The First Generation of Marine Engines in Central Canadian Steamers, 1809-1837[1]

Walter Lewis

> It seems as if God, admitting Man in participation of divine Omnipotence, had given him an element of his own, and said, "Go! take thou this as this command, with it thou shalt traverse every sea, thou shalt neither wait for winds, nor dread the storm; thy power shall exceed my power, thy element vanquish my elements, the most intricate channels shalt thou explore unaided by me"...The discovery of the Copernican system, the invention of the Press, the application of the Steam-Engine to the purposes of navigation, are epochs engraved on the tablets of eternity.[2]

With due allowance for hyperbole, Hugh Richardson's stirring cry captures the captain's sense of standing at the threshold of a new era in human history. Across that threshold, he fervently believed, lay great profits for those who seized the opportunities presented by marine applications of the steam engine.

From the rather different perspective of an economic historian, the substitution of steam power for the vagaries of water, wind and muscle lies at the heart of the spectacular productivity growth of the Industrial Revolution.[3] In North America, the technological advances of steam were channelled into the integration of regional and national markets using steamboats and, a generation or more later, railways.[4] A key element in both the Industrial and Transportation Revolutions was the constant innovation of the firms producing steam and, in particular, marine engines.

The "Steam Revolution" in North America began on the Hudson River in the spring of 1807.[5] Two years later it arrived on the middle St. Lawrence, where John Molson and his partners launched *Accommodation.*[6] Two more years would pass before the launch of the first steamboat on the Mississippi River system, four before commercial steam navigation began in British and European waters, and eight years before *Frontenac* and *Ontario* began serving ports on the Great Lakes.[7]

While the study of steam navigation is relatively well served in many regions, in general marine engineering is poorly understood. There are few general studies, the best surviving examples of the early engines are under water and most of the critical work of fine tuning the basic principles was done in the era before each alteration was an excuse for a trip to the patent office.[8] The best studies of marine engines deal with the massive

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power plants of ocean steamships and the dangerous experiments with high pressure steam in shallow-draft Mississippi steamers. Although these surveys draw attention to the single-cylinder, low-pressure, walking-beam engine, it is often simply to comment on the curious survival of a technological dinosaur.[9]

Canadian references to marine engineering in the first half of the nineteenth century first emerged in the context of business history and tended to take the technology for granted. Gerald Tulchinsky, George Wilson and Bruce Parker touch on the linkages between steamboat construction and the engine founding trades.[10] By contrast, most histories of Canadian engineering favour the civil and mining engineer or indulge the national passion for railway history.[11] Students of the iron and steel trades have concentrated on production at ironworks like Saint-Maurice and Normandale or on the production of consumer goods.[12]

The most effective Canadian approaches to the engine founding trades have been unpublished studies by Larry McNally, Kenneth Lewis and David McGee. While McNally addresses some key questions regarding locational factors, inputs, markets, labour and capital, his concentration on Montréal foundries leaves the limits of that city's "metropolitan dominance" of the trade unclear. By approaching the subject from a broader market perspective, we may better focus on this relationship.[13] Kenneth Lewis also raises questions about Montreal's competition with American and Great Lakes foundries, and the American and British origins of the firms.[14] McGee's study is far more ambitious and seeks to understand the entire history of Canadian marine engineering within the context of network theory, the essential insight that technical systems are composed of and interact with "an endless assortment of natural, social, economic and political elements."[15]

This paper has emerged from a larger investigation of the introduction of steam navigation on the Great Lakes. It encompasses the geography and "politics" of the trade, the people involved, as well as the technology which defined it. The technology, particularly the engines, had a significant impact on capital and operating costs, labour recruitment, the competitive position of vessels, and ultimately the profitability of a venture. All these issues prompted an examination of the available steam engines and who supplied them.

A number of questions have to be addressed. What was the technology available to steamboat proprietors prior to 1838? What were the qualities most in demand for different classes of vessels? What were the cycles in demand? How did various foundries meet the nature of the demand? Finally, I will draw some conclusions about the nature of the technology employed on the Canadian side of the Great Lakes, the state of innovation in the trade, and the role of marine engine founders in Canadian industrial development and their fate in the shipbuilding trades.

I

Before discussing the supply and demand of marine engines in central Canada, it is important to get an overview of the technology being used.[16] Examples drawn from Great Britain, the east coast of the United States, and the Mississippi and Ohio Rivers represent the rest of the "known universe" of steam engine designs for central Canadian investors.

In these regions a variety of opinions were held as to the most efficient way of transforming steam into vessel movement.

Throughout the previous century, "atmospheric" steam engines of the type developed by Thomas Newcommen had been used in Britain, usually to pump water. These were massive brutes guaranteed to break the back of any keel on which they were placed. James Watt's principal contribution was to attach a condenser to the side of the cylinder, which was connected by a sliding valve to both sides of the piston. The result was faster piston motion, which allowed great power to be produced by a smaller, lighter cylinder. Its greater fuel efficiency made it better for vessels which, unlike stationary engines, also had to carry their fuel supply.[17] It would take a North American, however, to convince the world that "fire engines" and ships could be profitably combined.

In the first decade of the nineteenth century, the most complicated "machines" built in the Canadas were probably water-powered saw and grist mills and the square-rigged vessels being launched from Québec shipyards.[18] But these were principally built of wood, the iron fittings being critical but relatively unsophisticated. By contrast, the typical products of the forge and tinsmith were horseshoes, nails, barrel hoops, and pipes. The most elaborate mechanical contrivances of the era, such as clocks or firearms, were rarely produced in the provinces.[19] Consequently, the requirements of the steam engine represented a quantum shift in the sophistication of metal working in the Canadas.

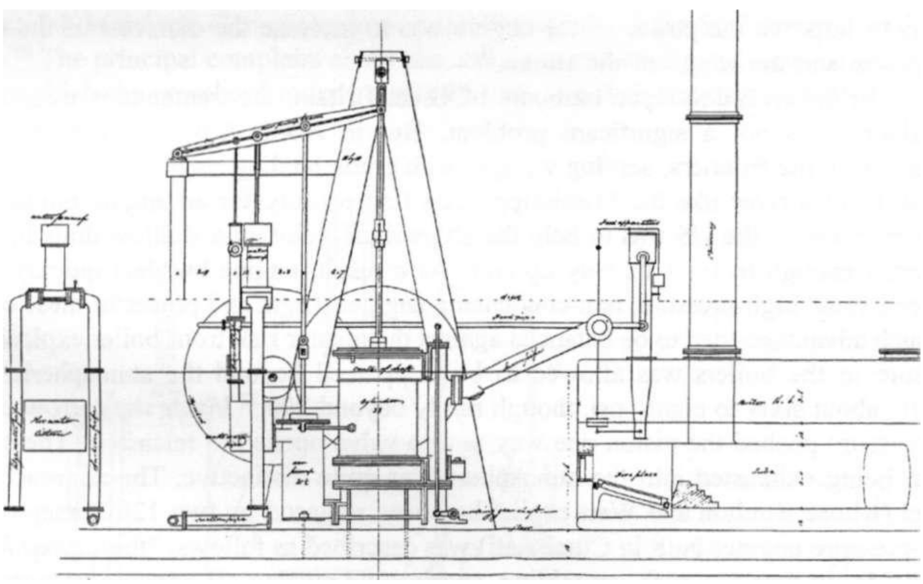

Figure 1: The *Frontenac* was powered by a fifty-horsepower, single-cylinder, crosshead engine built by Boulton & Watt.

Source: Birmingham Public Library, Boulton & Watt Collection, ff. 1213-1214.

For shipping, Boulton and Watt abandoned the overhead beam of their early stationary engines. Eminently suitable for pumping out mines, the ponderous beam engines pivoted on solid walls or frames which would have risen well above the main deck of a ship. Instead, they developed an arrangement of crosshead, connecting rod and either side-levers or cranks intended to keep the bulk of the engine low in the hull of the vessel. Arrangements like those for *Frontenac* (see figure 1) were designed for navigation in fairly boisterous seas, where they contributed to the stability of the craft. The vertical movement of the piston rod was transferred to the cranks or side-levers via a crosshead working up and down in slides. The arrangement required very careful machine work and was prone to misalignment. The firm's boilers were only suitable for fairly low pressures of seven to eight pounds per square inch (psi). Described as a "wagon" style, they were square bottomed with flues large enough for a man to climb inside to clean. Even at low pressures, the poorly sealed joints could give, exposing the engine crew to scalding.[20]

Because of Watt's healthy respect for the dangers of steam under pressure, his engines worked on the principle of condensation rather than expansion. Steam was introduced into the cylinder just as the piston completed its stroke. At this point a valve opened, allowing that steam to exhaust into a condenser where it was cooled. As its temperature dropped, a vacuum formed, pulling the piston to it. Meantime, on the other side of the piston the cylinder was filling with steam, which might impart a modest bit of momentum. The movement of the piston rod was connected with pumps that forced cold water into the condenser and air out. The whole apparatus was relatively ingenious but still weighed tons. Moreover, by limiting the pressure of the steam, the principal means to improve the power of the engine was to increase the diameter of the cylinder and piston and the length of the stroke.[21]

In the well developed harbours of Great Britain, the tremendous weight of this machinery was not a significant problem. But in North America, steamboats were operating on the frontiers, serving villages with crude landing stages or just lying against the banks of a river like the Mississippi. The first priority for an engine builder on the western rivers of the US was to help the shipwright maintain a shallow draft in a vessel powerful enough to fight its way upriver. As a result, engine builders quickly adopted Oliver Evans' high-pressure, non-condensing engines. Light and powerful these could be, but such advantages had to be balanced against the greater risk from boiler explosion. The pressure in the boilers was allowed to build up well beyond the atmospheric level — usually about sixty to eighty psi, though rarely beyond 200.[22] Inside the narrow cylinder, the pressure pushed the piston one way until a valve opened to release it. The sound of steam being exhausted into the atmosphere was quite distinctive. The approach of one vessel (whose Boulton and Watt engine had been replaced by two 120 horsepower (hp) high-pressure engines built in Cincinnati) was described as follows: "the *United Kingdom* still holds out firm as a rock, grumbling, snoring and puffing off her surplus steam, to the annoyance of fiscal fish and ducks."[23]

One of the problems with the massive low-pressure cylinders stemmed from the common assumption that they needed to be kept vertical. Lay the apparatus on its side, founders reasoned, and the heavy piston would steadily wear away the lower wall of the cylinder until a vacuum could not be produced — and no vacuum, no motion. But the cylinders and pistons in high-pressure engines were comparatively small and light, allowing them to be placed horizontally, the only practical direction for driving sternwheels.

Similarly, Mississippi boilers quickly shrank into fairly compact cylinders that were stronger than Boulton and Watt's "wagon" style. Although smaller tubes would increasingly be used in place of flues on eastern steamboats, tubular boilers were more difficult to clean. And Mississippi mud was considered responsible for a number of the fatal boiler explosions on that river system.[24]

In Upper and Lower Canada, steamboats faced different problems. Muddy or salty water was not among these, so boiler cleaning was a relatively minor concern. And apart from vessels on the Great Lakes, they operated on sheltered rivers and long narrow lakes, so the demand for low centres of gravity was less pronounced. Moreover, with some exceptions, the need for shallow-draft vessels was not as serious as on the Mississippi's tributaries, although the governing depth of most ports was a mere six or seven feet. More than anywhere else in the world, these conditions resembled those facing steamers working out of New York City. The St. Lawrence steamers had their counterparts on the Hudson River, while Great Lakes' vessels could draw inspiration from the steamers designed for Long Island Sound. Not surprisingly, the technology of engine building for central Canada formed a continuum with that used in the eastern US.

The type early favoured on these waters was closely derived from the Boulton and Watt engines imported by John Molson and Robert Fulton. Fulton preferred the crosshead style with the connecting rods from the crosshead working a side-lever for his Hudson River vessels.[25] The crank-crosshead-connecting rod variation was supplied by Boulton and Watt for *Malsham, Car of Commerce* and *Frontenac* of the St. Lawrence and Lake Ontario.[26] The principal complaint about this arrangement was the difficulty of getting the slides in which the crosshead moved perfectly true, and then keeping them that way.[27]

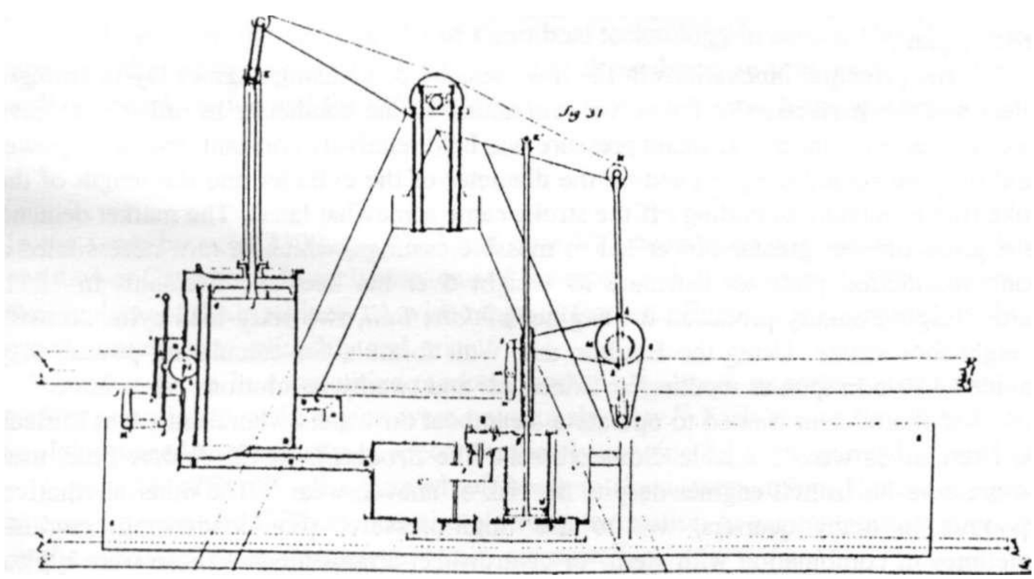

Figure 2: The Beam Engine of the *Atalanta,* built in New Jersey, 1816.

Source: Jean Baptiste Marestier, *Memoir on Steamboats of the United States of America* (Mystic, CT, 1957), figure 31.

The archetypical eastern steamboat engine replaced the tricky crossheads with the beam that was common in Newcommen and Watt's early engines (see figure 2). There is some disagreement as to the original application of the walking beam to marine engines. Some claim that Daniel Dod of New Jersey used it in his patent engine of 1811.[28] Others give the credit to Robert L. Stevens, also of New Jersey, for a design dated 1822.[29] The principal concern with walking beams in England was a massive beam rocking back and forth well above the deck. To others it must have seemed much less risky than carrying a full press of sail on towering masts. The criticism, almost reflexive in many modern accounts, ignores the fact that significant improvements in both design and materials were made. Skeletal iron beams replaced the heavy wooden beams strapped with iron. By 1830 walking beams contributed to the distinctive silhouette of the majority of steamers in the eastern United States and central Canada.

The persistence of the low-pressure "wagon" boilers for the period before 1838 is unclear because Canadian and American engine builders have not left us any sets of plans comparable to those in the Boulton and Watt Archive. But other evidence suggests that by the beginning of the 1830s cylindrical boilers with internal flues were more typical.[30] At least two vessels were equipped with "railway" tubular boilers, with larger numbers of smaller flues or tubes carrying the heat of the furnace through the centre of the boiler.[31] Two patterns evolved for the placement of the boilers. The "English plan" was to put them in the hold next to the cylinder, where the weight of the boiler and its water helped stabilize the hull, particularly in rough water.[32] The alternative was to situate them "on the guards" by the paddle wheels. This not only supplied a better draft for the fire (and consequently better fuel consumption) but also reduced damage to the hull in the event of explosion.[33] There is only occasional evidence of Great Lakes' vessels adopting the later plan.

The principal innovations in the low-pressure condensing engines lay in stronger boilers and the perfection of the valves and action of the condenser in order to achieve more strokes per minute.[34] If steam pressure was held relatively constant, increased power could only be achieved by expanding the diameter of the cylinder and the length of the stroke (the efficiency of cutting off the stroke came somewhat later). The market demand for engines of ever greater power led to massive castings, which in turn necessitated a strong foundation plate to distribute its weight over the keel and keelsons. In 1832, Wards' Eagle Foundry produced the engines of *John Bull,* two sixty-inch cylinders with an eight-foot stroke. Using the Boulton and Watt formula for calculating power, they provided 150 horsepower working at fifteen psi and twenty revolutions per minute.[35]

If the owners wanted to operate a steamboat on waters where draft was critical, two alternatives were available. Some vessels, like *Brockville* or *Sir Robert Peel,* used low-pressure horizontal engines despite the risk of uneven wear.[36] The other alternative, unpopular in many quarters, was to use "high-pressure" (non-condensing) engines, sometimes in combination with stern- or centrewheel arrangements. These were typical on the shallow waters of the Kawarthas, Lake Simcoe, Grand River Canal and Thames River after 1832.[37] Typically, these engines were imported from the US or built by smaller foundries that dabbled in stationary engines.[38]

Of shafts and paddlewheels, little has to be said. Broken shafts were a major cause of mechanical failure.[39] The solution, for those who could afford it, was to stop using

Canadian-made, cast-iron shafts. Instead, wrought-iron shafts from Glasgow would be incorporated by local engine builders into their products.[40] Although sidewheelers, sternwheelers and centrewheelers were all tried, the real progress in propulsion belongs to the era of the screw propeller and the feathering paddlewheel.

The process by which such improvements were achieved was one of constant innovation. As one observer described it, the builders:

> effected this great increase of speed [from five mph to fifteen or more] by constantly making experiments of the form and proportions of their engines and vessels, in short, by a persevering system of *trial and error,* which is still going forward; and the natural consequence is, that, even at this day, no two steam-boats are alike.[41]

Modern historians of technology have described the process as "innovation and emulation" or as "collective invention:" the constant process of copying and improving that is virtually impossible to track.[42]

With imperfect knowledge of most of the engines built in the region, it is very difficult to trace the thoughts and contributions of each engine builder. But a number were well-travelled, inquisitive men. We know, for example, that John Dod Ward was in England in 1829, and his brother Lebbeus visited in 1837.[43] While John was across the Atlantic, a third brother, Samuel, travelled south to Washington, visiting a friend of the family at the US Patent Office and commenting on a locomotive building concern in Baltimore.[44] They were also keen observers of what the local competition was building and of the performance of their own work.

In general, the development of steamboat technology in central Canada moved in step with that of the eastern United States. The dependence on low-pressure boilers, the walking-beam engine and the side paddlewheel was characteristic of both regions.

II

In the years between 1809 and 1837 just over 100 steamboats were launched by Upper and Lower Canadians. In each case, one of the most critical decisions for the owners was the purchase of the machinery. A wide range of factors influenced this decision, including speed, power, size, reliability and price.

For those in competitive markets, perhaps the most important was speed. The earliest steamboats in the region were notoriously slow.[45] Each succeeding vessel sought to claim precedence in terms of speed, frequently proving its claim in head to head races — a practice officially disapproved of because there were often "innocent" paying passengers on board.[46] There was also a strong temptation to set someone or something on the safety valve to increase the steam pressure.[47]

It was a simple step to equate increased speed with greater horsepower, especially in discussing the matter with engine builders who charged by the horse. Assuming that the horsepower figures bandied about by founders and owners are to some degree comparable, there was a distinct trend in vessels intended for any given route to greater power combined with greater tonnage.[48] This peaked in the early 1830s with *Great*

Britain, John Bull and *Royal William,* all driven by relatively powerful twinned engines.[49] Their engines proved tricky to build, expensive to operate and easy to put out of order. As owners came to realize the high operating costs and the loss of cargo and passenger space, the trend was reversed. If newspaper claims are to be believed, the result was a lower horsepower-to-tonnage ratio, but higher speeds.[50]

The physical size of a powerful low-pressure engine was a major concern. Perhaps a third of the length of the hull would be consumed by the boilers, cylinders, pumps, frame and cranks, not to mention the cords of wood required for fuel. Not only did this mass of castings and fuel reduce valuable cargo and passenger space but it also could have a dramatic effect on vessel draft. To some proprietors the lighter, more compact high-pressure engine neatly solved these problems. But with horrific reports of explosions of high-pressure boilers on the Mississippi prominent in the newspapers, public opinion in the Canadas was anything but receptive to the expansive use of steam. Safety was the primary concern of one correspondent of the *Montreal Gazette.*

> After all the improvements which he promised are made, the fact will still remain, that the use of steam of a high degree of tension is, and must ever be dangerous...for the strength of all materials used in the construction of boilers, put them in whatever form you please, is limited, and no limit has been found to the expansive power of steam.

While he agreed that high pressure was necessary for the comparatively small railway locomotive, "fewer persons are in the vicinity of the boiler and those are not liable to be drowned after being scalded."[51] Another letter to the editor claimed that the writer "should as willingly embark in a steamboat carrying two or three barrels of gunpowder as one propelled by a high pressure engine."[52] Nor was the concern confined to newspaper columns. The *Alciope,* for example, was denied a government contract despite being the low tender because the vessel "is intended it appears for a High Pressure Engine, and as far as I am able to form an opinion I cannot take upon myself the responsibility of contracting with the vessel for the Transport of His Majesty's Troops."[53] Its owner retorted that much of the concern was being whipped up by the "jealousy" of "ignorant people" and "those interested on the other side."[54]

The net result of the controversy over high-pressure engines was that they were rarely used in competitive waters, instead being employed in shallow-draft situations. They were usually built by American engine foundries at Pittsburgh, Buffalo, Cleveland or Detroit. Central Canadian foundries, and those building for the Hudson River and Long Island Sound markets, concentrated on improving the "low-pressure" condensing marine engine.

Much of the rhetoric surrounding the discussion of the use of higher pressures had revolved around the inherent weaknesses of the materials used in marine engines and the likelihood of breakdowns. For the prospective buyer, a premium was placed on simple, reliable, easily repaired engines. On Lake Ontario in the 1820s, the largest urban centre contained not much more than 3500 people and the most sophisticated metal working equipment was the blacksmith's hammer and anvil. It might take two or three weeks to get a replacement part from Montréal, have it installed and resume running.[55] A poor engine could bankrupt the venture as the crippled steamer lay at dockside.[56] If a major breakdown occurred, such as a broken shaft, the loss of revenue could be devastating. The purser of *Cobourg* estimated losses from factory delays and breakdowns in 1833-1834 at about £4200, the approximate value of the engines.[57] On the other hand, of course, repairs did constitute a revenue opportunity for engine founders.[58] Emphasis in recruiting marine engineers was on foundry-trained men who had been involved with the casting and assembly of the engine on board ship.[59]

While balky engines cost owners both in repair bills and lost revenues, the most significant cost factor that most owners appear to have considered was the initial capital outlay. Again, the most important variable here was power. In the 1820s, John Dod Ward routinely quoted for the entire range of mechanical apparatus from boiler to paddles, at the rate of £48.10 to £50 per horsepower.[60] For the typical forty- or fifty-hp engine of the 1820s this translated into an expenditure of from £2000 to £2500 before the cost of transport to the shipyard. This frequently was half the total cost of the vessel.[61] Another of the attractions of the high-pressure engine was its comparative cheapness. Robert Hamilton bought two engines (without the boilers) for $6000 or £6.5.0 per horsepower. Whether the savings compensated for the loss of contracts and general trade is not clear, but the vessel was sold after two and one-half seasons and converted to sail.[62]

Table 1 suggests how owners made the decision to purchase new engines based on the two principal criteria of the waters in which the steamers were to ply and the degree of competition in those waters. There is an element of change hidden in the table because competition tended to increase over time. It is generally conceded that the open lakes and Montréal-Québec routes were highly competitive and that vessels there became larger and more powerful. Steamers like *Great Britain,* for example, were among the largest on the continent when first launched. Little attention has been accorded the large number of small steamboats working narrow, shallow waters with relatively little competition. It is clear that after 1832 (all discussion of the safety of high-pressure engines aside) these were the engines of choice for shallow waters. The high-pressure installations both reduced draft and the initial capital cost of the vessel.

The purchase of a used engine represented more "respectable" savings for steamboat owners in the Canadas. While the process of fine tuning went on with each new engine built, constant experimentation carried with it the risk of failure. Used engines were not only significantly cheaper but also were a "known" quantity. While boilers were almost never transferred to a new hull, the cylinders, shafts and gearing represented a significant capital investment. The early wooden hulls, like boilers, had a life of ten to fifteen years, but there are stories of cylinders cast in the 1830s still propelling sidewheelers in 1900. Because of the expanding nature of the fleet, before 1838 many of these engines were still in their first vessel. Nevertheless, nineteen percent of installations were of used engines, while another fifteen percent were from unknown sources. One question which begs for further research is whether setting up a used engine (almost all labour) was more profitable to engine founders than building a new one.[63]

Along with the ten- to fifteen-year cycle of vessel replacement, demand for steamboat engines responded to the economic patterns of growth and expansion. In general, the size of the steamboat fleet in central Canada grew steadily. Before 1838 there was no long-term route abandonment. Indeed, the trend was to replace the passenger and "express packet" functions of sailing vessels and horse-driven ferries. But the most spectacular growth in steamboat service lay in expanding services on established routes, such as Québec-Montréal and Prescott-Niagara, from weekly to daily departures.[64]

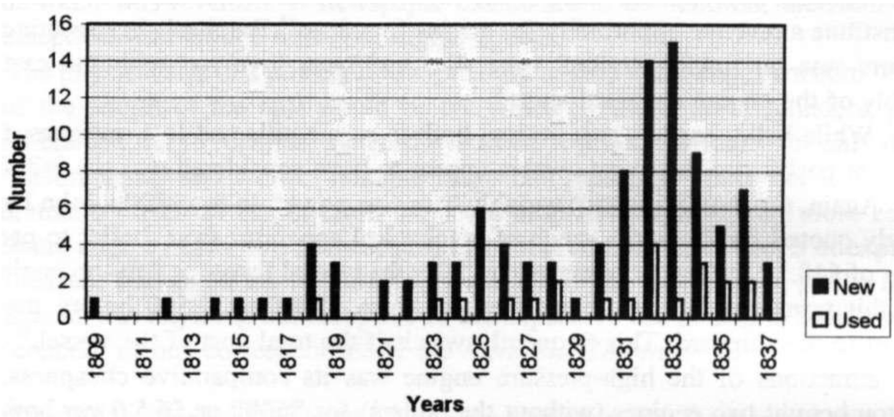

Figure 3: New and Used Engines in Central Canadian Steamboats, 1809-1837. "Unknowns" are included as part of the total of new engines; some may therefore represent additional used engines.

Source: See text.

The cycles of growth are evident from figure 3. The first cycle led from the introduction of steam navigation in 1809 to a burst of activity in 1818-1819. This seems to have absorbed as much of the profits from the War of 1812 as were likely to be directed towards steamboats, and the market sagged in 1820. Most of this demand was met by engines imported from England at prices ranging from £84 to £48 on the Liverpool dockside.[65]

The recovery from the postwar depression was associated with the emergence in Montréal of the major engine founding firm of John Dod Ward. Until 1829, despite would-be competitors, Ward and his brothers dominated the market and set the price of engines at £48.10 to £50 per horsepower. The apex of this cycle came in 1825 when service on Lake Ontario began to expand.

The third cycle ran from 1830 to 1837, peaking in 1832-1833. In those two years, almost one-third of the vessels launched before 1837 were equipped with engines. Two factors explain the boom. Serious competition in the Montréal trade finally emerged from the firm of Bennet and Henderson, a shift that led to lower prices for engines.[66] On the other hand, the trade in immigrants, which had grown steadily in the 1820s, soared to new heights. Potential investors saw the decks of established steamers crowded during the summer with hundreds of immigrants.[67] The expanding range of settlement prompted new ventures on Lake Erie, Georgian Bay, Lake Simcoe and other waters. Coupled with the demand for specialized steamboats created by the opening of the Rideau Canal in 1832, orders grew beyond what the established founders could manage and a wide variety of new sources were explored, including American, British and Upper Canadian foundries.

Table 1
Deployment of Steamboats with new engines, 1809-1837

Waters	Degree of Competition	Size of Vessel Builders	Objectives of Installations	% New Engine	General Observations
Shallow, narrow waters	non-competitive	small	preserve draft	pre '32: 17%	Low pressure, low h.p., side wheelers
				post '32: 15%	High pressure, low h.p., side, stern and centre wheelers
Shallow, narrow waters	competitive	small, medium	preserve draft, speed	19%	Low pressure, low h.p. (below 40). Occasionally using horizontal or inclined cylinders. Towboats use up to 70 h.p.
Open lake, river	non-competitive	medium	reliability	16%	Low pressure, 40-60 h.p., walking beam or crosshead/side lever.
Open lake, Montréal-Québec	highly competitive	medium to large	power/speed, safety	31%	Large low pressure, frequency double engines, 45-300 h.p.

Source: See text.

Table 2
Marine Engine Founding Firms in the Central Canadian Market, 1809-1837

Nationality	Name	Location	Years	Number
Great Britain	Boulton & Watt	Birmingham	1812-1820	6
	Maudslay & Sons	London	1818	1
	Fawcett, Preston	Liverpool	1831-1832	2
United States	Fuller & Copeland	Hartford	1832	1
	Drennan & Graham	Cincinnati	1832	1
	William Avery	Syracuse	1833-1834	3
	Unknown American			5
Lower Canada	John Jackson	Montreal	1809	1
	St Mary's Foundry	Montreal		
	Joseph Lough		1819	1
	Adam Hall		1820	1
	Bennet, Briggs & Burt		1821-1822	2
	Bennet & Henderson		1825-1826	3
	Eagle Foundry (Ward)		1830-1833	12
			1819-1837	33
Upper Canada	Charles Perry	York	1830-1833	3
	Sheldon & Dutcher	York	1833-1834	3
	Samuel Hulburt	Prescott	1834	1
	G.W. Yarker	Kingston	1835	1
	Niagara Harbour	Niagara	1836-1837	2
Unknown				11

Sources: Notes to individual firms in section III.

Demand for steamboat engines consequently was both cyclical and expanding. In highly competitive trades the demand for constantly improving, fast, safe, reliable, "conservative" technology helped maintain relatively high unit costs. The demand for improvement both accepted the risks of innovation and sought to minimize them by patronizing a limited range of well-known foundries. Those in the shallow backwaters of the region were much more price conscious and more likely to buy the cheaper, lighter, high-pressure engines, despite concerns about safety.

III

It is important to note that in twenty-nine years there were only 109 installations, ninety-one of which were of new engines. Consequently, the marine engine founders were very specialized, low-volume producers of a high-value, durable commodity. The firms listed in table 2 represent the known pool of steam engine founders from which central

Canadian steamboat promoters purchased their engines. Each will be examined in terms of the origins of their ownership and skilled labour, and the degree of their success.

Great Britain

The use of Boulton and Watt engines is hardly surprising. The firm unquestionably owned the best steam engine foundry in the world, their ascendancy initially assured by James Watt's patents. The Soho Engine Works in Birmingham had developed into a huge complex — *Frontenacs* engines were shipped within seven weeks of the dates on the engine drawings.[68] In North America, Boulton and Watt engines were uniformly successful; most can be traced through a succession of vessels prior to 1837.[69]

Before competitive engine works were established in Lower Canada, only one firm broke through Boulton and Watt's effective monopoly. Henry Maudslay and Sons of London included two of the most prolific and ingenious inventors in the marine engine trade. Henry and son Joseph developed the oscillating, steeple, twin-cylinder (or "Siamese") and annular engines, along with a variety of important devices for machining metal. Yet engines for *Quebec* and *Lauzon* seem to have been their only North American sales before 1838.[70]

The other British supplier was Fawcett, Preston and Co. of Liverpool. Unlike the Birmingham and London firms, this company had a modest presence in the North American market. At least six small, low-pressure engines had been exported to the lower Mississippi in the 1820s. Whatever their original purpose, by 1838 they were all driving sugar mills. During the tremendous boom in demand in the early 1830s, the Montréal foundries were heavily committed and two large, low-pressure engines were imported from this firm. Between 1834 and 1836, Fawcett, Preston and Co. also supplied engines for five coastal steamboats trading out of Savannah, Georgia.[71]

While British imports dominated sales before 1819, they could not compete with engines produced in the region by competent founders. Not only did shipping to Québec add £250 Sterling to one bill, but British imports were not necessarily exempt from Lower Canadian customs duties.[72]

Lower Canada

John Jackson

When John Molson began planning *Accommodation* in 1808, he formed a partnership with shipwright John Bruce and engineer John Jackson. Research has failed to determine much about Jackson except that he was a very hard man to get along with and that his engine was little better. It leaked badly, was difficult to keep up to power, and was abandoned (along with its builder) a full year before a replacement was available.[73]

St. Mary's Foundry

Located on the St. Lawrence River by the St. Mary's current and conveniently close to John Molson's brewery and Hart Logan's shipyard, the St. Mary's Foundry was one of the oldest in Montréal. Despite Merrill Denison's attempts to portray it as an early subsidiary of the Molson brewery, the operation had a much more varied history.[74]

In January 1816, founder Joseph Lough formed a partnership with three others to erect an air furnace on this site. This partnership involved not only Joseph Wildgoose and Thomas Mears of Montréal but also Jahaziel Sherman of Vergennes, each of whom was to supply £500.[75] Lough was described by a contemporary as "an Englishman [who] had lived in the States and married an American wife, he was a very clever man...and employed quite a large number."[76] He had also been involved with the construction of *Vermont* and *Champlain,* both on Lake Champlain.[77] The relationship between the partners was not happy and within a year and one-half Lough had assumed all the debts of the organization, £750 from Sherman and £2172 from the estate of Henry Cox. In 1819 Lough built the engine for *Ottawa,* which was partially owned by Alexander Allison.[78] After this date, Lough disappears along with references to the Montreal Air Furnace.

Despite some evidence that Lough was employed by Allison and his partner Thomas Turner, this seems to be the first association of these two men with the site. But Allison and Turner had been associated with the trade before the War of 1812, supplying some iron work for Jackson to use in *Accommodation.*[79] In 1820, Allison retained founder Adam Hall as engineer of *Ottawa,* the partners in that venture allowing Allison to employ their engineer as he saw fit during the winter.[80] Hall seems also to have constructed a thirty-two-hp engine for *Catharine* that spring. The nine-month delay between the launch of the vessel and the installation of the engines may account for the dearth of follow-up orders.[81] Instead, the St. Mary's Foundry produced a broad range of other goods, including stoves, cart boxes, rainwater spouts, weights and bark mills.[82] It was run for Allison's estate after his death until the executor, John Gray, moved the foundry to Côte-Sainte-Catherine in 1825.[83] Turner sold the old site to Bennet and Henderson four years later.[84]

John Bennet was a Scottish engineer who was delivered to Molson in 1812 with the latter's first purchase of a Boulton and Watt engine.[85] Only twenty-one and with his apprenticeship probably just completed, John Bennet was to be paid $400 (£100) a year for the next three years. During the decade that Molson imported engines from Britain, Bennet was working in Lower Canada putting them up and operating them.

In January 1820 Bennet formed a partnership with Lott Briggs, a local blacksmith, and Scott Burt, another steamboat engineer.[86] It is fortunate that Bennet had a major block of pay coming from the Molsons for it would be 1821 before Bennet, Briggs and Burt got their first commission, £600 for the twelve-hp engine for *Perseverance,* which was being built at Lachine. For their troubles the partners were "induced" to buy a £120 share in the little steamer.[87] Only one more commission came their way before Burt left to set up and operate a used engine in the first steamboat on the Ottawa River.[88] Bennet and Briggs built only three more engines in a small foundry on Panet Street before their partnership was dissolved in 1826.[89]

Even as the termination of his association with Briggs was being arbitrated, Bennet entered a new partnership with John Henderson in a former nail factory on Wellington Street in Griffintown.[90] Three years later, immediately after signing their first major steam engine contract, the partners bought the site of the St. Mary's Foundry from Thomas A. Turner. The contract for the engines of John Hamilton's *Great Britain* quickly established the partners' reputation even as it reflected the limits of their original operation. Hamilton arranged to import the boiler iron and deduct its price from their contract. He also contracted with Guy Warwick of Montréal for the iron castings.[91] Pricing their work about twenty percent less than the Wards' rates, Bennet and Henderson succeeded in capturing the contract for the engines of *Royal William,* being built in Québec to provide a service between that town and Halifax. When the vessel proved a financial disaster, it was dispatched to England for sale and became the first steamboat to cross the Atlantic completely under power.[92] Despite the poor performance of their engines, the excitement of the accomplishment of *Royal William* established for Bennet and Henderson an enduring reputation among early Canadian founders.

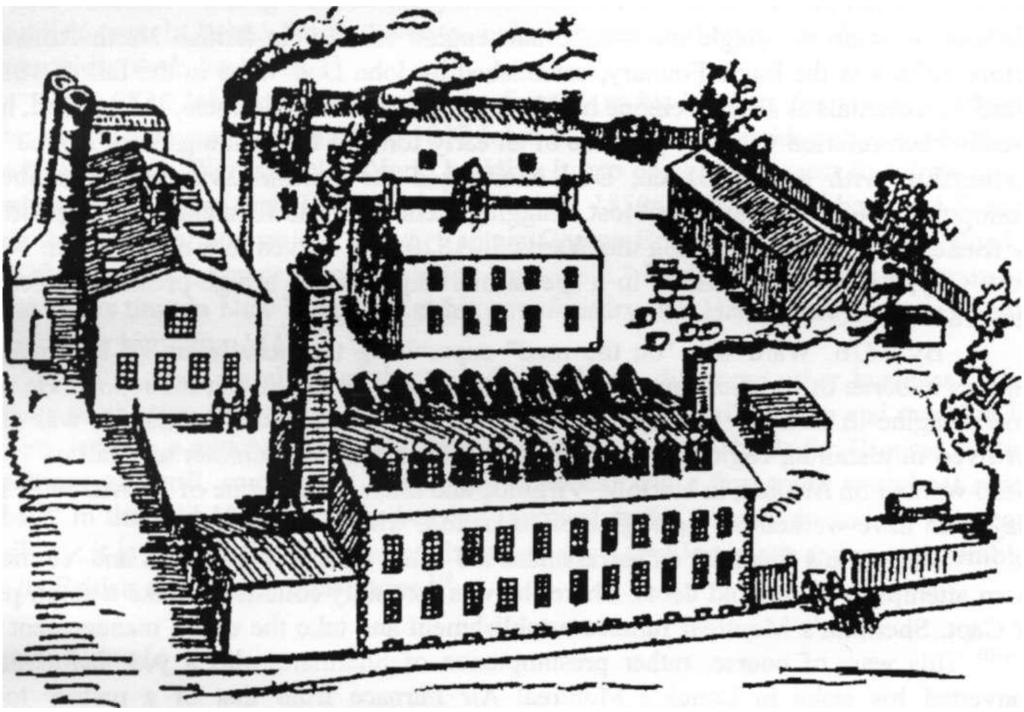

Figure 4: Bennet and Henderson's Foundry.

Source: *Daily Witness* (Montréal), 20 March 1897.

Between 1831 and 1833 Bennet and Henderson built three engines per year for the Great Lakes, Ottawa and St. Lawrence trades. An additional five stationary engines can be identified from the same period.[93] The result of this dramatic expansion was the borrowing of funds for a major building programme that resulted in the layout seen in figure 4.[94] In 1834, the market for new steamboats collapsed. By the end of 1834, with little prospect of new sales in sight, Bennet and Henderson assigned their personal belongings, receivables and the St. Mary's Foundry to their creditors.[95]

At the ensuing auction, John Molson, Sr. bought the foundry, with John, Jr. subsequently leasing the facility and recruiting James Irwin, an engineer, and Samuel

Workman as his agents.[96] Both Irwin and Workman had been associated with the Wards.[97] As agents, Irwin and Workman could tender for accounts but all contracts had to be ratified by Molson, an arrangement that was cancelled after two years. Instead, they agreed that Molson would hire Irwin and Workman at £200 a year each to run the establishment.[98] A modest operation by Bennet and Henderson's standards, the foundry was later managed by a variety of men, including William Parkyn, Warden King and George Rogers. Before 1840 it produced a few marine engines, and like other foundries, in the 1840s and 1850s began producing iron work for railroad carriages.[99]

Eagle Foundry

Without question the single most important engine foundry in British North America before 1838 was the Eagle Foundry, established by John Dod Ward in the fall of 1819. Ward's credentials as a steam engine builder were impeccable. His uncle, Daniel Dod, has already been referred to as the patentee of an early form of the walking-beam engine. In partnership with Aaron Ogden, Dod challenged the Fulton-Livingston steamboat monopoly in New York state and lost, dragging them both into financial ruin. Supported by friends and family, including the Wards, in 1820 Dod moved to a new plant in New York City, where he was killed in a spectacular explosion of a high-pressure boiler in May 1823.[100]

By 1816, Ward was "on the road" supervising the installation of his uncle's engines in some of the most important steamboats outside the Fulton monopoly. He put Dod's engine in *Ontario,* the first American steamer on the Great Lakes. He was also involved in installing engines on Lake Champlain. During the summer and fall of 1817 Ward worked on *Norfolk,* in Norfolk, Virginia, and altered the engine of *Powhatan.*[101] He may even have worked on the engine of *Savannah,* which Dod designed.[102]

His uncle's financial embarrassment led Ward back to New York and Vermont in an attempt to collect old debts. There, he was "strongly solicited to take a small part of Capt. Sherman's Montreal furnace establishment and take the entire management of it."[103] This was, of course, rather presumptuous of Sherman, who a year before had converted his stake in Lough's Montreal Air Furnace from that of a partner to a creditor.[104] Nevertheless, Ward was sufficiently intrigued by the offer to plan a trip to Montréal, returning the following summer, partly to collect a debt from Lough.[105] Whatever passed between them has not been ascertained, but that fall Ward was hired by the promoters of the steam ferry *Montreal* and opened his own foundry.[106]

The Eagle Foundry was established on a seventy by ninety-foot lot purchased in October 1819 on Queen Street in what became known as Griffintown.[107] Within a month, for a mere $250, a thirty by thirty-two-foot building with two blacksmith's fires was erected.[108] Two month's later, he had a good turning lathe, a punching machine and was anticipating delivery of a set of boiler tools. Ward claimed, justifiably, that when they arrived he would "have all the machinery for making a boiler as well and as conveniently as it can be done at any place."[109]

Despite some short-term cash-flow problems, Ward was an immediate success both in the construction and repair of steam engines — so much so, in fact, that with the exception of the few engines built by Bennet and his various partners, Ward supplied

Upper and Lower Canada with all its marine engines between 1820 and 1829: thirteen new engines and a wide range of replacement contracts. Most critical for his reputation was the 1823 contract for *Hercules,* £4500 for a 100-hp engine with a fifty-five-inch cylinder. At the time it was one of the most powerful single marine engines in North America.[110]

Reluctant to take outside partners, Ward had brought his younger brother, Samuel, north with him in 1819.[111] By 1826, another brother, Lebbeus, had joined him, and John D. Ward and Co. was formed.[112] The firm expanded across Queen Street, using the old site for the boiler shop and the larger new site for a new foundry and other shops. The space was needed for a regular staff of around 100, although as many as 300 were hired in peak seasons.[113] Along with the shipyards in Québec, it was one of the largest industrial establishments in British North America. Indeed it was on the same scale as some of the major New York foundries.[114]

In 1832 John sold his share of the foundry to his brothers for £5000.[115] Shortly after the final payment was made in 1837 John, this time with outside partners, purchased the Novelty Iron Works in New York, building it into one of the largest foundries on the continent with more than 1200 employees by the 1850s.[116] When Lebbeus and Samuel took in a new partner, an old friend, Captain George Brush, the foundry was valued at £7620 with no allowance being made for "good will." Lebbeus, however, was spending most of his time in New York City at his new foundry, the Hammersley, where Samuel would join him after 1842.[117]

Like other foundries of the period, the Wards did some other business. When engine production was off in 1829, orders included "a bark mill or two and machine for rolling leather, a puncher, a turning lathe, mill crank, a few wheels for Brouses carding machines and mill, some small wheels for Roebuck" and a few small steamboat repair jobs.[118] In the mid-1830s Lebbeus became involved in the Champlain and St. Lawrence Railway; it is reputed that *Dorchester,* that company's first locomotive, was re-assembled by its British engineer in their shops.[119]

Upper Canada

Although before 1838 the trade in marine engines was dominated by the Eagle and St. Mary's Foundries of Montréal, beginning in 1830 a number of engines were built in Upper Canada. Their appearance reflected both a growing market for iron products in Upper Canada and the emergence of some relatively sophisticated foundries.

The first Upper Canadian founder to sell a marine engine is also the least well known. Charles Perry sold three small, high-pressure engines for use on the upper waters of the Trent system. Perry's "York Steam Engine Works" is also known to have supplied engines for two sawmills and a distillery. The origins and fate of the foundry are unclear, although an Isaac Perry ran a blacksmith's shop in the vicinity in the preceding years.[120]

The most notorious Upper Canadian steam engine manufactory in the period was Sheldon and Dutcher's. Started by Frederick Dutcher, about 1828 the foundry moved to York from a location on Dundas Street, probably near the head of the lake.[121] Kenneth Lewis has argued that Sheldon and Dutcher ran a fairly small operation until 1833, when they expanded dramatically; he cites the evidence of the entry of the Van Normans of

Long Point into the partnership as the key to this expansion. An economic downturn a year or two later is blamed for the collapse of the firm.[122]

A close examination of available court records reveals a much more interesting tale. The foundry was initially in the hands of Frederick Dutcher, who in February 1830 gave it to his younger brother, William, as he "hot footed" it to the border.[123] After his release from debtor's prison, William Dutcher formed a partnership with William Bull Sheldon, a "retired" Hamilton merchant. Sheldon had the business background that the Dutchers apparently lacked.[124] In the spring of 1833, the partnership expanded to include Samuel Andruss (William Dutcher's father-in-law and a miller from Ancaster), Joseph and Benjamin Van Norman and Fred Dutcher, who had slunk quietly back into town.[125] The evidence suggests that the Dutchers had just swung the biggest deal of their lives and needed more financial backing.[126] Sheldon and Dutcher, however, was not a reliable risk.

The lack of reliability is directly and unequivocally related to the botched job they made of the contract for the engines of *Cobourg.* The foundry had expanded rapidly — as many as eighty men worked for the firm in the summer of 1833, including some of Ward's former employees.[127] They were late delivering the engines. As unforgivable as that was, one of the cylinders was badly cast, poorly patched and leaked. The boiler broke twenty-four stays one night and had to be constantly nursed along by the engine crew. Their shafts were undersized and broke twice at the beginning of the vessel's first season.[128] The contract to replace the engines of *John By* that same spring has been held up as something of a coup — replacing the engines of the famed Bennet and Henderson. In fact, the two small high-pressure engines failed to accomplish their intended purpose and were quickly discarded by the next vessel in which they were installed.[129] Only the engine for the Canada Company's *Minnesetung* can be acclaimed a success, albeit qualified — the steamer ran so infrequently the quality is difficult to judge.[130] Two stationary engines round out known production: one for themselves and a second for the Niagara Harbour and Dock Company, which promptly set up a rival foundry.[131]

Their credibility in shreds, Sheldon and Dutcher sued and were countersued by the owners of *Cobourg* over penalties and extra expenses. Between 1834 and 1838 the partners were involved in a minimum of thirty-one additional lawsuits at the Home District Assizes, involving pumps, mill castings, threshing equipment and unpaid suppliers.[132] The foundry was eventually taken over by another American living in Ancaster, Job Lodor, who slowly pushed Sheldon and the Dutchers out the door. Samuel Andruss and another son-in-law ran the operation until 1841, when a fire which started in the foundry burned down central Toronto.[133] Revived as the Phoenix, the foundry produced stoves, ploughs and assorted castings into the 1870s.

The engine for *Rapid* was built at Prescott in 1834 by Samuel Hulburt at the Prescott Steam Foundry and Engine Manufactory. Erected the previous year by John Ford, the foundry was conducted by Hulburt as both "Engineer and Agent."[134] The American-born Hulburt came recommended by a Syracuse engine builder, William Avery, and had worked on the high-pressure engines for *Iroquois* the previous season. The contract for *Rapid* was a direct result of Hulburt forming a partnership with Hiram Norton, who among other valuable connections, was a major investor in the steamboat.[135] In July 1833 the establishment was described as consisting of an eight-hp high-pressure engine, four forges, a "newly invented" punching machine and several lathes; it employed about twenty men.[136] Norton, Hulburt and Co. does not appear to have lasted long, but Samuel Hulburt was in the foundry business in Prescott for a good many years afterwards.[137]

Another Upper Canadian foundry capable of producing marine engines was that of George Yarker on the Kingston waterfront. In 1835 it supplied a small, fifteen-hp rotary engine using William Avery's patent.[138] The following year it included five departments: a smelting house, casting room, workshop "with an infinite number of lathes" and a ten-hp engine, blacksmith's shop with four forges and a pattern shop.[139] By the 1850s it would be absorbed into the shipbuilding complex that grew up around the Kingston Marine Railway.[140]

Through to the end of the 1840s, the most successful Upper Canadian establishment was the Niagara Harbour and Dock Company. When the firm was incorporated in 1831, its primary purpose was to provide a ship repair facility for vessels on Lake Ontario. But from the earliest discussions the intention had been to include shipbuilding and a foundry for steam engine construction.[141] In the winter of 1833 the company enduced George Arrowsmith and Adam Hall to leave the West Point Foundry in New York.[142] Just over a year later, John Lowe took over the foundry, which he would manage through the 1840s. Born in Upper Canada, Lowe had trained in Scotland before joining Bennet and Henderson in 1830 or 1831, where he was responsible for supervising much of the work on *Royal William's* engine.[143] After the failure of his Montréal employer, Lowe moved to Niagara, where two small marine engines were installed during this era.

United States

The number of American-built engines in central Canada during this period is difficult to determine precisely. Imperial tariffs of fifteen percent or more discouraged many imports. All American imports were delivered above the rapids of the St. Lawrence and most were high-pressure engines which, because of their lower cost, were less affected by customs barriers.[144]

Most sales came in special circumstances. Fuller and Copeland of Hartford, Connecticut, supplied two twenty-five-hp high-pressure engines for *Iroquois,* a small sternwheeler intended to work in the rapids below Prescott. The Wards usually supplied *Iroquois'* owner, Horace Dickinson, with his engines (it helped that Lebbeus Ward married one of Dickinson's daughters). Copeland, however, was located in the same town as another Ward foundry. It is possible that the brothers, who never built a high-pressure engine before 1837, used the family network to locate a likely engine. When the steamer was converted to a barge a few years later, the engine was sold, and by 1838 it was powering a sawmill in Michigan.[145]

Drennan and Graham of Cincinnati supplied only one pair of engines to the Canadian trades. Two 120-hp high-pressure engines were sold to Robert Hamilton (John's elder brother) to replace an old Boulton and Watt engine in *Alciope.* No evidence of the firm's other sales was found in a major US steam engine report in 1838.[146]

Of the few American manufacturers with Canadian sales, the best known was William Avery. The superintendent of E. Lynds and Co. of Syracuse, Avery built engines for *United States,* a "scaled down" version of John Hamilton's *Great Britain.* Canadian sales included *Enterprise,* a small sternwheeler on the Rideau, and two horizontal cylinder engines for *Brockville,* intended to replace *Iroquois* in the upper St. Lawrence rapids.[147]

Apart from these few it is possible to identify another five American engines used in Canadian steamers on Lake Simcoe (and later Georgian Bay), Lake Erie and the Detroit River. Finally, it is worth noting that the Wards sold a number of engines to the American-owned Lake Champlain Transportation Company.[148] Indeed, the Canadian exports were hardly surprising — as we have seen, the Upper and Lower Canadian founders were frequently American by birth or previous residence.

IV

From this examination of the various foundries in the central Canadian trade, it is possible to make some observations about locational factors, capital and labour requirements, and markets. How competive had the Montréal founders been with those located elsewhere inside and outside the region?

Barriers to entry in the engine building trades were relatively low. Part of this derives from the simple nature of the equipment required. A dirt floor was mandatory in the barnlike structure that sufficed to house the operation for the first few years. John Ward's first shop was built in less than a month for $250. Another $400 from his father enabled him to pay off his debts and acquire the requisite tools: a forge, turning lathe, punch and set of boiler tools.[149] To this the better shops added a furnace, usually a cupola furnace, to handle the castings. To supply a reasonably strong blast to this item, a small stationary steam engine was often assembled on the premises. In 1835, Bennet and Henderson's engine, blast cylinder, pipes and cupola furnace were valued at £700, and the balance of their equipment at nearly £1500.[150] A well-established foundry, such as the Eagle Foundry in 1838, included machinery, raw materials and inventory worth over £5000.[151] The range of equipment found in these plants was comparable in scale and quality to the leading New York foundries.

Still, a foundry's most valuable asset was the reputation and skill of its engineers and workmen. Much of this skilled labour moved freely back and forth across the border from the eastern US. These were not men unable to find employment closer to home. The Wards were among the finest engine builders from New York who, having dominated the Canadian trade, moved back to a larger market. Adam Hall, both inventor and shop foreman at another leading New York foundry, was associated with both Montréal and Niagara engine works. Apart from John Bennet, the Scots made only a small mark on the trade. By the mid-1830s, men who had trained under Ward and Bennet and Henderson were taking major roles in Upper Canadian foundries.

The demand for a quality product is not hard to understand. The capital cost of the engine and the demand for reliability have already been discussed. Perhaps more important was the fact that the financial risk for the production of the engine was squarely on the shoulders of the steamboat proprietors. In a Ward or Bennet and Henderson engine contract, payments were based on the production schedule. By the time the engine was through its trials, perhaps only one-quarter of the contract price remained to be paid. Giving an engine founder £2000 or £3000 before ever seeing the results was a powerful incentive to hire only those with proven skills.

A positive cash-flow during the course of a contract was important to foundries, even those as large as Eagle. Apart from a huge payroll, they had to assemble a variety of materials each season. Sources like the Van Norman's iron works or Les Forges du St. Maurice could supply only some of the necessary material; the rest would be recycled from scrap or imported from British works. Some evidence suggests that in the years between his management of the Eagle Foundry and the Novelty Ironworks, John D. Ward operated an ironworks near Vergennes, Vermont, from which he may have supplied his brothers in Montréal. After 1834 the wrought-iron shafts were imported from Glasgow, and expensive sheets of boiler iron were usually imported from British rolling mills.

The combination of "buyer financing" and low capital costs meant that there were few capital barriers to the trade. The range of Upper Canadian firms which appeared in the mid-1830s is indicative of how quickly a concern could add steam engines to its general line of business. Management stayed firmly in the hands of family connections or partnerships which combined engineering with business knowledge. Production remained, by and large, firmly rooted in the craft tradition. Producing and finishing iron castings and working malleable iron required large amounts of brute force. Despite the use of ten- or fifteen-hp engines in many of these plants, much of the work was done by hand.[152] As a result, a large workforce was often required, many of whom needed to be skilled in the use of a variety of hand tools and low-power machines.

At the same time, the constant evolution of the low-pressure marine engine and boiler encouraged experimentation. In the thirteen years before his bankruptcy, John Bennet and his partners are known to have built eighteen marine and five stationary engines from seventeen different models.[153] When important distinctions are made between high- and low-pressure,[154] marine and stationary, and side- and sternwheel, there were no duplications of power. As a result, only a quarter of Bennet's sales could be described as coming from "stock models." But neither do his contracts suggest any differential pricing to encourage people to order duplicates. Indeed, given the premium placed by the founders on enhancing their reputation with various improvements, this pricing scheme appears intended to discourage potential buyers from ordering "the same old thing."

The ratio of marine to stationary engine production varied from foundry to foundry. Research to date has revealed only two Ward installations, but Charles Perry's known output was half in the stationary line. The emphasis on marine engines in this era is not surprising. An abundance of mill sites still made water-powered mills more economical, while demand for marine engines was expanding steadily. Nevertheless, although the percentage is unclear, a number of marine engines, like those of *Iroquois,* ended their careers in industrial plants.

There was a definite bias in favour of "Canadian" engine builders in the region. To some degree, this may have been the product of the tariff on finished iron products, to which can be added the cost of transporting imports. This made British engines far too costly. One observer in 1831 added two other reasons for avoiding British engines: "principally the higher price demanded, and the chance of misunderstanding between the engineer and the builder of the Boat."[155]

In consequence, Montréal foundries dominated the market between Québec and Niagara before 1830. The emergence of Upper Canadian foundries was not a real threat to Montreal's dominance until a talented Scottish- and Montreal-trained founder, John

Lowe, set up shop in conjunction with the shipyard at Niagara. Above the falls, the Montréal presence was always negligible, with the initial demand being met by a number of relatively anonymous engines from small foundries in Buffalo and Cleveland.

The ability of Ward's Eagle Foundry to bridge the economic cycles, while shops like St. Mary's seem to have fallen prey to each, deserves some explanation. Ward was an early entrant into the trade, a position that allowed him to build up his modest capital investments slowly and remain out of debt. By contrast, competitors frequently expanded rapidly, buying their land and machinery over a much shorter period using borrowed capital. Creditors who themselves were being squeezed in periods of tight money could easily break the smaller manufacturers. But facile descriptions of the varying long-term capital requirements of mercantile as opposed to industrial establishments do not get to the heart of the matter.

The single most important asset of the engine builder was his skill and reputation. In unusual years like 1832 and 1833, the best builders were fully booked and opportunities for other potential engine founders opened. But the first orders still went to the established foundries with the best reputation — in particular, to the Eagle Foundry.

It should hardly come as a surprise that 1834 should have been a crisis year. Owners of the steamboats launched in the past two seasons were fighting for the most remunerative positions in various trades. New construction dropped off precipitously in the Canadas. While the established foundries were offered the few remaining contracts, the other survivors turned to producing ploughs, pumps, stoves and hollowware. Because our focus has been the demand for, and production of, marine engines, it is easy to lose sight of the fact that for most firms this was only a sideline — other castings remained the foundation on which they earned their profits. Engine building — especially the more complicated, large low-pressure marine engines — demanded specialized skills. Improved industrial financing might have helped John Bennet cross the gulf, but few of the others who leaped into the marine engine trades in the boom years had the skill or developed the reputation necessary to make a long-term impact.

The inescapable comparisons with American foundries suggest some conclusions. The principal Canadian foundry was as big and well-equipped as its American counterparts. With the eastern American builders, they shared a common set of preferences and biases about the appropriate technology to use, and worked constantly to improve it. In fact, the border is only relevant in terms of market definition and, at that, Canadian foundries made American sales. Those who controlled the foundries (with the notable exceptions of Bennet and Lowe) were American-born, recruited their labour force from both sides of the border, and invested wherever sufficient demand could be found.

Before 1838, the exception was the Niagara Harbour and Dock Company, which represented a new trend in marine engine founding — the integration of engine production into the shipyard. In the years to come Yarker's foundry would be incorporated into the Kingston Marine Railway complex. More significantly, the shipyard of Augustin Cantin in Montréal would come to include an engine works. Gradually, the Eagle and St. Mary's foundries would drift away from marine engines as Cantin came to dominate Canadian production.[156] Similarly, the foundries would expand into manufacturing iron work for Canadian railway rolling stock — until the railways took it upon themselves to manage their own shops.[157]

V

Prior to 1838, there was a distinct preference for Canadian-built engines for steamboats operating below the Welland Canal. The technology used was unique, in many respects, to the waters of eastern North America. The labour pool and entrepreneurial talent which designed and built them moved freely across the border and about the region. The costs of delivery and the relative ease of servicing from Montréal helped define that city's industrial hinterland. As similar foundries emerged along the Great Lakes in centres like York, Niagara, Buffalo and Cleveland, the reach of the Montréal firms was somewhat constrained.

The constant demand for speed and power from steamboat proprietors drove what may be described as "conservative innovation" in the low-pressure, walking-beam engine. In certain sectors of the Great Lakes' trades, the walking-beam would persist well into the twentieth century. But for the generation of engine builders before 1838, the independent foundries specializing in marine engines helped define the nature of the "Steam Revolution" in the Canadas.

NOTES

* Walter Lewis is pursuing a PhD in History. He is an editor of *FreshWater* and is co-moderator of MARHST-L, the internet discussion group dealing with Maritime History and Maritime Museums.

1. The author would like to acknowledge assistance in research from Maurice Smith and Rick Neilson of Kingston, ON; Larry McNally, Steve Salmon, Ken McLeod and Peter Dupuis of Ottawa; Richard Palmer of Tully, NY; J.D. Warner-Davies of Birmingham, UK; C.J. Heap of London, UK; Eileen Marcil of Québec; and especially John Mills of Toronto.

2. Hugh Richardson, *Steam Navigation on Lake Ontario* (York, 1825), 5-6.

3. David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present,* (Cambridge, 1969); Dudley Dillard, *Economic Development of the North Atlantic Community* (Englewood Cliffs, NJ, 1967), esp. 238-249; and T.S. Ashton, *The Industrial Revolution, 1760-1830* (Oxford, 1964), esp. chap. 3.

4. George Rogers Taylor, *The Transportation Revolution, 1815-1860* (New York, 1968); and Gerald J.J. Tulchinsky, *The River Barons: Montreal Businessmen and the Growth of Industry and Transportation, 1837-53* (Toronto, 1977).

5. "Steam Revolution" is the phase used in Michael Bliss, *Northern Enterprise: Five Centuries of Canadian Business* (Toronto, 1987), chap. 7. James Thomas Flexner, *Steamboats Come True: American Inventors in Action* (Boston, 1944) is an eloquent assessmentof Fulton and his predecessors.

6. George H. Wilson, "The Application of Steam to St. Lawrence Valley Navigation, 1809-1840" (UnpublishedMA thesis, McGill University, 1961); and Merrill Denison, *The Barley and the Stream: the Molson Story* (Toronto, 1955).

7. Louis C. Hunter, *Steamboats on the Western Rivers* (Cambridge, MA, 1949); G.W. Hilton, R. Plummer and J. Jobe, *The Illustrated History of Paddle Steamers* (Lausanne, 1976); Richard Palmer, *"Ontario:* First Steamboat on the Great Lakes?" *FreshWater,* II, No. 1 (Summer 1987), 20-27; and Walter Lewis, "The *Frontenac:* A Reappraisal" *ibid.,* 28-39.

8. For the relationship between patents and inventive activity in England see H.I. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution, 1750-1852* (Manchester, 1984), esp. chap. 6.

9. Hunter, *Steamboats,* chap. 3; John Guthrie, *A History of Marine Engineering* (London, 1971), 19-23; and Capt. E.C. Smith, *A Short History of Marine Engineering* (Cambridge University Press, 1938).

10. Tulchinsky, *River Barons,* chap. 12; Wilson, "Application;" and Bruce A. Parker, "The Niagara Harbour and Dock Company" *Ontario History,* LXXII (1980), 93-121.

11. Norman R. Ball, *"Mind, Heart, and Vision": Professional Engineering in Canada, 1887 to 1987* (Ottawa, 1987); Norman R. Ball, *Building Canada: A History of Public Works* (Toronto, 1988); Diane Newell, *Technology on the Frontier: Mining in Old Ontario* (Vancouver, 1986); and Paul Craven and Tom Traves, "Canadian Railways as Manufacturers, 1850-1880," Canadian Historical Association *Historical Papers* (1983), 254-281.

12. T. Ritchie, "Joseph Van Norman, Ironmaster of Upper Canada" *Canadian Geographical Journal,* LXXVII (1968), 46-51; Eric Arthur and Thomas Ritchie, *Iron: Cast and Wrought Iron in Canada from the Seventeenth Century to the Present* (Toronto, 1982); and William Kilbourn, *The Elements Combined: A History of the Steel Company of Canada* (Toronto, 1960).

13. Larry S. McNally, "Montreal Engine Foundries and their Contribution to Central Canadian Technical Development, 1820-1870" (Unpublished MA thesis, Carleton University, 1991).

14. Kenneth G. Lewis, "Early Steam-Engine Builders of York" and "The Significance of the York Foundry & Steam-Engine Manufactory" (Unpublished mss., University of Toronto, Department of History and Philosophy of Science and Technology, 1972).

15. David McGee, "Marine Engineering in Canada: An Historical Assessment" (Unpublished paper prepared for the National Museum of Science and Technology, Ottawa, 1995), 3.

16. The term "Canada" in the body of this paper is used in its contemporary context, that is as the combination of Upper and Lower Canada.

17. The relationship of Newcommen and Watt engines is explored in a wide variety of texts. See, for example, H.W. Dickinson, "The Steam-Engine to 1830," in Charles Singer, *et al., A History of Technology* (8 vols., Oxford, 1954-1984), IV, 173-187. Fuel economy is, of course, relative. Economy at the level which made ocean freighters feasible awaited the compound engine; for a discussion, see Robert Gardiner (ed.), *The Advent of Steam* (London, 1993).

18. Eileen Reid Marcil, *The Charley-Man: A History of Wooden Shipbuilding at Quebec, 1763-1893* (Kingston, ON, 1995); Louis C. Hunter, *A History of Industrial Power in the United States, 1780-1930* (2 vols., Charlottesville, VA, 1979-1985), I; and Felicity L. Leung, *Grist and Flour Mills in Ontario* (Ottawa, 1981).

19. See Arthur, *Iron;* and Donald Blake Webster (ed.), *The Book of Canadian Antiques* (Toronto, 1974).

20. Guthrie, *Marine Engineering, 30-31*; Birmingham Public Library (BPL), Boulton & Watt Collection (B&W), ff. 1213-1214 and 1240-1242; and Hunter, *Industrial Power,* II, 317-319.

21. Dickinson, "Steam Engine," 185-186; and Carroll W. Pursell, *Early Stationary Steam Engines in America: A Study in the Migration of a Technology* (Washington, DC, 1969). 13.

22. Hunter, *Steamboats,* chap. 2; P.R. Hodge, *The Steam Engine, Its Origin and Gradual Improvement, from the Time of Hero to the Present Day; as Adapted to Manufactures, Locomotion and Navigation* (New York, 1840), 124-126.

23. *Chronicle and Gazette* (Kingston), 14 September 1833, quoting *Grenville Gazette.*

24. Hunter, *Steamboats,* 123-128 and 157-158. See also United States, Congress, House of Representatives, 25th Cong., 3d Sess., H. Doc. 21, Letter from the Secretary of the Treasury Transmitting, in obedience to a resolution of the House of the 29th of June last, information in relation to Steam Engines, &c, 13 December 1838 (hereafter "US Steam Engine Report"); David John Denault, "An Economic Analysis of Steam Boiler Explosions in the Nineteenth-Century United States" (Unpublished PhD thesis, University of Connecticut, 1993); and Gene Erick Salecker, *Disaster on the*

Mississippi. The Sultana *Explosion, April27, 1865* (Annapolis, 1996), 208.

25. Jean Baptiste Marestier, *Memoir on Steamboats of the United States of America* (Mystic, CT, 1957), 80.

26. BPL, B&W, ff. 1213-1214 and 1240.

27. Dickinson, "Steam Engine," 195.

28. "Dod, Daniel," *National Cyclopedia of American Biography* (New York, 1898-), XXIV, 359-360 (hereafter *NACB);* and John H. Morrison, *History of American Steam Navigation* (1903; reprint, New York, 1958), 39-40. Dod's engine used a wooden connecting rod as well as a wooden beam.

29. Guthrie, *Marine Engineering,* 147; and Charles H. Haswell, "Reminiscences of Early Marine Steam Engine Construction and Steam Navigation in the United States of America from 1807 to 1850," Institution of Naval Architects *Transactions, XL* (1898), 104.

30. See, for example, Archives nationales du Québec-Montréal (ANQ-M), Greffes du Henry Griffin, no. 9837, 7 May 1832; and N.B. Doucet, no. 22241, 12 February 1835.

31. National Archives of Canada (NAC), Manuscript Group (MG) 28, III, 57, v. 34, f. 12, #2370, contains a sketch of the boiler of the *Dolphin (ex-Black Hawk).* See also *Chronicle and Gazette, 2* August 1834, quoting *Montreal Herald (Rapid).*

32. *Upper Canada Herald* (Kingston), 3 November 1835; and *Chronicle and Gazette,* 13 September 1834 and 28 October 1835.

33. David Stevenson, *Sketch of the Civil Engineering ojNorth America* (London, 1838), 171-172; and ANQ-M, Griffin, no. 3892, 3 November 1829.

34. Stevenson, *Sketch,* 122-147.

35. *Ibid.,* 159; and *Montreal Gazette,* 10 September 1831.

36. *Brockville Recorder,* 10 January 1834; and *Montreal Gazette,* 18 April 1837. The *Rapid* used a compromise, inclined cylinder. Hull, Patent Office, Patent no. 147 (old law), Nathan Sanford, 6 May 1834. I would like to thank Ken McLeod and Peter Dupuis for this reference.

37. These included *Morning Star* (1830) and *Pemedash* (1832) on Rice Lake; *Sturgeon* (1833) on Sturgeon Lake; *Sir John Colborne* (1832) on Lake Simcoe; *Sir Walter Scott* (1834) for the Grand River; and *Thames* (1833) and *Cynthia* (1833) on the Detroit and Thames Rivers. *Thames* quickly moved to Lake Erie. My thanks to John Mills for helping to identify many of these engines.

38. Builders of engines in the above note include Charles Perry of York and unnamed foundries in Buffalo and Cleveland. No builder was identified for the *Sir Walter Scott,* which blew up on its trials; see *HallowellFree Press,* 3 November 1834, quoting *Montreal Gazette.*

39. On the Great Lakes these included *Canada* (1827), *William IV* (2 in 1833, 1834), *United Kingdom* (1833), *St. George* (2 in 1833, 1834), *Great Britain,* (1833, 1834, 1836), *Cobourg,* (2 in 1834), *Brockville(\834)* and *Britannia*(1834 and 1837).

40. *Cobourg Star,* 21 May 1834 *(Cobourg); Chronicle and Gazette,* 14November 1835 *(Traveller);* and *Montreal Gazette,* 18 April 1837 *(Sir Robert Peel).*

41. Stevenson, *Sketches,* 120-121.

42. Brooke Hindle, *EmulationandInvention(Nev</* York, 1981). See also Robert C. Allen, "Collective Invention," *Journal of Economic Behaviour and Organization,* IV (1983), 1-23.

43. NAC, MG24, D19, Ward Family Papers, L.B. Ward to John D. Ward, 1 July 1829; and *Montreal Gazette,* 7 November 1837. Not seen by this author was Columbia University, John D. Ward Diaries, 5 August 1827-11 March 1830, which reportedly cover his research trip to England and the continent.

44. *Ibid.,* Samuel S. to John D. Ward, 18 February 1829.

45. See Lewis, *"Frontenac",* 35. NAC, MG 28, III, 57, v. 10, f. 35, #2937, Robert Fulton, "Notes

on a Steamboat," 7 September 1810, includes plans for a vessel to run at five mph in still water.

46. Wilson, "Application," 191-200.

47. *British Whig* (Kingston), 20 May 1834; and *Montreal Gazette,* 19 April 1832.

48. For estimates on the Great Lakes see Lewis, "Frontenac," 36. This calculation used John Hamilton's tonnage estimates *(Chronicleand Gazette,!!* November 1843) which, while seriously flawed, have the advantage of internal consistency.

49. *Montreal Gazette,* 10 September 1831; Stevenson, *Sketches,* 159; ANQ-M, Griffin, no. 8492, 3 November 1829; G.D. Arnoldi, no. 3884, 2 January 1835; and Wilson, "Application," 163-164.

50. The rise in acceptable "low pressures" through greater boiler strength was not accounted for in standard horsepower equations and may mean that reported figures underestimated "real" power.

51. *Montreal Gazette,* 19 April 1832.

52. *Canadian Courant,* 15 June 1832.

53. NAC, Record Group (RG) 8, I, C Series, v. 377, 141-142, R.J. Routh to Lt. Col. Glegg, 16 March 1832.

54. *Ibid.,* 159-61, Robert Hamilton to ?, 16 March 1832. The reference was a rather pointed one to his younger brother and former partner, John, who did get the contract. *Ibid.,* 165-173, 17 April 1832. Robert would later sue John's Niagara agent for slandering the steamboat. Archives of Ontario, (AO), RG 22, Series 390, Box 2, file 10, Niagara District Assizes, September 1834, Hamilton vs. Walters.

55. The *Canada's* shaft broke on 31 July 1827 and the ship recommenced her trips on 17 August 1827. *Colonial Advocate* (York), 2 August 1827; *United Empire Loyalist* (York), 4 and 18 August 1827.

56. Lewis, "The Steamer *Toronto* of 1825," *FreshWater,* I, No. 2 (Autumn 1986), 26-27.

57. AO, RG 22, Series 390, Box 22, file 2, Home District Assizes, October 1835, Bethune, *et al.* vs. Ketchum, *et al.,* 215-216. All references to currency are to Halifax Currency unless otherwise noted.

58. NAC, MG 28, III, 57, v. 80, Account Book, 1822-1827; Metro Toronto Reference Library, Baldwin Room, microfilmed ms., reel 4, item 5, Accounts of the Steamboat *Caroline.*

59. ANQ-M, Doucet, no. 15070, 31 January 1828; Wilson, "Application," 48 and 233-234; Walter Lewis, "Leys, John" *Dictionary of Canadian Biography* (Toronto, 1966-), VII, 505-506 (hereafter *DCB);* and *Montreal Gazette,* 5 June 1832.

60. NAC, MG 28, III, 57, v. 19, f. 17., 14 September 1822, quoted in Wilson, "Application," 127. See also contracts for *WilliamAnnesley(£47.*10/hp, ANQ-M, JB Lindsay, no. 42, 13 May 1824) and *Hercules* (£45/hp, NAC, MG 24, D19, 78-83, Articles of Agreement [3 Feb. 1823]).

61. See, for example, table in Lewis, *"Frontenac,"* 33.

62. NAC, MG31, A10, Andrew Merilees Coll. v. 33, f. 19, Agreement July 1831; v. 37, f. 8, Drennan and Graham to Robert Hamilton, 6 November 1831 and 7 June 1832; NAC, MG 24, 126, Alexander Hamilton Papers, v. 4, Drennan and Graham to Robert Hamilton, 13 October and 2 November 1831, and 18 February, 6, 11 and 26 April 1832; *Chronicle and Gazette,!!* December 1834 and 3 October 1835.

63. Contracts for placing used engines include ANQ-M, Griffin, no. 7225, 3 May 1825 *(John Molson);* Doucet, no. 22241, 12 February 1835 (Toronto); and Griffin, no. 7531,9 November 1827 *(Alciope).* See also AO, RG 22, Series 390, Box 3, file 5, 255-262, Home District Assizes, 1836, Sheldon, Dutcher and Andruss vs. Wm Chisholm *(Oakville).*

64. W.R. Wightman, "The Evolving Upper Canadian Steam Packet Service, 1816-1850," *Ontario Geography,* No. 37 (1991), 23-38.

65. BPL, B&W, Engine Book 243, 4 March 1812; Engine Book 244, 14 May 1817 and 16 March 1820; Engine Book 258, 185, 20 May 1816. My

thanks to J.D. Warner-Davies, principal archivist at BPL, for these references.

66. ANQ-M, Griffin, no. 6173, 6 January 1826; Griffin, no. 8493, 3 November 1829; Griffin, no. 9524, 8 October 1831; Griffin, no. 9837, 7 May 1832; and Lukin, no. 2714, 16 November 1832.

67. See Helen I. Cowan, *British Emigration to British North America* (rev. ed., Toronto, 1961).

68. BPL, B&W, f. 1213-1214, Letter Books, Boulton & Watt to Gillespie, Gerrard & Co., 10 June 1816.

69. Lewis, *"Frontenac,"* 37; and Wilson, "Application," 262-269.

70. H. Philip Spratt, "The Marine Steam-Engine," in Singer, *et al., Technology,* IV 145-6. See Guthrie, *Marine Engineering,* 67-68, for Maudslay's contributions to machine shop equipment. Information on the *Quebec* and *Lauzon* was supplied by the National Museum of Science and Industry, London.

71. Wilson, "Application," 268-69; and "US Steam Engine Report," 274-275.

72. NAC, MG 28, III, 57, v. 10, f. 41, #1092, Henry Wood to John Molson, 11 June 1817; and Lewis, *"Frontenac,"* 32. For a guess of the cost of transport from England to Kingston, see *Kingston Gazette,* 30 March 1816.

73. Denison, *Barley and the Stream,* 62-73; Wilson, "Application," 7-22; and McNally, "Montreal Engine Foundries," 21-22.

74. Denison, *Barley and the Stream,* 64, 93 and 156; and Tulchinsky, *River Barons,* 216.

75. Denison, *Barley and the Stream,* 69; and ANQ-M, Griffin, no. 1308, 26 January 1816; nos. 1916-18, 7 July 1817.

76. NAC, MG 24, D12, J.H. Dorwin Papers, v. 1, 54.

77. Wilson, "Application," 5, note. 2.

78. ANQ-M, Griffin, no. 2471, 23 January 1819. At over ninety-four pounds Halifax currency per horsepower, Lough's pricing could hardly have encouraged repeat orders.

79. Wilson, "Application," 13.

80. ANQ-M, Griffin, no. 2964, 22 February 1820.

81. Wilson, "Application," 74-75.

82. *Montreal Herald,* 29 July 1820.

83. Carman Miller, "Gray, John," *DCB,* VI, 297.

84. ANQ-M, Doucet, no. 17303, 7 December 1829.

85. NAC, MG 28, III, 57, v. 34, f. 1, Agreement of John Bennet and John Molson, 3 February 1812. This contract was renewed twice at the rate of 230 pounds Halifax currency per annum and finally expired in April 1819. A further one-year engagement to the Molsons ran for the 1821 season at 180. ANQ-M, Griffin, no. 942, 25 April 1815; Griffin, no. 1698, 18 January 1817; and Griffin, no. 3448, 26 January 1821.

86. The origins of Lott Briggs are unclear, but in 1819 he had done some blacksmith work for Molsons; see NAC, MG 28, III, 57, v. 65, 254. Scott Burt may well have been related to the Samuel Burt who had worked on the *Ontario* with John Dod Ward. (Letter of L.B. Ward, 26 December 1889, with enclosures in Capt. James Van Cleve, "Reminiscences of the Early Period of Sailing Vessels and Steam Boats on Lake Ontario..." (Unpublished ms., City of Oswego Clerk's Office [microfilm, Marine Museum of the Great Lakes], inserted after 66). In the fall of 1819, John Dod Ward attempted to recruit an "S. Burt" to come to Montreal (NAC, MG 24, D19, John D. Ward to Silas Ward, 3 October and 4 November 1819). Whether related to the Burt of Ward's acquaintance, Scott Burt, like John Bennet, was hired by the Molsons for the 1821 season (ANQ-M, Griffin, no. 3487, 26 January 1821).

87. NAC, MG 28, III, 57, v. 65, 397; and ANQ-M, Lukin, no. 73, 31 January 1821. Ward's contempt for this practice is evident in a letter to his father (NAC, MG 24, D19, John D. Ward to Silas Ward, 30 October 1821). Nevertheless he also purchased steamboat stock as a marketing technique. *Ibid., 9* August 1819; Wilson, "Application," 84,

note 1; and NAC, MG24, D93, *William Annesley,* file 2, Ledger 1824, f. 8.

88. ANQ-M, Griffin, no. 4438, 18 January 1823; and Griffin, no. 6698, 29 July 1826.

89. ANQ-M, Griffin, no. 6905, 27 November 1826.

90. Wilson, "Application," 232.

91. ANQ-M, Griffin, no. 8492, 3 November 1829.

92. Wilson, "Application," 163-164. *Daily Witness* (Montréal), 20 March 1897.1 would like to thank Larry McNally and Ken McLeod for this reference.

93. ANQ-M, Arnoldi, no. 3884, 2 January 1835; and Griffin, no. 10851, 20 April 1833.

94. ANQ-M, Lukin, no. 2083, 30 November 1830; Doucet, 21000, 4 October 1833; and NAC, MG 24, D64, Peter Lowe Papers, [John Lowe] to Peter Lowe, 9 October 1831.

95. ANQ-M, Arnoldi, no. 3884, 2 January 1835.

96. ANQ-M, Griffin, no. 12965, 24 March 1835. For an advertisement, see *Montreal Gazette,* 26 March 1835.

97. *Canadian Correspondent* (York), 14 June 1834. Samuel Workman, clerk, witnessed L.B. Ward's will (ANQ-M, Doucet, no. 19285, 14 January 1832).

98. ANQ-M, Griffin, no. 14720-21, 27 January 1837.

99. Alfred Dubuc and Robert Tremblay, "Molson, John," *DCB,* VI, 632.

100. See note 25; and "US Steam Engine Report," 100 and 404. Also relevant, but unavailable to the author, is John D. Ward, *An Account of the Steamboat Controversy between Citizens of New York and Citizens of New Jersey from 1811 to 1824, Originating in the Asserted Claim of New York to the Exclusive Jurisdiction over All the Waters between the Two States* (Newark, NJ, 1863).

101. Van Cleve, "Reminiscences," after 66.

102. Although it sailed much of the distance, *Savannah* was indisputedly the first vessel equipped with steam engines to cross the Atlantic. Frank O. Braynard, *S.S. Savannah: The Elegant Steam Ship* (Athens, GA, 1963), 44-45; and "Dod," *NACB,* XXIV, 360. Ward may also have built engines for *Charlotte* while still in the US. See Lewis, *"Frontenac,"* 36 and note 84.

103. NAC, MG 24, D19, John D. Ward to Silas Ward, 6 August 1818.

104. ANQ-M, Griffin, no. 1916, 7 July 1817.

105. NAC, MG 24, D19, John D. Ward to Silas Ward, 9 August 1819.

106. *Ibid.,* 16 September 1819.

107. *Ibid.,* 3 October 1819; and ANQ-M, Doucet, no. 20032, 23 November 1832.

108. NAC, MG 24, D19, John D. Ward to Silas Ward, 4 November 1819 and 14 January 1820.

109. *Ibid.,* 14 January 1820.

110. *Ibid., 9* May 1823, 78-83, Agreement, 2 February 1823; Wilson, "Application," 125-130; and Denison, *Barley and the Stream,* 92.

111. NAC, MG 24, D19, John D. Ward to Silas Ward, 9 August 1819.

112. *Ibid.,* Dissolution of Partnership, 23 November 1832. The notarial copy of this agreement is ANQ-M, Doucet, no. 20032, 23 November 1832.

113. Kilbourn, *Elements,* 8.

114. Philip W. Coombe, "James P. Allaire: Marine Engine Builder," *Steamboat Bill,* XLIII (1986), 265. See also Coombe, "Life and Times of James P. Allaire: Early Founder and Marine Engine Builder" (Unpublished PhD thesis, New York University, 1991).

115. ANQ-M, Doucet, no. 20032, 23 November 1832.

116. Ward Letter in Van Cleve, "Reminiscences," 66; Clyde A. Sanders and Dudley C. Gould, *History Cast in Metal: The Founders of North*

America (Des Plaines, Illinois, 1976), 257; *Longworth 's American Almanac, New York Register and City Directory* (New York, 1839), 684; *ibid.* (1841), 738-739; and Jacob Abbott, "The Novelty Works with Some Description of the Machinery and the Processes Employed in the Construction of Marine Steam-Engines of the Largest Class," *Harper's New Monthly Magazine,* II (May 1851), 721-734.

117. ANQ-M, Doucet, no. 25796, 31 December 1838; and "Ward, Lebbeus Baldwin", *NCAB,* I, 246. The Wards still maintained a membership in the partnership in 1842. ANQ-M, Doucet, no. 28001, 31 December 1842; and Gerald J.J. Tulchinsky, "Brush, George," *DCB,* XI, 120-121.

118. NAC, MG 24, D19, L.B. Ward to John D. Ward, 1 February 1829.

119. Tulchinsky, *River Barons,* 110-111; and Robert R. Brown, "The Champlain and St. Lawrence Railroad," *Bulletin of the Railway and Locomotive Historical Society* (1936), 20-21. I would like to thank Larry McNally for the latter reference.

120. K.G.Lewis, "Steam Engine Builders," 56-60; *Montreal Gazette,* 20 November 1832, quoting *York Courier,* and *Colonial Advocate,* 4 July 1833.

121. KG Lewis, "Steam Engine Builders," 5.

122. *Ibid.,* 29-37, 44-47.

123. AO, RG 22, Series 390, Box 20, fde 4, Home District Assizes, Oct 1830; fde 6, April 1831; fde 7, October 1831; Box 21, fde 2, April 1832; all cases were Reuben A. Parker vs. William A. Dutcher.

124. *Colonial Advocate,* 8 July 1830; and "Sheldon, William B." *Dictionary of Hamilton Biography* (Hamilton, 1981).

125. William D. Reid, *Death Notices of Ontario* (Lambertville, NJ, 1980), 117, quoting *Christian Guardian,* 7 January 1835; and *Colonial Advocate,* 11 April 1833. While across the border in Lockport (near Buffalo), Fred Dutcher got married *(Canadian Courant,* 7 July 1830), which tends to confirm the suspicion that the Dutchers were Americans.

126. Captain Charles Mcintosh, who lived just up Yonge Street from the foundry, was the leading shareholder in the *Cobourg,* and the foundries of Montréal were fully booked that season. George Walton, *The City of Toronto and the Home District Commercial Directory and Register with Almanack and Calendar for 1837,* (Toronto, 1836), 32 and 41. From the perspective of the Van Normans, Sheldon and Dutcher probably represented a client with tremendous potential and an unreliable track record. They would have wanted not only access to the York market for their products but also some means of controlling that account. The Van Normans were Americans who operated Upper Canada's most successful bog ironworks at Normandale. (Norman N. Ball, "Van Norman, Joseph," *DCB,* XI, 897-898). They employed Elijah Leonard, Sr. (Christopher Alfred Andreae, "Leonard, Elijah," *DCB,* VIII, 499-500), who may have been related to Carleton Leonard, the senior clerk at Sheldon and Dutcher. The Van Normans were never mentioned in any of the evidence given at Sheldon and Dutcher's many trials.

127. K.G. Lewis, "Steam Engine Builders," 22; *Montreal Gazette, 1* May 1833, quoting *York Courier;* AO, RG 22, Series 390, box 22, file 1, Sheldon, *et al.* vs. Smith, *et al.,* Home District Assizes 1834, 48; Box 3, file 4, Sheldon, *et al.* v. Bethune, *et al.,* 352.

128. AO, RG 22, Series 390, Box 22, file 1, Home District Assizes, April 1834,43-52, Sheldon, *et al.* vs. Smith, *et al.;* October 1835, 207-222, Bethune, *et al.* vs. Ketchum, *et al.;* Box 3, file 4, October 1835, 335-352, W.B. Sheldon, *et al.* vs. J.G. Bethune, *et al.*

129. K.G. Lewis, "Steam-Engine Builders," 38; W. Lewis, *"John By,"* Freshwater, I, No. 1 (1986), 31-33; and AO, RG 22, Series 390, Box 3, file 5, Home District Assizes, March-April 1836, 255-262, Sheldon, Dutcher and Andruss vs. William Chisholm.

130. *Montreal Gazette, 23* October 1834.

131. *Canadian Courant,* 8 May 1833, quoting *York Courier.*

132. AO, RG 22, Series 390, each Home District Assize prior to 1838.

133. *Courier of Upper Canada* (Toronto), 12 May 1835 and 27 November 1836; and K.G. Lewis, "Steam-Engine Builders," 51-55.

134. *Upper Canada Herald,* 10 April 1834.

135. *British Whig,* 1 April 1834; and *Montreal Gazette,* 6 June 1835.

136. *Cobourg Star,* 31 July 1833. Another account says forty; see *Canadian Courant,* 8 June 1833, quoting *Grenville Gazette.*

137. Hulburt registered five Canadian patents for ploughs and churns between 1850 and 1867. *List of Canadian Patents from the Beginning of the Patent Office, June 1824 to the 31st of August 1872* (Ottawa, 1882) 1st Series, nos. 297, 371, 568, 1070 and 2233.

138. *Montreal Gazette,* 31 October 1835; and *Chronicle and Gazette,* 20 May 1835.1 would like to thank Rick Neilson for these references.

139. *British Whig,* 20 April 1836.

140. *Daily News* (Kingston), 5 April 1862.

141. Parker, "Niagara Harbour," 103.

142. NAC, RG 1, E3, Upper Canada State Papers, v. 56, 129-131, Petition of Niagara Harbour and Dock Co., 2 December 1833. Hodge, *Steam Engine,* 11, gives credit to Adam Hall, "long the foreman at the West Point Foundry," for the notion of using high-pressure steam by cutting it off in mid-stroke.

143. Parker, "Niagara Harbour," 103; and NAC, MG 24, D64, [John Lowe] to Peter Lowe, 9 October 1831.

144. Ben Forster, *A Conjunction of Interest: Business, Politics and Tariffs, 1825-1879* (Toronto, 1986), 17; Upper Canada, *Statutes,* 4 Geo. IV, (1824), chap. 1, sec. 1 (twenty percent); and NAC, RG 16, A 1, v. 1, Amherstburg Customs Returns, 25 October 1833 *(Thames* engine at fifteen percent).

145. *BrockvilleRecorder,29* March 1832, quoting *Montreal Gazette.* In fact, one report claimed that the Wards were supplying the engines *(Canadian Courant,* 29 September 1832). On L.B. Ward's marriage, see *ibid.,* 9 September 1829; and *The Pocket Register for the City of Hartford* (Hartford, 1825), 19 and 21. Samuel Ward's second marriage was to a girl from Hartford *(Montreal Gazette,* 10 April 1834); and "US Steam Engine Report," 347. Copeland made a number of high-pressure marine engine sales in Georgia *(ibid.,* 274-275 and 286).

146. See note 60.

147. *Onondaga Standard* (Syracuse, NY), 14 October 1835; *Brockville Recorder,* 10 January 1834; and *Montreal Gazette,* 18 June 1833. Additional information was supplied by John Mills and Richard Palmer.

148. "US Steam Engine Report, 38 and 339;" and University of Vermont, Bailey/Howe Library, Special Collections, Champlain Transportation Company, "A", correspondence of Ward and Co. to Champlain Trans. Co., 10 March 1836-27 October 1837.

149. NAC, MG 24, D19, John D. Ward to Silas Ward, 14 January 1820.

150. ANQ-M, Arnoldi, no. 3884, 2 January 1835.

151. ANQ-M, Doucet, no. 25796, 31 December 1838.

152. Hunter, *Industrial Power,* II, chap. 4.

153. ANQ-M, Arnoldi, no. 3884, 2 January 1835.

154. Bennet and Henderson built the only two high- pressure marine engines used below Montréal before 1838. *Ibid.* They used John D. Douglas's patent high-pressure boiler. Wilson, "Application," 171, note 6.

155. Specifications enclosed in ANQ-M, Griffin, no. 9321, 19 March 1831.

156. Tulchinsky, *River Barons,* 208-210.

157. Craven and Traves, "Canadian Railways."