3
Outerspace Bins	None
Marine Leg	1: fixed (1906) 1: mobile (1922) 2 x 12,500 bu/hr (active 1990)

DATE	1931
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	1,400,000 bu.
Main Bins	6 x 4 rows, 20"ID x 125' high
Innerspace Bins	5 x 3
Outerspace Bins	16
Marine Leg	See above

American Elevator was established by the great U.S. malt trust, American Malting incorporated in 1897. Its proprietors included J.P. Morgan and maverick chicago grain speculator Joseph Leiter. In 1905 American Malting proposed a Buffalo riverside malthouse and elevator to supplant its smaller facility on a rail line in the city. The original elevator was constructed in 1906, and it ran profitably until 1919 when the trust ran afoul of the Volstead Act and Prohibition. Unlike its neighbor, Perot Malting, American Malting could not successfully convert to general grain trade operations and went bankrupt. The Chancery Court of New Jersey directed the grain trust to liquidate its holdings including the Buffalo elevator and malthouse. In 1921 the site was purchased by a subsidiary of Russell-Miller Milling which built a flour mill to replace the malthouse in 1925. In 1933 they enlarged the elevator, their only eastern operation, and successfully entered eastern markets with their retail brand, Occident Flour. Less than 20 years later they were taken over by another giant grain merchant, Peavey, Co., the sixth largest flour trader in the world. Peavey modernized and expanded the mill (but not the elevator) making it the world's largest pneumatic mill and Buffalo's fourth largest overall. In 1988 a much smaller upstart food processor based in Omaha absorbed Peavey and therefore the elevator property. ConAgra now runs the elevator and mill as part of its merchant mill business.

PEROT MALTING

DATE	1907
DESIGNER	James Stewart & Co.
BUILDER	James Stewart & Co.
CAPACITY	500,000 bu.
Main Bins	3 x 3 rows, 24'ID x 90' high
Innerspace Bins	2 x 2
Outerspace Bins	None
Marine Leg	None

DATE	1933
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	431,000 bu.
Main Bins	3 x 3 rows, 21'ID x 90' high
Innerspace Bins	2 x 2
Outerspace Bins	8
Marine Leg	None

[For history and operations see Friday Tour #3]

LAKE & RAIL ELEVATOR
INTERNATIONAL MILLING FLOUR MILL

DATE	1927
DESIGNER	Unknown
BUILDER	James Hettelsater
CAPACITY	1,600,000 bu.
Main Bins	10 x 3 rows, 23'2"ID x 110' high
Innerspace Bins	16

Outerspace Bins	20/ Square-10 6 x 6
Marine Leg	2: mobile (1927)
	2 x 12,000 bu/hr (active 1990)
DATE	1928
DESIGNER	Unknown
BUILDER	James Hettelsater
CAPACITY	650,000 bu.
Main Bins	4 x 3 rows, 23'2"ID x 110' high
Innerspace Bins	4 x 2
Outerspace Bins	8
Marine Leg	See above
DATE	1929
DESIGNER	Unknown
BUILDER	James Hettelsater
CAPACITY	1,000,000 bu.
Main Bins	South annex: 14 irreg. geometry. Max diameter 32'2" x 110' high.
	Southwest annex: 16 irreg. geometry. Max diameter 32'2" x 110'
Innerspace Bins	21 irreg. geometry
Outerspace Bins	21 irreg. geometry
Marine Leg	See above
DATE	1930
DESIGNER	Unknown
BUILDER	James Hettelsater
CAPACITY	1,150,000
Main Bins	14 x 3 rows, 15'ID x 150' high
Innerspace Bins	13 x 2
Outerspace Bins	30
Marine Leg	See above

In the 1920s, International Milling Co. was the second largest flour miller in the nation. It combined U.S. and Canadian grain processing and elevator operations, hence the name. Founded in Fairibault, Minnesota, it went bankrupt in 1891 then recovered by 1904 to begin its international expansion. by the mid 1920s, International's concentration in Canadian grain shipments pointed to Buffalo as the logical Great Lakes site for a terminal elevator and mill to handle this massive supply. In November, 1926 they established a wholly-owned subsidiary to acquire and manage an elevator property, Lake & Rail Warehouse & Elevator. International owned 100% of Lake & Rail stock and leased the Buffalo property back from the Buffalo company. International's commitment to the elevator was substantial; they expanded its capacity and upgraded its facilities over a four-year period, 1927-1930 and completed the mill as soon as possible in 1927. They milled and marketed the familiar Canadian "Robin Hood" brand flour which became popular in eastern markets. In 1937 Lake & Rail as a company was dissolved and the Buffalo operations absorbed by the parent company which retained the Lake & Rail name for the elevator. International had incorporated originally in Delaware for tax purposes, but in 1963 they reincorporated in New York to protect themselves from corporate takeover. They established their new company, IMCO, in Buffalo then quickly reincorporated again as International Milling and restoring their headquarters to Minneapolis. Shortly thereafter they began vigorously diversifying their product line to include general food processing. To reflect the change in purpose they were renamed International Multifoods. Flour milling and grain dwindled as a corporate interest, and in 1988 International sold the Lake & Rail to another food processor/flour miller, ConAgra which continues to operate the elevator and mill for their merchant milling line.

BUFFALO UNION FURNACE CO. ORE DOCK
foot of Hamburg St.

This site was once occupied by Buffalo's earliest blast furnaces, established in the early 1860s and consolidated shortly thereafter as the Union Iron Works. Frank B. Baird subsequently redeveloped pig iron production on Farmer's Point in conjunction with the Hanna interests beginning in the 1890s; three stacks were eventually brought under the aegis of the Buffalo Union Furnace Company. Those works too eventually petered out and were dismantled in the 1930s, leaving the former ore dock as the principal material relic. The dock is used today as the berth of the two tugs stationed by Great Lakes Towing to assist vessels navigating on the Buffalo River or other portions of the harbor. Both the Delaware (1951) and the Kansas (1958) have been repowered with diesel engines. Both tugs are 98 gross tons and have the same overall dimensions: length, 81', beam, 21'3", draft, 12'5".

MARINE A ELEVATOR

DATE	1925
DESIGNER	A.E. Baxter Engineering Co.
BUILDER	James Stewart & Co.
CAPACITY	2, 042,600 bu.
Main Bins	8,7+8, 8, 30'6"ID x 110' high
Innerspace Bins	6
Outerspace Bins	None
Marine Leg	2 x 30,000 bu/hr: mobile (1925)

Marine A was built by C. Lee Abell, son of a Buffalo grain trader and himself a jack-of-all-trades before returning to the family business. The Abells ran a wooden railroad elevator for several years before purchasing the 6 3/4-acre riverside parcel where they intended to build a concrete elevator. In 1920 Abell died before he could finish his plans, leaving the business to his playboy son, Harold. Harold took his responsibilities seriously if not as competently as his father, and in 1925 the company subscribed to a $1.5 million first mortgage to carry out the construction plans. Despite the new elevator's superb technical qualities and enormous handling capacity, the company barely squeaked through the Depression years. Saddled with an enormous debt that posed very restrictive terms on Marine's expansion and stock growth, the company began to founder. By 1940 they were in default on their loan and were put into foreclosure. In 1945 Harold Abell was removed from active control and was forced to post his own life insurance policy as collateral against new capital needed to preserve Marine Elevator Co. as a going concern. The shock may have been too great for high-living Abell. Twenty-five days after the trustee was appointed, Abell died. The company limped along for another nine years then was taken over by the Chicago grain trading giant, Norris Grain Co. By 1957 Marine Elevator ceased to exist, the last locally-owned grain operation in Buffalo. The elevator was finally abandoned in 1974 but was purchased in 1985 by local attorney Glen Claytor who someday hopes to rehabilitate the facility into a purified-water fish hatchery to serve the local restaurant trade.

SUPERIOR ELEVATOR

DATE	1914-1915 ("A")
DESIGNER	H.R. Wait/Resident Engineer A.E. Baxter
BUILDER	Monarch Engineering
CAPACITY	1,500,000 bu.
Main Bins	14 x 3 rows, 19'6"ID x 95' high
Innerspace Bins	13 x 2
Outerspace Bins	28
Marine Leg	1 x 25,000 bu/hr: mobile (1914-1915) 1 x 25,000 bu/hr: mobile (1917

DATE	1923 ("B")
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	1,100,000 bu.
Main Bins	7 x 3(+4 angled junction with "A"), 20'ID x 95' high
Innerspace Bins	6 x 2(+4 asymmetrical between 4 whole bins, junction A-B) + 1 inner bin with 3 interspace surrounding
Outerspace Bins	17
Marine Leg	See above

DATE	1925 ("C")
DESIGNER	T.D. Budd
BUILDER	James Stewart & Co.
CAPACITY	1,098,371
Main Bins	7 x 2, 33'6 1/2"ID x 100'6" high
Innerspace Bins	6 x 1
Outerspace Bins	None
Marine Leg	1 x 30,000 bu/hr: fixed (1925)

The Superior Elevator had its origins with Edwin M. Husted founder of Husted Milling & Elevator Co. He owned two small elevators, the Husted and the Nickel Plate along inner city rail lines but was interested in expansion. In 1914 he changed the name of the Nickel Plate to Superior Elevator, Inc. and by embarked on a building program to erect a concrete elevator that would suit the new company name. In June, 1915 the new complex was complete. Husted remained with the company until 1925, then died in 1926. Upon his retirement, however, the company revised its basic purpose to include grain speculation and brokerage. To effect the transition, they became the Premier Elevator Corp. for just one day the reincorporated again as Superior. Over the next years, the company changed its identity several times to evade debts which they incurred while speculating or over-extending their credit. In a fever of acquisition mania, they acquired to other Buffalo elevators, the Saskatchewan Pool and the Connecting Terminal, but they could not sustain these operations. In the spring of 1939 the company was forced to divest itself of many assets to cover their debts. They sold the Superior Elevator to Cargill, Inc. As with the Electric, which Cargill acquired at about the same time, the giant elevator represented a toehold in the eastern grain shipping market. The Superior had a nearly identical history of use and of abandonment by Cargill that did Electric. By the mid 1960s, the Superior was no longer useful to Cargill and was finally closed. It was purchased by Bauer Corporation of Ft. Collins, Colorado but has not been reopened.

CONCRETE CENTRAL ELEVATOR

DATE	1915 ("A")
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	1,050,000 bu.
Main Bins	9 x 3, 20'ID x 95' high
Innerspace Bins	8 x 2
Outerspace Bins	20
Marine Leg	2 x 24,000 bu/hr:mobile (1915)

DATE	1916 ("B")
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	950,000 bu.
Main Bins	7 x 3 (+3 additional, diagonal, north elevation) 20'ID x 95'6" high
Innerspace Bins	7 x 2(+1 between 3 end bins)
Outerspace Bins	16(+2 on diagonal end)
Marine Leg	See above

DATE	1916-1917 ("C")
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	2,500,000 bu.
Main Bins	20 x 3(+4 at end of diagonal wall), 20'ID x 95' high

Innerspace Bins	20 x 2(+5 within end bins)
Outerspace Bins	39
Marine Leg	1 x 24,000 bu/hr: mobile (1917)
	1 x 24,000 bu/hr: fixed (1917)

Concrete Central was built by local grain traders Nisbet Grammer and John J. Rammacher under the various holdings of their parent company, Eastern Grain, Mill & Elevator. Prior to construction they had amassed several individual elevator companies and decided to concentrate these disparate operations once the elevator was under construction. The construction of Concrete Central was made possible by Grammer's family connection to the New York Central Railroad where his father had been an executive. Concrete Central did not own the property outright but, rather, was ceded an entailed transfer from the railroad which kept reversionary rights should young Grammer default on his stated purpose of erecting and operating a grain elevator. Grammer did succeed, and over three years the massive facility was not only built but expanded. The virtually instant success of this venture led Eastern Grain to expand and to acquire further elevator properties, although Concrete Central was the only elevator the company ever built. Between 1915 and the 1930s when both company founders died, Eastern Grain at various times owned or controlled the Electric, Standard, Connecting Terminal. They developed an impressive shipping line in conjunction with Armour Grain, the grain-trading arm of the meat-packing company. At the time of the founders' deaths, the company was most lucrative and might well have become a major national trading and marketing concern. Instead, the company was liquidated on behalf of Grammer and Rammacher's heirs. In 1944 Concrete Central was sold to Continental Grain, the second largest grain trader in the world run by the Belgian Fribourg family. The elevator served Continental well for they, as with Cargill, dealt with government surplus grain storage and the export trade. However, the same factors that affected Cargill's decision to abandon Buffalo and the Electric Elevator had an impact on Continental as well, and in 1966 they ceased active operations at Concrete Central. A local concern, Buffalo Grain Elevator Co. purchased the facility in 1967 and, from storage records in the elevator, clearly were storing government surplus grain as late as 1973. By 1976 they, too had abandoned the elevator, and it has reverted to city property as a derelict property.

LAKE SHORE & MICHIGAN SOUTHERN RR BRIDGE

In 1913 the Lake Shore & Michigan Southern RR, then a leased line of the New York Central, constructed the present through, skewed, single-leaf, double-track Strauss heel-trunnion bascule bridge over the Buffalo River. It replaced two 140' Whipple trapezoidal truss fixed spans as part of a comprehensive navigation improvement program for improving access to upriver industrial sites such as New York State Steel. In the Strauss design the friction of trunnions--steel pins turning within a steel casting on bronze journal bearings--was substituted for the rolling friction used in such designs as the 1914 Scherzer bascule of the New York, Chicago & St. Louis RR immediately upstream. Also in contrast to the Scherzer design, the pivot point is fixed. A parallelogram of linkages among four trunnions folds up as the counterweighted leaf is raised by a toothed operating strut engaging a motor-driven pinion gear. Once known as Bridge #2.67, the structure consists of a c.125' draw span with additional approach spans on either bank. The draw span is a through Warren truss with verticals and riveted connections. The bridge was fabricated by the Pennsylvania Steel Co. of Steelton, PA; a planned companion bascule was never erected.

NEW YORK, CHICAGO & ST. LOUIS RR BRIDGE

This single-leaf, double track Scherzer rolling lift bascule was built in 1914 to carry the trains of the former Nickel Plate and Pennsylvania lines. William Scherzer designed the first movable bridge of this type in 1893 for the four-track crossing of the Metropolitan West Side Elevated Railroad over the Chicago River near Van Buren St. In operation, the leaf simultaneously rises and retreats shoreward. The counterweight is carried on a quadrant described about the center of gravity. Openings [Tread plates] in the bottom of the rolling quadrant mesh with teeth on the horizontal track girders. Power is applied through a pair of pinions to racks fastened to the leaf at the center of gravity. The bridge was originally moved by electric motors with standby diesels. The recession of the draw span afforded a wider channel opening than in the heel-trunnion design, but the changing center of rotation and horizontally-shifting center of gravity required that the piers for rolling lifts have particularly solid foundations. As the draw span is skewed, its through, riveted Waren trusses (with verticals) are of unequal length: the short truss measures 154'7", center-to-center of bearings, while the long truss is 175'5 1/2". The builder was the King Bridge Co. of Cleveland. [This bridge is now permanently raised.]

These aforementioned railroad bascules illustrating contrasting designs occupy a central position in the modest array of movable bridges on the Buffalo River. Immediately upstream is the Buffalo Creek RR Strauss heel-trunnion bascule (1914), which now carries the majority of east-west rail traffic; beyond that lie the South Park Bridge, a vertical lift (1917, rebuilt 1954) and the Strauss heel-trunnion bascule of the former Delaware, Lackawanna & Western RR (1914/1926).

Inner Harbor: City Ship Canal

On the waterfront of 19th-century Buffalo the centerpiece in the patchwork of slips and basins dotting the harbor was the artificial waterway excavated by E.R. Blackwell during 1849-1852. Most commonly known as the City Ship Canal, this commercial artery has been lengthened and shortened on several occasions, reaching the limit of its elasticity during the mid-1880s when it was extended to the former Tifft Farm, then being redeveloped for coal, iron ore and lumber docks by the Lehigh Valley Railroad. These docks have been abandoned, and the old basin is now part of the Tifft Nature Preserve. When the city filled in a portion of the connecting channel after World War II, Blackwell's canal began shrinking back to its present length of some 9000'. It is 200' wide, and navigable depth, originally 12' and 15' as of 1873, is maintained at 22-23' by the Corps of Engineers. The multitude of wooden grain elevators, coal trestles and railroad warehouses that once lined the waterway during its heyday have passed from the scene as have the movable bridges at the South Michigan St. and Hamburg Tpk. crossings, the latter a bascule of the Brown design. The major industries still operating on the City Ship Canal include General Mills, which continues to receive grain via laker through its Frontier Elevator, and Pillsbury, which has idled the historic Great Northern Elevator; an occasional self-unloading vessel also delivers sand to the Founders Supplies dock near the southern terminus.

FRONTIER ELEVATOR
WASHBURN-CROSBY FLOUR MILLS

DATE	1909 (Washburn-Crosby B)
DESIGNER	James Stewart & Co.
BUILDER	James Stewart & Co.
CAPACITY	250,000 bu.
Main Bins	4 x 2, 19'2"ID x 89' high
Innerspace Bins	3 x 1
Outerspace Bins	None
Marine Leg	None

DATE	1909 (Frontier C-1)
DESIGNER	James Stewart & Co.
BUILDER	James Stewart & Co.
CAPACITY	750,000 bu.
Main Bins	6 x 2, 31'ID x 107' high
Innerspace Bins	5 x 1
Outerspace Bins	None
Marine Leg	1 x 22,000 bu/hr:fixed (1911) 1:mobile (1924) 2 x 25,000 bu/hr: mobile (active 1990)

DATE	1913 (Frontier C-2)
DESIGNER	James Stewart & Co.
BUILDER	James Stewart & Co.
CAPACITY	2,388,100 bu.
Main Bins	5 x 5. 31'ID x 116'4" high 5 smaller bins, NW: 24'ID x 116'4" high
Innerspace Bins	4 x 4
Outerspace Bins	4 x 4
Marine Leg	See above

DATE	1925 (Frontier C-3)
DESIGNER	Unknown
BUILDER	Unknown

CAPACITY	1,200,000 bu.
Main Bins	a) 5 x 5 with 3 x 3 at 90° angle, 22'ID x 117' high b) 1@ 30'ID; 1@ 17'ID; 1@ 22'ID x 117' high
Innerspace Bins	20
Outerspace Bins	5
Marine Leg	See above

The current General Mills complex began in 1886 as Frontier Elevator Co. In 1903 the Minneapolis-based Washburn-Crosby Co. established a flour mill in the same general site and developed a working relations with Frontier which received and transferred the flour mill's grain supply. The mill had several tile bins for storage but no marine leg for unloading. Buffalo was strategic for Washburn-Crosby's business because of favorable water and water-rail rates to and from the city than cut the cost of transportation of both raw grains and finished flour products. Buffalo also was permitted to "mill in bond" for export thus having immunity from import duties on Canadian grain imports. In 1907 Washburn-Crosby bought the Frontier elevator then in 1909 built both a second mill and a second elevator. Work was completed on the "C" elevator to replace the original wooden Frontier that had served the milling company so well. By 1913 the Frontier subsidiary had added two more elevator annexes making the facility the fourth largest in the nation. In the years surrounding the first World War and its aftermath, Washburn-Crosby steadily bought up smaller concerns that in 1937 were merged under Washburn-Crosby's control. The name was changed to reflect these events so that General Mills was born. By 1930 Buffalo had surpassed Minneapolis as the milling capital, and General Mills thus poured large sums of capital into its Buffalo operations. The product line diversified, and by the end of World War II General Mills was producing more than 30 different consumer items. Post-war expansion has taken General Mills away from the basic milling and cereal business and led the company to cut back on its flour and cereal production in favor of other consumer goods. They shut the older mills in the 1960s and scaled back in other milling processes. Nevertheless, the Frontier elevators and 2 Washburn-Crosby elevators are still active and still provide the grains needed to make all the Cheerios and the world and half the Total cereal.

GREAT NORTHERN ELEVATOR
PILLSBURY FLOUR MILL

DATE	1897
DESIGNER	M. Toltz-bins; D.Robinson-machinery
BUILDER	D. Robinson/Steel Frame: Riter-Conly
CAPACITY	2,500,000 bu.
Main Bins	10 x 3, 38'ID x 70' high
Innerspace Bins	9 x 2, 18'ID s 70'6" high

Outerspace Bins	West: 9 @ 9'9"	North: 8 @ 8'
	East: 18 @ 9'9"	South: 4 @ 6'
Marine Leg	3 x 20,000 bu/hr: mobile (1897)	

Great Northern was built as the easternmost terminal elevator for James J. Hill's Great Northern Railroad. The railroad had begun to purchase parts of the site in 1883 under its Island Railroad subsidiary, but, for the company's own economic reasons, it did not build the elevator for another 14 years. Great Northern's ownership of the elevator after it was established was short lived. Hill suffered enormous financial strains in his attempt to take over the Northern Pacific in 1901. He decided to retrench and sell off valuable assets for cash. Thus in 1903 the elevator and the Island Railroad were purchased by a group of investors. The new elevator company was known as Mutual Elevator Co. This holding company was comprised of representatives of several other large railroad companies including the New York Central, the Erie, The Delaware, Lackawanna & Western, and even the Santa Fe. These diverse railroad men agreed to use the Great Northern for the benefit of all their companies as the name "Mutual" implies. The alliance survived until 1923 when it was dissolved. In its wake came the Island Warehouse Co., a fictitious "cut-out" for Pillsbury, the Minneapolis-based miller. Island Warehouse was established by Grammer and Rammacher, founders of the Eastern Grain company (see Concrete Central). They maintained direct supervision of the elevator and mill properties for Pillsbury, and both Rammacher and another Eastern Grain officer Edwin T. Douglass, were on the Board of Island Warehouse along with top Pillsbury officers. Island Warehouse dissolved with the founders' deaths, and in 1936 Pillsbury took over the Great Northern outright. In 1981 Pillsbury bought the nearby Standard Elevator to use for its transfer grain loading and thus had no more use for the elegant but aging Great Northern. As soon as Standard was put in operation, the Great Northern closed and is currently in jeopardy of being demolished by Pillsbury.

CONNECTING TERMINAL ELEVATOR

DATE	1914
DESIGNER	H.R. Wait
BUILDER	Monarch Engineering
CAPACITY	1,048,000 bu.
Main Bins	10 x 3, 20'ID x 90' high
Innerspace Bins	9 x 2
Outerspace Bins	30
Marine Leg	1 x 24,000bu/hr:mobile (1914)
	1 x 24,000bu/hr:mobile (1917)

DATE	1954
DESIGNER	George B. Field
BUILDER	Hydro Construction Co. (Buffalo)

CAPACITY	600,000 bu.
Main Bins	5 x 2, 30'ID x 109' high
Innerspace Bins	4 x 1
Outerspace Bins	None
Marine Leg	See above

Connecting Terminal Elevator was built by the Connecting Terminal Railroad, a .31 mile long line that was absorbed into the Pennsylvania Railroad system. The elevator was built in 1914 to replace the railroad's first wooden elevator, "A", that burned March 9, 1914. The rail line depended on the elevator to handle its grain traffic, the primary source of its income, so replacement was a top priority. The new elevator was of presumably fireproof concrete construction, the better to safeguard the investment. The Pennsylvania Railroad ran the elevator directly until 1925 when the Lake Elevator Corporation, a partnership between Buffalo's Eastern Grain Mill & Elevator Company and Armour Grain, a subsidiary of the Chicago meatpacker, was formed to manage elevators in a number of Great Lakes city locations. Lake Elevator took over the operation of the elevator, and Connecting Terminal began its long history of serving many users while still remaining the railroad's property. In 1931 Eastern Grain relinquished its business, and Atlas Grain, a subsidiary of Van Dusen Harrington which three years earlier was absorbed by Peavey, picked up the grain handling business at the elevator. During World War II, Superior Grain Corp., an offshoot of the Superior Elevator Company, handled all grain transactions at Connecting Terminal, benefitting from the wartime volume and from the post-war bumper crop seasons that made elevator space a scarce commodity. Superior also handled government surplus grain storage as well. In 1959 General Grain of Indianapolis acquired the lease, but four years later Connecting Terminal was leased to Continental Grain, one of the global leaders in grain exporting. When Continental lost interest in Connecting Terminal as it had in all Buffalo elevators, it dropped the lease in 1965, and the elevator stood idle. Finally the Pennsylvania Railroad subsidiary, Penndel, their property development arm, put the elevator on the block to be sold. In 1979 the Buffalo River Marina Co. bought the property to provide riverfront access and dockage to small boat owners. Connecting Terminal was finished as a grain handling facility and remains abandoned to this day.

Inner Harbor Entrance

SOUTH PIER LIGHT

Built in 1833, this octagonal lighthouse is the oldest structure in Buffalo still located on its original foundation. It replaced the earliest local harbor improvement, the lighthouse of 1818. When first constructed the lower stone portion of the tower was 44' high, 20' in diameter at its base tapering to 12' at the top, built of smooth-faced limestone ashlar. A surmounting course of stone casement windows along with a two-story metal lantern were added in 1856 when the illuminating apparatus was upgraded to a third-order fixed white beacon, then 76' above Lake Erie including the elevation of the South Pier. In 1905 the fixed lens was replaced by a four-panel lens flashing white every six seconds. In 1914 the pierhead light went dark when the third-order Fresnel lens was moved out to the Old Breakwater.

Even darker days seemed in store for this historic symbol of maritime prominence when the Army Corps of Engineers announced plans in 1958 to widen the mouth of the river and demolish the lighthouse in the process. The threat of demolition galvanized a public campaign to preserve this utilitarian structure; the effort went well beyond any defense mounted on behalf of Wright's Larkin Administration Building a decade earlier--and it was successful. By 1961 restoration of the 1833 light was being undertaken with the Buffalo & Erie County Historical Society as lead agency. A second noteworthy grass-roots preservation program began in 1985 when the Buffalo Lighthouse Association was formed to stabilize the structure and enhance access to it. This organization has installed a replacement lens and placed interpretive signage along a trail through the Coast Guard base. The second revival of the lighthouse in many ways symbolizes Buffalo's hopes for waterfront redevelopment.

The 1833 light commands the head of the South Pier, a much-extended and expanded descendant of the timber-crib structure cobbled together by Samuel Wilkeson and others in 1820 as part of a plan for scouring the sand bar that obstructed the mouth of the river. Wilkeson's success with this privately-funded navigation improvement marked the beginning of Buffalo harbor and the city that sprang from it. Local nineteenth-century patriarchs grew accustomed to the constant maritime parade and the wealth it brought to their doorsteps; they retrospectively canonized Wilkeson as a provincial Romulus and considered thoroughly apt the inscription carved on his headstone: "Urbem Condidit." The stone lighthouse that once guided vessels to Wilkeson's harbor now shares the South Pier with a steel-plate "bottle light", transplanted from the North Breakwater where it stood from 1903 until 1985.

Outer Harbor

Wrangling among competing railway interests retarded shoreline development along the outer harbor until the 1920s. By then a series of detached offshore breakwaters had enclosed a protected anchorage for vessels as well as affording protection to riparian property.

OLD BREAKWATER

Construction of the first breakwater in the outer harbor began in 1868. The intent of the Army Engineers was to build the first fully-exposed, timber and stone coastal protection structure on the Great Lakes. Lying in 27-31' of water, it was to have consisted of 36'-wide timber cribbing, filled with stone and sunk in place, surmounted by a continuous timber framework superstructure, packed with stone and decked over with planking to provide protected inshore mooring sites. Aligned parallel with the shore, the projected length of the breakwater was 4000'. However, the project experience many delays and modifications; it was not completed until 1893. By that time the overall length had stretched out to 7608'. During 1887-1891 3878' of timber superstructure had been replaced with concrete: the recipe for the new material was a heart of "natural cement concrete" and a facing of "Portland cement concrete." In 1893 a gale wrecked the southern shore arm and precipitated a decision by the Corps of Engineers to expand the breakwater system. By 1924 the entire timber superstructure of the Old Breakwater had been replaced with concrete. Subsequent provision for a new ship channel also required removal of 982' of the original structure.

SOUTH BREAKWATER

The Rivers and Harbors Act of 1896 authorized the Corps of Engineers to construct a 12,800' outer harbor breakwater system, extending south from the Old Breakwater to the shore at Stony Point, which within three years would be selected as the site of the new Lackawanna Steel plant. The original plan of Maj. Thomas W, Symonds envisioned a 10,000' breakwater, a 600' south harbor channel, and a 2800' breakwater from the navigation channel to Stony Point. What is now known as the South Breakwater--the larger structure in Symond's scheme--was to feature two different types of construction: 5000' of economical gravel hearting and rubble stone facing with cut revetments and capstones; the other half of sunken stone-filled timber cribbing, each 36' wide, resting on gravel backfill and rubble stone foundations with a timber superstructure to facilitate moorings. However, the timber superstructure was severely damaged by a storm in 1900 and had to be replaced with concrete. The contract for the entire breakwater system was let to Hughes Bros. & Bangs of Syracuse, NY in 1897. Work on the South Breakwater was completed in 1902. [Its present length is 10,200', of which the stone section comprises 7500' rather than the planned 5000'. The dimensions are: 150' wide at the base; 14' wide at the top; height 14 1/2' above mean lake level. The timber crib/concrete superstructure section is 16' wide at the top and rises 15' above mean lake level. The depth of the water in this part of the outer harbor is approximately 27'.

STONY POINT BREAKWATER

This component of the outer harbor protection works was constructed during 1897-1899 as part of Maj. Thomas W. Symonds overall plan to provide a safe anchorage for shipping during the navigation season and for the grain vessels that wintered over to replenish local elevators while the lakes were frozen. Originally 2803' in length, the structure was at first composed of sunken stone-filled timber cribs, 36' wide, and a timber superstructure. Lackawanna Steel removed a portion of the breakwater around 1918 to fill in the surrounding area with slag. The present length is 1603'. The timber superstructure was replaced with concrete during 1923-1924.

NORTH BREAKWATER

The North Breakwater was the second on the Great lakes to feature a concrete superstructure in its original design: the first in its class lies in the harbor of Dunkirk, NY. Authorized by the Rivers and Harbors Act of 1899 to protect the Black Rock channel entry as well as Erie Basin where much canal shipping terminated, this addition to the outer harbor network was completed in 1901. The concrete superstructure covered a series of sunken rock-filled timber cribs resting on rubble foundations in 16-22' of water. The 2203' breakwater was divided into two sections of approximately equal length. The cribbing in the southern half was of standard 36' width while that in the northern section was narrower by some 12'.

FORD FUHRMANN BLVD. ASSEMBLY PLANT

The former vehicle assembly plant on the waterfront represents the third Ford production facility in Buffalo. In 1911, acting on advice from Buffalo native Charles E. Sorensen (eventual major-domo of machinery), Henry Ford acquired the John R. Keim stamping company, a Kensington Ave. firm that had evolved from manufacturing bicycle parts to supplying automobile makers. Around Labor day of the following year machinists, molders and patternmakers at the Keim plant called a wildcat strike. Ford responded with a demonstration of the axiom that capital is inherently more mobile than labor: he moved the presses to Detroit where they helped revolutionize production methods at Highland Park. However, the migration to Michigan did include several Keim engineers, including William S. Knudsen who later headed General Motors. The vacated Keim plant may have been used as an assembly site for a time, but mushrooming demand for the Model T and the need to decentralize assembly operations led to construction a new four-story building at 2495 Main St. in 1915-16. This building featured a handsome brick and terra-cotta facade patterned after the exterior of the 1913 Ford plant in Cambridge, Massachusetts. Designed by Albert Kahn, the Main St. plant had a capacity of 225 units per day. Fords were produced there until 1931 when the waterfront plant opened. Vessels in the Ford fleet could discharge cargoes directly into the new plant from an adjacent wharf. Crowned by butterfly monitors, the main Fuhrmann Blvd. building measured 1200' x 320' and was built to produce 400 cars a day. It closed in 1958 when Ford shifted assembly operations to Lorain, Ohio. The plant is now used for warehousing.

SASKATCHEWAN CO-OPERATIVE (POOL) ELEVATOR

DATE	1925 ("A")
DESIGNER	C.D. Howe
BUILDER	C.D. Howe
CAPACITY	1,100,00 bu.
Main Bins	11 x 3, 20'6"ID x 95' high
Innerspace Bins	10 x 2
Outerspace Bins	24
Marine Leg	2 x 30,000bu/hr:mobile (1925)

DATE	1926 ("B")
DESIGNER	C.D. Howe
BUILDER	C.D. Howe
CAPACITY	900,000 bu.
Main Bins	9 x 3, 20'6"ID x 95' high
Innerspace Bins	8 x 2
Outerspace Bins	18
Marine Leg	See above

The Saskatchewan Pool Elevator is the only grain elevator on Buffalo's outer harbor. The facility was built by Saskatchewan Co-Operative Elevator Co., a producers' cooperative based in Canada's grain belt and an outgrowth of that country's grange movement. Incorporated in 1911, by the 1920s Saskatchewan operate 451 country elevators on the Canadian plains plus terminal elevators in Ontario and then Buffalo. The co-operative had three export arms, one of which was American that gave Canadian farmers legal and practical access to U.S. markets. The Buffalo elevator was a logical extension of that privilege plus a wholly-owned elevator would assure the member farmers of control over prices and standards and freedom from price manipulations so often a factor at privately-owned elevators. In 1925, even as the elevator was under construction, Saskatchewan Co-operative sold out entirely to Saskatchewan Pool Elevator Ltd., another farmer cooperative and a subsidiary of Canada's largest wheat pool. When the elevator opened it did so under the new owner's name and remained "the Pool" in local parlance for all its days. The Pool handled over 50 million bushels in its first year of operation, 1926, making the expansion plans most timely. The Pool continued to do well and to benefit its owners throughout the Depression years, but in 1939 the coop decided to lease the elevator and did so to Superior Grain Co., the offshoot of Buffalo's Superior Elevator. They operated the Pool as they did Connecting Terminal all through the war year then organized the Pool Elevator Corp. to buy out the Canadian interests. The new private corporation promptly entered into a series of lease arrangements with many grain companies, perpetuating the elevator's function as a shared facility. Pillsbury was one of the users, and in 1952 decided to buy the facility outright while promising to continue its operations as a pool. The early 1960s were uncertain for the grain industry, and Pillsbury elected to sell the Pool, this time to Cargill. Cargill took over the Pool even after it jettisoned other elevators due to its reputation as the most efficient elevator in the area, partially due to its lakeside location. But as always

Cargill was fickle and did not maintain active interest in the Pool for very long. The Pool eventually was abandoned, gutted, and derelict. It has recently been purchased by Buffalo businessman Fred Langdon who now uses the property for small boat storage.

LEHIGH PORTLAND CEMENT CO.

The very massive, foursquare elevator along the lakeside just south of Saskatchewan Pool is a cement rather than grain elevator. Built as a cement storage elevator in 19__, it was originally owned and operated by Lehigh Portland Cement until 1971. At that time is was purchased by Wyandotte Cement which later absorbed Independent Cement as an operating division. Independent the assumed the name of the subsidiary in 1976. In turn Independent was acquire by St. Lawrence Cement, a Canadian firm, which now operates and supplies cement to the elevator.

The elevator has a 55,000-ton capacity with 24 silos (as the cement trade calls the bins) that are 125' high. In addition to one side are 6 older silos that are no longer used. For many years the cement was both delivered and sent out via truck. The railroad access is no longer used. The cement is bagged in the basement bag warehouse. In 1991-1992, however, Independent added a barge unloading conveyor system to allow St. Lawrence Cement to send its shipments from Mississauga to Buffalo via the Welland Canal and a more economical water-born method. This represents the first elevator in Buffalo to be refitted for water delivery and unloading.

HANNA FURNACES

The merchant blast furnaces that once occupied this site represented early 20th-century models of vertical integration and plant layout. In 1902 the Buffalo & Susquehanna Iron Co. was formed. Its principals included: William A. Rogers of Rogers, Brown & Co.; Frank and Charles Goodyear of the Buffalo & Susquehanna Railroad; and S.M. Clement of Marine National Bank. To design the plant the entrepreneurs engaged Julian Kennedy whose career as an engineer was comparable to the work of Louis Sullivan or Frank Lloyd Wright in modern architecture. Kennedy's brother, Hugh, became the plant manager.

The company's vertical integration was predicated on control over raw materials and transportation. Iron ore was obtained from properties at Iron Mountain, Michigan and Hibbing, Minnesota. Coke was available from mines and ovens at Tyler and Sykesville, Pennsylvania. The Goodyear interests controlled the rail lines from the coal fields and had a finger in Great Lakes shipping as well. Roger, Brown & Co., which had interests in a total of 23 blast furnaces, marketed the pig iron through its extensive distribution network. The first two furnaces were blown in on September 27, 1904 and July 5, 1905. However, Buffalo & Susquehanna Iron ran into financial difficulty when the Goodyear's railway business foundered. By the time the second pair of stacks was added in 1912 Rogers-Brown Iron had taken over. The Cleveland-based Hanna companies operated the plant during the late 1920s, and the Susquehanna furnaces were merged into National Steel as of 1929.

Julian Kennedy's original plant layout stressed economy in the handling of materials. Beginning in 1903 the Buffalo & Susquehanna and the Pennsylvania railroads collaborated on construction of the Union Ship Canal where lake steamers could dock. Now abandoned, the canal was once 2240' long and 222' wide; it could accommodate vessels drawing up to 23'. Vessels were unloaded by 5-ton Brown Hoisting Machinery travelling bridges, part of the array of mechanized ore-handling equipment devised by Cleveland engineers during the late 19th century to accommodate the rising tide of ore inundating Lake Erie receiving ports. As of 1912 five Brown ore bridges with spans of 225' commanded the dock and the 600,000-ton ore yard. By the early 1950s a sixth rig had been added, and the capacity of the yard had reached 700,000 tons of ore and 60,000 tons of stone for fluxing. The bulk of the stone was delivered by self-unloader to the former Buffalo Union Furnace site on the Buffalo River and was subsequently trucked to the plant. On the north side of the Union Ship Canal opposite the Hanna Furnaces, the Pennsylvania Railroad established the James Thompson ore dock, equipped with a 10-ton electric Hulett unloader.

By the mid-1930s the Hanna (Susquehanna) Furnaces had a pig iron and ferro-alloy capacity of 674,700 tons annually. Lack of extensive modernization, foreign competition (especially from Brazil) and the decline of domestic foundry capacity contributed to the closing of the plant in 1982. The high-level viaduct known as the Father Baker Bridge (c1961) as well as a 1905 Scherzer rolling lift bascule have both been replaced by the present low-level bridge carrying NY 5, which is gradually acquiring the nickname of the "Baby Baker."

BETHLEHEM (LACKAWANNA) STEEL

When the Lackawanna Iron and Steel Co. pulled up stakes in Scranton and built its new plant south of Buffalo in 1990-1903, equipment for unloading ore delivered on lake vessels was organized along the east side of a newly-excavated ship canal. Finished products such as rails were shipped out from the west dock. This waterway was eventually enlarged by Bethlehem Steel, which acquired the Lackawanna plant in 1922, to its present dimensions of 4000' x 200'. The canal can accommodate 1000' lakers at Seaway draft (26-27'). Though steelmaking on the site ceased as of 1983, the ship canal still handles commercial traffic as part of Gateway Metroport.

During the Lackawanna Steel era vessels were unloaded by means of five 10-ton Huletts. Three 7 1/2-ton reloading bridges commanded the ore yard that was located between the canal and the stocking trestle for the blast furnaces. This array of machinery was sufficient for handling, storing and reclaiming the amount of raw materials required to feed blast furnaces making 4800 tons of iron daily.

By the early 1950s ironmaking capacity had doubled with the completion of J Furnace (29' hearth). To keep pace with the plant's growing appetite for hot metal, lake carriers delivered 5,500,000 tons of ore and 1,700,000 tons of limestone to Lackawanna annually. Bethlehem had to bulk up its materials handling capacity in proportion. Four Huletts with 17-ton buckets had replaced the original models. The next generation of reloaders would have 15-ton capacities. The ore yard, 3900' x 280', held up to 2,500,000 tons, but even a larder of this magnitude proved insufficient. A new ore yard west of the ship canal and the coke plant was supplied by a series of conveyors from the original dock. This conveyor system was designed to handle 5000 tons of ore per hour; maximum belt speed was 500 fpm. The initial capacity of the new storage field, adjacent to the coal storage area, was 1,500,000 tons. A tripper and stacker discharged ore from the #3 Belt. A new 13-ton bridge crane distributed ore in the west field and subsequently reclaimed it for the return trip to the stocking trestle or the sinter plant. Reclaiming capacity via this route averaged 1200 tons per hour as of 1955. The conveyor system also handled limestone, dolomite or coal delivered by self-unloading lakers. As of 1973, when receipts of iron ore and pellets by water totalled 7,700,000 tons, the estimated capacity of the main ore yard was 2,195,000 tons, that of the auxiliary yard 2,000,000 tons, and the reclaiming rate 800 tons./hr.

Many elements of the ore handling system are no longer extant, and the original yard has been converted to other types of bulk storage. One of the 15-ton Wellman reloading bridges still stands beside the ship canal.

Black Rock Canal and Niagara River

PEACE BRIDGE.

The Peace Bridge linking the U.S. and Canada was built 1925-1927. Designed by Edward P. Lupfer, it has five steel arches of 347 to 424 feet in length plus a bow-truss section spanning the Black Rock ship canal. The length of the 5-arch span is 1927 feet while the truss alone is 360 feet. In the river section at the highest point, the deck is 100 feet over the river. Abutment to abutment the Peace Bridge is approximately 3600 feet long.

BIRD ISLAND PIER
Between Niagara River & Black Rock Canal, south of Squaw Island
Buffalo

In 1822 the New York State Canal Commissioners contracted with Peter B. Porter and Sheldon Thompson to connect Bird and Squaw Islands with a timber and stone pier, 530 rods long and 18' wide. Their intent was to protect the natural harbor at Black Rock, then a separate political entity and bitter rival of Buffalo for the coveted designation as the Erie Canal's western terminus. Construction of the original pier was completed in 1825 despite loss of the prized terminal location to Buffalo, which later proceeded to annex stagnating Black rock itself in 1853. Regularly buffeted by lake storms and ice, the Bird Island Pier has been rebuilt several times; the most recent reconstruction was completed in 1988 and had improved accessibility for local fishermen. Now nearly a half mile in length, the structure forms part of the west retaining wall of the Black Rock Canal (1909-1914) which provides a smooth-water passage to Tonawanda Harbor and the entrance to the Erie Barge Canal.

WEST FERRY STREET BRIDGE
Over Black Rock Canal to Squaw Island
Buffalo

This single-leaf, Strauss heel trunnion bascule is the oldest movable bridge for vehicular traffic in the City of Buffalo. It was built in 1913 by the American Bridge Company's works in Elmira, NY to cross the new Black Rock Ship Canal, then in the process of construction. The bridge consists of a single 55'6" approach span on the east bank and the 165' draw span, a Pratt through truss with riveted connections. Subsequent remodelling programs replaced the original wooden deck with a steel grate, relocated the control house to the south side, and converted the electrical system from 25-cycle current to 60-cycle. The most recent rehabilitation replaced the original motors and drive systems; the bridge is now controlled through a PLC.

INTERNATIONAL RR BRIDGE
Over Upper Niagara River
Fort Erie, ON - Buffalo

The International Bridge, which now spans the river from Niagara Boulevard in Fort Erie to Squaw Island on the U.S. side, was constructed during 1870-1873 to provide a crossing for the trains of the Grand Trunk Railway and other lines. The chief engineer for this important undertaking was Casimir S. Gzowski (1813-1898), who had emigrated from his native Poland at the age of 20. At first he engaged himself in the practice of law at Pittsfield, MA, but transferred his interest soon thereafter to the practice of civil engineering. In 1841 he immigrated to Canada and took a position with the Toronto Department of Public Works. Having established an impressive resume over the ensuing three decades, he and his consulting firm, the Gzowski-MacPherson Company, were chosen to bridge the Upper Niagara and forge a major link in radiating international railway network. Gzowski was assisted by E.P. Hannaford, chief engineer of the Grand Trunk, as well as Joseph Hobson of the railroad's design staff.

The Niagara River section of the bridge was carried over the swift current on eight masonry piers; these remain in place. Novel watertight caissons were used in the erection of Piers #4, 5 and 6. The entire superstructure was replaced during 1900-1902 with steel truss members substituted for the original wrought iron. It now consists of seven through, pin-connected Pratt truss fixed spans and a single through-truss swing span. Spans #1,2,3 and 8 are 193'11" in length, center-to-center of bearings; spans #4,5 and 6 are 244'7"; the length of the swing span near the American shore is 358'. Overall length is 1895'4", face-to-face of backwalls. The trusses on all spans are spaced 18" apart, and their depth is 30'. The swing span was moved 50 hp motors operating on 500 volts DC, but these are no longer in use. The bridge carries a single track. A 219' fixed span and a 218" movable span at the Erie Canal in the Black Rock section at Buffalo have been replaced by the present swing bridge (see below).

INTERNATIONAL RR BRIDGE, SWING SPAN
Squaw Island-Niagara St.
Buffalo

The swing span over the Black Rock Ship Canal that carries rail traffic crossing the Niagara via the International Bridge was constructed in July 1911. It is 431'5" long and was originally moved by two 53 hp motors. There were also two 15 hp end-lift motors and two 5 hp motors for operating rail wedges. An on-site power station contained redundant gas-engine-drive and motor-driven generating units. Surprisingly, there was little difference initially in the comparative cost of operating the bridge with gas versus electric service. The rate then charged for comparatively small amounts of Niagara Falls current was relatively high. The gas engine was also seen as a reliable backup in the event that transmission from the Falls was interrupted.

BLACK ROCK SHIP LOCK

The Black Rock Lock has a very small (5') lift but fulfills a very necessary role to permit ship navigation along the Niagara River. Built 1909-1914, the lock opened August, 1914. It is 650' x 70' with a depth of 21'6" over the sills. Ship traffic today consists of both large commercial vessels such as the 600' bulk carriers that make 45-50 trips per year hauling coal to Huntley Station (see Tour # 5) or the 20-30 tankers from Marathon AMOCO headed for the docks near the Grand Island bridge to unload petroleum and asphalt. However, the greatest regular volume of lock traffic comes from pleasure craft that use the waterway extensively.

The Lock is under the supervision of the Army Corps of Engineers. The lock has recently undergone major renovation. The original lock structure is partly comprised of limestone and dolomite interspersed with layers of gypsum. It was constructed originally with no foundation but placed directly on bedrock. Over the years the hydrostatic pressure has washed away the gypsum leaving holes that recently began to leak noticeably. The repair work consisted of the contractor's drilling down 53' and drilling 1000 holes into which he poured concrete grout. (The white silos on Squaw Island are his grout silos). At no point could the contractor see what the results were, and it will not be decisively known until winter when the lock is thoroughly drained during annual maintenance. However, to all appearances, the leaks have ceased.

BUFFALO SMELTING WORKS
Foot of Austin St.
Buffalo

The Buffalo Smelting Works grew directly out of the city's position on the Great Lakes. Maurice B. Patch, a mineralogist with backing from Boston capital, perceived the cost economy inherent in bringing copper down from the upper lakes by water. He set up a plant between the Niagara River and the Erie Canal in 1890. By the turn of the century the works were using nine electric furnaces, operating on direct current, to produce 39,000 tons of copper ingots, bars and others semi-finished forms annually. [Never absorbed by any of the contemporary nonferrous smelting conglomerates]The plant was considered a cynosure in the movement toward sanitary manufacturing conditions. However, alternative sources of copper undermined its once-advantageous location and contributed to the firm's demise. Curtiss Aircraft used the riverfront site during the First World War to produce [& test] flying boats, and American Radiator subsequently occupied portions of the complex until the 1940s. The elaborate dockside materials handling equipment has since been removed, and some original structures have been demolished. Four survivors with mysterious pedigrees include two structure with gable roofs, fronting on Austin Street, and two with monitor roofs, south of the street and nearer the Black Rock Canal. A marina presently occupies the site.

WICKWIRE STEEL CO.
4000 River Rd.
Town of Tonawanda

The Wickwire Steel Co. of Cortland, NY erected its Harriet Furnaces on the Niagara River during 1908-1910. By 1917 operations on the 104-acre site had become integrated with the addition of open-hearth steelmaking and a blooming mill, rod mill, wire mill, nail mill and galvanizing building. The plant became part of the Wickwire-Spencer Steel Co. merger in 1920, the Spencer segment having originated in Massachusetts. Colorado Fuel & Iron acquired the works in 1945 as part of what proved to be a vain attempt at penetration of eastern markets. In 1963 CF&I shut the Tonawanda plant down. The property was subsequently acquired by Roblin Steel which scavenged the site for scrap to feed its melt shop in Dunkirk, NY (site of the first twin-strand continuous billet caster in the U.S., installed in 1964). Roblin shot down the Wickwire blast furnaces and stoves in 1964 and also dismantled the riverside ore-handling equipment. Other structures still survive in various stages of decay. Roblin itself was out of business by 1987. Hazardous wastes dumped by a disposal company have recently been discovered on the site.

GRAND ISLAND BRIDGES

The Grand Island Bridges are paired access ways between the shoreline of Western New York and Grand Island, a large, flat island in the middle of the Niagara River. The bridges were constructed originally in the 1930s to provide Grand Island residents with a more efficient means of access to the mainland that the ferry system they were then using. After the advent of the superhighway system, the Thruway Authority used the bridges to link a shortcut on I-190 from the Tonawandas to Niagara Falls.

Both north and south bridges are erected in pairs, but they were not so originally. In the 1930s each bridge was alone with only two lanes. That proved insufficient to handle modern traffic so virtually identical mates were provided for each bridge in the 1960s. Of the South bridges, the southbound bridge was built in 1933-1934 with the northbound bridge being constructed in 1962-1963. It is the older southbound bridge which is currently being rehabilitated. In the North Bridge pair, the northbound bridge is older, also built 1933-1934 while the southbound bridge was constructed in 1962-1963.

The South bridges are combined girder span/truss span ("through truss") construction. Its overall length is 3300-3400 feet. The North bridges are a deck truss and are approximately 4000 feet long. Three of the four sections have concrete decks with a concrete wearing course, but the northbound North Bridge has a monolithic concrete deck. Each span has a sidewalk on its right-hand side.

NEW YORK CENTRAL RR MOVABLE BRIDGES
Tonawanda, North Tonawanda

Possibly the most ancient movable bridge in the Buffalo area is the inclined-chord, double-intersection Warren through truss swing bridge that carried a single-track spur of the New York Central over an inlet from the Niagara River to Tonawanda Island. Erected in 1887, the bridge has a span of 167' with a 111' pile-and-timber approach at the west end and a 250' easterly approach of similar construction. The swing span is supported by a stone central pier. The abutments are concrete. Originally operated by hand, the turntable was electrified in 1908, at which time the truss was also strengthened. A similar crossing also remains in place over nearby Tonawanda Creek. These bridges were once identified as #11.56 (old #B-18-A) and #11.57 (old #B-18-C).

Construction of the Barge Canal caused considerable realignment of the New York Central branch lines serving the Tonawandas. The project included the present single-leaf Strauss heel trunnion bascule over the Tonawanda Creek portion of the canal. The counterweight for c100' draw span was supported on an A-truss fixed span, a departure from ordinary arrangements that was chosen in order to improve access to the north dock wall in the enlarged harbor. The new bascule was carrying traffic by 1920.

THE NIAGARA PENINSULA: WATER TRANSPORTATION AND POWER

The following essays and site descriptions have been condensed--with regret--from Mark Fram, ed., Niagara: A Selective Guide to Industrial Archaeology in the Niagara Peninsula (Toronto: Ontario Society for Industrial Archaeology, 1984). The original authors, particularly Michelle Greenwald on the Welland Canals and Robert D. Barnett on hydroelectric generation, bear no responsibility for these paraphrases of their work.

THE FOUR WELLAND CANALS

The eastern part of the Niagara peninsula is not a peninsula. It is actually an island, cut off from territory to the west by the 27-mile line of the Welland Canal. The modern canal and its three predecessors have tied two lakes together for over 160 years and catalyzed the development of distinctive communities. An integral component of the St. Lawrence Seaway, the Welland provides this mid-continental region with a exotic maritime atmosphere as domestic and foreign flag vessels transit the historic waterway.

Lake Erie is about 326' higher than Lake Ontario. Most of that change in elevation lies in the northern third of the peninsula, and more than half represents the precipice of the Niagara escarpment. Through all its phases the canal has been a series of lift locks from Lake Ontario through what is now Thorold with a long reach of water and few locks from there south to Lake Erie. Successive builders have tackled the same series of problems with different techniques. The results of much of their labor may still be read in the landscape.

Maintaining a steady supply of water for lockages and navigation presented a particular problem to the Welland's first generations of engineers. There were three potential sources: the Welland River, the Grand River and Lake Erie itself. The most convenient feeder would have been the Welland River, but early excavators could not take advantage of its proximity due to soil instability in the area of the Deep Cut. The more remote Grand River required a lengthy connecting channel in order to supply the first two canals. The giant reservoir of Lake Erie was tapped only after half a century.

Few traces of the original canal now remain accessible to public viewing. However, a surprising number of locks and other structures from the second and third rebuildings survive in various stages of decomposition.

The first canal (1824-1833)

Spurred by the impending completion of the Erie Canal with its promise of improved transportation and threat of trade diversion, the government of Upper Canada granted a charter to the privately-financed Welland Canal Company in 1824. The purpose of this venture was to circumvent the barrier of Niagara Falls by linking the two lower Great lakes with an artificial waterway. The prime mover behind the enterprise was William Hamilton

Merritt, a St. Catharine's frontier magnate with interests in real estate, trade and manufacturing.

After discarding several ambitious plans, Merritt and his associates settled on a ship canal rather than a barge canal such as the Erie, thereby establishing a basic distinction between the two competing water routes from the inland seas to the ocean; the ramifications of this decision would persist for well over a century. Merritt's canal had to traverse difficult terrain and consisted of more than just a ditch. The route worked its way up from Port Dalhousie on Lake Ontario along Twelve Mile Creek, gained the escarpment through a ravine, and passed through the Deep Cut to reach the approximate level of Lake Erie at Chippewa Creek, also known as the Welland River, which was to serve as both summit channel and feeder. From this point the original canal branched eastward to the Niagara River and west toward the Grand River which was pressed into service as a feeder after an 1828 wall collapse at the Deep Cut precluded drawing on the Welland River. The first upbound schooners reached Buffalo from Port Dalhousie on November 30, 1829. Navigation was subsequently extended to Port Colborne on Lake Erie by 1833 because the passage via the treacherous Niagara proved impractical.

Though time has certainly vindicated the soundness of Merritt's overall vision, the Welland Canal Company's cheeseparing operations failed to capitalize on the advantages inherent in the concept. The circuitous routing of the canal's channels and the location of its locks betrayed a predilection for cheap solutions to inevitable technical difficulties. Natural watercourses were incorporated into the navigation (as they would later become part of the Barge Canal system, though for different reasons), and ravines were used in ascending the steepest grades. The locks were built of timber rather than stone as another economizing measure. Shoddy construction practices accelerated the natural tendency of wooden structures to decay after prolonged exposure to moisture.

There were a total of 40 lift locks on the completed system of which 35 were required for travel between Lake Ontario and the top of the escarpment. The most common lock dimensions were 110' length by 22' width and 7 1/2' depth over the mitre sills, though three expanded locks were built below St. Catherines in anticipation of steamer traffic. Lifts per lock were in the ranges of 6-11'. Locks were filled and emptied by means of paddle valves in their gates; balance beams opened and closed the gates. Other features of the first canal included a single towpath and five guard locks as well as an aqueduct over the Welland River.

The second canal (1842-1851)

In 1841 a new provincial government bought out the Welland Canal Company which had amply demonstrated its inability to maintain and improve the system. The principal effort in upgrading the canal as a public works project focused on replacing the small wooden locks with larger and more durable stone structures. Dimensional specifications displayed considerable elasticity, but designers finally settled on 150' x 26 1/2' for the 24 interior locks and 200' x 45' for the entrance locks at Port Dalhousie, Port Colborne and

Port Maitland. Single lifts ranged from 9'6" to 14'3". A navigable depth of 9' was achieved by 1845 and another foot was added ten years later when crews bolted timbers to the tops of lock walls and gates.

Other significant improvements included converting the Feeder into a navigable branch from Port Maitland to Welland as well as shifting the towpath from the east bank to the west as a means of compensating for prevailing winds which had tended to slacken lines, driving vessels into the bank. The Welland River aqueduct was rebuilt in stone and completed in 1850. Harbor works at the Lake Ontario and Lake Erie terminals kept pace with the demands of an increasing commerce. However, operating delays still ranged from annoying to disastrous. Particularly vexing were landslides into the Deep Cut where maintaining the banks became a Sisyphean labor resembling the later trials of French engineers in Panama.

The third canal (1872-1887)

This phase of construction and change reflected a governmental effort to establish uniform lock sizes on both the Welland and St. Lawrence Canals; the goal was a more effective commercial linkage between the Atlantic trade and the upper lakes (and, perhaps more than parenthetically, a boost for Quebec interests over the competition from Ontario). The new lock dimensions were to be 270' long x 45' wide x 12' deep; by the time the project was completed ruling depth had been increased to 14'. Lock lifts varied from 12' to 16'.

A new line from Port Dalhousie to Thorold required 25 locks to reach the summit level; ships then had only to pass the guard lock at Port Colborne to reach Lake Erie. The Department of Public Works, led by John Page as chief engineer and designer and Thomas Munro as superintending engineer, elected not to use flight locks for climbing the escarpment, the nearby example of Lockport on the Erie Canal notwithstanding. Deepening the main channel allowed Lake Erie to be used as the water supply for the entire system, a task inaugurated in 1846 but not completed until 1881. The Feeder to Port Maitland, with its junction lock at Welland to maintain the separate levels, accommodated a dwindling number of small craft until the 1920s.

Operation of the stone locks and gate valves hewed to established principles, though chain winches replaced balance beams for opening and shutting the gates. For the first time tunnels were dug for canal crossings: a road tunnel beneath Lock 16 and a railway tunnel under Lock 18. Though a towpath was still provided, most traffic moved under its own power or with the aid of steam tugs which locked through along with their consorts. Superintendent James Weller adapted the canal to the electrical age in 1907: electric motors operated the lock gates with rack-and-pinion machinery; electric lights replaced gas fixtures installed as early as 1855.

The fourth canal (1913-1932)

The most recent attempt at scaling the escarpment opted for fewer but larger locks and a channel with as few bends as possible--in effect, an expressway for freighters. The route upbound now commenced at the new artificial harbor of Port Weller, two miles east of Port Dalhousie, and followed the former valley of Ten Mile Creek. Above the escarpment, the fourth canal generally followed the line of the third, straightening out the kinks near Allanburg, Welland and Port Colborne. Though canal superintendent Weller wanted to avoid the winding course through Welland itself, the local industrial community lobbied successfully to retain its downtown waterway.

Construction began in 1913, but wartime shortages of money, men and materials halted the project by 1917. A new series of postwar contracts was let in 1919, but not until the Queenston-Chippewa power project had run its course were sufficient resources available to complete the Welland. The fourth canal finally opened for business late in the 1932 shipping season.

For surmounting the escarpment three pairs of flight locks performed the task formerly handled by 14 locks on the third canal. The new locks had concrete walls and steel gates with interlocking safety horns to ensure a tight fit. Concrete breast walls protected lock gates in the event a vessel lost control as did movable wire rope fenders (known as "ship arresters"). Some of these safety features had been adapted from later improvements to the third canal.

Seven locks made the climb from Lake Ontario to Thorold. Each was built 820' long, 80' wide and 25' deep. Subsequent deepening has added another five feet over the mitre sills. Since Lock 8, the guard lock at Port Colborne, frequently remains open at both ends, the Welland passage now requires only seven lockages as compared with 25 on the third canal.

The Welland by-pass (1967-1973)

Plans were announced in 1965 for a new and straighter channel to avoid the narrow and congested passage through downtown Welland. The railway swing bridge in the center of town limited the size of passing ships to those that could squeeze by its central pivot. Frequent delays at lift bridges also left highway traffic constantly jammed. The new 8.3-mile channel runs south from Port Robinson to Ramey's Bend, north of Port Colborne. The by-pass prism measures 350' wide at its bottom and 500' at the surface.

FOURTH WELLAND CANAL SINGLE LIFT LOCKS

LOCK 1
Lakeshore Rd. & Government Rd.
Port Weller, St. Catharines

LOCK 2
Carlton St. & Government Rd.
St. Catharines

LOCK 3
Government Rd., north of Glendale Ave.
St. Catharines

LOCK 7
Hoover St./Portland St.
Thorold

Excavation for the locks of the fourth enlargement commenced in 1913. Average lift of each single-chambered lock is 46.5'. Pre-WWI designs provided for single leaf gates, but when construction resumed in 1919 designers switched to double-leaf mitre gates that would permit a larger lock chamber. Part of Lock 1 had been built before the change was made so a recess had to be cut out of the west wall in order to accommodate the new design.

The massive lock chambers required correspondingly massive plumbing: the supply and discharge culverts inside the lock walls were built 16' high and 14' wide with 25 4' x 3' openings in the chamber walls. Four Taintor-type valve gates were installed at each lock intake with openings 15' high and 7' wide; four additional Taintor valves controlled the discharge. Each lock can be filled or emptied in 8-10 minutes.

Vulnerable points in the system--the southern end of Lock 1 and both ends of Lock 7--were originally protected with double gates in case of failure. Subsequently, the pair of mitre gates furthest upstream (south) at Lock 7 have been replaced by sector gates that are able, in an emergency, to close against a head of water and prevent the long summit level reach from flooding the lands below.

FOURTH WELLAND CANAL TWIN FLIGHT LOCKS 4, 5 AND 6
Canal Rd.
Thorold

This spectacular staircase is the system's centerpiece. Though there was ample precedent for linking locks together without intervening reaches, such a scheme had never been executed on this scale. Lock 6 lifts vessels 43.7'; each of the others has a lift of 47.9'. Each lock features double gates for security. The flight locks were twinned in order to reduce the waiting time for ships travelling in opposite directions (plans to twin Lock 7 have never materialized). A power house at the bottom of the flight locks was designed to house three 5000 hp vertical-shaft turbines and three corresponding 5000 kva generators for supplying the system's lighting and motive power needs. The turbines operated under a head of 186' with water conducted through a penstock running from above Lock 7 inside the western walls down to the north end of Lock 4.

FOURTH WELLAND CANAL LOCK 8

At 1380' this is the longest lock, but its function is mainly to compensate for fluctuations in the level of Lake Erie and to guard against flooding of the summit level. Lock 8's maximum lift is 14'. As in the case of the contemporary Davis and Sabin locks at Sault Ste Marie, it was built extra long to accommodate two ships simultaneously, thus saving some of the time required for lockages. However, the advent of the 730' Seaway-class vessels, built since the 1960s to fit the dimensions of the other locks in the system, has practically eliminated doubling up.

FOURTH WELLAND CANAL CULVERTS

WELLAND RIVER SYPHON CULVERT
Aqueduct St. & Merritt St.
Welland

The increased depth of Welland IV's channel precluded continuing to carry the canal over the Welland River on a aqueduct. Instead, the river was diverted under the canal through an inverted syphon culvert. River water is sucked from west to east through six 22' concrete tubes of circular cross-section, constructed 1926-1930.

WELLAND BY-PASS SYPHON CULVERT
River St.
Port Robinson, Thorold

As a part of the project to re-route the canal out of the city of Welland in 1967-1973, the Welland River was diverted under the new line of the waterway through a four-tube culvert similar in design and function to the earlier syphon.

FIRST TO FOURTH WELLAND CANALS, DEEP CUT
Allanburg to Port Robinson
Thorold

This section of the first canal was also followed by all subsequent routes. It cuts through the highest ground on the peninsula. Subsequent excavations to enlarge the cut have totally obliterated earlier traces. The most recent reconstruction provided for a minimum channel width of 200' at the bottom of the prism. The upper banks are now more than 300' apart, and the depth of the widened cut is as much as 80'.

FOURTH WELLAND CANAL MOVABLE BRIDGES

MICHIGAN CENTRAL RR SWING BRIDGE (#15)
Over disused fourth canal at Canal Bank Rd.
Welland

Constructed over the third Welland Canal during 1910-1911 in anticipation of its imminent enlargement, this is the only surviving swing bridge on the line of the fourth canal. Its 260' span carried a pair of tracks for the Michigan Central Railroad and the Toronto, Hamilton and Buffalo Railway. It was built with the intention that the central pier would eventually occupy the middle of a doubly-wide channel, but instead the pier wound up posing a significant hazard to canal traffic. Vertical-lift and bascule bridges presented fewer obstructions to navigation so no more swing bridge were built over the canal.

BASCULE BRIDGES

LAKESHORE ROAD BRIDGE (#1)
Lock 1
Port Weller, St. Catharines

CARLTON STREET BRIDGE (#3)
Lock 2
St. Catharines

HOMER BRIDGE (#4)
Queenston Rd.
St. Catharines

CANADIAN NATIONAL RR BRIDGE (#6)
Lock 4
Thorold

MAIN STREET BRIDGE (#19)
North end of Lock 8
Port Colborne

MELLANBY AVENUE BRIDGE (#19A)
South end of Lock 8
Port Colborne

In a bascule bridge, whether it be of rolling-lift or heel-trunnion design, the span or "leaf" is counterweighted and hinged to tip upward at one end from the fulcrum of its abutment. Seven bridges of this type were built over the fourth canal between 1925 and 1930; two have since been removed, but a new one carrying Mellanby Avenue was added in 1981. All were built as single-leaf bridges except for the double-leaf bridge at Homer and the twin single-leaf Bridge #6 immediately below the flight locks. All but the CN bridge now carry only vehicular traffic, but the Lakeshore Road and Homer bridges once served electric railways as well.

The Scherzer Rolling Lift Bridge Company designed the 220 1/2' Homer span. The other bridges, spanning between 90 and 98 1/2', were engineered by the firm of Harrington, Howard & Ash. All were fabricated by the Hamilton Bridge Company.

The Welland bascules fall into the category of rolling lifts. Their mechanical principles of operation are quite simple, even though up to 2000 tons of bridge must move with each raising and lowering. Large gussets at one end of the leaf support segmental girders holding a steel and concrete counterweight. The segmental girders roll onto a fixed track built into the concrete structure on which the whole assembly rests. Tread plates on the bottom of the segmental girder mesh with teeth on the track. Two pinions, powered by electric motors, move along horizontal tracks to tilt the leaf up or down. Pneumatic buffers reduce the force of opening or closing impacts.

VERTICAL LIFT BRIDGES

GLENDALE AVENUE BRIDGE (#5)
St. Catharines

CANADIAN NATIONAL RR BRIDGE (#10)
Near Hayes Rd., Thorold South
Thorold

LUNDY'S LANE BRIDGE (#11)
Allanburg
Thorold

MAIN STREET BRIDGE (#13)
Over disused fourth canal
Welland

BROADWAY STREET BRIDGE (#16)
Over disused fourth canal
Welland

CANADIAN NATIONAL RR BRIDGE (#17)
Over disused fourth canal, Welland Junction
Welland

DAIN CITY BRIDGE (#18)
Forks Road, Welland Junction
Welland

CANADIAN NATIONAL RR BRIDGE (#20)
Princess St.
Port Colborne

CLARENCE STREET BRIDGE (#21)
Meeting Durham St.
Port Colborne

Twelve vertical lift bridges were originally planned to cross the enlarged canal, though the Parnell crossing in St. Catharines was never built. Of the remainder, five still operate and four stand inoperable over the bypassed route through Welland. The Lincoln St. crossing (Bridge #14) in Welland has been replaced by an embankment, and Bridge #12 at Port Robinson was destroyed when rammed by the Bethlehem Steel vessel "Steelton" on August 25, 1974.

Harrington, Howard & Ash designed all the vertical lift bridges. Two were built by Hamilton Bridge, eight by Canadian Bridge of Walkerville, and one by Dominion Bridge of Montreal. Their spans ranged from 208.1' to 232.8' and their widths from 18 to 34.5'. Their mechanisms were even more elementary than those of the bascule bridges. Wire ropes attached to counterweights pull the central span up and let it down just as they would in an elevator.

FOURTH WELLAND CANAL TUNNELS

THOROLD TUNNEL
Highway 58
Thorold

The newer road tunnels are of some interest to collectors of engineering statistics, but have little distinction as landmarks beyond their considerable rearrangement of the landscape. The Thorold Tunnel, built between 1965 and 1968, tries to be virtually seamless, slipping from daylight to darkness with a streamlined black concrete slipcover. It is 2400' long and 74' wide with two 26' roadways. Its engineers, the Acres firm of Niagara Falls, sought to prevent leaks with massive doses of bentonite, a clay that expands when wet. However, the tunnel has never proven watertight--the geological strata through which it was cut are subject to the same very slow but persuasive horizontal movements that continue to affect the hydro plants at the Falls.

TOWNLINE TUNNEL
Highway 58A and CN RR
Welland

Engineered by Acres and constructed as part of the by-pass project in 1967-1973, this tunnel and its earthworks are perhaps the most cartographically conspicuous of the Welland Canals' many features. Because it accommodates three railway lines, the grades have to be gentle and that in turn entails a long trench cut out of the soil and rock on either side of the by-pass. The trench is even more conspicuous because it is essentially devoid of vegetation that might relieve its uncompromising starkness. The tunnel itself is 1080' long, 116 1/2' wide and about 35' high; the excavated approaches account for an additional five miles. Because much of the work lies below the natural water table, the surrounding soil and bedrock is riddled with relief wells and drains, all leading to a main sump pump at the tunnel.

EAST MAIN STREET TUNNEL
Welland

As in the case of the Townline Tunnel, much of this roadway under the by-pass lies below the water table, and pumps must be run constantly to keep it dry. Statistics: 724' long (1044' overall with portal), 74' wide, 26 1/2' high. Opened: May 20, 1972. Engineers: Gibb, Albery, Pullerits & Dixon of Toronto.

MORNINGSTAR MILL
Decew Road at DeCew Falls
St. Catharines

This flour mill was originally constructed in 1872 by Robert Chappel. It was built from stone quarried out of the mill pond excavation and took water from Beaverdams Creek through a culvert under the second Welland Canal. Water supply was irregular, affected by changes in the canal and by establishment of the St. Catherines reservoir. The city ended up buying the mill in 1878 and eventually sold it to Wilson Morningstar in 1883.

A fire gutted the mill in 1895, and Morningstar installed machinery of his own design during the rebuilding process. The mill ran as a custom operation until the proprietor's death in 1933. His traditional charge for milling was 1/12 of the flour rather than cash.

Morningstar Mill is now operated by the city of St. Catherines as the Mountain Mills Museum. It is particularly remarkable for the integrity with which its machinery has been preserved. The mill has three milling systems: a run of French buhr stones for whole wheat or buckwheat flour; steel roller mills for white flour; and a chopping mill and oat flaker for animal feed. The unique sifting machinery was Morningstar's own invention.

Electrical Niagara

Three strands are woven into the tale of hydroelectric development on the Niagara peninsula. The first is part of the story of the Welland Canals, and features the oldest generating station still active in Ontario. The next thread picks up the establishment of central power stations right at Niagara Falls, where waters of the four upper Great Lakes tumble over the escarpment. The third strand, colored by the debate between public power and private capital, represents the most ambitious hydroelectric project of its day on a global scale.

By the 1890s Thomas Edison's low-voltage direct current (DC) operating systems faced a formidable rival: higher-voltage alternating current (AC) that permitted much longer transmission distances with less energy loss coupled with the ability to decrease (or "step down") voltages for safer domestic and commercial consumption. These advances had been made practical by George Westinghouse during the previous decade. In 1891 the Frankfurt Electrical Exhibition demonstrated the practicality of an 8500-volt AC transmission line from a waterfall at Lauffen, 110 miles distant.

It now became possible to envision a radical transformation of the nascent utility business. Instead of small hydroelectric generators with limited capacity serving individual mills or central steam plants generating electric light for small urban districts or power for street railways (the Edison model), huge hydroelectric stations could harness the immense flows of natural waterways and send the current great distances, creating entire new industrial districts. Such massive new sources of energy could also foster production of novel commodities using technologies with an insatiable thirst for power.

The first indication of the potential inherent at Niagara appeared in the form of the power house for the Niagara Park and River Railway of 1892-1893. However, it was the 1898 DeCew Falls plant of the Cataract Power Company, Ontario's first long-distance generation and transmission scheme, that marked the real introduction of the new technology on a commercial scale. The original plant remains in operation, though modified to some extent.

Switching on the Falls

Entrepreneurs on the American side of Niagara Falls, led by New York investment banker Edward Dean Adams, were poised to build hydroelectric stations as soon as the new AC technology became available. Electrical development on the Ontario side proceeded under the aegis of the Queen Victoria Niagara Park Commission, created in 1885 as a reaction to the excesses of commercial tourism at the Falls. In 1891 the Commission seized on the notion of building a scenic electric railway along the river's edge as a means of securing funds for park maintenance from water-lease fees. The railway proved a success, but the Commission's need for augmented cash flow continued. It granted a monopoly to Adam's U.S. company in 1892, but the project did not come to immediate fruition. As a consequence of the hiatus the Ontario Power Company and the Electrical Development company both gained a piece of the action at the Falls along with the Adams interests.

The Rise of Public Power

The spectacle of private oligopolies profiting from the natural resources of Niagara provoked major debates about the wisdom and justice of public ownership for electrical utilities. Municipal pressure failed stop prevent the Electrical Development Company's franchise grant in 1903, but the movement for a cooperative transmission system tied into the Niagara stations gained a powerful advocate in Adam Beck, mayor of London and a Tory member of Ontario's provincial legislature. Beck became the first chair of a permanent Hydro-Electric Power Commission (now Ontario Hydro) in 1906. By 1908 Hydro had contracted with the Ontario Power Company for a supply of electricity and had begun stringing its own transmission lines.

Beck's network subsequently integrated backward from distribution into generation. By 1914 Hydro had begun to acquire or build small stations throughout southern Ontario. The extraordinary demands of the First World War accelerated the pace of Hydro's expansion. This phase of development culminated in 1917 with the acquisition of Ontario Power and the unveiling of the Queenston-Chippewa project. Beck's scheme to utilize the maximum head available at Niagara entailed reversing the flow of the lower Welland River at Chippewa, cutting a power canal 8.5 miles long, digging an immense forebay out of the hard limestone atop Queenston Heights, and building a power house designed to generate 400,000 kw-- more than all the stations at the Falls combined.

Since renamed Sir Adam Beck Generating Station #1, the Queenston-Chippewa project delivered its first power in 1921 and was more or less at full capacity by 1925. It has since been dwarfed by the companion Beck #2 and many other installations, but during the 1920s Beck #1 ranked as the world's largest hydroelectric development.

DECEW FALLS GENERATING STATION NO. 1
Power Glen, below Moodle Lake
St. Catharines

In the 1890s the most attractive site for hydroelectric development to supply the industrial center of Hamilton lay at DeCew Falls. There were, however, two major obstacles: insufficient flow over the falls and the transmission distance, a then-prohibitive 35 miles. The solution to the first problem was to cut a 4.5-mile channel from the Welland Canal at Allanburg to the top of the escarpment overlooking Twelve Mile creek. A steel penstock would carry the water to the power house at the foot of the hill. The solution to the transmission problem was offered by Montreal's Royal Electric Company whose engineers designed generators and transformers to deliver power at an electric pressure of 22,500 volts, far in excess of the general 10,000 volt maximum of the day. The Cataract Power Company began construction in October 1897 and first power was delivered to Hamilton the following August 25. The formal opening took place on November 12, 1898.

The considerable flow of water and the comparatively high operating head of 254' created some difficulties in the design of the American-built turbines; the last units installed during completion of the initial construction phase were of Italian design and manufacture. Two more turbines by A.Ing. Riva, Monneret & Co. of Milan and two more Royal Electric generators brought the station's capacity up to 10,000 hp by 1900.

Expansion plans were announced in 1902. By 1904 a new reservoir, four new penstocks, and an extension to the power house were under construction. Six new 6100 hp turbines by J.M. Voith of Germany were installed, as were several generators by Royal Electric, Canadian General Electric and Westinghouse. By 1908 the company (now called Dominion Power and Transmission) had boosted the voltage of its long-distance line to 45,000.; the station could produce a steady supply of 28,000 kw and meet a peak demand of 36,000 kw. The last addition to the station was completed in 1912. Ontario Hydro bought out the private utility in 1930.

The four initial units (#0-3) were taken out of service as early as 1967, but others remain in operation. The adjacent DeCew Falls #2 station (1943) has nearly four times the generating capacity of its neighbor.

CANADIAN NIAGARA GENERATING STATION
West side of Niagara Parkway at upper rapids

Niagara Falls

In 1992 the Rankine Station of Niagara Mohawk celebrates the centennial of hydroelectric development by American capital on this site. However, because the predecessor company, Edward Dean Adams' Canadian Niagara Power Company, experienced technical and financial difficulties in meeting the terms of its original agreement actual development was delayed for several years. In 1899 Canadian Niagara received a new franchise from the Queen Victoria Niagara Park Commissioners to develop 110,OOO hp rather than the exclusive rights originally granted. This station was the third built by Adams' company, following the precedent set across the river at their pioneering AC generating facilities. Construction on the Canadian side commenced in 1901. Work proceeded under the guidance of Harold Buck, electrical director of Niagara Power after 1900.

A submerged weir or gathering dam hooks out into the upper rapids to divert water into the station's intake. The water flows through an ice rack of 2" steel bars, under a stone masonry bridge, and into the 600'-wide outer forebay. A special ice run was provided at the north or Falls end of the forebay. The water then passes through another series of submerged arches into the inner forebay, through steel grids called trash racks, and then into the tops of the penstocks. There is a head gate at the top of each penstock to shut off water as required.

The Canadian plant took advantage of incremental technical advances and initially doubled the capacity of individual units from 5000 to 10,000 hp. Two units began delivering power in 1905, and the last of a grand total of 11 was installed in 1924. The vertical-shaft turbines sit at the bottom of a narrow wheelpit, 570' long and 165' deep. All but the eleventh unit are double-runner, central discharge, Francis-type turbines, controlled by ring gates. The exception is a single-runner turbine, controlled by a wicket gate. The units run from 10,000 to 12,500 hp. The long shaft connecting turbine with generator is supported by three bearings, each braced against the walls of the wheelpit. The generators are all similar, with a capacity of about 12,000 volts each. The station continues to generate power at 25 Hz under U.S. ownership.

Used water discharges through a tailrace tunnel to a portal in the gorge wall below Table Rock. Electricity is conducted out of the station in underground conduits to a separate transmission station up on Portage Road so that no overhead wires intrude into the park. The power house itself is a close stylistic relative of the McKim, Mead and White designs for the Adams plants in the U.S.
It bears testimony to the success of the Park Commissioners in ensuring that industrial development would remain compatible with the sylvan setting.

ONTARIO POWER GENERATING STATION
Intake at Dufferin Islands, Niagara Parkway
Station at foot of Horseshoe Falls

Niagara Falls

The Buffalo-based Ontario Power Company obtained a water lease for 180,000 hp from the Queen Victoria Niagara Park Commissioners in 1900. Construction began in July 1902, and first power was delivered on July 1, 1905. The company president was Paul N. Nunn, an American engineer, who designed a system quite different from the rather compact stations of the other two companies. Ontario Power's works are scattered through the park above and below the Falls, linked by conduits, penstocks and tunnels. Other engineers on the project included L.L. Nunn, V.G. Converse and Charles H. Mitchell. Ontario Hydro took over the facility in 1917.

At the Dufferin Islands above the upper rapids are the intake works, including a gathering dam and outer and inner forebays separated by a screen house that served originally as a public promenade. The small gate house controls the flow of water through the penstocks that run beneath the park behind the other generating stations to the main complex just downstream from the Falls. The power house sits at the bottom of the Gorge with the transformer station atop the bluff above. At the level of the Parkway are a small tunnel entrance building and two camouflaged surge tanks.

There are three penstocks in all, the steel conduit of the original construction and two additions, one of concrete in 1911 and the other of wood (a wartime project) in 1918. The latter penstock was reputed to have been among the largest wood-stave pipes ever made. The penstocks are approximately 7000' long. The upstream intake design gave Ontario Power a greater head of water (175') than that available at the other stations which used a straight vertical drop to their turbines. The park grounds are dotted with picturesque cobblestone cairns, situated between the intake and the lower works, that acted as vents for the penstocks below.

The power house contains 16 units, some of which have been permanently shut down for spare parts salvage. Instead of long vertical shafts reaching down into a deep wheelpit, Ontario Power's turbines and generators have horizontal shafts and sit coupled together on the floor of the main hall. Each turbine unit is in fact a pair of central-discharge Francis wheels with a combined capacity of 12,000 hp. Each generator has a capacity of 12,000 kva. Their combined output originally ran through underground conduits to the red-brick transformer station and office building at the top of the bluff. This building has been abandoned in favor of other transformer stations and an automatic control room miles away.

The large cylindrical structure next to the Parkway is a surge tank used in emergency situations when a turbine has to be shut down suddenly and the pressure of the water in the penstock must be released. South of the tank is the entrance to the station's tunnels, a concrete Beaux-Arts cottage fashioned to emulate stone masonry.

TORONTO POWER GENERATING STATION

(Electrical Development Company)
East side of Niagara Parkway at upper rapids
Niagara Falls

Of the three power companies on the Canadian side of the Falls only the last on the scene, the Electrical Development Company, was controlled by Canadian capital. This syndicate intended to transmit power along high voltage lines to serve their electrical and street railway utilities in Toronto, 80 miles away. Transmission over such a distance was technically feasible but had yet to be attempted.

Following negotiation of a water lease to permit development of 125,000 hp, engineering work and excavation began in 1903. New York engineer and financier F.S. Pearson acted as consulting engineer on the project which closely resembled the Canadian Niagara plant with its long, narrow wheelpit and tailrace tunnel. The powerhouse cornerstone was laid in 1906, and the first power was delivered to Toronto early in 1907. The station was built in two stages. About half of the construction was finished in 1907. However, financial difficulties and political struggles over the emerging public-power movement delayed further work until 1911-1913.

In operation, Toronto Power was quite similar to Canadian Niagara's station just downstream, though its individual turbines and generators were of greater capacity. Water was taken in by a gathering dam and channeled through an outer forebay and an interior inner forebay before passing through the trash racks, past the intake control gates and down the tubular steel penstocks to the turbines at the bottom of the wheelpit. The first four turbines installed were 13,000 hp Francis-type models; the remaining seven, of similar design, had 15,500 hp capacities. The first four generators by General Electric and Canadian General Electric had 8000 kva capacities, the remainder 10,000 kva. Their output was channelled through underground conduits to the transmission station on Portage Road where the voltage was stepped up for the trip to Toronto. For a period beginning in 1917 this plant also supplied Buffalo with up to 14,000 hp.

Ontario Hydro took over the Toronto Power station in 1922. As Ontario converted to the 60 Hz frequency standard, demand for the 25 Hz current generated at the station declined. The last of the units was shut down in 1974. Since then, no alternative use has been found for the grand Beaux-Arts building, designed by Toronto architect E.J. Lennox.