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**MONTREAL ENGINE FOUNDRIES AND THEIR CONTRIBUTION TO
CENTRAL CANADIAN TECHNICAL DEVELOPMENT, 1820-1870**

by

Larry S. Mc Nally, B.A.

A thesis submitted to the Faculty of
Graduate Studies and Research in partial fulfillment
of the requirements for the degree of
Master of Arts
in Canadian Studies

Carleton University

OTTAWA, Ontario

April 1991

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"Montreal Engine Foundries and Their
Contribution to Central Canadian Technical
Development, 1820-1870"

submitted by Larry McNally, Hons. B.A.
in partial fulfilment of the requirements for
the degree of Master of Arts

.....
Thesis Supervisor

.....
Director
Institute of Canadian Studies

Carleton University

Ottawa, Ontario

March 1991

ABSTRACT

Engine foundries developed in Montreal in the 1820s to produce marine steam engines for vessels on the St. Lawrence River and later on the lower Great Lakes. Up the mid 1830s, Montreal engine foundries turned out a substantial proportion of all the marine engines used in central Canada. After this there was a downturn in engine building in Montreal, but a new generation of engine founders revived the industry in the 1850s. Because of their specialized equipment and techniques, engine builders also produced stationary engines, equipment for saw and flour mills as well as custom built factory machinery. By the 1870s Montreal's engine foundries were fully mature. These engine foundries were a major source of technological knowledge and their contributions helped mechanize and industrialize central Canada.

ACKNOWLEDGEMENTS

This thesis owes a great deal to friends and colleagues who supplied both information and encouragement. Walter Lewis of Acton, Ontario, supplied me with unpublished data and insights from his own research on early Canadian steamboats. I thank Robert Tremblay and Peter Bishoff, both Ph.D students at Université de Québec à Montréal, for a series of enjoyable evenings spent exchanging information about Montreal foundries. Prof. Jean Belisle of Concordia University gave me access to his research notes on the Boulton & Watt Archives. McGill University's Montreal Business History Project, under Prof. Robert Sweeny, provided data from their abstracts of notarial documents. I am grateful to Prof. Gerald Bloomfield of the University of Guelph for providing pre-release data on Montreal power from his 1871 database. Dana Ashdown of Etobicoke, Ontario, gave useful information about Ontario foundries.

I thank the Manuscript Division of the National Archives of Canada for four months of leave to draft my chapters. To Dr. Norman R. Ball, formerly of the Institute of Canadian Studies, Carleton University and now with the Faculty of

Engineering of the University of Waterloo, goes my thanks for his continuing support which kept this thesis going in spite of numerous obstacles. Finally I owe the most to my wife Mireille Gravel Mc Nally for helping to raise two children during this project. Without her unfailing support this thesis would have not seen the light of day.

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INTRODUCTION

This study examines the building of marine and stationary steam engines by specialized foundries in Montreal from 1819 to the 1870s. This period covers the beginnings of engine building in Montreal to when the industry was fully mature. After the early 1870s there is very little information available on the engine foundries or their activities until the mid-1880s when conditions had changed considerably, including the death of several notable founders.

Montreal engine founders played an important role in the technological development of central Canada. They built the first marine steam engines in Canada and helped equip steam vessels on the St. Lawrence/Great Lakes waterway with engines built in Canada. These foundries also produced stationary steam engines which became increasingly important to Canada's industrial production after 1850. Because of their specialized machinery, techniques and skills, they built saw and grist mill equipment as well as many types of equipment and machinery. Though harder to document than engine production, machinery building was of considerable importance to an industrializing Canada.

The major problem in studying this important subject is the lack of primary sources of information on Montreal's engine foundries. The best manuscript collection for a Montreal engine foundry is the Ward Family Papers (MG 24, D 19) in the National Archives of Canada which contains however only family correspondence 1819-1836. The Molson Archives (MG 28, III 57) also at the National Archives has material on the early vessels built by the Molsons. There are no surviving business papers for any of the other engine foundries. Other types of primary sources are also scarce. The notarial records in the Archives nationales du Quebec a Montréal are a useful source of information on contractual aspects of engine foundry activity. The Montreal Business History Project of McGill University has indexed much of the information from these notarial documents which makes research much more efficient. The manuscript census returns for 1861 and 1871 in RG 31 of the National Archives of Canada provide valuable comparative material on engine builders. The printed reports for the 1852-1871 census were also of value. The credit reports in the R.G. Dun Papers at the National Archives (MG 28, III 106) have useful information on the engine founders themselves and their enterprises.

Much of the information in this thesis was obtained from printed primary sources. Newspapers, particularly the

Montreal Gazette, were of use. Montreal city directories provided information from the 1840s onwards. Other directories covering the Province of Canada 1857-58 and Ontario in 1871 were very useful. Of upmost value were Montreal in 1856 and Montreal Business Sketches (1863) which provided many details about foundry facilities and products. Various reports by the Department of Public Works contain some useful information on engine foundries which used water power from the Lachine Canal.

In the secondary literature there has been recognition of the contributions and importance of Montreal's engine foundries. Merrill Denison's The Barley and the Stream: The Molson Story (1955) provided the framework and background for the role of the Molson Family in building the earliest steamboats in Canada. Denison pointed out the importance of John Bennet and the St. Mary's Foundry in particular. One of the best works on early steamboats is George H. Wilson's 1961 M.A. thesis "The Application of Steam to St. Lawrence Valley Navigation" painstakingly researched from early Montreal newspapers. It has been widely used by all subsequent researchers.

A more recent work which has been influential in the study of engine foundries is The River Barons: Montreal Businessmen and the Growth of Industry and Transportation 1837-1853

by Gerald Tulchinsky (1977). He is particularly strong on the contribution of John Ward's Eagle Foundry to Montreal engine building. Tulchinsky is also the first person to glance at the new generation of Montreal engine founders that developed after 1850. Walter Lewis' unpublished paper to the Canadian Historical Association in 1986 "Fire on the Water: The First Generation of Marine Engines in Central Canadian Steamers, 1809-1837" is a detailed description and analysis of the suppliers of early marine engines to St. Lawrence and Great Lakes vessels.

For early locomotive engines there is more research available. There have been a number of articles on the early Montreal area engines and railways in various railway history journals. Prof. Fritz Lehmann has written a series of articles on Canadian engine founders who built early locomotives.

For reasons difficult to understand there are no known books or articles on the history of the stationary steam engine in Canada. W. and E.M. James' book A Sufficient Quantity of Pure and Wholesome Water: The Story of Hamilton's Old Pumphouse (1978), a study of the twin Cornish pumping engines in Hamilton, is the exception. Water power from the Lachine Canal, which was used by a number of Montreal engine foundries, has been studied for Parks Canada by Larry Mc

Nally "Waterpower on the Lachine Canal, 1847-1900" (1981) and John Willis "The Process of Hydraulic Industrialization on the Lachine Canal 1840-1880: Origins, Rise and Fall" (1987). Gerald and Elizabeth Bloomfield are just completing their computerized data base from the industrial schedule from the 1871 Census. The CANIND71 data base will add a great deal to our knowledge of steam and water power in Canada.

The history of the foundry industry in Canada has been badly served. The Forges du Saint-Maurice has been heavily studied by Parks Canada which has published numerous reports in their Manuscript Report Series. In recent years there has been an increased interest in other Quebec haut fourneau complexes. Peter Bishoff has done valuable research on the migration of skilled moulders in "Des Forges du Saint-Maurice aux fonderies de Montréal: mobilité géographique, solidarité communautaire et action syndicale des mouleurs, 1829-1881" (1989). Interest in city-based foundries has come mainly from labour historians who have paid little attention to the contributions of foundries. Greg Kealey discussed the evolution of industry and metal working in Toronto Workers Respond to Industrial Capitalism, 1867-1892 (1980) but it was in terms of conflict between capital and labour. Kenneth Lewis, a student at the University of Toronto, wrote several papers on early foundries and engine

building in Toronto. Hamilton's founders, particularly those in the stove trade, have been studied in an article by John Weaver "The Attraction of Manufacturing Enterprises: The Case of Hamilton's Attraction of Foundries, 1830-1890" (1983). Marcel Moussette's Le chauffage domestique au Canada: des origines à l'industrialisation (1983) looked at the origins of stove manufacturing in both Quebec and Ontario. The book The Decline and Rise of Charcoal Iron: The Case of Canada (1986) by Kris Inwood has one interesting chapter on secondary iron manufacturing in Montreal which sheds light on the complex relationships between hardware wholesalers and iron manufacturers including founders. Eric Arthur and Thomas Ritchie's Iron: Cast and Wrought Iron in Canada from the Seventeenth Century to the Present (1982), while good on the use of iron in architecture, is inadequate on the use of industrial iron. One technological history which does pay credit to Canadian engine founders is J.J. Brown. Ideas in Exile: A History of Canadian Invention. (1967) but unfortunately his facts are not always right.

The various manufacturing sectors of the Canadian economy have been badly served by historians. Two studies which have been of use are: Felicity Leung. "Grist and Flour Mills in Ontario: From Millstones to Rollers, 1780-1880" a Parks Canada MRS (1976) and Barbara Robertson. Sawpower: Making Lumber in the Sawmills of Nova Scotia (1987). Both of these

A second type of furnace called the cupola is attributed to the famous iron master John Wilkinson (1728-1808) in 1794. However it was based on European precedents and perhaps even English ones. It was high and narrow like a miniature blast furnace. Alternate layers of pig iron and coke were put into it and under a strong blast the iron melted. Its advantages were that more control could be exercised over the metallurgical composition of the cast iron and smaller charges could be melted.⁷

The first independent foundries started to appear in the mid and late eighteenth century. The Phoenix Foundry of Liverpool was established by George Perry in 1758. He was an agent of the Coalbrookdale Company and it was more convenient for him to cast pans and vats from Coalbrookdale pig iron rather than to transport the finished goods. Foundries in Lancashire began to cast parts for machinery and for steam engines starting in the 1780s.⁸

STEAM ENGINES

By the end of the eighteenth century, the need for additional sources of power for industrial processes was a pressing problem. The existing water power sites were being used to their limit, windmills were unreliable energy

of American technology concentrates on evolution of machine shops, the textile industry and the armoury system. Foundries and engine building have almost been completely neglected. Two exceptions are: Bruce L. Simpson. History of the Metal-Casting Industry (1969) and C.A. Saunders and D.C. Gould. History Cast in Metal: The Founders of North America Vol. 1 (1976) neither of which are completely satisfactory. One excellent study on steam engines is Carroll Pursell. Early Stationary Steam Engines in America: A Study in the Migration of a Technology (1969).

Outline

The aim of this study is to combine this diverse information together in order to reconstruct the activities and contributions of Montreal engine foundries. An important component of this study is an evaluation of their contribution to Canadian technical development.

Chapter 1 gives the background to the evolution of metal working in Britain and the United States. Though iron casting had existed for a long time, it was in association with blast furnaces where ore was turned into metallic iron. It took the development of new types of furnaces before the iron founding could become an independent activity and free

to relocate to urban areas. The building of steam engines required the use of machine tools, particularly the boring mill and the lathe. It was the demand for early steam engines that led to development of metal working machine tools capable of accurate work. Many of these developments took place in Britain where the steam engine was born. Many of them were picked up by Americans who gradually developed their own foundry and engine building industry. Both of these countries had an influence on the use and building of steam engines in Canada.

Chapter 2 concerns the use of the steam engines in Montreal. The first steam engine in Canada, a marine one, was built by John Molson in 1809. Technical problems forced the importation of marine engines from Britain for the next ten years. By 1819 the American John Ward was ready to build marine engines in Montreal. Ward's Eagle Foundry was the only major engine builder in Montreal until Bennet & Henderson started to build engines on a large scale in 1829. After the failure of Bennet & Henderson in 1833 and the gradual return of the Ward brothers to the U.S., steam engine building in Montreal slowed down considerably during the late 1830s and 1840s. The types and numbers of marine engines built in Montreal will be discussed. The introduction and building of stationary steam engines in Montreal will also be investigated. The engine foundries also used their

skills and facilities to build a wide range of industrial equipment which benefitted central Canadian development.

Chapter 3 looks at the engine foundry industry after 1850 when a new generation of founders took over. The background and activities of this new generation are investigated. Though marine engines remained a staple product, stationary engines became increasingly important. A wide variety of equipment and machinery was made for saw and grist mills. The custom building of industrial machinery was a speciality of Montreal engine foundries. It is noticeable that engine foundries remained generalists and did not specialize in newer activities such as locomotive or machine tool building. Because of the specialized technical knowledge of the owners, corporate management never developed thus leaving the engine foundries vulnerable as their owners grew old.

The concluding chapter is an attempt to assess the contributions of Montreal engine foundries to technical and industrial developments in central Canada. They are evaluated in terms of marine and stationary engine production, equipment for the staple industries of flour milling, saw milling and mining. Their role in building simple machines as well as factory equipment is also reviewed. Since there is little documentary evidence for assessing their contributions, this had to be done indirectly through census statistics and from

published descriptions. There is also comparative information from engine foundries in Ontario and the Maritimes.

In the conclusion, evidence from previous chapters is used to examine some of the larger themes in Canadian history. Some of the issues to be looked at include the role of merchants in supporting early industrial enterprises, the reasons why foundries did not develop a system of corporate management and their failure to survive beyond 1900. The role of the foundries in supporting both the staple trades and early manufacturing will be discussed. The engine foundries as a possible node of Canadian technological skill is mentioned.

CHAPTER 1

THE DEVELOPMENT OF STEAM ENGINE BUILDING

In order to appreciate the nature of steam engines used and built in Montreal it is necessary to understand the origins of the technologies used in their manufacture. These manufacturing techniques had developed rapidly in the late eighteenth century. The oldest technique was the casting of liquid iron into moulds. Cast iron was the basic material from which steam engines were made as were many nineteenth century objects. The size and quality of large castings, such as engine cylinders, improved dramatically. Another traditional technique was the forging of wrought iron. Forged iron was well known in the form of hardware, nails, horseshoes and tools. Marine and stationary steam engines used large components made of wrought iron. The third technique was a newly invented one, machining. Traditional hand methods of turning and finishing were not adequate for steam engines. Machine tools such as boring mills had to be developed to deal with the new products. These improvements in metal working techniques were made largely in Britain. Americans adopted these methods and sometimes made their own contributions. By the time engine building started in Canada, the basic principles of metal working had already

been worked out.

FOUNDRIES

The problem of purifying iron ore in order to produce metallic iron was a major technological impediment for several millennia. In primitive bloomeries slag impurities were literally pounded out of a mass of heated iron. Between 1400 and 1500 A.D. the blast furnace for reducing iron ore to produce cast iron was developed in central Europe. In the blast furnace, the iron melted leaving behind the slag. The blast furnace which developed in Britain was a tapered stone tower about 25 to 30 feet high. The central cavity was packed with alternating layers of iron ore, hardwood charcoal and a flux such as limestone to bind the slag. The blast for the fire was obtained from bellows powered by water. Once the furnace started, a continual process was developed by adding additional raw materials at the top. As the temperature increased in the furnace, the iron liquified and settled to the bottom of the furnace. The lighter slag which floated upon the iron was removed periodically. The iron was released every eight hours or so into a bed of sand in front of the hearth. This iron contained 3 to 5 percent carbon and could be used for two different purposes. Simple cast iron objects such as

firebacks for hearths, stove plates and anchors could be made by running the iron into simple impressions in the sand. If it was to be further processed into wrought iron, then the iron was run into simple lines in the sand producing "pigs" which could easily be broken off. This pig iron was then sent to forges where it was converted into wrought iron which had a different physical structure and a carbon content of less than one percent.¹

Cast iron items formed only a very small portion of a blast furnace's output. About 95 percent of all cast iron was converted into wrought iron. This wrought iron in the form of rods or bars was turned by blacksmiths into nails, hardware and tools.² Pig iron could also be further refined by putting it through the blast furnace again to remove additional impurities, and thus make better castings. However, this was rarely done.

Beginning in the seventeenth century, there were major changes in both blast furnaces and moulding techniques. A shortage of charcoal was hampering the growth of iron furnaces. The first person to find an alternative fuel source was Abraham Darby (1678-1717) of Coalbrookdale in Shropshire. Others before him had tried coal as a fuel, but impurities such as sulphur contaminated the iron and made it unsuitable for further use. Darby overcame this problem by

roasting his coal to produce coke before using it in his blast furnace. The coke produced higher temperatures in the furnace making the iron more fluid and adding silicon to the iron. This process minimized the number of defects such as holes and cracks. The higher temperature iron could be cast into much more intricate moulds. Darby augmented his first innovation by developing a moulding method using foundry sand instead of loam, a mixture of sand and clay. He could produce much thinner walled pots and pans than his competitors could. Darby's one gallon pot weighed 6.5 pounds while those of his competitors weighed twice that. Because of this, he turned 70 percent of his iron production into castings, which made him substantial profits.³

Unfortunately for other ironmasters, Darby's coking process could not be easily duplicated because of Shropshire's low sulphur coal. However in time, this problem was overcome and the British iron industry began to develop very quickly.

The demand for wrought iron continued to grow, but there was also a stronger market for cast iron.⁴ General population growth led to increased demand for more firebacks, pots and pans. The numerous wars of the eighteenth century created a large demand for military goods such as cannon and shot. There were also new uses for cast iron especially for replacing wood. As more power was required for industrial processes, the limitations of wood were felt. Cast iron

shafting could replace large and cumbersome wooden shafts. Machines using iron components were less likely to break or get out of line. John Smeaton (1724-1792) was the first engineer to specify cast iron shafting in a windmill in 1754, and another engineer, John Rennie (1761-1821) used cast iron gearing and machine framing in a grain mill in 1786. Cast iron could also be used as a structural material. Abraham Darby III (1750-1791) built an arch bridge at Coalbrookdale which used 70 foot single unit cast iron ribs instead of wooden ones. The demand for cast iron increased greatly and by 1800 cast iron was approaching wrought iron in importance.⁵

One of the major obstacles to the development of the cast iron industry was the absence of furnaces capable of remelting pig iron. The first type of furnace developed was a reverberatory or a remelting furnace generally known as an "air furnace" which began to be used in England around 1702. It consisted of a brick furnace in which the flames from a coal or coke fire were deflected over the top of a stack of pig iron so as to prevent the contamination of the iron by impurities in the fuel. When iron melted, it was let out through a small channel into moulds. This type of furnace was used by both blast furnace complexes and by independent foundries.⁶

A second type of furnace called the cupola is attributed to the famous iron master John Wilkinson (1728-1808) in 1794. However it was based on European precedents and perhaps even English ones. It was high and narrow like a miniature blast furnace. Alternate layers of pig iron and coke were put into it and under a strong blast the iron melted. Its advantages were that more control could be exercised over the metallurgical composition of the cast iron and smaller charges could be melted.⁷

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STEAM ENGINES

By the end of the eighteenth century, the need for additional sources of power for industrial processes was a pressing problem. The existing water power sites were being used to their limit, windmills were unreliable energy

sources and horsemills had severe limitations. The need for large scale power to drain land and mines and to supply air for blast furnaces was particularly acute. Steam had long been recognized as a possible power source but it presented many problems such as producing large volumes of steam and creating a mechanism for converting this steam into useful mechanical motion. The first British person to succeed in harnessing steam was Thomas Savery (1650?-1715) who designed a usable steam pump in 1698. Though terribly inefficient, it filled a pressing need to drain mines. The next step in the evolution of the steam engine was made by Thomas Newcomen (1663-1729) in 1712. He separated the boiler from the cylinder and devised a method of producing mechanical motion. Though it was still inefficient and required a large building to house it, desperate mine owners adopted it.'

The manufacture of Newcomen engines caused a major problem. The heart of the engine was the cylinder. This was a large casting which was required to be as round as possible to minimize steam loss. The first cylinders were finished by hand, but this was not accurate enough. Around 1725 the Coalbrookdale Company built a boring mill to bore out cylinders. This technique was based on long-established cannon-boring methods. Between 1722 and 1738 the company made 38 Newcomen cylinders between 17 and 38 inches in diameter. By 1763, they could bore a cylinder 74 inches in

diameter, 10.5 feet long and weighing 6.5 tons. The Carron Company, established in 1759, also had a boring mill built by John Smeaton, the famous engineer. However, the mill was probably based on the Coalbrookdale model.¹⁰

The development of the steam engine underwent another transformation at the hands of James Watt (1736-1819). While repairing a model of a Newcomen engine for the University of Glasgow, Watt became aware of its inefficiency and started thinking of improvements. Combining practical mechanics with the abstract scientific thinking of the day, Watt developed a condenser separate from the cylinder which he patented in 1769. He was fortunate in 1775 to find Matthew Boulton, a wealthy Birmingham brass manufacturer, to be his partner. Boulton was able to support both Watt and his research on the steam engine. In 1781, Watt patented his sun and planet gears which gave his engines rotary motion. His other major innovations included double action, where the cylinder was powered both on the up and down strokes and parallel motion, a system for transmitting energy from the piston rod to the beam.¹¹

Watt's patent was not his only protection. Because of the separation of the cylinder and condenser, a much tighter fit was required between the piston and cylinder than in the older Newcomen engine. Even Watt himself could not produce

such an accurate cylinder. However, Boulton recommended John Wilkinson of the Bersham Iron Works. In 1774, Wilkinson devised a boring machine in which the cylinder remained stationary and the cutter revolved and this enabled large cylinders to be accurately machined. Because of this invention, Wilkinson became Boulton and Watt's favoured supplier of engine components.¹² Boulton and Watt functioned as consultants, providing the design of the engine, arranging for the manufacture of components and sending a fitter/millwright to erect the engine. At first, the partners supplied very few components but from experience they found it easier to manufacture themselves some of the more critical components, such as valves. By 1794, Boulton and Watt were supplying 50 percent of the parts of their steam engine.¹³

At this time Boulton and Watt faced a serious problem. The extension of Watt's 1759 patent would expire in 1800. The partners also knew that their subcontractors such as Wilkinson, were becoming rich at their expense. The coordination of the manufacture and delivery of parts was a major problem which greatly inconvenienced engine construction. Finally, Boulton and Watt had problems with the lack of quality control over parts. For these reasons, it was decided to invest £10,000 to build a foundry/machine shop complex which could produce the entire Watt engine in-

house.¹⁴ In 1796, the Soho Foundry opened near Birmingham with a complete foundry, large boring mills, lathes and drill presses and a sophisticated production sequence.¹⁵ This foundry/machine shop complex became a prototype for heavy engineering shops of the nineteenth century in Britain, the United States and later Canada.

The workshops of Boulton & Watt as well as their numerous competitors have attracted historians of technology ever since their creation. However there are other sources for the origin of heavy engineering and machinery building. As A.E. Musson and E. Robinson have ably demonstrated, the textile industry, such as cotton in Lancashire, acted as a powerful motor in the creation of advanced mechanical technology.¹⁶ This industry, as it intensified from the 1780s onwards, demanded new combinations of old skills and the creation of new ones. To build early textile factories and their equipment required craftsmen such as millwrights, carpenters, joiners, clockmakers, iron and brass founders and blacksmiths. Together their skills created a basis from which newer, more specialized crafts developed. Among the new breed of craftsmen were mechanics, machine builders, turners, pattern makers and suppliers of spinning machine components. In some cases these trades were amalgamated into engineering companies which had as their basis a foundry. Such a firm could supply the water wheel, shafting and

textile machinery for a mill. Eventually some firms moved into general engineering and manufactured products such as steam engines, presses, machine tools and even locomotives.¹⁷ In most cases there was a slow accretion of skills and products in these engineering firms. Because of Canada's later development, this process took place in a more truncated fashion in this country.

THE AMERICAN FOUNDRY - MACHINE SHOP TRADITION

The history of the iron industry in the United States is similar to that of Britain. The industry started with colonial era blast furnaces often built and operated by British talent.¹⁸ The furnaces produced pig iron for conversion into wrought iron or direct cast iron goods. There was a large and continually expanding market for cast iron goods.

While there is a large literature on colonial era blast furnaces, there is little available on the development of the independent iron foundry.¹⁹ The first American foundry appears to have been at Messaponax, Virginia, in 1772. Its pig iron came from the Blenheim Blast Furnace fifteen miles away and was melted in a air furnace.²⁰ The advantages of using an air furnace rather than a blast furnace to produce

cast iron is outlined in a 1787 advertisement:

Peter C. Curtenius and Company have repaired the New York Air Furnace and have procured the best workmen together with the necessary apparatus to carry on the manufactory of cast iron in the completest and best manner. Castings made in the air furnace are allowed by all who are acquainted with the nature of foundries to be better than that made in a blast furnace; because in an air furnace, the ware is made of the softest and best pig metal, and, by its being melted the second time, the scoria, or dross, is expelled and nothing but the pure metal remains. In a blast furnace the castings are made out of the first melting of the crude ore and are more or less mixed with dross, which subjects the ware to be rough, spongy, and often full of cold shuts; the difference, in short, is nearly the same as there is between refined and bloomery iron. The ware they have made is allowed, by good judges, to be as light, as smooth, and as good as any imported from Europe.²¹

The development of the self-sufficient foundry did not really start until the 1820s. Cupola furnaces made foundries independent.²² Different types of pig iron with varying characteristics could be melted together with scrap iron to produce a superior cast iron. Small or large amounts of iron could be melted under close supervision. Also foundries, by importing their pig iron, could exist in areas with no native iron resources. The date of the first cupola furnace in the United States has been given as variously as Baltimore in 1815 and Pennsylvania in 1820.²³ American foundrymen made fundamental changes to the cupola which simplified its construction and greatly increased its output of cast iron.²⁴

Steam engines were important products of sophisticated American foundry-machine shops. In spite of the traditional emphasis put on the importance of steamboat and locomotive engines to American growth and development, stationary engines were of considerable importance. The earliest steam engines in the United States were in fact stationary. In 1754 a British Newcomen engine was erected near Newark, N.J. to drain a copper mine. The first American built engine was used to pump water in New York City in 1776. A third Newcomen engine was built for a Rhode Island iron mine in 1780.²⁵

An 1838 U.S. government census found 3,010 steam engines of which 1,860 were stationary, 800 marine and 350 locomotives.²⁶ Within several years the number of steamboat and locomotive engines would grow considerably, but the stationary engine was important to American industry from a very early date.

The first foundry-machine shop complex for building steam engines in the United States was constructed by Nicholas Roosevelt around 1795 in New Jersey. His Soho Works built early marine engines as well as two large pumping engines for the Philadelphia Waterworks in 1800.²⁷ By 1812 there were engine shops in both Philadelphia and New York. The most famous one was the Mars Works of Oliver Evans in

Philadelphia. Evans built his Mars Works in 1807 to produce his high pressure steam engine. By using high pressure steam, Evans' smaller engine could produce the same amount of power as a much larger low pressure Watt engine. Evans' complex contained a furnace producing 10 to 11 tons of cast iron a week, a pattern and blacksmith shop, a machine shop containing only lathes, drills and boring machines. However the Mars Works had a broader significance beyond the twenty or so steam engines it built.

While steam engines continued to be the chief products of the Mars Works, the skills and experience that accrued from engine building were applied to other kinds of heavy machinery. It was shops such as these that transformed the industrial capabilities of the United States and developed the "know-how" of the modern age.²⁸

The other goods produced included boilers, iron gearing, pans, rollers, large screws and machinery for cotton and woollen mills. During the War of 1812 it also made cannons for the U.S. Army.

Other foundry-machine shop complexes developed in New York City. Though the main components of Robert Fulton's first successful steamboat, the Clermont were made in England by Boulton & Watt, Fulton also used the services of two local New York foundries, Robert McQueen and James P. Allaire. After the success of the Clermont, the Livingston-Fulton partnership built fourteen more steamships between 1807 and 1816. The difficulties of accurately machining castings led

them to set up a large engine works in Jersey City, N.J. to finish the castings produced by McQueen and Allaire.

After Fulton's death in 1815, his machine ship was bought by Allaire and moved to New York City. Because of the demand for marine engines, the two New York foundries prospered, together employing 130 men and having capital of \$300,000 by 1820.²⁹

SUMMARY

In Britain during the eighteenth century large advances were made in metal working techniques. The production of cast iron had grown immensely, due in part to independent urban foundries. The demand for steam engines had stimulated the production of larger and more accurate castings plus new machine tools to bore cylinders and turn pistons. The marriage of the newly created machine shops and foundries produced a new combination which was to revolutionize metal working everywhere including Canada.

CHAPTER 2

MONTREAL ENGINE FOUNDRIES 1820-1849

Montreal, by 1825, was the largest city in Upper and Lower Canada with a population of 22,540. It was also the commercial centre of the two Canadas. Taking advantage of its geographical position, Montreal controlled the St. Lawrence, Richelieu and Ottawa River valleys as well as the area around the Great Lakes. The city was the largest supply centre for the central Canadian economy which was primarily agricultural with a developing trade in square timber. To supply this economy Montreal merchants imported vast amounts of tools, metal goods, clothing, food and many other items. These merchants, often the subsidiaries of large British merchant houses, developed direct links to British suppliers and manufacturers.¹

Though a mercantile city, Montreal had its own technological base. Like any city of that date, there was a population of craftsmen. A detailed census by Jacques Viger in 1825 revealed that of 22,540 working adults, 8,656 had a profession. Ten percent were in commerce, ten percent in construction and a surprising 21.5 percent in fabrication.

Of this last group, over 1,860 people (13 percent) were in metalworking. The 18 nailers, 30 tinsmiths, 130 blacksmiths and others did more than provide for needs of Montreal alone.² They were turning imported iron, copper and other metals into agricultural, lumbering and consumer goods. Their nails, tacks, tools, tin and copperware formed a substantial part of Montreal's economic power.

In Lower Canada, there already existed a well-established iron centre. Les Forges du Saint-Maurice, founded in 1738, represented the French metallurgical tradition. The complex was built around the traditional haut fourneau or blast furnace. It produced both pig iron and cast iron goods such as stove plates, pots, potash and soap kettles and other domestic implements. The pig iron was converted by forges into wrought iron which was sold as bar iron or further processed into more sophisticated products such as gearing and cranks for mills and axes.³

A major milestone for mechanical technology in Montreal was the building of the steamboat Accommodation in 1809 by John Molson (1763-1836). Though the Accommodation lasted less than two years, from November 1809 to the summer of 1811, and was something of a failure, it was the first steam engine in Canada.⁴ In British North America, there was no previous history of using steam either for industrial power

or transportation. Molson took full advantage of the advances in steamboat design made only two years previously in the United States.

Robert Fulton (1765-1815), after many years of trials and experiments, had finally succeeded in building the steam-powered vessel, the North River Steamboat later known as the Clermont. In August 1807 it successfully travelled from New York City to Albany in twenty hours, averaging five miles an hour. Though the idea of using steam to propel a boat had been thought of long before and had been the subject of numerous experiments, some of them technically successful, it was Fulton who combined the necessary elements to produce a viable steamboat. Fulton himself had experimented with various propulsion schemes and boat designs in both France and the USA. He had the backing of the rich Hudson Valley land owner and diplomat, Robert R. Livingston. The most critical part of a steamboat, the engine, was built by the most experienced steam engine builder in the world, Boulton, Watt & Co. of Birmingham. Fulton was able to combine these elements to produce a practical and commercially successful steamboat.⁵

Once the practicality of steamboating had been demonstrated, steamboats were quickly introduced elsewhere. One vessel that probably had a direct influence on Montreal's

development was the Vermont, built on Lake Champlain in 1808. Though very little is known of its construction, it is important for several reasons. A number of people connected with early steamboating on Lake Champlain such as Jahaziel Sherman, John Ward and George Brush, ended up in Montreal. Perhaps more directly implicated was John Molson who undoubtedly heard of the Vermont and perhaps saw it in action.⁶

John Molson's Accommodation of 1809 owed its existence to a variety of people, crafts and industries. In order to build the vessel, Molson hired two British craftsmen to help him, John Bruce, a shipwright and John Jackson, an engineer. Unfortunately, nothing is known about the origins of these men. They started work in March 1809 in a local shipyard to build the hull of the vessel.⁷ The parts for the engine came from les Forges du Saint-Maurice. It seems that the Forges supplied only the rough castings. The engine parts were finished and fitted in Montreal under George Platt (1774-1818). The son of an edge tool maker, Platt started off as a blacksmith and then moved into "a general iron mongery business" importing and dealing in iron and hardware.⁸ His accounts for the finishing of the engine parts present a tantalizing view of the earliest engine building in Canada. Itemized in a list of 28 September 1809 are forging, turning, brass casting and brazing. Among the tools

mentioned are "files, auger, steel-cutters, drills..." and other implements.⁹ These passing references serve to show the sophistication of metal working in Montreal at the beginning of the nineteenth century.

This specialized work attracted skilled workers who later left their imprint on Montreal. The turning of the engine parts for George Platt was done by Ezekiel Cutter, an American. In 1809, Cutter had a contract with Platt to manufacture nails and spikes according to the T. & E. Odwine patent.¹⁰ Cutter is not heard of again until 1824 when he agreed to manufacture nails and wool cards for Thomas Busby Wragg of Montreal. Later in 1827, Cutter was employed as a manager of "Wraggs Nail Manufactory".¹¹

From the account books in the Molson Archives, it is possible to follow partially the construction of the Accommodation. Cash payments and postage sent to both Jackson and Bruce at les Forges du Saint-Maurice near Trois-Rivières can be traced between May and October 1807. There is a payment of £1-10 for the cartage of models, that is to say patterns, to Trois-Rivières on 12 September and £3-12-6 for a bateau load from Trois-Rivières on 5 October. Other payments for cartage, most likely between the harbour and the brewery, include 1s-3d for an air pump and 2s for an "iron spindle [shaft] for Steamboat". However for the

cylinder, generally a large and heavy casting, the cartage was one shilling on 12 April 1809. There is also a reference in Platt's account to an "iron hoop to go around Cylinder".¹²

As explained in the first chapter the cylinder of steam engine was a very difficult piece to cast and then machine. Producing an accurate cylinder required a boring machine, the largest and most expensive machine tool of its time. Les Forges du Saint-Maurice did not have large and specialized machine tools such as this.¹³ As far as it is known, neither John Molson nor anyone else in Montreal had such a machine tool. Therefore it is likely that either the cylinder was cast at les Forges du Saint-Maurice, but never machined or the cylinder may have been made of wood rather than metal. The cylinders for early Newcomen engines were sometimes cast and then finished by hand without any machining.¹⁴ The use of wooden cylinders, built like barrels and hooped with iron, is mentioned in a Thomas Molson notebook of 1822.¹⁵ A wooden cylinder would explain the small cartage fee and the need for an iron hoop around the cylinder. Perhaps this is why the Accommodation had so many problems and was scrapped after a life of less than two years. A third possibility is that an outside supplier made the cylinder. The absence of any references to an outside supplier does not necessarily disprove this possibility.

When John Molson was planning a replacement for the Accommodation, he made a number of significant changes. To overcome the problem of obtaining a suitable engine, he ordered one from the most famous engine builders in the world, Boulton, Watt & Co. Though his British connections, Molson met the long retired Watt in the fall of 1810 and, given his excellent credit rating, Molson was able to obtain his engine.¹⁶ The engine ordered was 26 horsepower with a 26 inch diameter cylinder and a 48 inch stroke.¹⁷

Just as importantly, Boulton & Watt reluctantly agreed to find and train a "proper" man to install and operate the engine of the Swiftsure. Through their agent in Glasgow, a young millwright named John Bennet (1785-1849) was hired in November 1811. He was brought to Manchester and trained in the Soho Foundry. By April 1812 he was on his way to Montreal.¹⁸ Boulton & Watt, knowing of Bennet's superficial training, warned Molson that he was not very familiar with marine engines or how they were to be used to propel a boat. The company recommended that if there were problems, Bennet should accompany Molson for a tour of steamboats already working in the U.S.¹⁹ This warning was unnecessary judging from the success of the Swiftsure.

The contract that Bennet signed with the Molsons in 1812

stipulated that he was to install steam engines and instruct in millwrighting for the sum of \$400 per year. Bennet renewed his contract for two years in 1815 and for two years more in 1817.²⁰ After the termination of this extension, Bennet set out on his own, though he still did work for the Molsons.

The Boulton & Watt engines for the Swiftsure were only the first of three additional orders. An engine for the Malsham, launched in September 1814, was accompanied by William Brackenridge. Another Boulton & Watt engine went into the Lady Sherbrooke launched in July 1817. The final ones were twin engines for the New Swiftsure in 1818 and they were installed by David Bruce (d. 1821).²¹ The Boulton & Watt connection was extremely important to the Molsons. It gave them direct contact with the foremost foundry-machine shop in the world, superior engines for their vessels and skilled engineers to run them. Boulton & Watt also provided more than marine engines: they supplied a stationary engine for the brewery in 1811, the first stationary steam engine in Canada, spanners, taps, and dies in 1814 and a custom built lathe in 1816.²²

THE FOUNDRIES

a) The Eagle Foundry

After the Accommodation of 1809, no engines were built in Montreal until 1819. The only non-Boulton & Watt engine used was for the Quebec in 1818 and built by Maudslay & Sons of London.²³ The first engine to be built in Montreal after this hiatus was made for the Ottawa by the Montreal Air Furnace. Though details are extremely sketchy, it seems that the Montreal Air Furnace was started c. 1816 by Joseph Lough an American from Albany, N.Y.²⁴ The Ottawa also had the distinction of being the first steamboat to operate up river from Montreal.

Joseph Lough was also indirectly responsible for bringing to Montreal its most famous early engine builder: John Dod Ward (1794-1873). As pointed out by Tulchinsky, Lewis and others, John Ward had a profound influence on marine engine building and machine shop practice in Montreal.²⁵ Ward came to his calling naturally; his father Silas was an engine builder in New Jersey and his uncle Daniel Dod (1778-1823) is reputed to be the inventor of the walking beam marine engine. Dod was a partner with Aaron Ogden and they battled the Fulton-Livingston steamboat monopoly in New York State which cost Dod his fortune.²⁶

John Ward worked for his uncle Daniel Dod, installing engines in vessels from the Atlantic coast to Lake Ontario. In 1818, as a result of trying to collect money owed the family, Ward was asked to take over the unprofitable Montreal Air Furnace then being run by Jahaziel Sherman. Sherman was a pioneer builder of steam vessels on Lake Champlain and a celebrated captain.²⁷ Ward was impressed enough by the potential for steamboat building in Montreal that he returned the following year. Ward got his chance when an engine ordered from England did not arrive on time and he was asked to build one. Starting on a small lot of land on Queen Street in Griffintown, Ward quickly built a shop. Though he tried to keep costs to a minimum, Ward often had to appeal to his father for funds to buy items such as a turning lathe or a set of boiler tools. By the end of 1819, Ward desperately needed \$700-800 to pay off his debts, "I see but two alternatives, a British jail or disgraceful retreat".²⁸ His father forwarded the necessary funds.

By January 1820, John Ward had "built a shop 30' X 32' with two good blacksmith's fires, a very good turning lathe, a planing machine and before the end of next week should have all the machinery for making boilers as well and as conveniently as it can be done any place".²⁹ Ward, at this time, was building one engine and repairing two others. Though he had already been joined by his brother Samuel,

there was a constant shortage of skilled mechanics to repair and build engines. Later Lebbeus B. Ward joined his brothers and together they formed the Eagle Foundry.

The Wards resented their second class treatment at the hands of Montreal's Scottish elite. They remained in close contact with American developments and eventually returned there. In 1832 John Ward sold his share of the Eagle Foundry to his brothers. Samuel and Lebbus Ward made George Brush a partner in the foundry in 1838. Brush (1793-1883), a Vermonter, was a steamboat captain at the age of 23. In 1817 he came to Montreal and ran several of the largest vessels on the St. Lawrence and was the manager of the Kingston branch of the Ottawa and Rideau Forwarding Co. Brush became the full owner of the Eagle Foundry in 1845 and ran it until his death in 1883.³⁰

John Ward had picked a good time to start his enterprise in Montreal. British engines were so expensive that only very rich merchants, such as John Molson, could afford them. Also Montreal investors must have been tired of the unofficial Molson-Boulton & Watt monopoly. In 1823, Ward was quoting his engines at £48-50 per horsepower which meant that the typical 40-50 horsepower engine cost £2000-2500. On top of this was the cost of a hull and furnishings for the vessel.³¹

b) Bennet & Henderson

The only Montreal founder/engine builder to give the Ward Brothers competition before 1835 was John Bennet. Soon after his third contract with the Molsons expired in 1819, he joined Lott Briggs, a local blacksmith and Scott Burt, a steamboat engineer, in a partnership in 1820. Bennet, Briggs & Burt advertised themselves as "millwrights, engineers, brass founders and blacksmiths".³² Their one and only engine was for the Perseverance, a 12 horsepower engine for service on Lake St. Louis. Burt left by 1823 and the remaining partnership of Bennet & Briggs carried on providing three more engines before the partnership was dissolved in 1826.³³

Bennet's next partner in 1827 was John Henderson of whom nothing is known.³⁴ The firm established itself in an ex-nail factory on Wellington Street. Bennet & Henderson were forced to wait for three years before getting their first marine engine contract. It was for the engines of the Great Britain, a vessel that John Hamilton of Queenston, Upper Canada was building. The partnership had such limited resources that Hamilton arranged to import the boiler iron and for Guy Warrick's Phoenix Foundry to produce some of the castings.³⁵

MR. JOHN BENNET.

Figure 1. The Bennet & Henderson Foundry and John Bennet.

MontrealDaily Witness. 20 March 1897

As soon as the engine contract had been signed by Bennet & Henderson, they purchased the site of the St. Mary's Foundry, near the Molson Brewery and Hart Logan's shipyard. This had been the site of Joseph Lough's Montreal Air Furnace 1816-1819.³⁶ After its bankruptcy, the foundry was taken over by Alexander Allison, a leading Montreal merchant. Allison did not attempt engine building but instead produced staple foundry products such as stoves, cart boxes, rainwater spouts and bark mills. In December 1821 Alexander Allison died and his executor, John Gray (1755-1829), took it over. The St. Mary's Foundry was put up for sale in 1823, but in the absence of any takers, Grey dismantled the equipment and moved it to his property in Cote Ste. Catherine in 1825.³⁷ In 1829 Thomas Turner, an ex-partner of Allison, sold the site to Bennet & Henderson who were in desperate need of space near a major shipyard.

The engines for the Great Britain were quite successful and they were a good advertisement for the skills of Bennet & Henderson. Between 1830 and 1833 Bennet & Henderson produced a dozen marine engines as well as five stationary engines and other products. Their most famous engines were those for the Royal William. This vessel was built by Maritime and Lower Canadian interests to link Québec City with the Maritimes. The hull was launched by Lord and Lady Aylmer on 27 April 1831. It was then towed to Montreal where Bennet &

Henderson had the contract to build and install two engines of 90 horsepower each. Bennet & Henderson hired John Lowe, a Canadian who had been trained in Scottish shipyards, to supervise the construction of the engines.³⁸ The vessel performed very well in the first year but in 1832 the cholera epidemic caused quarantine problems for the Royal William. By March 1833 large debts forced the sale of the vessel but it had to be sold a second time in England. On 18 August 1833 it left Pictou with seven passengers and an enormous load of coal. Twenty-five days later it reached London; the first vessel to cross the Atlantic by steam alone. The Royal William was sold for £10,000, about two-thirds of its construction cost. Finally in 1834 it was bought by the Spanish navy and used as a gunboat during the Spanish Civil War against the Carlists.³⁹

The engines for the Royal William were the nadir of Bennet & Henderson. The physical growth of their company was impressive, but most of it was financed by borrowing. When the steamboat boom broke in 1834, the partners were stranded with outstanding debts they could not pay. In all, Bennet & Henderson owed £4,028 and even with the sale of their assets they could only pay off £1,000.⁴⁰ Their twelve marine engines and five stationary ones made a substantial contribution to central Canadian transportation and manufacturing. After the dissolution of the partnership,

Bennet moved to Kingston. He returned to Montreal in 1844 and died of cholera in 1849.⁴¹ Nothing is known about the fate of Henderson.

c) Other Engine Foundries

When Bennet & Henderson's property was put up for sale, the St. Mary's Foundry was bought by John Molson Sr. in 1835 for £2,963 of which £2,000 was for the land, £891 for tools and machinery and the rest for interest and legal fees.⁴² His son John Molson Jr. (1787-1860) took over the running of the foundry and brought in James Irwin and Samuel Workman to act as his agents. Irwin had worked as an engineer for the Eagle Foundry, installing engines in Ontario steamboats 1833-1834. Apparently Workman also worked for the Ward Brothers in their office. Irwin and Workman had to have the approval of John Molson Jr. before they could accept any major contracts. This relationship only lasted until 1837 when Irwin and Workman rented the St. Mary's Foundry for £200 a year from Molsom.⁴³

In 1840, John Molson Jr. brought in William Parkyn to be his partner in the St. Mary's Foundry. Parkyn (1807-1876) was born in Cornwall, moved to Halifax in 1818 and then to Montreal in 1824. He was the captain of various steamboats

on the St. Lawrence including the Cornwall, St. Lawrence, John Molson, and others. Like his contemporary George Brush, he switched from piloting steamboats to building them. The Molson-Parkyn partnership did not last long for in the same year Parkyn leased the foundry until 1850. Parkyn produced three interesting vessels, the Prince Albert, Firefly and Richelieu. Their wrought iron plates were pre-cut in Scotland and sent to Parkyn for assembly. These were the first iron steamers built in Montreal.⁴⁴ Parkyn also built the Iron Duke in 1846 for the Champlain and St. Lawrence Railroad. This vessel had an extremely shallow draft so that it could traverse the Laprairie Basin to connect Laprairie and the Island of Montreal.⁴⁵ He also built the Emerald and Oregon for the Upper Ottawa River. Parkyn's last vessel, one that he built for himself, was the Jenny Lind (1850). He spent \$20,000 on its construction to make it the best steamboat on the St. Lawrence, but was forced to sell it at a \$4,000 loss the following year.⁴⁶

"There were other engine builders in Montreal during the 1840s, but almost nothing is known about them. Besides Irwin and Workman, there was Clarke and Johnson. The Johnson referred to might have been Isaac Johnson, a master shipwright who had built several Molson vessels between 1816 and 1818."⁴⁷ Another engine founder was William Kerr on Prince St. near Wellington, who probably built stationary

engines.⁴⁸ The period from the mid 1830s to 1850 was not a good one for Montreal engine foundries. The Ward brothers gradually withdrew from the Eagle Foundry starting in 1832, eventually turning it over to George Brush. After the failure of Bennet & Henderson in 1833, the Molsons were never able to make St. Mary's Foundry as productive as before. The lack of information on the engine founders of the 1840s probably represents their lack of distinction. Even newspapers of the day could not add very much.⁴⁹

There were a number of reasons for this decline. The great steamboat boom of 1830-1837, especially 1832-1833, had led to an overproduction of vessels.⁵⁰ The demand for engines dropped off rapidly as did the repair business. This oversupply coincided with the economic and political troubles of the two Canadas. The rebellions of 1837-1838 as well as commercial troubles in the late 1830s and mid 1840s made large capital investments, such as steamboats, undesirable. This low level of activity left only one major engine builder, George Brush, and a few other smaller builders who were all but anonymous.

THE PRODUCTS

a) Marine Engines

Two distinct types of marine engines were developed for early steamboats: low pressure condensing and high pressure non-condensing. The first type was developed by Boulton & Watt based upon their stationary steam engine design. Low pressure boilers, less than 14 pounds per square inch, supplied steam to a large vertical cylinder. Steam, admitted to the bottom of the cylinder, pushed up the piston. At the top of the stroke the steam exhausted to a condenser underneath the cylinder where it was cooled by a spray of cold water, producing a vacuum which pulled down the piston, completing the cycle. In place of the traditional balance beam which was thought to be detrimental to the stability of a vessel, Boulton & Watt used two side levers attached to the base of the engine. This lowered the centre of gravity considerably, by putting the weight in the bottom of the vessel where it increased stability. The side levers transmitted the power to a shaft to which were attached the side paddle wheels.⁵¹ However the Americans developed a lightweight skeleton iron beam, known as a walking beam, to transmit power to the paddle wheels which became standard in North America.

The high pressure engine for steamboats in the United States

was developed by Oliver Evans. By using higher pressure steam, generally 60-80 pounds per square inch, he was able to reduce the size of the cylinder considerably and still get the same power as a much larger low pressure engine. These engines were non-condensing; the steam exhausted directly to the atmosphere. The cylinders of these engines were also horizontal and directly powered the paddle wheel generally in the stern. The high pressure engine was widely used on the Mississippi River system and other shallow waters where a light weight engine was necessary. These engines were also cheaper to manufacture, but did not last as long as low pressure ones.⁵²

The low pressure engine, as developed by Boulton & Watt, was exported to the eastern seaboard of the United States and to the St. Lawrence/Great Lakes System. The first generation of steamboat promoters such as Robert Fulton and John Molson were able to draw directly upon Boulton & Watt's expertise to get workable engines.⁵³ In spite of the information available on these engines there is still much that is not known about the design and manufacture of engine components, and how they were installed on board a vessel.

The Boulton & Watt Papers in the Birmingham Public Library contain diagrams of the engines produced, accounts and correspondence.⁵⁴ In the Molson Archives at the National

Archives of Canada there are accounts and correspondence for steamboat operations.⁵⁵ Though these documentary sources tell us a great deal, many small practical points are missing. In order to resolve some of these questions, the Comité d'histoire et d'archéologie subaquatique du Québec has undertaken the underwater excavation of the Lady Sherbrooke between 1984 and 1989 at the Boucherville Islands where John Molson had his farm and where his steamboats were moored for the winter. This excavation has provided a considerable amount of information on the hull of steamboats but unfortunately less has been learned about the engines and power transmission system which were removed before the hull was scuttled. Nevertheless current understanding of early steam vessels has increased greatly.⁵⁶

Less is known about the engines John Ward built than those by Boulton & Watt. The tradition that John Ward brought to Montreal in 1819 was based on the Hudson River/Long Island experience. This area used Boulton & Watt's low pressure condensing engines with large diameter cylinders.⁵⁷ Ward, because of his family connections and experience, was able to bring American steamboat innovations to Montreal. Ward's uncle Daniel Dod was responsible for a number of innovations for the boiler, and condenser and perhaps the lightweight "walking" beam. It was found that it was easier to use a composite wood and wrought iron beam than to build and

maintain tricky side levers. The Ward Brothers remained in close contact with their father Silas in Elizabethtown, N.J. and they made trips to the United States and Britain to see recent developments.⁵⁸

The contracts for engine building in Montreal generally mentioned only the power required, for example 100 hp. It was left to Ward to determine the size of cylinder, length of stroke and how to arrange the machinery so that it would fit into the hull which was being built separately.⁵⁹

John Bennet also came out of the Boulton & Watt tradition. His various partnerships and limited facilities indicate that he had a much harder time establishing himself as an engine builder than John Ward did. Perhaps this influenced Bennet not to be as catholic in engine building as the Wards. Between 1821 and 1833 Bennet built 18 marine and 5 stationary engines based on 17 different models, stationary/marine, high/low pressure, side wheel/stern wheel. The wide variety of production provided little chance for standardization. The very rapid growth of Bennet & Henderson in the early 1830s was done at a high price of borrowed money and credit. These two factors contributed to their downfall when the boom in steamboats started to fade in 1833.⁶⁰ They did not have the specialization or the financial resources of the Ward brothers.

Marine engines were masterpieces of the founder's art. Most of the engine was made of cast iron, including the cylinder, condenser, bed plate, and even crankshafts. Because of the lack of facilities for forging wrought iron, crankshafts were made of brittle cast iron. Their breakage could tie up a vessel for several weeks before a replacement could be installed. To alleviate this problem steamboat promoters with large financial resources began to import wrought iron shafts from Britain. The Royal William's cranks were ordered from John Napier of Glasgow in 1831.⁶¹ Other wrought iron parts included the piston rod, rods for valves, air and water pumps as well as pins, keys and other connecting devices. Early boilers were apparently built of copper plates but soon were made of cheaper rolled wrought iron plates.⁶² Brass was used for bearings and guides.

Documentation is available on the tools and equipment of the Ward Brothers and Bennet & Henderson. It is possible to compare the list from the assignment of Bennet & Henderson's assets in January 1835 to a similar list from the deed of December 1838 admitting George Brush as a partner in the Eagle Foundry.⁶³ Although the categories and terms used are not always compatible, the lists reproduced in Appendix 1, are close enough to get useful comparisons and a sense of the value.

The most valuable pieces of equipment were the cupolas, steam engine and blowing apparatus. The Bennet & Henderson (B&H) steam engine, blast or blowing cylinder, cupola and cranes were worth £750. For the Wards, their steam engine, blowing apparatus, three furnaces and cranes were worth a total of £600. Probably on account of its newness, the B&H boring mill was worth £300 while the Ward brothers' two boring mills were worth only £200. Strangely enough B&H had no planing machine, although the Wards' was valued at £100. However B&H had 6 lathes (£290) while the Wards' list did not have a separate category for them. The Wards did have a large category called "Drilling Machine, Vices, Anvils, Bellows, Purchase Blocks, Machinery, Tools" worth £1415. There were still large amounts of hand tools: anvils, blacksmith and finishing tools. The most common implement was undoubtedly the ordinary metal file. B&H's old files were worth £20 while those of the Wards were worth £50. One significant difference was in the value of patterns. For B&H, their marine and stationary engine patterns were valued at £1195. For the Wards their "sundry" patterns were listed as being worth only £400. Most of this equipment and machine tools were probably made in-house. The only known exceptions was a nut milling machine and a wheelcutting machine bought from Nasmyth Gaskell & Co. at Bridgewater near Manchester in 1837-38.⁶⁴

There is almost no comparable equipment list for other Canadian engine foundries. A newspaper description of Sheldon, Dutcher & Company of York in May 1833 lists: 1 boring mill, 7 turning lathes, 1 drilling machine and a blowing apparatus all powered by a 10 horsepower high pressure engine.⁶⁵

b) Stationary Engines

While the history of marine engines in Canada, as discussed in the previous section, is more or less known, the equivalent history of stationary engines is not. Marine engines were quite common: 109 engines were used in Canada, 1809-1837⁶⁶ but the number and distribution of stationary engines is not known. In central Canada steampower served to supplement but rarely displaced the water power available at numerous sites. Another reason for the dominance of marine engines was that transportation was more important than manufacturing at this stage of Canada's development. The steamboat was also a highly visible symbol of steam power while the stationary engine often worked in near anonymity in a factory or other structure. An attempt at listing early stationary engines used and built in Montreal is given in Appendix 2.

The first Boulton & Watt engine for Canada was ordered by the Hudson's Bay Company in April 1811. Recent research has revealed that a 20 horsepower engine was ordered for a sawmill just south of Moose Factory, on Hudson Bay. Shipping problems delayed the starting of the engine until July 1814. By 1827 the engine was considered "unproductive property".⁶⁷ In 1811 there are references to another Boulton & Watt stationary engine arriving in Montreal. Research has revealed that it was for John Molson's brewery.⁶⁸ It is ironic that John Molson is famous for importing the engine for the Swiftsure in 1812, but it has not been realized that he received a Boulton & Watt stationary engine the previous year. Other early steam engines in Canada included a pre-1818 one for James Goudie's sawmill at Quebec City and another one for a sawmill at Portland, New Brunswick, in 1822. In the same year the Handyside Brothers, the Montreal brewers, received a British built 10 horsepower engine weighing 15 tons.⁶⁹

The Ward Brothers specialized in marine engines and consequently only four Ward stationary engines have been identified. Their first stationary engine was probably for William Wilson's distillery in Montreal in 1823. This installation provoked a legal dispute and an arbitrated settlement. Because Wilson did not place the boiler in the

correct place, the engine did not work as well as it should have. Wilson was ordered to rebuild the brickwork for the boiler in the correct place and Ward was told to supply the parts for connecting the boiler and engine.⁷⁰ Around 1828 the Wards built an engine for George Brouse's steam grist mill in Matilda, Upper Canada. In February 1829, Lebbeus Ward wrote to his brother John about the engine's difficulties probably due to a too light flywheel. A major engine installation for the Wards was Thomas Molson's distillery in Kingston, Upper Canada, in 1826. In 1835 this engine was said to be 33 horsepower.⁷¹ The Wards were almost certainly the builders of the engine used in their own foundry.

Bennet & Henderson were more involved with stationary engines. Their first steam engine rated at 20 horsepower was built in 1831 for the nail factory of T.B. Wragg in Montreal. The following year they built an engine for A. Ritchie's sawmills at Les Etchemins, near Québec City. A brewery engine was made for John Molson in 1833 which was to cost no more than £750. According to a list of patterns produced at the time of Bennet & Henderson's bankruptcy, they also produced a sixteen horsepower engine for the Handysides and a ten horsepower engine for the Government at Quebec.⁷² Unfortunately, there are no other details available on what type of engines Bennet & Henderson built.

After the bankruptcy, the Molson's St. Mary's Foundry under Irwin and Workman produced a number of stationary engines. In 1836, an engine was made for William Price & Company's sawmills at New Liverpool, near Quebec City. A low pressure engine was also built for the Montreal Water Works in 1839.⁷³

c) Industrial Products and Equipment

Most early nineteenth century foundries did much of their business as general foundries, producing a wide variety of cast iron goods such as stoves, kettles, agricultural implements, household goods and sometimes industrial equipment. Occasionally, they might produce a custom made steam engine or a piece of complex equipment. The Montreal engine foundries did the reverse. The demand for marine engines kept much of their resources devoted to engine building. In periods of quiet demand, the foundries turned out other types of goods. During one extremely slow period in early 1829, the Eagle Foundry turned out "a bark mill or two, [a] machine for rolling leather, a pump, a turning lathe, a mill crank... and wheels [gears]" for Brouse's carding machine and mills. Later on the foundry also produced metal punching machines, potash and maple sugar

kettles. The Wards made equipment for the Molson Brewery in 1833 which included an engine, mill shafts, burr stones and pumps.⁷⁴

The St. Mary's Foundry also did the same thing. In 1829 it was producing castings for the Rideau Canal then under construction between Bytown, now Ottawa, and Kingston. Men such as John Bennet were accomplished engineers, able to turn their hand to many types of technological projects. Bennet, trained as a millwright, was also an expert draftsman, wheelwright and mill builder.⁷⁵ Unfortunately, nothing is known about his contributions to these areas. After the bankruptcy of Bennet & Henderson, the new St. Mary's Foundry advertised "mill castings, wrought and cast iron work of every description, bells, brasses..." as well as steam engines and boilers.⁷⁶

By the 1840s, there was an increased demand for machinery and equipment. The Eagle Foundry was producing high and low pressure steam engines, mill gearing, single and double bank engines, pans and kettles, mill and jack screws and iron tackle.⁷⁷

d) Specialized Services

As the most advanced metal working establishments of the time, the engine foundries were often involved in various "high technology" projects. Since they possessed a foundry, forges and machine tools, they could make and maintain just about any type of equipment. The special skills of the Montreal engine founders were of great value in a number of early engineering projects.

The Ward brothers were deeply involved in Canada's first commercial railway, the Champlain and St. Lawrence Railroad. A charter had been granted in 1830 for a railway from Laprairie on the south shore opposite Montreal to St. Johns (Saint-Jean sur Richelieu) fourteen miles away. One of the large backers of this railway was John Molson who personally put up £9,000.⁷⁸ Recognizing that the trip across the St. Lawrence from Montreal to Laprairie was a weak link, the company ordered a custom built ferry boat. The Princess Victoria was 119 feet long but only 19 feet wide. The shallow draft of only 2.5 feet enabled it to traverse the shallows of the Laprairie Basin. The engine for this vessel, which had a 40 inch cylinder and a 10 foot stroke, was built by the Eagle Foundry in 1836.⁷⁹ One vessel was enough until 1843 when the Prince Albert was built by William Parkyn at the St. Mary's Foundry. The iron plates for its hull were

made in Scotland and then sent to Parkyn for assembly; this was the first iron-hulled steamboat built in Canada. Parkyn also built the much larger iron-hulled steamboat Iron Duke for the Champlain and St. Lawrence Railroad in 1848.⁸⁰

The Wards did more than supply the engine for the Princess Victoria. They built twelve complete freight cars for the railroad and supplied the castings for eight others. The Eagle Foundry also supplied other castings including track switches and splice plates.⁸¹

Like the early marine engines from Boulton & Watt, the first locomotive for the Champlain and St. Lawrence came from the best builder of locomotives of its day: Robert Stephenson & Co. of Newcastle. It arrived by boat, probably in June 1836. It has never been clearly established where the locomotive was assembled and tested, but given the Molson connection, it might have been the St. Mary's Foundry. After its first season, the locomotive was taken to the "machine shop of the steamboat line", perhaps St. Mary's Foundry again, for a complete overhaul.⁸² In 1837-38 the Ward Brothers were paid £89.9.0 for locomotive and freight car repairs. In the following year, this foundry made repairs to the "Jason C. Pierce", the second locomotive of the line.⁸³

Much later in January 1850, the St. Mary's Foundry assembled

and renovated two second hand Scottish locomotives for the St. Lawrence & Atlantic Railway.⁸⁴ In the days before railways had developed their own shops, engine foundries were the logical places to assemble and overhaul locomotives. These foundries had the necessary heavy equipment and machine tools as well as experience in working with steam engines.

SUMMARY

Though the engines of the Accommodation were a precursor, Montreal engine building began in 1819-1820 with the arrival of John Ward. He and his brothers brought the American form of the Boulton & Watt low pressure engine to Montreal. The success of the Eagle Foundry ensured at least one stable and prosperous engine builder in Montreal. John Bennet, briefly trained by Boulton & Watt, was the other major engine founder in Montreal. Bennet & Henderson's explosive growth in the early 1830s brought down the firm, but only after a significant number of engines had been built. Overproduction of engines and bad economic times resulted in a generation of smaller, mainly anonymous engine founders. All builders branched out from marine engines to build stationary ones and industrial machinery.

CHAPTER 3

MONTREAL ENGINE FOUNDRIES 1850-1870s

From the 1820s Montreal had expanded considerably. From a total population of 22,000 in 1825, the city climbed to 57,715 by 1851. During the next decade the population grew an unprecedented 56.6 percent to 90,323. Though growth returned to a more moderate 18.7 percent, Montreal's population reached 107,225 by 1871.¹ The growth in population was also a reflection of the enormous changes taking place in the city's economic and productive structures.

Montreal was still largely a mercantile city. The Province of Canada had rebuilt and enlarged the St. Lawrence canal system from Montreal to Lake Huron. Though it was never able to successfully challenge the Erie Canal, the St. Lawrence canals carried impressive amounts of wheat, flour and timber to Montreal and returned with imported foodstuffs and manufactured goods. Montreal's connection with the Atlantic was also improved by dredging a deep water channel through the shallow parts of the St. Lawrence such as Lac St-Pierre. Ocean going steam vessels could now reach

Montreal directly and steam tugs towed sailing vessels up the St. Lawrence.² Montreal continued to function as the chief wholesale distribution centre for central Canada. The city's wholesalers and merchants controlled much of the export trade through Montreal and the importation of British and American goods for redistribution to smaller centres and local retailers.³

The rebuilding of the Lachine Canal through Montreal in the late 1840s greatly improved water transportation facilities. There was one extremely beneficial byproduct: surplus canal water that could be leased as hydraulic or water power. Starting in 1846 this power was leased to manufacturers on Canal Basin No. Two, not far from Montreal harbour. In 1851 the water power at the St. Gabriel Locks, which was two miles from the harbour, was leased to a group of entrepreneurs. The third hydraulic site at Cote St. Paul, six miles from the harbour, was leased at the same time to William Parkyn, but development was slow at this isolated rural lock station. In spite of significant problems such as the mills drawing off so much water that it inconvenienced shipping and unchanging annual rents which were considerably below market value, Montreal's industrial development got a significant head start because of the water power available within the city. Traditional industries such as flour and saw milling and nail making

relocated to the hydraulic sites to build much larger mills. New industries such as textiles, tool factories and machine shops took root at these sites. By 1861 there were 1103 employees working in water powered factories at Canal Basin No. Two and the St. Gabriel Locks of the Lachine Canal. Ten years later the sites employed 1529 people which represented 20 percent of the work force of the Montreal West Census District and 7 percent of the total Montreal workforce. These workers needed a place to live and suburbs such as Griffintown and Cote St. Paul developed to take care of their social, cultural and economic needs.⁴

The growing railway system provided another major change for Montreal. Though a number of early railways had developed in the Montreal area, they were short portage lines. The building of long distance lines began in 1847 with the St. Lawrence and Atlantic Railway which linked Montreal with Portland, Maine.⁵ In 1853 work began on the construction of the Grand Trunk Railway which by 1860 linked Sarnia to Rivière de Loup. Railways had a profound effect on Canadian transportation patterns.⁶ Unlike waterways, which were frozen for five months a year, railways ran year around. They were also much faster than steamboats and linked inland cities to major centres.

Railways had a substantial impact on manufacturing. The

paper "Canadian Railways as Manufacturers, 1850-1880" by Craven and Traves demonstrates the railways' voracious appetite for all manner of goods from bolts and locomotives to lubricating oils and square timbers. This stimulated the creation of new companies and industries to supply the demand as well as creating new markets for existing manufacturers.⁷

The Engine Foundries

By the 1850s Montreal had a diversified and thriving foundry industry. The foundries ranged from small artisanal shops to very large general foundries producing all manner of iron objects for the home, farm, shop and factory. A developing speciality was the casting of stoves and furnaces. Canada's climate demanded numerous heating appliances and a large market developed for them.

Montreal's engine foundries took a new lease on life in the early 1850s. The most significant change was their relocation to the hydraulic sites on the Lachine Canal. One engine foundry started on Canal Basin No. Two and three more relocated to or developed at St. Gabriel Locks. The Eagle and Gilbert engine foundries were also near the canal. It was these foundries that would dominate Montreal engine

building for the rest of the century.

The predominance of the Eagle Foundry suffered from the greatly increased competition after 1850. Its pre-eminence in building marine engines was challenged by newer enterprises, some of them capable of building both hull and engine together. There were also new engine builders developing around the Great Lakes. This forced George Brush into other, but not necessarily new, markets. He started to build more and more stationary engines and boilers. Other products from the Eagle Foundry included gearing and millwork for various types of mills, bark mills for removing tree bark, winches, screw jacks and capstans. Though much less sophisticated than steam engines, these products were standard implements in numerous industrial shops. ⁸

By the 1860s Brush was building high pressure stationary engines cheaper than those imported from the United States. The foundry built ore crushers and stamp mills for Eastern Townships copper mines, grain elevator machinery, tobacco presses and debarking mills. It even built railway spike machinery which was sent to England. One of the foundry's strengths lay in its accumulation of wooden patterns used to make the moulds for casting. Once a pattern was created, it could be used over and over again, thus encouraging repeat business. Brush's 45 year collection of patterns was valued

at \$20,000 in 1868.⁹ By 1871 the foundry was capitalized at \$90,000, employing 80 men, using \$25,000 of material and producing steam engines and machinery worth \$80,000.¹⁰

Brush continued to operate the Eagle Foundry until his death on 21 March 1883 at the age of 90.¹¹ From 1852, his son George S. Brush (1827-1906) had been a partner in the firm. The younger Brush continued the Eagle Foundry until his own death and it closed down soon afterwards.¹² Under the Wards and the Brushes the Eagle Foundry operated for a total of 84 years and was the prime producer of a whole generation of marine engines followed in later years by numerous stationary engines, boilers, mining, lumbering and other equipment.

One of the new generation of shipbuilders to compete with the Eagle Foundry was Augustin Cantin (1809-1893). He was a French Canadian from Cape Santé, near Quebec City. After learning shipbuilding at various yards in Montreal, he went to New York City for three years to learn American shipbuilding techniques. Cantin returned to Montreal and opened a small shipyard in 1841. Two years later he leased land on the Lachine Canal above the St. Gabriel Locks from the Commissioners of Public Works of the Province of Canada. On this land he started his shipbuilding complex.¹³ Cantin was unique in that he was a French Canadian working in an

English-dominated environment. Beyond that he was the only francophone to lease water power along the Lachine Canal. Though there were many francophones artisans in Montreal, very few of them became owners of large enterprises. There have been long discussions on the reasons for this, but one of the main problems was probably the lack of access to the larger Anglo-American world of finance, technology and skills. Without this access, creating a large enterprise would have been very difficult.¹⁴

By 1856 Cantin's Montreal Marine Works occupied nearly fourteen acres including two large basins and a marine railway powered by a high pressure 15 hp engine to pull vessels out of the water. There was a continuous 800 foot row of brick and stone buildings containing drafting and modelling rooms, a moulding loft for tracing patterns, as well as saws and woodworking machinery which were run by waterwheels producing 80 horsepower. The engineering department, which built marine engines, was established in 1854. It used a 20 horsepower condensing beam engine to furnish power to the foundry, blacksmith, machine, erecting and finishing shops. Cantin had spent £6000 on his premises and employed 200-250 workers.¹⁵

Gerald Tulchinsky credits Cantin with being the first shipbuilder to integrate hull and engine building in

Figure 2. The Canada Marine Works of Augustin Cantin. Lithograph from de Volpi and Winkworth. Montréal: Recueil Iconographique. Pictorial Record. Plate 127. N.A. 137386.

Montreal. A customer could now order his vessel and engine from the same builder. This advantage made Cantin the most largest shipbuilder in mid-nineteenth century Montreal. Between 1846 and 1856 Cantin built more than 70 vessels including seven steamboats in 1855 alone. By 1862 he had built and launched 94 vessels and built as many as 23 engines.¹⁶ The financial crisis of 1857 plus the opening of the Grand Trunk Railway between Montreal and Toronto which severely depressed the shipping trade caused Cantin's bankruptcy. His backers, the hardware firm of Brewster & Mulholland, were unable to carry him any longer. After the bankruptcy was resolved in 1859, Cantin lost some of his property to the engine founder E.E. Gilbert.¹⁷ It is possible that Gilbert built the engines for Cantin's hulls. Presumably there would have been close cooperation between Gilbert and Cantin.

Cantin had wanted to get into building iron hulled steamers. He eagerly awaited the auction of water power rights for St. Gabriel Locks to get the additional power he needed for shear presses and punches. Unfortunately for him the entire St. Gabriel site was sold as one lot in 1851 and Cantin was never able to lease additional power directly from the Department of Public Works. From the 1887 Royal Commission report on leasing water power on the Lachine Canal, it was revealed that the successful bidders and Public Works had

rigged the auction. Afterwards the shortage and high cost of water power frustrated Cantin's dreams of building iron ships.¹⁸ In later decades he built many wooden vessels and did a great deal of repair work.

In 1849 three lots and twelve runs of stone on Canal Basin No. Two were leased to the foundry firm of Gilbert, Milne and Bartley. Ebenzer Edwin Gilbert (1823-1889) was born in Montreal and worked in the forwarding business. His mechanical abilities were demonstrated by patents such as one for machinery for unloading cargo from ships.¹⁹ Though the exact activities of Gilbert, Milne & Bartley are not known, they undoubtedly built engines and repaired ships. For unknown reasons Gilbert and Milne left, leaving the enterprise with Bartley.

By 1856 Gilbert was running the Beaver Foundry whose main product was marine engines. He employed 80 men and boys to turn out products worth £7,300 (\$29,200) in the first six months of 1856. By the following year he had built the engines for thirteen steamers, powerful engines for three major sawmills as well as the engines and equipment for numerous ordinary saw and grist mills.²⁰

Gilbert's enterprise also encountered serious financial trouble in 1858-1858. His backer and brother-in-law L.H.

Holton (1817-1880), a prominent politician, banker and member of the forwarding firm of Hooker & Holton, had already supported Gilbert through several crises. With the financial backing of the hardware wholesale firm of Frothingham & Workman, who supplied raw materials, W.P. Bartley and Gilbert were re-united in 1858. However in 1861 Bartley & Gilbert went bankrupt with debts of \$125,000 of which three-quarters were due to Frothingham & Workman. Gilbert was able to re-establish himself at Cantin's Canada Marine Works because Holton gave his brother-in-law Gilbert the mortgage to some of the property and machinery.²¹

An 1864 description of Gilbert's Canada Engine Works is quite enlightening. The machine shop contained huge lathes, one with a bed 30 feet long, an immense boring mill capable of boring cylinders up to 70 inches in diameter and 12 feet long plus the standard machine tools. The forge contained a "Condie" pattern steam hammer in which the cylinder moved and not the piston as in the Nasmyth steam hammer.²² Gilbert also had powerful shears, punches and drill presses for working iron plates up to one inch thick. Since starting in business in 1849 Gilbert claimed to have built 90 marine engines including some for the best known vessels on the St. Lawrence and Ottawa rivers. By 1871 Gilbert's capital was \$65,000 and he employed 125 men and 20 boys to produce steam engines and machinery worth \$120,000.²³

E. E. GILBERT,
Canada Engine Works,

MONTREAL, P. Q.,

MANUFACTURER OF
STEAM ENGINES AND BOILERS,
Heavy Forgings and Castings,
Iron Ship and Bridge Work, Machinery
for Saw Mills, Grist Mills, Sugar
Factories, Tanneries, &c., &c.

Figure 3. The Canada Engine Works of E.E. Gilbert.
Advertisement from Lovell's Province of Ontario Directory
for 1871. p. 1095.

The man who twice was Gilbert's partner was William Patrick Bartley (1817-1885). Little is known of Bartley except that he was a rural blacksmith who came to Montreal to work as a ship smith.²⁴ Presumably he learned the foundry business as a partner in Gilbert, Milne & Bartley, 1849-1853. When Bartley took over he obtained an additional two and a half lots on Canal Basin No. Two to supplement the three he already had.²⁵ Bartley's partner in the St. Lawrence Engine Works was James Dunbar. Dunbar had originally come to Canada to install an engine in a dredge for the Montreal Trinity Board in 1831.²⁶ He was later the foreman of the Eagle Foundry under George Brush. The R.G. Dun Co. considered Dunbar to be "a first class workman and a good businessman" while it merely said that Bartley was "acquainted with the business". Dun considered the St. Lawrence Engine Works to be "A new firm not [known] to have any means of their own, backup by Frothingham & Workman, don't know far they would support them."²⁷

By 1856 The St. Lawrence Engine Works consisted of finishing, blacksmith, pattern and boiler shops and a foundry. The machine tools included ten lathes, five drilling machines, four planers and other machine tools. To work iron plates there were punching machines, rollers for bending plates and "pinching machines" for cutting them.

BARTLEY & DUNBAR, ST. LAWRENCE ENGINE WORKS, MONTREAL,

ARE NOW PREPARED TO EXECUTE ORDERS FOR
**IRON STEAMBOATS,
LOCOMOTIVES.**

Steam Engines and Boilers,

For Steamboats, Propellers, Saw and Grist Mills.

DREDGING MACHINERY,

WITH EVERY DESCRIPTION OF

WATER WHEELS & MILL WORKS,

Heavy Forgings,

From ten inches down to the smallest sizes.

ARCHITECTURAL CASTINGS FOR BUILDINGS,

PLAIN AND ORNAMENTED

Pot Ash Kettles of the best quality, Cast Lip up.

With every other description of Iron and Brass Castings, all of the best material and workmanship, and on the

Most Reasonable Terms.

HAVING lately added to our already large stock, the whole of the TOOLS, MACHINERY and PATTERNS of the Firm of MILNE & MILNE, and being situated on the CANAL BASIN, in possession of AMPLE WATER POWER, and SHIPPING ACCOMMODATION, for shipping and receiving everything our business requires, we are enabled to do MORE WORK, and at a LESS PRICE, than any other Establishment in these Provinces. — On the River St. Lawrence, Steamer "UNION," Whitehall, Montreal Harbor, Cummings' wharves, Kingston Mill Lane, Propeller "OSHAWA," Detroit, Mich., "UNION," G. W. R. R. Co., Steam Locomotive and Grist Mill, DISTILLERY Messrs. T. & W. BROWN, Montreal.

Figure 4. The St. Lawrence Engine Works of Bartley & Dunbar.
Advertisement from The Canada Directory, 1857-58. Vol. 2, p. 1209

These large tools enabled the works to build steamers with iron plates imported from Scotland. Bartley & Dunbar had 160 employees who earned £190-200 a week. Like many mid-nineteenth century foundries, it had an extensive product list. The company was ready to build steamers complete with engines, locomotives, stationary engines and boilers, saw and grist mill equipment, waterwheels and produce all types of iron and brass castings.²⁸

In spite of all these machines and products, Bartley & Dunbar failed in 1857. Gilbert also experienced the same problem and in 1858 the new partnership of Bartley & Gilbert was formed. With the backing of Frothingham & Workman, it lasted until a second bankruptcy in 1861.²⁹ The bankruptcies seem to have had little effect on Bartley's business. In 1864 his shops were busy with engines, steamboats and machinery building. Bartley produced a variety of beam, horizontal and oscillating engines. Other foundry products included boilers, steam pumps, railway equipment and numerous types of castings and forgings. Because of the crowded conditions on the Canal Basin, which limited vessels to 175 feet long, Bartley had started another shop at Sorel, Quebec, whose 200 foot dock made shipbuilding and engine installation much easier. This site also had the necessary facilities for building engines, boilers and iron vessels.³⁰ However Bartley was unable to

shake his continuing financial problems. In 1865 he was forced to turn over three of his five and a half lots to Frothingham & Workman.³¹

In 1871 Bartley stated his total capital to be \$210,000. He used \$66,400 worth of raw materials and paid his 222 employees \$49,200 to produce \$128,175 of engines and machinery. This left him with a net income of \$12,575 which represents a maximum possible return of 5.9 percent on capital.³² Very little is known of Bartley's activities in the 1870s and early 1880s. It is assumed that the enterprise was moribund by the time of his death in 1885.

A foundry to relocate to the Lachine Canal was Redmond & Company. This foundry had been established by John Redmond (d.1857) in 1840. He operated a foundry on St. Antoine Street which produced general castings and the occasional steam engine. His two sons, James (1813-1859) and Francis (1818-1860), were described as "practical men & work with their own hands, live economically, buy closely, pay promptly, are in good & seemed safe and responsible to talk to".³³ Two years after their move to St. Gabriel in 1854, the foundry/machine shop contained two large furnaces, four lathes, a planer, drilling machine and bolt threader. Their 30 employees produced 300 tons of castings. The Redmond product list of 1857 included stationary and marine engines,

REDMONDS & Co.,
GENERAL IRON FOUNDERS, &C.,
ST. GABRIEL LOCKS,
MONTREAL.

Manufacturers

OF

STATIONARY AND MARINE STEAM ENGINES,
HIGH AND LOW PRESSURE BOILERS,
STEAM PUMPS,
GLOBE VALVES, SAFETY VALVES, HYDRANTS,
Stop-Cocks, Reflux-Valves, &c., &c.

Are also prepared to execute Orders for

Water Wheels, Mill Gearing,
HAFTING, PULMES, &c.,

BARK MILLS.

Horizontal & Vertical Engines, Grinders,
COLUMNS, HOUSE FRONTS,

Railway Wheels,

POT ASH KETTLES,

PIPES;

And all description of Castings used in distribution by

Gas and Water-Works.

Montreal, October, 1857.

Figure 5. Redmonds & Company.

Advertisement from The Canada Directory, 1857-58. Vol. 2, p.1213.

waterwheels, potash kettles, valves and pipes.³⁴

After the death of the two Redmond brothers nine months apart, another brother Thomas (d.1869) took over in 1860. According to the 1861 census, Thomas Redmond's capital was only \$16,000. He used \$15,700 worth of cast and bar iron to produce castings valued at \$30,000. Significantly he also manufactured six steam engines worth \$10,000." Redmond's enterprise showed an extremely high added value.

At some point in the early 1860s Thomas Redmond rented the adjoining foundry of Augustin Cantin which enabled him to expand his operations considerably. By 1864 in Cantin's foundry there were two large cupola furnaces with a "monster" 12 ton ladle, a pattern shop, light iron and brass foundries, engine and boiler shops. In his own shops Redmond had machine and finishing shops and a foundry specializing in waterpipes. The pipes, still red hot after being cast, were dumped into a bath of distilled coal tar which penetrated the pipe to prevent rust. The pipes were later hydraulically tested at 400 lb/sq.in. to insure there were no cracks or pin holes. Because of the high quality of his pipes, Redmond was able to charge ten percent more than imported English ones. He sold great quantities of pipe, hydrants and valves to the growing waterworks of Montreal and other cities. Redmond also "...has now entered largely

upon the manufacture of stationary steam engines though always more or less engaged in this branch of business." He claimed he could sell his engines for less than American ones which had to pay a twenty percent import duty. Redmond had recently erected several engines for Montreal firms but unfortunately no details are given.³⁶

Another product field which Redmond got into was the manufacture of railway car wheels. The growing network of railways centred on Montreal created a large demand for charcoal cast iron wheels. Though mentioned in his advertisement in the Canada Directory of 1857, it is not known when Redmond started to produce these wheels on a large scale. When he died in 1869, his enterprise was taken over by his neighbour, the founder John McDougall.³⁷

Another general foundry at the St. Gabriel Locks was that of William Burry & Company. Burry, perhaps a millwright, had been producing millstones, the heart of any flour mill, since 1840. In 1853 Burry started the Caledonia Works to produce mill equipment, general castings and machinery. Three years later he was employing 70 people and exporting four-fifths of his production out of the province.³⁸ Burry died in 1857 and the foundry was taken over by his partner John McDougall.³⁹ McDougall (1826-1892) was born in Berkshire, Scotland and came to Lower Canada in 1832. It is

not known if he had any foundry experience before becoming Burry's partner.⁴⁰

Under McDougall, the Caledonia Works continued to grow. By 1861 he was employing 80 people and producing castings and wrought iron worth \$52,800.⁴¹ McDougall gradually expanded his product line from saw and grist mill equipment and machinery castings to boilers and steam engines. Special projects which were underway in the summer of 1864 included a turbine and pumps for the Montreal Waterworks, equipment for a floating grain elevator in Kingston Harbour and a very large boiler for the Canada Inland Navigation Company.⁴²

McDougall in association with Alfred Brown, a Montreal iron dealer, started to produce cast iron railway wheels. This lasted from 1864 to 1873 whereupon McDougall made his brother-in-law, Robert Cowans, a partner in John McDougall & Co.⁴³ As previously mentioned McDougall took over the Redmond foundry in 1869 which gave him more land, water power and foundry capacity. In the 1871 Census McDougall's enterprises were listed separately.

TABLE 1

JOHN McDOUGALL'S ENTERPRISES - 1871⁴⁴

	<u>Capital</u>	<u>Emp.</u>	<u>Power</u>	<u>Product</u>	<u>Value</u>
Car Wheels	\$90,000	60	15hp	2,000 wheels	\$144,000
Boiler Wks	\$10,000	35	15hp	180 T. boilers	\$27,000
Caledonia	\$40,000	132	25hp	900 T. machinery	\$104,000
Millstones	<u>\$3,000</u>	<u>8</u>	<u>---</u>	45 sets millstones	<u>\$5,800</u>
Totals	\$143,000	235	55hp		\$280,800

The preferred material for railway car wheels was cold blast charcoal pig iron. This high quality cast iron was extremely durable, even under the severe wear and tear of railway service. The source for this iron was the traditional cold blast charcoal fired haut fourneau such as the Forges du Saint-Maurice. McDougall used 3000 tons from the Forges in 1871 but since their output was decreasing, it was necessary to look elsewhere. In 1874 McDougall bought the St. Francis Iron Works which had been established by La Compaigne des Mines de la Rivière St. François in 1869 at St. Pie de Guire near Drummondville, Québec. Needing even more capacity John McDougall & Company opened the Grantham Iron Works blast furnace near Drummondville in 1880 to supply iron for their car wheel works at the St. Gabriel Locks. McDougall was the only iron manufacturer on the Lachine Canal to get into primary iron production.⁴⁵

CALEDONIAN WORKS,
MONTREAL.
JOHN McDUGALL, PROPRIETOR.
MANUFACTURER OF
Steam Engines and Boilers,
MILLRIGHT WORK & MILL MACHINERY OF ALL KINDS.
Water Wheels on the Newest and most Approved Plan.
BARK AND SMUT MILLS.
MANUFACTURER OF MILL STONES, & DEALER IN BOLTING CLOTHS.
Plans and Specifications prepared, at L. M. H. ST. LOUIS.
CALEDONIAN WORKS, ST. GABRIEL LOCKS.

Figure 6. The Caledonia Works of John McDougall.
Advertisement from Mitchell's Canadian Business Directory
1864-65. Vol. 1, p. 388.

John McDougall ran the Caledonia Works, the blast furnaces and his other business ventures until his death in 1892. Robert Cowans managed the enterprises until he was replaced by Edgar, a son of John McDougall, in 1900. In 1908 the McDougall companies became part of the Canada Iron Corporation, an amalgamation of blast furnaces and foundries. This company went into voluntary liquidation in 1913 and was restructured two years later as Canada Iron Foundries Ltd.⁴⁶ The Caledonia Works was the only Montreal engine foundry to evolve a system of corporate management.

One of the smaller foundry/machine shops that produced steam engines among their other products was the Novelty Works of Robert Gardner (d.1891). He was born in Scotland and trained as a pattern maker with the famous engineering firm of Donald & Craig of Paisley. He came to Montreal in 1842 and was immediately employed by John Molson Jr. at the St. Mary's Foundry. Two years later he became foreman of William Kerr's foundry on Wellington Street. In 1846 Gardner went to New York to become pattern foreman at the Novelty Iron Works and later the Allaire Works, two of the most famous engine foundries in the United States.

With the formation of Gilbert, Milne & Bartley in 1849, Gardner returned to Montreal to direct their foundry.⁴⁷ The following year he set himself up as an engineer, machinist

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Figure 7. The Novelty Works of R. Gardner & Son. Illustration from Canadian Illustrated News. Vol. 10, 5 Dec. 1877. No. C-61556.

and pattern maker. His ad in the Canada Directory of 1857 mentions blacksmithing, millwrighting, machinery building, railway work and equipment supplies. There is no specific mention of a foundry or engine building. However by 1864 he had a foundry and was building steam engines, though no details are available. The Novelty Works produced the usual range of goods plus turning lathes, cracker and biscuit machinery.⁴⁸ In 1869 the company was renamed Robert Gardner & Son. By 1871 it employed 32 workers and produced \$60,000 worth of general machinery.⁴⁹

ENGINE FOUNDRY PRODUCTS

a) Marine Engines

It is increasingly difficult to trace Montreal marine engine building after 1850. Before 1837, a large percentage of the marine engines of central Canada were built in Montreal. In the post-1837 era engine building spread to Canada West and to the American side of the Great Lakes. By 1850 Montreal engine foundries were facing stiff competition from many sides. Marine engines, like steamboats themselves, were no longer examples of elite technological skill. As steamboats penetrated smaller rivers and inland lakes, the high pressure non-condensing marine engine became increasingly common. These small and fairly simple engines could be

built by local foundries which now had sufficient equipment and skills to build them.⁵⁰ This decentralization of engine building sharply reduced Montreal's pre-eminence in the field.

The low pressure, large cylinder, condensing marine engine still remained dominant for major passenger steamers and many cargo vessels on the St. Lawrence and Great Lakes system. These engines were the preferred power source for passenger and excursion steamers because the side wheels could be individually disconnected from the engine thus increasing the maneuverability of the vessel. Vessels with sidewheels and condensing marine engines lasted well into the twentieth century. Propeller driven vessels, first developed in the U.S. in the early 1840s were being built in Montreal by the mid-1850's but they were mainly for cargo vessels.⁵¹

The Montreal foundries involved in constructing marine engines after 1850 included W.P. Bartley, George Brush, Augustin Cantin, E.E. Gilbert, John McDougall, Millin & Milne and perhaps the Redmonds. The best known builder was Augustin Cantin. Though he was the first in Montreal to integrate hull and engine building, it is not known how long he actually produced his own engines. Cantin seems to have lost his foundry to Gilbert by 1861. If so then Cantin

would be dependent on his fellow founders for engines. Of the 94 vessels Cantin built by 1862, it is not known how many were steam powered.⁵²

It is equally difficult to evaluate George Brush as a marine engine builder after 1850. A recent article on the Eagle Foundry lists only eight known engines by him between 1851 and 1854. These engines had cylinders ranging between 19 and 46 inches. There is also an 1864 reference to Brush building a large steamer with plates sent from Scotland. Since Brush did not have a shipyard, it is not known where this vessel was built.⁵³

E.E. Gilbert was the most productive post-1850 marine engine builder. By 1864 he had built 90 engines "including those for some of the best steamers on the St. Lawrence and the Ottawa..."⁵⁴ Unfortunately only a number of the names of these vessels are known. In the 1870s E.E. Gilbert & Sons built the engines for four railway car ferries for the Great Western and Grand Trunk Railways. Most of them transported freight cars between Windsor and Detroit all year around. The engines were noncondensing horizontals of both high and low pressure design. As proof of Gilbert's high level of quality, the engines of the Michigan (1873) were put into the Lansdowne (1884) which worked on the Detroit River until a paddle shaft broke and destroyed one of the engines in

1970.⁵⁵

Gilbert was also an innovator. One engine he built was a hybrid marine screw engine which could be used as a high pressure non-condensing engine or as a low pressure condensing engine.⁵⁶ Gilbert was the first engine builder outside the United States to recognize the steam engine valve system invented by George H. Corliss (1817-1888). The Corliss valve system was able to quickly shut off steam entering the cylinder and thus make better use of the expansive power of the steam. Gilbert built his first engine with Corliss valves in 1859. The following year he tried this valve system on a much larger project, the steamer Montreal which had a cylinder 60 inches in diameter and eight foot stroke. He also pressurized the stokehold in order to improve the efficiency of boiler combustion which became a standard feature on steamships. These features made the Montreal "a fine specimen of marine engineering" which was still running at the time of Gilbert's death in 1889.⁵⁷

An engineer who helped Gilbert design and build the Montreal was William Inglis (1835-1890). Inglis was born in Ottawa, served an apprenticeship with Gilbert 1852-1856 and then went to Britain to work in Robert Napier's shipyard and Robert Stephenson's locomotive shops. After completing his

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MICROCOPY RESOLUTION TEST CHART
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STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No 2)

training in the best British engineering shops, Inglis returned to work with Gilbert on the engines of the Montreal. Inglis returned to Britain in 1863 to become a consulting engineer. In 1868 he became the manager, and later a partner, in the famous engineering firm of Hick, Hargreaves & Company. Inglis is credited with introducing the Corliss valve, which he learned about from Gilbert, into Britain.⁵⁸

It is difficult to identify the engines constructed by William P. Bartley. In 1856 Bartley & Dunbar mentioned only the building of the iron steamer Kingston, their first ship for Great Lakes interests and three iron light ships for the Montreal Trinity Board. In contrast to Gilbert's list of engines for thirteen vessels in 1857, Bartley and Dunbar mentioned only three vessels, one of which was a "propeller".⁵⁹ It is difficult to separate the responsibility for engines constructed by Bartley from those of Gilbert when they were partners from 1858 to 1861. Interestingly Bartley also took credit for the construction of the Montreal, but since it was probably built in the St. Lawrence Engine Works shops, this is understandable. Bartley's small cramped shipyards on the Lachine Canal, though augmented by another one in Sorel, must have hampered his ship and engine building activities.⁶⁰ Much of his work therefore would consist of ship repairs, altering steamboats

such as the ferry Iron Duke in 1864 or building iron barges.

A little known firm of mechanics and engineers was Milln & Milne. William H. Milne had been a partner in Gilbert, Milne & Bartley, 1849-1853. Milln and Milne formed the Dry Dock Engine Works on Canal Basin No. Two, probably at the Tate Brothers' dry dock. However the existence of this company was quite brief since Bartley and Dunbar announced in Oct. 1857 that they had taken over "...the whole of the TOOLS, Machinery and Patterns of the late Firm of Milne [Milln] & Milne..." As far as known they only produced engines for the Blue Bonnet and the Tinto which both had twin engines working at right angles to the same shaft.⁶¹

Other Montreal foundries that claimed to build marine engines in 1864 were Thomas Redmond and Robert Gardner, but no evidence for these claims has come to light yet. John McDougall's Caledonia Works also made this claim but the only known engine built was for the ferryboat Pilot (1884) which ran between Quebec City and Levis.⁶²

b) Stationary Engines

In Montreal there seems to have been little differentiation between marine and stationary engine building.

Advertisements and descriptions mentioned both in the same line. In the case of the horizontal high pressure engine, there were few significant differences. By mid century there was a variety of stationary engines being produced. The traditional Boulton & Watt beam engine was still being manufactured but newer designs such as high pressure horizontal and oscillating engines were becoming popular. There was also quite a choice of slides and valves available to regulate the engines.

It is difficult to get a portrait of the power developed in Montreal. The Canadian Industry in 1871 Database, based on the Industrial Schedule of the 1871 Census, has almost been completed. Pre-release data reveals that 142 steam powered establishments in the City of Montreal produced 2,559 horsepower.⁶³ However it is not known how many steam engines this represents, what type they were or who built them.

In 1857 Bartley & Dunbar were producing steam engines and boilers for saw and grist mills. It cited a steam engine and grist mill for the Great Western Railway in Toronto and the engine and machinery for the T. & W. Molson Distillery in Montreal. Seven years later Bartley was building beam, horizontal and oscillating engines with conic slides and Corliss valves. For his shops in Sorel, Bartley had a high

pressure oscillating engine, presumably of his own manufacture.⁶⁴

Over time George Brush increasingly built stationary rather than marine engines. At the Provincial Exhibition of 1860 in Montreal he won a prize for a high pressure horizontal engine. Afterwards it was installed in the Hon. John Young's large grain and flour warehouse. This 15 horsepower engine drove numerous grain and barrel elevators. In 1864 it was said that the Eagle Foundry had "of recent years...turned out many stationary [engines]". Brush stated that all the components of his engines were made in his shops; nothing was imported. Because of the twenty percent tariff on imported engines, he claimed that his engines were cheaper than imported ones.⁶⁵

Gilbert, from at least 1857, specialized in building large engines;

...powerful mill engines belonging to Messrs. Gilmour & Co., at Trenton, Joseph Aumond, Esq., at Ottawa City, and Wm. Price, Esq., at Quebec, together with numerous smaller engines for Grist and Saw Mills in various parts of the Country.⁶⁶

Each of the three sawmills mentioned needed large engines to drive their gang and circular saws as well as numerous other woodworking machine tools.

Gilbert also specialized in high power pumping engines for municipal water works. As cities continued to grow in the second half of the nineteenth century, so did their demand for water. This ever increasing demand necessitated extremely powerful and reliable engines to pump water into the municipal water systems. By the 1880s Gilbert had won considerable recognition for his water works engines in Montreal, Toronto and other Canadian cities.⁶⁷

Details on the stationary engines fabricated by other Montreal builders are extremely scarce. Robert Gardner did not start producing steam engines until the early 1860s and still was producing them in the 1870s. Although he probably built the occasional engine, he seems to have stayed with millwork and other equipment. John McDougall's heavy engineering work included large boilers and engines though no details are available for this period. In the 1861 Census Thomas Redmond reported that he had built six steam engines worth \$10,000 in the preceding year.⁶⁸ In 1864 Redmond had recently erected stationary engines for several Montreal manufacturers but no specific installations were identified. He, like George Brush, emphasized that he could build engines for less than they could be imported because of a twenty percent tariff. An 1865 advertisement listed five sizes of horizontal stationary engines ranging from 9 x 16" to 15 x 30" with single or double cylinders.⁶⁹

c) OTHER FOUNDRY PRODUCTS

As the largest and most complex of all types of foundries, engine foundries were well equipped to get into most aspects of secondary iron production. Most, if not all, engine foundries had the facilities to carry out iron and brass founding, forging, machining and the fabrication of large pieces of equipment. They had an immense product range that went from light castings to the largest and most complex machinery. To understand the contribution of Montreal engine foundries, it is necessary to see their total product range, not just their engine production. Castings, forgings and machinery will be looked.

All Montreal engine foundries produced general iron castings. Some of them specified that they did both light and heavy casting, though most of their work would have been heavy. In producing cast iron objects, engine builders would be in direct competition with numerous other Montreal foundries which ranged from small artisanal shops to large stove and hardware foundries which did quite sophisticated work. For example, in 1864 the William Rodden & Co. stove foundry cast a 28,000 pound anvil block for a steam hammer which was said to be the largest casting ever poured in Canada.⁷⁰ Given the large overhead of an engine foundry, it

was probably cheaper to get ordinary castings done at a general foundry except if the engine foundry already had the necessary pattern.

One speciality product was cast iron kettles for making potash, maple sugar and other substances. The special demands put on a potash kettle included a very hot fire in excess of 1150°F that burned for days to convert ashes to potash. The potash itself, a form of lye, was quite corrosive. Only potash kettles made from the best cast iron could withstand these forces. They had been made by the Forges du Saint-Maurice since 1818. Bartley & Dunbar were making these kettles in 1857 as well as the Redmonds. The St. Lawrence Engine Works was casting its kettles lip up which enabled any impurities in the liquid iron to rise from the bottom of the kettle to the lip. Since it was the bottoms of the kettles that were exposed to the flames, any impurities there would cause weakening and cracking.¹¹ By 1864 the only manufacturers of these kettles was Rogers & King, successors to the St. Mary's Foundry.¹²

A similar speciality casting which had to withstand very high levels of stress and wear were railway car wheels. As previously mentioned the best material for this application was the traditional cold blast charcoal cast iron. The pig iron from the Forges du Saint-Maurice and other furnaces in

the area had a very good reputation and was extensively used. The first Montreal foundries to produce railway wheels was the St. Mary's Foundry and Bonner & Hedge in the late 1840s. The Molsons complained to the Provincial Secretary of the Province of Canada that Samuel Bonner, an American, was competing unfairly with them but the outcome is not known.^{'3} The next maker of railway wheels was Redmonds & Co. in 1857 followed by John McDougall & Co. in 1864. This led John McDougall to acquire his charcoal blast furnaces.

Architectural and ornamental castings were a new area of development by the 1850s. Foundry techniques had progressed to the point where very large and relatively thin castings could be made. This included fencing, entire facades of buildings, fountains, statues and stairways. Bartley & Dunbar advertised ornamental iron castings in 1857 while Brush and Redmond mentioned it 1864. It is not known if any of these foundries besides Redmonds produced cast iron beams and columns. The competition in this fields came from stove and general foundries such as Ives & Allen and William Rodden & Co.^{'4}

Most engine foundries had brass foundries since steam engines contained a fair number of brass components such as valves, guides and bearings. Montreal engine foundries frequently advertised brass casting but once again they were

in direct competition with well established brass foundries. Firms such as Montreal Lead, Copper and Brass Works owned by Charles Garth or the Montreal Brass Works of Robert Mitchell would have provided stiff competition.⁷⁵

The range of equipment produced by Montreal engine foundries was typically very large. All the foundries shared standard lines of equipment and then each had their own specializations. All Montreal foundries had as a staple product millwork which included shafting, hangers, pulleys, and gearing. These elements formed the standard power transmission system for both steam and water power in the nineteenth century.⁷⁶ The most ubiquitous installations were the local grist and sawmills that dotted the Canadian landscape. Another large market was the machinery for saw and gristmills such as saws, log carriages, shingle machines bark and lath mills. Bartley, Brush, McDougall and Redmond all built this type of equipment. By 1864 Bartley was advertising himself as "Manufacturer of every description of Self Acting Machinery of Circular, Gate, Muley and Cross Cut Saws." He produced a double carriage, self feeding shingle mill which could produce 30-40,000 shingles a day. He listed twelve users of his mill from Peterborough to Ottawa and Quebec City.⁷⁷ McDougall in particular was a well known supplier of millwrighting material. He continued the tradition of his predecessor, William Burry, of supplying

millstones of which he produced 45 pairs worth \$5,800 in 1871.⁷⁸

Another piece of equipment that all engine foundries produced was boilers. Since boilers were an integral part of the steam engine, all engine foundries had their own boiler shops. They made marine, stationary, heating and near the end of the period, portable boilers. In order to work the iron plates it was necessary to have shear presses, punches, rollers, drilling and riveting machines. Besides boilers this equipment could produce tanks, girders, and other large pieces involving rivetted iron plates.⁷⁹

Lifting devices, both hand and steam powered, were common products. They ranged from simple screw jacks, capstans and winches to large cranes and elevators. Elevators for the grain trade were being built by both by Brush and McDougall in 1864. Brush had built "the machinery for the new and particular grain elevator of Cumming & Parrish, situated on the Canal Basin."⁸⁰ McDougall, who had already built a number of floating and stationary grain elevators on the Lachine canal, was building a floating elevator for Kingston Harbour.⁸¹ Pumps had a range similar to that of lifting devices. The engine foundries made a variety of them both hand and steam powered. Globe, safety, stopcock and reflux valves were made by Bartley and Redmond to go along with

their water and gas pipes. Presses made by the engine foundries, found markets in many different industries."⁸²

The Eagle Foundry also specialized in mining equipment. It is not known when Brush started building this type of machinery, but by the mid-1860s he was manufacturing ore crushers and stamp mills for the copper mines that were rapidly developing in the Eastern Townships of Quebec."⁸³ The Eagle Foundry continued to build mining equipment for the rest of the century.

At first glance, waterwheels and water turbines were products with a slightly ironic twist for Montreal steam engine foundries. It has to be remembered that Bartley, Redmond and McDougall all used water power from the Lachine Canal to run their foundries and machine shops. Since the term "waterwheel" could be applied to both the traditional iron framed waterwheel and to the newer turbine, it is very difficult to date the transition from one to the other. Brush, who never used water power, made waterwheels. Bartley and Redmond were making them in the 1850s. By the next decade it is clear that the foundries were making turbines. McDougall made a large turbine wheel for the Montreal Water Works. He was a manufacturer of Leffel turbines, perhaps under licence.⁸⁴

One technique rather than a product that these foundries offered was forging. The working of wrought iron requires the use of heat to soften the iron then hammering to give it the desired shape. Ordinarily this was done by a blacksmith with a forge, anvil and hammer. For larger shafts and axles the traditional trip hammer was used. A cam on a rotating shaft caused a heavy beam with a hammer on the end to rise and then fall on the piece being formed. All foundries, with the possible exception of Redmonds, made reference to heavy forging facilities. For instance Bartley & Dunbar could forge a shaft four by ten inches in 1856. McDougall had an "immense" trip hammer for making forgings of any size in 1864.⁸⁵ The other type of hammer for forging wrought iron was the steam drop hammer developed by James Nasmyth in 1843. Only Gilbert and Cantin were known to have steam hammers. Gilbert had a twelve ton Condie rather than the usual Nasmyth type steam hammer.⁸⁶ In the Condie it was the cylinder and attached hammer which moved on a stationary piston rod that hammered the metal. Forging was an important technique possessed by Montreal engine builders.

It is difficult to identify special projects of Montreal engine foundries after 1850. Many types of work considered to be special up to this time became routine afterwards. Was the casting and machining of a three ton roller for an iron rolling mill by Gilbert in 1864 to be considered as a

special project or a fairly standard job? It would seem from the description of this project that it was not out of the ordinary.⁸⁷ However there was one project of Gilbert's that could be considered special. In 1879 the federal government asked him to convert a smooth-bore 32 pound gun into a rifled 64 pounder. This was done by boring out the gun barrel and inserting a steel liner. The first gun was such a success that the Canadian government gave him another ten guns to convert.⁸⁸

SUMMARY

The role of Montreal engine foundries changed considerably after 1850. A new generation of foundries developed in the city, most of them along the Lachine Canal. Marine engines, though still an important product, gradually declined as did Montreal shipbuilding. In its place grew the production of numerous types of stationary engines. They were becoming the dominant source of industrial power and the engine foundries were in the forefront of this change. These foundries built numerous types of other equipment including turbines, power transmission systems, and machinery for mines, saw and flour mills. There was also a diversity of cast forged and machined items, large and small, that came out of these shops.

Engine foundries became large industrial enterprises requiring large capital investments. In spite of the investments of large hardware merchants, the decisions were still made by the owner, almost always a former master workman. The success of these enterprises were dependent on the judgements of former workmen and these firms often died with them.

CHAPTER 4

CONTRIBUTIONS OF MONTREAL ENGINE FOUNDRIES

Montreal engine foundries played an important role in the mechanization and industrialization of central Canada. This chapter will evaluate their contribution. Sectors to be investigated include transportation, staple industries and manufacturing. Competitors to Montreal engine foundries in Quebec, Ontario and the Maritimes will be examined.

TRANSPORTATION

The first and most significant contribution of engine foundries in Montreal was their marine steam engines. Starting with the engine for the Ottawa by the Montreal Air Furnace in 1819, marine engines were still important products fifty years later. Marine engines were the reason for the creation of engine foundries in Montreal and the principal reason for their continued existence.

For a country as large as Canada transportation has always

been a priority. Before steamboats the speed of travel, and therefore of communication itself, was limited to the speed of sailing vessels, canoes and winter sleighs. These limitations gravely affected the movement of goods including staple products such as furs and squared timber as well as complicating the control and direction of these enterprises spread out over large distances. Steamboats were seen as the solution to many of these problems. Only two years after Fulton's first commercially successful steamboat in 1807, John Molson had the Accommodation running on the St. Lawrence. Given the scarcity of mechanical skills in British North America at this time, the building of the Accommodation was a heroic feat.

After the engine of the Accommodation proved to be less than successful, Molson turned to Boulton & Watt, the best engine builders in the world, for his engines. The arrival of John Ward in Montreal in 1819 had a profound effect; the unofficial Boulton & Watt monopoly was broken, new companies could now get into shipping using steamboats and a stable engine foundry base established. Under the Ward brothers, the Eagle Foundry built the engines for 33 vessels between 1819 and 1837, not including vessels that had second and third hand Eagle engines. John Bennet's various partnerships were responsible for building another seventeen engines 1821-1833. In all Montreal built engines accounted

for 56 percent or 52 of the 93 engines used in central Canada in the period 1809-1837.¹

With both the Wards and Bennet producing engines, the number of steamboats on the St. Lawrence grew rapidly after 1820. When regular steamboat service was established with most of the ports on the St. Lawrence, communications and the handling of passengers and freight improved considerably. Intense competition, especially between the Molson and Torrance lines brought down the price considerably of a trip between Quebec and Montreal. Steamboats were towing barges almost from the beginning. The building of the tug Hercules in 1824 enabled sailing vessels to be towed to Montreal with fewer problems and delays.²

The explosion of steamboat building in the early 1830s created an oversupply of vessels that lasted well into the 1840s. Lower Canada was also racked by rebellion and frequent downturns in the economy in the 1840s. These factors had a negative impact on Montreal engine foundries. As well, new engine foundries were established at Kingston, Niagara-on-the-Lake and on the American side of the Great Lakes. In spite of the increased competition, the Eagle and St. Mary's foundries were still building new engines and repairing old ones.

After 1850 the role of Montreal foundries in producing marine engines is even more difficult to evaluate. The horizontal high pressure engine was fairly easy to build and numerous foundries, both large and small, were ready to build them throughout the Great Lakes region and beyond. The percentage of engines built in Montreal after 1850 has yet to be determined but there is a definite downturn. Some builders such as George Brush turned increasingly to other fields. Augustin Cantin suffered financial problems and perhaps lost his engine foundry. The only Montreal marine engine builder to do well was E.E. Gilbert. By 1864 he had built 90 engines including heavy duty ones for railway car ferries and the first Corliss engines in Canada.³

Montreal engine builders had a spotty record as shipbuilders. Cantin was the first one to be able to build the hull and engine together. However he was limited to building wooden vessels since his plans for building iron ones were frustrated by the lack of water power for plate working machinery. The only other founder with shipbuilding facilities was W.P. Bartley. With his limited space on the Lachine Canal, he produced an unknown number of vessels. Because of their machinery for working iron plates, other engine foundries became involved in hull assembly. William Parkyn, while running St. Mary's Foundry in the 1840s, built six iron ships from plates imported from Britain. Bartley &

Dunbar were building the Kingston with imported plates in 1856. George Brush also constructed an unidentified vessel with Scottish made plates in 1864. In spite of the efforts of the engine builders, hull and engine building were never totally amalgamated in Montreal.⁴

Montreal foundries made definite contributions to railway transportation. This relationship goes back to the first one in Canada, the Champlain and St. Lawrence Railroad. The Eagle Foundry started producing railway cars and track switches in 1835. The first locomotive in Canada was probably assembled in the St. Mary's Foundry. This pattern continued for the next several decades. The foundries cast, forged and machined components for railways as well as doing major repair work which became staple work for them. Companies such as Gardner's Novelty Works and the St. Lawrence Engine Works mentioned "railway work" in their advertising.⁵ The only known engine founder to build railway cars was Augustin Cantin who built 36 boxcars for the Grand Trunk Railway in 1860-1861.⁶

Unlike a number of other prominent engine foundries in North America, Montreal engine foundries did not get into locomotive building. The West Point Foundry of Cold Springs, N.Y., famous for their marine engines and cannon, built three of the earliest locomotives in the United States

between 1830 and 1833.⁷ The machine shops of large cotton mill complexes of New England such as the Lowell Machine Shop which built 150 locomotives from 1835 to 1864 and the Amoskeag Manufacturing Co. of Manchester, N.H. turned to locomotive manufacturing as a means of diversifying their production.⁸ The first Canadian built locomotive was built by the James Good Foundry of Toronto in April 1853. Good (c.1814-1889) built a total of nine engines between 1853 and 1855.⁹ William Montgomery's Nova Scotia Iron Works was in the process of building ten locomotives for the Intercolonial Railway when it went bankrupt in 1874. Other foundries which built locomotives were the Phoenix Foundry of St. John, N.B. and the Ontario Foundry of Kingston. Though only the Kingston foundry became a full time locomotive builder, engine foundries were often the earliest producers of locomotives.¹⁰

Although Montreal engine builders did not build any locomotives, this did not mean that they were not interested in doing so. In 1853 Gilbert petitioned the Department of Public Works for an island in the Lachine Canal where he wanted to build locomotives, but nothing came of this. Bartley & Dunbar listed locomotive building in their advertisement in the Canada Directory of 1857.¹¹ There were a number of reasons why Montreal founders did not get into the locomotive field. Even though the first Canadian

railways were in Quebec, there was little railway building between 1836 and the start of construction on the St. Lawrence and Atlantic in 1847. The few locomotives that were needed were generally imported from Britain. Once the St. Lawrence and Atlantic and later when the Grand Trunk started operating there was an instant demand for engines which was met by importing them from abroad.¹²

The first locomotive to be built in Montreal was by William L. Kimmond (1814-1878) and his brother Peter in September 1853, just a few months after Good's first locomotive. They had already supplied several locomotives for Montreal area railways from their Dundee, Scotland, foundry before coming to Montreal in 1851. The Locomotive Engine Works built twelve locomotives, eleven of them for the GTR, before closing their operations in 1857 due to a shortage of orders.¹³ The GTR, with by far the largest number of locomotives, experienced severe problems with the British and American locomotives that it had acquired. To better meet its needs, the railway decided to start building its own locomotives at their Point St. Charles shops. Frederick Trevethick, the son of Richard Trevethick the builder of the first railway engine in the world, was responsible for turning out the first GTR built locomotive in May 1859.¹⁴

Montreal engine foundries found that after years of low

demand for locomotives, there was a sudden surge in the mid 1850s when they were already busy with many other orders. The need for engines was first met by importing them, then by the Kimmonds building some in Montreal and finally by the GTR building its own. This left very little, if any, market for Montreal foundries which might have wanted to get into locomotive construction.

STAPLE PRODUCTS

Canada's economic development has often been seen as the exploitation of staples, natural products that are exported with a minimum of processing to a metropolitan centre. Canada's staples started with the fish of the Grand Banks and the furs of Nouvelle France and the Northwest and moved to timber, minerals and wheat. Though a staple based economy is extremely susceptible to changing economic conditions and though it does not favour broad sustained growth, it was the dominant economy in Canada during the nineteenth century.¹⁵ Montreal engine foundries participated in the exploitation of Canada's staples in the areas of saw milling, flour milling and mining.

Saw milling was generally the first industrial enterprise in a frontier community. It converted trees into planks and

boards needed by settlers for homes and barns. In 1827 there were 565 saw mills in Lower Canada and this total continued to grow rapidly. Most of these saw mills were small operations producing for the local market. However very large mill complexes developed on the Ottawa, St. Maurice and St. Lawrence Rivers that produced for the British and American markets. See Appendix 6 for census statistics relating to the sawmilling industry.

The market for saw mill equipment was a large one. What did Montreal engine foundries have to offer? Most sawmills were located on rivers that delivered logs and provided water power. By the 1850s and 1860s sawmills were using turbines which were mechanically more efficient than traditional waterwheels and less susceptible to ice problems in the winter. Bartley, Brush, McDougall and Redmond all manufactured turbines and/or waterwheels.¹⁶ McDougall manufactured Lefell turbines and Bartley made Cole/Sampson, Jonval, Tyler and Lefell turbines. If needed, the foundries could also supply steam engines. As previously mentioned, Gilbert had supplied mill engines to three major saw mill complexes by 1857.¹⁷

All Montreal engine builders had millwork as one of their major products. This included the power transmission systems which linked the turbine or steam engine to the

ESTABLISHED 1849.

St. Lawrence Engine Works,

No. 17 to 29 MILL STREET, AND CANAL BASIN No. 2,

MONTREAL,

W. P. BARTLEY & CO.,

PROPRIETORS.

TO STEAMBOAT OWNERS, CAPTAINS AND ENGINEERS.

Builders of Iron Steamers' Engines and Boilers ;
Builders of Screw Propellers' Engines and Boilers ;
Builders of Steam Yachts' Engines and Boilers ;
Builders of Steam Launches' Engines and Boilers ;

Builders of Grist Mills, Saw Mills, Breweries, Distilleries Engines ;

Builders of small Pony Steam Pumps for Steamboats, and the supply of Public and Private Buildings.

Builders of every description of motive Power for all kinds of manufacturing purposes ;

Builders of Bartley's Compound Engine, and every other description of Compound Engine ;

Builders of large pumping Engine for the supply of Cities and Towns ;

W. P. BARTLEY & CO.,

To Saw Mill and Lumber Men:

Builders of best Saw Mill Engines and Boilers, builders of improved or old Saw Mills, with ratchet feed head blocks, long journals and saw carbores.

Builders of Millstones, Sheddies and Board or Deal Gangs.

Builders of Double and Single Edgers, Butters, &c., also circular planers.

Builders of Chapboard Mills, to saw two (2) boards going forward and two returning ; log turned with the same operation—no loss of time.

Builders of Shafting, Hangers, Pulleys and every description of Saw Mill Machinery made on shortest notice.

W. P. BARTLEY & CO.,

SPECIALTIES.

The best Shingle Mills in the world. The Double Carriage Self-Feeding Mill is capable of sawing from thirty to forty thousand Shingles per day. No Saw Mill should be without one. Great saving in working up waste lumber, end of logs, &c., which can be cut into first quality Shingles at very little expense.

The Single Carriage Hand-Feeding Mill is easily managed ; does not get out of repair, and makes from fifteen to twenty thousand Shingles per day.

Builders of the Gardiner Shingle Mill at a low price, it will saw from 12,000 to 15,000 per day.

W. P. BARTLEY & CO.,

To Architects, Builders and Proprietors:

Iron Fronts, Iron Roofs, Wrought or Cast Iron Girders, Cast Iron Columns, Window Sills, Lintels, Stair Plates, Railings, &c., &c.
Every description of Heating Apparatus for heating Buildings by steam or Hot Water, Furn and Lift Pumps, Winches, Cranes, Hydraulic Jacks, Screw Jacks, and every description of Hoisting

Tackle ; Patent Hoisting Apparatus for Stores or Hotels, Builders of every description of Machinery for Extract Factories.

Heavy Cast, Dry and Green Sand Castings. We have the largest stock of every description of Patterns in the Dominion, and can consequently make Castings in a shorter time, and at a lower rate than they can be made elsewhere.

Steamboat and Mill Repairs promptly attended to.

WATER WHEELS.

THE JONVAL TURBINE.

As made by the Bolline Manufacturing Co., Lowell, Mass.

THE TYLER WHEEL.

This is a well known and most efficient wheel where the supply of water is good.

THE LEFFEL WHEEL.

As manufactured by Messrs. JAS. LEFFEL and Co., Springfield, Ohio, and by the JOSEPH HALL MANUFACTURING CO., Oshawa.

THE COLE OR SAMSON WHEEL.

Two of these Wheels can be seen driving the machinery of these works.

We are prepared to construct any of the above Wheels, of all

sizes, ranging from 10 in. to 8 feet diameter ; and will furnish any information relative thereto, on application.

STONE-BREAKING MACHINES.

We are also prepared to take orders for Archer's or Blake's Patent Stone Breakers, the most efficient and powerful Machine yet used for breaking Road Metal, and for crushing and reducing Rocks, &c., &c. These Machines are coming rapidly into use in all parts

of the globe, as they work very economically, and do away with a large amount of manual labor, not always to be procured for that class of work.

Figure 8. The St. Lawrence Engine Works of W.P. Bartley & Co. Advertisement from Lovell's Province of Ontario Directory for 1871. p. 1093.

woodworking machinery. Up to mid century this meant shafting and gearing made of cast and wrought iron. However, as the need for greater speeds grew, there was a switch to leather belting to drive the lines of shafting and to link the shafting to individual machines.¹⁸

The Montreal foundries also built saw milling machinery. George Brush built single, double and triple bark mills which removed bark from saw logs. They had been built by the Ward Brothers as far back as 1828. Redmond was also building them in 1857. Bartley was a major supplier of saw mill equipment. His advertisement in the 1869 McAlpine's Halifax City Directory described his double carriage shingle mill which was used by twelve major saw mills in Ontario and Quebec but there were no clients in the Maritimes. An advertisement in an Ontario directory two years later mentioned saw mill engines, circular, muley, slabbing, board and deal gang saws as well as single and double edgers and other machinery.¹⁹

Grist mills were often the second industry to be established in a pioneer community. Milling grain to produce flour was a necessity for the diets of early settlers. Grist mills were local mills producing a fairly rough flour. The term flour mill implied a higher class of mill that used bolting and other processes to produce a higher quality flour. Some

flour mills were merchant mills which bought wheat from farmers to mill and export out of the region.²⁰ Wheat growing, and indirectly flour milling, were encouraged by the British system of preferential tariffs which allowed colonial flour to enter the UK below the standard tariff. John McCallum in Unequal Beginnings: Agricultural Development in Quebec and Ontario Until 1870 has shown how important the wheat staple was to the economy of Ontario by putting the profits from wheat sales into the hands of numerous small producers who in turn invested in local enterprises.²¹ The number of grist mills in Quebec which stood at 324 in 1827, more than doubled by 1861. Their number increased even more in succeeding decades as shown in Appendix 6.

As with sawmills, grist and flour mills constituted large markets for equipment. Almost all the foundries in central Canada produced machinery for them. In a Parks Canada report Felicity Leung compiled a list of suppliers of mill furnishings for Ontario grist and flour mills. The number of foundries, particularly in Ontario, which supplied everything from steam engines to bolting cloth was remarkable. Even foundries in quite small towns made millwork and milling machinery. It is quite evident that foundry and machinery building technology had diffused to the local level. Leung's list mentions all the Montreal

engine foundries from the Wards onwards as suppliers of mill furnishings.²²

Engine shops in Montreal produced turbines and millwork for flour mills as they did for saw mills. There are indications of other equipment that they supplied. William Burry was the founder most closely connected with flour milling. Besides producing the usual millwork and machinery in his Caledonia Foundry, Burry imported bolting cloth and French burr stone in order to make his own millstones. His partner and successor John McDougall maintained this tradition. An 1864 description of McDougall said "During the past ten years the Caledonia Works have furnished the machinery of numerous grist and sawmills in various parts of the country...". One of his major clients was the flour milling enterprise of A.W. Ogilvie & Co. and perhaps the other major milling companies along the Lachine Canal.²³ Both Brush and McDougall were building grain elevating machinery in 1864; Brush for the Cummings and Farish grain elevator on the Lachine Canal and McDougall a floating elevator for Kingston harbour. Bartley had already built a steam engine and grist mill for the Great Western Railway in Toronto previous to 1857.²⁴

The other staple industry for which at least two Montreal engine foundries supplied equipment was mining. In the mid

1860s the Eagle Foundry was providing ore crushers and stamp mills to the copper mines under development in the Eastern Townships of Quebec. In the 1880s it was building hoisting engines and centrifugal pumps for mines. In the 1869 Halifax directory, W.P. Bartley advertised "...stamp mills for quartz crushing and every description of mining machinery".²⁵

CANADIAN MANUFACTURING

The second most important contribution to Canadian development by Montreal engine foundries was the stationary steam engine. At first engines were often used to supplement water power but soon started to supplant waterwheels and turbines. The connection between Montreal foundries and stationary engines went back to at least 1823 when the Eagle Foundry built an engine for William Wilson's distillery in Montreal. Other Ward engines were for George Brouse in 1828 and for Thomas Molson sometime before 1835. Bennet & Henderson produced a stationary engine annually between 1831 and 1833 for T.B. Wragg, A. Ritchie and John Molson. The few details available on early Montreal built engines are presented in Appendix 2. G. Brush, J. Redmond and the St. Mary's Foundry continued the stationary engine tradition during the late 1830s and 1840s. The new

generation of founders of the 1850s were deeply involved in producing stationary engines, especially as their share of the marine engine market dropped.

By the second half of the nineteenth century, stationary engines were becoming crucial to industrial growth. Readily accessible water power sites were almost completely developed and the remaining ones were located far from the centres of production and consumption. The demand for power was greatest in urban areas where production was now entering the factory stage. Power requirements for large shops began to exceed even what water power could provide. When the Montreal rolling mill firm of Pillow Hersey & Co. needed to build a new rolling mill in 1872, it switched from water to steam power. From the U.S. census of 1880 it is known that steam powered rolling mills averaged 101 horsepower and water powered ones only 67 horsepower."

The recently released compilation of data from the Industrial Schedule of the 1871 Census provides interesting data on the comparative value of water and steam power in Montreal. The 142 steam powered establishments in the City of Montreal produced a total of 2559 horsepower for an average of 18.2 horsepower. However it should be noted that 62 percent of them used less than ten horsepower each. The three water power sites on the Lachine Canal produced 2305

horsepower which averages out to 57.6 horsepower per establishment. The total was a mere 254 horsepower less than all the steam power in Montreal. However the similarity ends there since steampowered industries employed 8500 more workers than waterpower and the value of products was \$12,000,000 greater for steam. These figures demonstrate that while waterpower was still a powerful motive force in Montreal, steampower had become a much more valuable commodity.²⁷

Boilers were important products of engine builders. They were a vital part of any steam engine system. Though steam engines generally lasted a long time, boilers did not since they were subjected to high temperatures, extremes of pressure, boiler scale and other strains.²⁸ Replacements kept boilermakers busy. Other functions for boilers were for heating and providing steam for industrial processes. There is little available on the boiler making activities of Montreal engine builders. McDougall's boiler making operations were listed separately in the 1871 census. His 35 employees made 180 tons of boilers and girders worth \$27,000.²⁹

Most foundries made simple tools and machinery that were widely used such as screw jacks, purchase blocks, windlasses, wagons and hand presses. Though not

sophisticated equipment, they were staple products of the foundry trade. Montreal engine foundries made this type of equipment but they were much more famous for their large and sophisticated machinery. This included steam powered pumps and presses, hoisting engines, elevators and hydraulic jacks.³⁰ The Novelty Works of Robert Gardner had a reputation for certain lines of equipment. He built hand tools and presses for the tobacco trade, book binding and letter copying press. His best known product was bakers and confectionary machinery such as biscuit cutters, cracker and candy machinery. These lines of equipment which Gardner started in the 1860s, were used all across Canada and some even went to Prussia.³¹

Through the activities of Montreal engine foundries it is possible to see the origins of what is now known as heavy engineering. This refers to the custom building of large machines and pieces of equipment. Engine foundries had the tools and techniques to fabricate large pieces of machinery from smaller wrought and cast iron components. The majority of these items were custom made rather than bought off-the-shelf. Previously cited examples of heavy engineering have been turbines and pumps for the Montreal waterworks and rollers for a rolling mill.³²

Manufacturers needing large pieces of equipment had three

NOVELTY WORKS,

ESTABLISHED 1850.

R. GARDNER & SON,

MONTREAL, P. Q.

Makers of every description of

Machinery, Steam Engines, &c., &c.

98a

TURNING LATHES

Of a superior quality,

Dark Mills,

SHAFTING, HANGERS,

MILL GEARING, &c., &c.

We also keep constantly on hand, and make to order,

Bookbinders' Presses, all sizes,

Improved Copying Presses,

Shoemakers' Relling Machines,

Patent Band Sawing Machines,

Patent Hand Drilling Machines,

Railway Hand Cars,

Turntables, Signal Switches, &c.,

AND EVERY DESCRIPTION OF

Railroad Work, Tobacco Shapes,

Presses, Knives, &c.,

FOR MANUFACTURERS

Sole Agent in Canada for

SOLID ENGLISH EMERY WHEELS.

For Saw Mills, Factories, Foundries, &c.

Steam Engines, Belting, &c., &c.

Having greatly increased our facilities, and constantly adding new Patterns to our already large stock, we are now prepared to execute all orders with promptness and dispatch.

Figure 9. The Novelty Works of R. Gardner & Son.
Advertisement from Lovell's Province of Ontario Directory
for 1871. p.18

choices: make the equipment themselves; order it from a speciality manufacturer, generally outside of the country; or have it custom made by an engine foundry. The first option was not generally feasible, especially if it involved castings. The second was expensive and slow. The third one was often preferred because the customer could generally consult with the foundry on the details. If a manufacturer was unsure of what was required, the foundries could often design it since many of them had drafting offices.

Machine tool building was part of the repertoire of engine builders. It was after all machine tools that turned a general foundry into one that could build engines. The extensive holdings of machine tools of the Eagle Foundry and Bennet & Henderson are listed in Appendix 1. By 1856 the foundries along the Lachine Canal had among them 30 lathes, 8 planing machines, 10 drill presses as well as trip hammers, pinching machines, shears and bolt cutting machines as shown in Appendix 3. The descriptions of their machine tools from the 1850s and 1860s are rife with adjectives including immense, monstrous and powerful. It is not clear how many of them were built in-house and how many were imported. A recently discovered 1857 inventory lists 19 of Gilbert's machine tools. Only three of them seem to have been Montreal made, two by Kinmond and one by Bartley. Gilbert is perhaps an exception since he is known to have

had a preference for English and Scottish lathes.³³

Though they did build the occasional machine tool, the engine foundries did not make them a regular line of business. A 1909 article on the history of machine tool building in Canada said "Miller Bros. and Bartley & Gilbert were old concerns who built a few machine tools but gave their energies to the construction of engines."³⁴ Robert Gardner was the only engine founder to produce a line of lathes and planers. R. Gardner & Son continued to build various types of lathes well into the twentieth century.³⁵ Because Montreal engine foundries were preoccupied with engine building, machine tool building fell to young specialized Ontario firms like McKechnie & Bertram of Dundas and Cant, Gourlay & Co. of Galt.

COMPETITORS TO MONTREAL ENGINE FOUNDRIES

Except in the field of engine building itself, Montreal engine builders always faced local competition. The earliest competitors were G. Warrick & Co.'s Phoenix Foundry (1815-1832) and the early St. Mary's Foundry (1820-1827). They supplied general castings and on occasion, components for engines.³⁶ Other competition came from the traditional haut fourneau of Quebec such as the Forges du Saint-Maurice.

Brass finishers' lathe, from an 1876 catalogue of R. Gardner & Son, Montreal, shows progress of machine tool design.

Iron planer from R. Gardner & Son. The company's primary field was bakers' machinery.

10 horse-power engine of 1876, described as "just the thing for small bakeries where steam power is required."

Figure 10. Machine Tools and Steam Engine Built by R. Gardner & Son. Illustration from Industrial Canada. Vol. 60, No. 1 (May 1967) p. 68. NA. C-137387.

They had a diversified product range making everything from pig iron and millwork to steel tools and railway wheels.

In 1827 there were two foundries in Montreal out of only four in Quebec. The industry started to grow in the 1830s and 1840s due to the rapid development of stove foundries.³⁷ By 1851 there were seven foundries in Montreal but there are no details on them in the census reports. For engine building there was one manufacturer, probably George Brush, employing 275 men and "3 factories of mill and steam machinery, 65 men employed".³⁸ By the mid 1850s there was a fully developed foundry industry in Montreal consisting of general, stove, brass and engine foundries.

The 1861 census revealed that there were twelve foundries of all types in Montreal with a capital of \$205,600, nearly 700 employees and products worth \$651,000 as shown in Appendix 5. However the distinction between engine and non-engine foundries was fairly close. The work of William Rodden's stove foundry has already been mentioned previously. Even closer to the work of the engine foundries was the Vulcan Iron Works of Alexander Fleck. He had come to Montreal from Scotland to work as a blacksmith in 1842. Gradually Fleck acquired additional resources and products. By 1864 he had pattern, moulding and blacksmith shops and a large, well developed foundry. The Vulcan Iron Works' products

consisted

chiefly of Fleck's patent improved Tyler waterwheels [turbines], machinery for flour and sawmills, running machinery...light and heavy forgings and castings of every kind.³⁹

Except for producing steam engines, Fleck did everything that engine foundries did. In 1869 Fleck moved his iron works to Ottawa.⁴⁰ The reasons for this move are not known but perhaps the Ottawa lumber market looked more promising. This is the only known example of a direct technological transfer from the Montreal foundry industry.

The census of 1871 made a distinction between Foundries & Machine Working and Engine Building. There were twelve foundries and three engine foundries in Montreal. Taken together their 1141 employees and \$979,175 of product far exceeded the 1861 Montreal foundry totals. Details from the 1871 census report are given in Appendix 5.

Machine shops independent of engine foundries were slow to develop in Montreal. Ezekel Cutter somehow did the turning work for John Molson's Accommodation in 1809. Others said to have "mechanical workshops" were James Herecourt in 1832 and William Kerr & John Bennet across the river in Longueuil in 1837.⁴¹ The building of wood working machine tools, as opposed to metal working ones, was started by the "engineer" Daniel Munro in 1843. He built planing, grooving and

tonguing machines as well as producing iron and brass castings. In the 1855 Paris Exposition Munro's machines won a second class medal.⁴² Other Montreal machanists of the era were: J.N. Walker, a machinist and printing press manufacturer active between 1842 and 1847; William Berry, a general smith, machine maker and later a sewing machine manufacturer working from 1848 to 1864 and Robert Gardner, an engineer and machinist before he acquired foundry facilities in the early 1860s.⁴³ There were undoubtedly other early machinists and machine shops whose names have been lost.

Throughout the 1850s founders, engineers and machinists were listed together in city directories. By the 1860s they started to be listed separately. According to the Canada Classified Directory for 1865-66 there were 29 individuals and companies listed as machinists in Montreal.⁴⁴ Six engine foundries were listed as well as a number of general foundries and other small equipment manufacturers. However there were also the names of newcomers who had established their own small machine shops. By this time machine tools and machinists had become common. Materials were also changing. Wrought iron bars, rods, angle iron and plates were readily available from hardware wholesalers. As the machining, forge welding and rivetting of wrought iron became more common, cast iron started to decline in

importance. It was no longer necessary to have a foundry to get into the iron working business. The replacement of cast iron became even more pronounced with the use of steel as a construction material. Eventually companies specializing in the new techniques such as Dominion Bridge Co. and Hamilton Bridge & Tool Co. displaced the engine foundries in heavy engineering.⁴⁵

As factories and industrial complexes grew larger and more sophisticated after mid-century, there was a need for in-house machinery construction and repair facilities. By 1856 some of the tool, nail and textile factories along the Lachine Canal had their own small machine shops equipped with lathes and drill presses.⁴⁶ The first enterprises to develop comprehensive machine shops were the railways. The Champlain and St. Lawrence Railroad did not have any repair facilities beyond those required for day-to-day maintenance. When the railway moved its terminus from Laprairie to St. Lambert in order to be closer to Montreal, it built the first comprehensive railway shops in the Montreal area. An 1852 article described a 150 X 90 foot engine house which could hold eleven locomotives and tenders, a machine shop 100 X 50 feet and a blacksmith shop 50 X 50 feet.⁴⁷ The St. Lawrence and Atlantic Railway was also preparing to build their shops in nearby Longueuil. However the Grand Trunk Railway, which soon controlled these two railways, decided

to consolidate maintenance facilities at Point St. Charles near the Victoria Bridge, then under construction. Starting off fairly small these shops were constantly being expanded and upgraded to take care of the ever growing number of engines and railway cars. Facilities to build cars were in place by the mid 1850s and locomotives by 1859."

ENGINE FOUNDRIES IN OTHER CANADIAN CITIES

Montreal engine foundries were not the only ones in Canada. Though Montreal was dominant in engine building in the 1820s and 1830s, engine foundries were starting to develop in other Canadian cities by the 1830s. These shops exhibited many of the same characteristics as Montreal's. Individual craftsmen set up small engine foundries in the 1830s and 1840s and were followed by newer and much larger competitors with extremely varied product line in the 1850s. Individual ownership continued to be the norm. Each major city had its own spectrum of general, stove, brass and engine foundries. The only major exception was foundries producing agricultural machinery which were far more numerous in Ontario than in other parts of Canada.

The foundry bases of major Canadian cities largely developed independently of each other. On the ownership level, the

only direct transfer of Montreal foundry technology to another city was by Alexander Fleck, though there was a continual interchange of skilled craftsmen.⁴⁹ In Ontario there was a migration of foundry technology as second generation founders left the established foundries around Lake Ontario and moved inland to establish new ones. This section will look at some of the notable engine foundries in Quebec, Ontario and the Maritimes.

Quebec City was certainly more famous for its wooden shipbuilding than for its engine building. The first Quebec foundry was the Tweddell Foundry opened in 1830. However it was still the Montreal engine builders who supplied the engines for Quebec built steamboats and ferries. James Tibbets (1804-1890), a timber merchant from New Brunswick, was impressed enough by Quebec's potential that he established a shipyard and engine foundry at Point Levis, across the river from Quebec City, in the late 1840s. This prompted his relative Benjamin F. Tibbets (1818-1853) to move to Quebec. He had already designed and built the Reindeer, the first vessel with a compound steam engine in Canada. Together the two Tibbets built five steamers including engines in the early 1850s.⁵⁰ Carrier, Laine & Co. of Levis, established in 1863, became renowned for their marine and stationary engines.⁵¹

In Upper Canada, Kingston was a major shipbuilding centre on Lake Ontario from the War of 1812 onwards. By 1857 the city had a sizeable foundry industry. Of the five foundries there, three produced marine and stationary engines and a fourth was manufacturing locomotives.⁵²

The Niagara Harbour and Dock Company, established at Niagara-on-the-Lake in 1831, had the most impressive early shipyards and engine foundry complex in Upper Canada. The first steamboat was built in 1835 and was followed by another twenty more plus four others at a subsidiary yard at Chippawa. Most of its steamers were passenger vessels, a few were steamers capable of being used as naval vessels by the Canadian government as well as three propeller schooners and the first iron hulled vessel on the Great Lakes in 1847. The company also manufactured six engines for vessels built elsewhere. Also of importance were ten stationary engines, each between five and twenty horsepower, built between 1832 and 1845. The foundry superintendent was John Lowe who had helped build the engines of the Royal William for Bennet & Henderson. A series of bankruptcies of the owners of the Niagara Harbour and Dock Co. in the late 1840s and early 1850s kept the company's facilities under-utilized. Eventually the foundry became the Niagara Car Works in 1854.⁵³

The first steam engines built in Toronto were not the products of an engine foundry. In March 1831 Charles Perry, a blacksmith, unsuccessfully petitioned the Legislative Assembly of Upper Canada for a premium for constructing the first steam engine in Upper Canada. Unfortunately there were no details available on the engine. The next year Perry was advertising the "York Steam Engine Works" which was ready to build high or low pressure marine and stationary engines. From his blacksmith/machine shop Perry built four stationary engines, two for sawmills, one for Gooderham and Worts' grist mill and an engine to supply furnace blast for the Union Furnace Co. The second engine building company in Toronto was the York Foundry and Steam Engine Manufactory of Sheldon Dutcher & Co. By May 1833 the company had a ten horsepower engine to work its seven lathes, boring machine, drill press and other machinery. It had 30 workers employed in more than ten different shops building two engines each for the Cobourg and John By plus a twelve horsepower engine for the Niagara Dock and Harbour Co. One of the reasons for its demise in December 1836 was the poor quality of its engines.⁵⁴

The Hamilton area had numerous foundries started by American founders moving northwest from New York State. Their principal product was stoves and eventually Hamilton became the stove capital of Canada. In 1882 stove foundries

employed 600-700 men using 9,000 tons of iron to cast 25,000 stoves which were sent to all parts of Canada.⁵⁵

Scottish millwrights/founders were also prominent in the region. The most important one was John Gartshore (1810-1873). Born in Scotland, he came to Canada in 1833. After trying his hand at various ventures, he started a foundry at Dundas, twelve miles north of Hamilton in 1838. The Dundas Iron Foundry and Machine Shop built millwork for grist and sawmills and later moved into stationary and portable engine building. It also built boilers, millstone machinery, storage tanks, water pipes and railway wheels. The foundry's most famous product was the twin pumping engines for the Hamilton Waterworks built in 1857-1859. These compound engines had double 30 foot long walking beams, each weighing 25 tons. Still intact and one of them working on summer weekends for tourists, these engines are an impressive testament to Gartshore's knowledge and skill.⁵⁶

Gartshore is also noted for training a whole generation of founders who went on to dominate the Ontario foundry industry in the late nineteenth century. Gartshore's successor, Thomas Wilson (1829-1891) started off as an apprentice machinist and worked under Gartshore for 25 years before purchasing the shops in 1870. Under Wilson, the shops retained their high reputation. Even more famous

workers were Robert McKechnie (1834-1909) and John Bertram (1829-1906). In 1863 they formed McKechnie & Bertram to produce first woodworking machine tools and later metal working ones. Known as John Bertram & Sons after 1886, it became the leading manufacturer of machine tools in Canada.⁵⁷

With Confederation in 1867 Nova Scotia and New Brunswick became part of Canada. The two maritime provinces already had a well established foundry industry which undoubtedly helped minimize foundry competition from central Canada. Saint John NB was a major centre of foundry production. George Fleming (1801-1887) was working in Saint John's first foundry in 1834 and by 1860 he owned it. Like many others, the Phoenix Foundry had a diversified product line.

...this establishment has been largely employed in building marine and stationary engines. The first low pressure marine engine ever built in this city was from these works for the Carleton ferry boat and two-thirds of all built in the Province, have been done here...and a large number of mill engines.

They have built a number of first class locomotives for the Intercolonial and Western Extension railways and more recently they have executed a large amount of mining machinery...

The New Brunswick Foundry of James Harris (1803-1888) was even larger because it had a rolling mill in addition to complete foundry, blacksmith and machine shops. The rolling mill enabled the foundry to do a great deal of railway

work.⁵⁹

The first successful steam engine in Nova Scotia was erected by the General Mining Association at Albion Mines, now Stellarton, NS in 1827. By 1838 eight stationary and three marine engines were producing 280 horsepower. W.H. Davies, who had been hired as the superintendent of the Albion Mines Foundry, was responsible for building several of these engines. In 1855 Davies moved to Pictou, NS to start the Pictou Iron Foundry. Besides manufacturing castings for mines, ships and railways, it produced five stationary engines from 1856 to 1860.⁶⁰

In 1852 Thomas Mitchell started the Chebucto Foundry in Halifax. This general foundry was taken over in 1860 by William Montgomery (fl. 1820-84) and renamed the Nova Scotia Iron Works. The new enterprise was ready to build stationary and marine engines, boilers, millwork, sawmill and mining equipment. By 1870 Montgomery "...constantly kept on hand **Steam Engines** of 6, 7, 8, 9, 10, 12 and 14 inch cylinders with boilers to suit." In 1871 Montgomery won an order for ten Intercolonial Railway locomotives. In trying to build them, Montgomery over-reached himself and went bankrupt in January 1874.⁶¹

SUMMARY

Montreal engine foundries made significant contributions in several fields. The most important one was building engines for steam vessels, especially from 1820 to the 1840s. Even afterwards the foundries continued to build numerous engines. Their contribution to railway development, consisting mainly of fabricating and repairing components, was less significant. The foundries were major suppliers of equipment to flour and sawmilling, the two major industries of mid-nineteenth century Canada.

From having almost a virtual monopoly on engine production in the 1820s, Montreal engine foundries suffered increasing competition. Montreal general and stove foundries gradually acquired the facilities and techniques that allowed them to compete with engine foundries. However engine foundries, because of the large size of their product, remained substantial enterprises. From a look at other foundries in Quebec, Ontario and the Maritimes, it is evident that Montreal firms were not substantially different from those in other parts of the country. It is also noticeable that each city had an unique spectrum of foundries to serve its particular needs.

CONCLUSION

Montreal engine foundries played a key role in the technological evolution of central Canada. When engine foundries were first established in Montreal, there was almost no machinery in the country other than early grist mills, a few sawmills and the Forges du Saint-Maurice. By the 1870s, steam-based technology had become dominant in water and long distance land transportation and a developing force in resource extraction and manufacturing. A large amount of this progress can be attributed to Montreal's engine foundries. Based on the preceding research it is possible to develop some generalizations relating to Montreal engine foundries.

The first engine builders in Montreal were largely American, notably Joseph Lough, the Ward brothers and George Brush. The British tradition was represented by John Bennet and William Parkyn. Scottish founders did not arrive until around 1850. Though they were important to the development of the Canadian foundry industry, Robert Gardner was the only Scottish-trained Montreal engine founder. By 1850 a native-born generation of founders had developed including E.E. Gilbert, W.P. Bartley, A. Cantin and the Redmonds.

The only francophone to have an engine foundry in Montreal was Augustin Cantin. Though there were other francophone founders and shipbuilders, Cantin was the only one to combine engine founding with shipbuilding. Anglophone founders had fairly easy access to the larger Anglo-American world for training, new technology and skilled workers. As Tulchinsky explains for francophones to make similar contacts was an almost insurmountable handicap.¹ Cantin's training in New York shipyards may be one of the reasons why he was able to gain access to this world. Montreal engine founding confirms the stereotypical view of Montreal business and industry being dominated by anglophones.

Engine building required large amounts of capital. Engine foundries were among the very largest of industrial enterprises with shops filled with large and expensive machinery and employing up to several hundred workers. The trade was also closely tied to the cyclical markets of shipbuilding and internal trade. Some founders, such as the Wards, the Redmonds and John McDougall, were able to raise their own capital by hard work, making profitable deals and reinvesting their profits. Others, who were not so lucky, needed the help of large merchants. Three examples will suffice. The bankrupt Bennet & Henderson foundry was bought by the Molsons who owned St. Mary's Foundry until 1852. The

hardware importers Frothingham & Workman and Brewster & Mulholland backed a number of engine foundries.²

Montreal merchants realized the value of value of improving the St. Lawrence River transportation system. Many of them invested in shipping ventures, and later in railway companies. Merchants realized the necessity of investing in transportation ventures if they were to maintain their hold on their hinterland. A smaller number of merchants appreciated the potential value of manufacturing. The involvement of merchants in these activities has been well described by Tulchinsky in The River Barons. Montreal merchants seemed to be ahead of those in Saint John NB who chose to stay with lumbering and shipbuilding even when there were clearly in decline.³

It is no accident that hardware importers and wholesalers were behind several of Montreal's foundries. From the 1820s onwards this group realized that they could develop secure sources of supply and make larger profits by manufacturing their own products. They created backwards linkages by acquiring and creating foundries, hardware, tool and nail factories.⁴ The consequences of their support of engine foundries had both positive and negative effects. Foundries benefitted since they could obtain cast and wrought iron at wholesale prices. Also the hardware merchants' network of

hardware stores throughout central Canada acted as conduit for orders for turbines, engines and equipment. It also meant that major foundries did not go bankrupt and close down. In spite of the failure of the Bartley, Gilbert and Cantin foundries in the late 1850s, none of them closed, though Bartley and Gilbert were forced to amalgamate temporarily and Cantin eventually lost some of his facilities.⁵ It appears that these facilities were so important to Montreal's needs that they not allowed to close. In this case it could be said that foundry facilities and skills were more important than credit and financial solvency.

On the negative side, merchant control probably interfered with the continued development of the engine foundries. This situation would have limited the ability of engine builders to determine which areas of production to get into, what additional facilities and equipment to acquire or how much to re-invest in their company. As a client-producer, many financial options were closed to the founder such as creating a joint-stock company. More research is needed to see if there were significant differences between the independent engine foundries and which who were merchant controlled.

There have been numerous studies of large merchants in

Britain, the United States and Canada. The merchants' wealth, power and status make them natural subjects for research. Their involvement in transportation enterprises, and to a lesser extent in early industries, has been documented.⁶ However there is very little information available on early Canadian manufacturers. It is unfortunate that the manufacturer/mechanic is not given more credit for his substantial contribution. It was not the merchant or his capital that produced goods but the knowledge and skills of the manufacturer. In comparison to other countries where there is knowledge and appreciation of early manufacturing, Canada lacks this basic knowledge. There is not one book on the history of Canadian manufacturing and even the names of early industrialists have been forgotten. There is a great need for more information on the history of the productive base in Canada.

From the available evidence it seems that engine foundries were organized around the engine founder/owner. It was his skill, knowledge and coordination that allowed the foundry to function. In spite of the large size and numerous specialized shops, it was the master engine founder communicating directly with his skilled employees which enabled the system to function. In these artisanal shops there were no non-technical supervisors nor a specialized managerial group. Engine foundries had incorporated new

technologies but still used pre-industrial forms of management. The establishment of engine foundries predated the system of management that railways started to develop in the 1850s.' The lack of a system of management control meant that a foundry could not establish branches in other cities. There was also a serious possibility that a foundry would go into decline as its owner got older. Indeed the Bartley and Gilbert foundries closed when their owners died.

Few engine foundries in Montreal were taken over by the sons of the original owner, the exceptions being the sons of John Redmond, George Brush and Robert Gardner. From what is known, there was little direct formal diffusion of technology from Montreal engine foundries to other centres in Canada. No founders relocated to other cities except for Alexander Fleck who moved to Ottawa in 1869. The sons and skilled employees did not set up their foundries either. This is different from the Ontario experience where the sons and senior employees left the established foundries around the lower Great Lakes and moved further inland to establish their own shops. Examples of this process are Elijah Leonard Jr. (1814-1891) who moved from the family foundry in St. Thomas, Ont. to London in 1840. There he established a general foundry which eventually specialized in engines. A later immigrant to London was William M. Gartshore (b.1853),

a son of John Gartshore of Dundas, who became superintendent of the London Car Wheel Works in 1873. Three years later he became manager of the John McClary stove foundry in that city. Charles H. Waterous (1814-1892) left his bankrupt foundry in Buffalo, NY to establish another one in Brantford in 1848.⁶ This process did not happen in Montreal.

Were Montreal engine foundries examples of entrepreneurial failure because they did not develop a management system? If the overall life-cycle and contributions of engine foundries are considered, then their failure to develop a corporate management system becomes a relatively small point. Engine foundries were responsible for a considerable number of contributions. They were among the first large multi-disciplinary industrial enterprises and they integrated three important metal working functions, casting, forging and machining. Montreal's first engine foundry in 1820 came only 25 years after Boulton & Watt's Soho Foundry, the first in the world, and 13 years after Oliver Evan's Mars Works. Starting as small artisanal shops in the 1820s, both the Eagle Foundry and Bennet & Henderson became large operations by the following decade. The pattern had been set; besides building marine and stationary engines, they also made equipment for saw and grist mills, standard industrial equipment and custom built machinery. By mid-century their product range was enormous, consisting of cast

iron pipes, valves, grain elevator machinery, turbines, pumps, light and heavy castings as well as numerous types of marine and stationary engines. They worked in iron, steel, brass, copper and other metals.

Engine foundries were fairly conservative in their outlook, in part because of the nature of the technology itself. Patterns, the life blood of any foundry, represented a type of capital. Once a manufacturer had a pattern made at a foundry, he would invariably return to the same foundry to have the part cast there again. Over the years engine builders accumulated great stocks patterns. One description of the Eagle Foundry in 1868 mentioned with awe George Brush's 45 year collection of patterns valued at \$20,000." This type of capital would tend to inhibit radical departures from the norm. There were few major innovations by Montreal engine builders. Instead their success came from adopting foreign innovations to Canadian conditions. The first use of the Corliss valve outside of the U.S. by Gilbert in 1859 is a good example. Contrary to the pattern of development in other North American cities, Montreal engine foundries did not get into locomotive building. It is not known whether this decision was due to a very cyclical market, order books that were already full or merchant backers who did not want to invest additional funds. However, given the poor showing of other Canadian

foundries building locomotives, perhaps the Montreal builders were wise to avoid getting into this field.

Starting out as generalists, the engine foundries essentially remained nonspecialist manufacturers, producing something for everybody. By the 1870s however, it was noticeable that newer, more specialized firms were beginning to invade the traditional markets of engine foundries. Machine tool builders, boiler makers, machine, structural steel and heavy engineering shops were their new competitors. One of the reasons why engine foundries went into decline was that many of their specialities became separate trades. There was also an associated change in materials technology. The gradual shift from cast to wrought iron and later to steel meant that it was possible to do ironwork without the use of a foundry. Standard sized wrought iron bars, rods and plates, readily available from hardware merchants, helped make this trend possible. By remaining generalists, the engine foundries put themselves at risk when specialized manufacturers developed later in the century.

One of the continuing questions in Canadian history is the nature of the staple trade. For much of the nineteenth century the export of staple products such as timber, wheat and minerals and the importation of processed goods

dominated the Canadian economy. There is a continuing debate over the implications of this type of economy. The case of Montreal's engine foundries provides some insight into this question.

Much of the production from engine foundries went into the staple trade. Marine engines for steamboats were vital to the improvement of transportation. This improved the importing of manufactured and processed goods and the distribution of supplies. It also greatly improved communication which was vital to the efficient running of business such as lumbering which was often spread over a wide a geographic area. The engine foundries also contributed to the growth of railways which had an even more profound effect on Canadian transportation. Sawmilling equipment, such as sawmill carriages, shingle machines as well as mill engines to run entire complexes came from the engine foundries. Equipment for grist and flour mills was also a prominent product. These products definitely contributed to the exploitation and export of Canada's resources.

It is too simplistic to say that engine foundries serviced only staple industries. Instead they had a broader impact. The building of stationary engines served both the staple and manufacturing industries. From almost the beginning the

foundries built engines for breweries, distilleries and water pumping purposes. The building of engines for manufacturing purposes became predominant after 1850. As demonstrated by the 1871 Census steam power had become dominant in Montreal manufacturing. It has been asserted that the staple economy created little in the way of industrial diversification.¹⁰ Overall this is probably correct but engine foundries should be considered an exception. Created originally to serve the staple trade, they also served Canadian manufacturing in numerous ways.

Another preoccupation of historians is the role of the state in the development of the Canadian economy. Considerable attention has been devoted to the impact of MacDonald's National Policy of 1879. However this is not the first instance of tariff protection of Canadian industry. The Galt-Cayley tariff of 1857 and its revision in 1859, though ostensibly to provide revenue for the Province of Canada, gave protection to Canada's nascent industrial base.¹¹ In 1864 both Brush and Redmond mentioned that their steam engines were cheaper than imported American ones because of a twenty percent tariff.¹²

A second, though generally unrecognized, contribution of the Province of Canada was the provision of surplus canal water as water power. First started as a method of raising

revenue to pay for the reconstruction of the Lachine Canal, the leasing of surplus water became standard on the other St. Lawrence Canals. Though it caused problems for the shippers, canal water power was an important stimulus for industrial development.¹³ Three Montreal engine foundries used this power and all of them benefitted from easy access to canal shipping. Though not a major factor, the government provided some stimulation and protection to engine foundries.

These foundries should be seen as an important node of technological skill in Canada. The engine foundries had an impact on many diverse areas of the Canadian economy. It was not only the products, but also the skills and technical knowledge that foundries contributed to Canada. This country did not have the centres of technological development that Britain and the United States did. Britain, like Canada, had foundries and engine builders to train mechanics and promote mechanical development. It also had a textile machinery business which was a fertile training ground. As well a large military complex stimulated industrial development. The case of the United States is similar to that of Britain. Early American textile developments stimulated inventors, machine shops and the construction of large New England mill towns, each with its own machine shop to produce the necessary textile

equipment. These shops later turned out locomotives, fire engines, turbines and other products.¹⁴ The need of the U.S. government for small arms and cannon led to the creation of a military-industrial complex. It was the American government which underwrote the cost of developing the interchangeable principal for small arms production which eventually revolutionized manufacturing.¹⁵

In Canada the situation was different. As a colony, Canada obtained its military equipment from Britain. The first arsenal to manufacture ordinance was in Quebec and established only in 1878.¹⁶ Canada's textile industry had a slow development with the first woollen mills developing in the 1830s and cotton mills coming a decade later. By this time the basic principles of textile manufacturing had already been established and Canada imported its machinery from abroad.¹⁷ Where did mechanical skills develop in Canada? A tentative conclusion is that they originated in engine foundries such as those in Montreal. More research is needed to determine to what degree skilled employees left Montreal engine foundries to work in machine shops and companies manufacturing turbines, machine tools or other machinery. Did railways, the other wellspring of technical development in Canada, also get workers and techniques from engine foundries? In their ground breaking study Craven and Traves discussed the size of railway shops in relationship

to central Canadian engine foundries. One also has to look not only at the work done by the foundries for the railways but also the possible transfer of skilled craftsmen and techniques from the engine foundries.¹⁸

CHAPTER ONE: ENDNOTES

1. There is a very large literature on the iron industry, especially in Britain. One of the major works is: H.R. Schubert. History of The British Iron and Steel Industry, from c. 450 B.C. to A.D. 1775. (London: Routledge & Kegan Paul, 1957). A very useful modern source which critically integrates previous scholarships is Charles K. Hyde. Technological Change and the British Iron Industry, 1700-1870. (Princeton: Yale UP, 1977).
2. Hyde. pp. 10, 127
3. Ibid., pp. 40-41. For information on the Darbys, see Arthur Raistrick A Dynasty of Iron Founders. (London: Longmans, 1953). It is interesting to note that while Darby did not patent the use of coke in blast furnaces, he patented his moulding technique and kept it under great secrecy.
4. Hyde. p. 128.
5. Eugene S. Ferguson. "Metallurgical and Machine Tool Developments" in M. Kranzberg & C. Pursell Technology in Western Civilization. Vol. 1. (N.Y.: Oxford UP, 1967), p. 267.
6. H.R. Schubert. "Iron and Steel" in C. Singer et al. A History of Technology. Vol. 4 (Oxford: Oxford UP, 1958), p. 10.
7. W.K.U. Gale. The British Iron & Steel Industry. (Newton Abbott: David & Charles, 1967), pp. 51-2.
8. C. McCombe "The Early Development of Iron Founding in North West England" Foundry Trade Journal. 21 June 1984, p. 565; Owen Ashmore. The Industrial Archaeology of Lancashire. (Newton Abbott: David & Charles, 1969), p. 83. In spite of the voluminous literature on the British iron and steel industry, there is almost nothing on the evolution of the cast iron foundry.
9. L.T.C. Rolt. James Watt. (London: Batsford, 1962), p. 15.
10. L.T.C. Rolt. Tools for the Job: A Short History of Machine Tools. (London: Batsford, 1965), pp. 50-51.
11. Rolt. James Watt. pp. 123-25.

12. Jennifer Tann. The Selected Papers of Boulton & Watt. Vol. 1 (Cambridge, Mass. MIT Press, 1981), pp. 8-9.
13. Ibid., pp. 45.
14. Ibid., pp. 45-46.
15. Rolt. Tools for the Job. pp. 67-77.
16. A.E. Musson & E. Robinson. "The Origins of Engineering in Lancashire" in A.E. Musson & E. Robinson. Science and Technology in the Industrial Revolution. (Manchester: Manchester UP, 1969), pp. 427-458.
17. A.E. Musson. "An Early Engineering Firm: Peel, Williams & Co. of Manchester" in Ibid., pp. 459-72.
18. Standard works on the American iron industry include: James M. Swank. A History of the Manufacture of Iron in all Ages and Particularly the United States... (Philadelphia: American Iron and Steel Assoc., 1892); Peter Temin. Iron and Steel in Nineteenth Century America: An Economic Inquiry. (Cambridge: Harvard, 1964) and David W. Lewis Iron and Steel in America: A Brief History. (Wilmington: Hagley Museum & Library, 1976). An account of the first iron works in the United States is: Edward N. Hartley. Ironworks on the Saugus: The Lynn and Braintree Ventures of the Company of Undertakers at Ironworks in New England. (Norman: University of Oklahoma, 1957).
19. Two works on the history of American foundries are: Bruce L. Simpson. History of the Metal-Casting Industry. 2nd Ed. (American Foundrymen's Society, 1969) and Clyde A. Sanders and Dudley C. Gould. History Cast in Metal: The Founders of North America. Vol. 1 (Cast Metal Institute/American Foundrymen's Society, 1976). Most books on American iron and steel either do not deal with iron foundries or just mention them in passing.
20. Sanders and Gould. pp. 24, 75-76.
21. (New York) Daily Advertiser. 17 Oct. 1787. Quoted in Sanders and Gould. p. 173.
22. Ibid., p. 24.
23. Simpson. p. 191; Sanders and Gould. p. 172.
24. Ibid., pp. 172-78.
25. Carroll Pursell Jr. Early Stationary Steam Engines in America: A Study in the Migration of Technology. (Washington:

Smithsonian Institution, 1969), p. 28-32.

26. Ibid., p. 73.

27. Ibid., pp. 31-32.

28. Ibid., p. 47; Eugene Ferguson. Oliver Evans: Inventive Genius of the American Industrial Revolution. (Wilmington: Hagley Museum & Library, 1980), pp. 45-46.

29. Pursell. p. 51.

CHAPTER TWO: ENDNOTES

1. The traditional description of the role of Montreal in the early nineteenth century is in Donald Creighton. The Empire of the St. Lawrence. (Toronto: Macmillan, 1956) especially Parts II and III.
2. J.P. Bernard, P.A. Linteau et J.C. Robert. "La structure professionnelle de Montréal en 1825" Revue d'Histoire française d'Amerique. Vol. 30, No. 3 (dec. 1976) pp. 383-411.
3. See the numerous reports by Parks Canada including: Andre Bérubé. "Rapport préliminaire sur l'évolution des techniques sidérurgiques aux Forges du Saint-Maurice, 1729-1883" MRS 221 (1976), Serge Saint-Pierre. "La technologie artisanale aux Forges du Saint-Maurice, 1729-1883" MRS 307 (1976) and Johanne Cloutier. "Répertoire des produits fabriqués aux Forges du Saint-Maurice" MRS 350 (1980).
4. The main source of information on the Accommodation is the account books in the Molson Archives at the National Archives of Canada (hereafter NA) MG 28, III 57, vol. 44, 46, and 48. The best known secondary source is Merrill Denison. The Barley and the Stream: The Molson Story. (Toronto: McClelland & Stewart, 1955) pp. 57-73.
5. See the Fulton biography in the Dictionary of American Biography. (DAB) Vol. 7, pp 68-72; James T. Flexner. Steamboats Come True: American Inventors in Action. (N.Y.: Viking, 1944). See also Pursell. Early Stationary Steam Engines. in passim.
6. Denison. pp. 60-61.
7. Ibid. pp. 62-63.
8. François J. Audet. Les Députés de Montréal. (Montreal: Les Editions des Dix, 1943) pp. 86-87; Robert Campbell. A History of the Scotch Presbyterian Church, St. Gabriel Street. (Montreal: W. Drysdale, 1897) p. 234.
9. Denison. p. 63; George H. Wilson. "The Application of Steam to St. Lawrence Valley Navigation" (McGill University, MA Thesis. 1961) Appendix 1, pp. 255-257.
10. Denison. p. 64; Wilson p. 253.
11. Archives nationales de Québec à Montréal (hereafter ANQ-M). Greffe de Henry Griffin, No. 5097, 11 Mar. 1834; No. 5486, 27 Dec. 1824 and No. 7579, 21 Dec. 1827.

12. Molson Archives. Vol. 44. pp. 115 and 215 for cylinder; pp. 218 and 221 for air pump and Vol. 46 p. 86 for iron spindle. For the iron hoop see Wilson. Appendix A, p.256.
13. A review of the literature about the Forges du Saint-Maurice has failed to reveal any references to a boring mill.
14. Rolt. Tools for the Job. pp. 49-50.
15. Personal communication from Walter Lewis, Apr. 1988.
16. Denison. p.80.
17. Jennifer Tann and M.J. Brechin. "The International Diffusion of the Watt Engine, 1775-1825" Economic History Review. Vol. 31 (1978) p. 563.
18. Birmingham Public Library. Boulton & Watt Papers. Letter Book: Office Vol. 35, pp. 79, 172 and 216. My thanks to Prof. Jean Belisle of Concordia University, Montreal, for allowing me to consult his notes on the Boulton & Watt Papers.
19. Ibid. Letterbook: Office, Vol. 35, p. 239, 9 April 1812.
20. Ibid. Letter Book: Office, Vol. 35, p. 172; Wilson p. 233.
21. Wilson. pp. 60, 234-5.
22. Boulton & Watt Papers. Order Book: Foundry Vol. 344 (taps, dies, wrenches) and Letter Book: Office Vol. 40, p. 86.
23. Wilson. p. 263.
24. Ibid. pp. 63, 95-96; Walter Lewis: "Fire on the Water: The First Generation of Marine Engines in Central Canadian Steamers, 1809-1837" Unpublished Canadian Historical Association Paper, 1986. pp.19-20. A slightly modified version of this paper has been used.
25. Ibid. pp. 21-22; Gerald J.J. Tulchinsky. The River Barons: Montreal Businessmen and the Growth of Industry and Transportation, 1837-1853. (Toronto: University of Toronto Press, 1977) pp. 212-215. A recent authoritative article on Ward and the Eagle Foundry is Walter Lewis. "The Ward Brothers, George Brush and Montreal's Eagle Foundry" FreshWater. Vol. 4 (1989) pp. 29-33.
26. DAB. Vol. 5, pp. 339-40.

27. Ross Ogden. The Steamboats of Lake Champlain, 1809-1930. (Burlington, Vt.: Champlain Transportation Co., 1930) pp. 30-47.
28. Ward Family Papers. NA. MG 24, D 19, Vol. 1, p. 18, 24 Dec. 1819.
29. Ibid. pp. 21-22.
30. Brush, George. Dictionary of Canadian Biography. (DCB). Vol. 11, pp. 120-21; Lewis. "The Ward Brothers, George Brush and Montreal's Eagle Foundry" p. 31.
31. Lewis. "Fire on the Water" p. 20.
32. Wilson. p. 232.
33. Lewis. "Fire on the Water" p. 20.
34. Henderson may have been the "business" partner who contributed capital to the firm.
35. Lewis. "Fire on the Water" p. 20.
36. Ibid.
37. "Gray, John" DCB. Vol. 6, pp. 296-97.
38. Peter Lowe Papers. NA. MG 24, D 64. Lowe became head of the foundry of the Niagara Harbour and Dock Co. and later superintendent of Niagara Car Works at Niagara-on-the-Lake. See Bruce A. Parker. "The Niagara Harbour and Dock Company" Ontario History. Vol. 72, No. 2 (June 1980) p. 98.
39. Archibald Campbell. "The Royal William: The Pioneer of Ocean Steam Navigation". Literary and Historical Society of Quebec Transactions. Vol. 20 (1889-1891) pp. 31-62.
40. ANQ-M. Griffin no. 3884, 2 Jan. 1835.
41. Lewis. "Fire on the Water" pp. 20-21; Montreal Daily Witness. 20 Mar. 1897. p. 13.
42. Denison. p. 157.
43. Wilson p. 249; Lewis. "Fire on the Water" p. 21.
44. J.D. Borthwick. Montreal - Its History, to Which is Added Biographical Sketches... (Montreal: Drysdale, 1875), p. 109.

45. The Ward brothers built the engines for the Iron Duke. Robert R. Brown. "The Champlain and St. Lawrence Railroad". Bulletin of the Railway and Locomotive Historical Society. (1936) pp. 22-23.
46. Borthwick. Montreal - Its History. p. 109.
47. Wilson. pp. 32-54 in passim.
48. Robert W.S. MacKay. Montreal Directory for 1842-3. (Montreal: 1842) p. 222. Kerr's name appeared until 1847.
49. See Canadian Economist. 8 August 1846.
50. Lewis. "Fire on the Water" pp. 15-16.
51. The low pressure marine engine, first built by Boulton & Watt, is described in almost all the histories of steam engines and marine engineering. Of relevance to North America is Robert M. Thurston. A History of the Growth of the Steam Engine (Ithica, N.Y.: Cornell, 1879, 1939) and Louis C. Hunter. Steam Power: A History of Industrial Power in the United States, 1780-1930. Vol. 2 (Charlottesville, Va: University Press of Virginia, 1985). For the Canadian experience see James Croil. Steam Navigation and Its Relationship to the Commerce of Canada and the United States. (Toronto: William Briggs, 1898, 1973) and Lewis "Fire on the Water".
52. The high pressure noncondensing steam engine was invented by Richard Trevithick of Britain and by the American Oliver Evans at almost the same time (1803-4). However it was Evans who first applied the engine to marine engineering. For accounts of Evans and his engine see: Ferguson. Oliver Evans. and Hunter. Steam Power. For the development of the classic American riverboat consult Louis C. Hunter. Steamboats on the Western Rivers: An Economic and Technological History. (Cambridge; Harvard, 1939, 1967). The use of high pressure engines in Canada is described in Croil. Steam Navigation and Lewis "Fire on the Water".
53. Robert Fulton imported Boulton & Watt components for the Clermont in 1805-6 and John Molson imported the Swiftsure's engine in 1811.
54. Jean Belisle's notes and photocopies on the Boulton & Watt Papers.
55. Correspondence relating to vessel construction and operation is in Molson Archives. NA. MG 28, III 57 vol. 13. The steamboat accounts are in vol. 44-48.

56. See the annual reports of the Comité d'histoire et d'archéologie subaquatique du Québec. Le projet Molson. from 1985 onwards.
57. Lewis "Fire on the Water" p. 3-4.
58. John Ward went to England in 1829 at the same time Samuel was in Washington and Philadelphia. Ward Family Papers. pp. 56-60.
59. Tulchinsky. The River Barons. p. 214.
60. Lewis. "Fire on the Water" pp. 21, 31.
61. Ibid. p. 39; K.T. Rowland. Steam at Sea: A History of Steam Navigation. (N.Y.: Praeger, 1970). p. 70.
62. Lewis "Fire on the Water: p. 8.
63. ANQ-M. Greffe de G.D. Arnoldi, no 3884, 2 Jan. 1833 (Bennet & Henderson) and N.R. Doucet, no 25796, 31 Dec. 1838 (Eagle Foundry).
64. J.A. Cantrell. James Nasmyth and the Bridgewater Foundry: A Study of Entrepreneurship in the Early Engineering Industry. (Manchester: Chatham Society, 1984) p. 184.
65. Montreal Gazette. 7 May 1833.
66. Lewis. "Fire on the Water" p. 116. This includes 91 new engines and 18 reused ones.
67. David R. Dyck. "Loggers at Moose Factory: The Company Diversifies" The Beaver. (Feb.-Mar. 1991) pp.31-34.
68. Boulton & Watt Papers. Plans for a engine and boiler for John Molson Esq., 14 Aug. 1811. My thanks to Jean Belisle for this information. See also Wilson. p.247.
69. Goudie, James DCB. Vol. 6, p. 291; A.J.H. Richardson. "Indications for Research in the History of Wood-Processing Technology" Assoc. for Preservation Technology APT Bulletin. Vol. 6, No. 3 (1974) p. 89; Denison. p. 153.
70. ANQ-M. Griffin. no 4729, 4764, 4771 and 4800, 11 June to 10 July 1823. Notes from files of Montreal Business History Project, McGill University.
71. Felicity L. Leung. "Grist and Flour Mills in Ontario: From Millstones to Rollers, 1780-1880" Parks Canada, MRS 201, 1976. Appendix A, p. 283; Ward Family Papers. 1 February 1829 pp. 52-5; Denison pp. 145, 161.

72. ANQ-M. Griffin. no 9,434, 1 July 1831 (Wragg engine); no 9,669 19 Jan. 1832 (Ritchie engine); no 10,851, 20 Apr. 1833 (Molson engine) and Arnoldi. no 3884, 2 Jan. 1835. Unfortunately there is no information on the engines produced by the foundries for their own use, other than that the Bennet & Henderson engine and accessories was worth £700 and the Wards' £400.
73. ANQ-M. Griffin. no 13,629, 1 Feb. 1836 (Price engine) and no 16,525, 11 Apr. 1839 (Montreal Waterworks engine).
74. Ward Family Papers. 1 Feb. 1829, pp. 52-55; Tulchinsky. The River Barons p. 215; Denison. The Barley and the Stream p. 178.
75. Denison. p. 157; Montreal Daily Witness. 20 Mar. 1897.
76. Montreal Gazette. 24 March 1835.
77. Tulchinsky. The River Barons. p. 216.
78. Brown. "The Champlain and St. Lawrence Railroad" p. 15.
79. Ibid. pp. 22-3. The cost of engines and boilers, was to be £2,565. See ANQ-M. Arnoldi. no 4595, 28 Nov. 1835.
80. Brown. "The Champlain and St. Lawrence Railroad" p. 23.
81. Ibid., p. 21. Lebbeus B. Ward was a director of the railroad in 1835-36. See Lucien Brault. "Le premier chemin de fer au Canada: Etude historique" (Thèse, 1937) Appendice No. 3.
82. Brown. "The Champlain and St. Lawrence Railroad" pp. 26, 32.
83. John B. Thompson. "Jason C. Pierce: The Man and the Machine" Canadian Rail. No. 229 (Feb. 1971) pp. 35, 44.
84. Omer Lavallée. "Dundee-Built Locomotives on Canada's First Railways" Railroad History. No. 149 (Autumn 1983) p. 37.

CHAPTER THREE: ENDNOTES

1. Canada. Censuses of Canada, 1608 to 1876. Vol. 5 (Ottawa; Maclean, Roger & Co., 1878). Census of 1851-1861-1871. Table E. pp.32-33.
2. John P. Heisler. Canals of Canada. (Ottawa: Indian Affairs and Northern Development, 1973) pp. 92-118.
3. Tulchinsky has a good description of this trade in The River Barons. pp 35-49.
4. Larry Mc Nally. "Water Power on the Lachine Canal, 1846-1900" (Parks Canada. Microfiche Report Series No. 54, 1983); John Willis. "The Process of Hydraulic Industrialization on the Lachine Canal 1840-1880: Origins, Rise and Fall" (Environment Canada. Microfiche Report Series No. 322, 1987).
5. For early Montreal area railways, see Tulchinsky The River Barons. pp. 107-202.
6. The full importance of the Grand Trunk has yet to be fully studied. The best study of the GTR is still A.W. Currie. The Grand Trunk Railway of Canada. (Toronto: University of Toronto Press, 1957).
7. Tom Traves and Paul Craven. "Canadian Railways as Manufacturers, 1850-1880" CHA Papers. 1983. pp. 254-81.
8. The Canada Directory for 1857-58. (Montreal: John Lovell, 1857). Vol. 2, p.1208.
9. Montreal Business Sketches. (Montreal: Railway Advertising Co., 1864). pp. 23-25; Montreal Gazette. 18 July 1864; Commercial Sketch of Montreal and Its Superiority as a Wholesale Market. (Montreal: Chisholm & Dodd, 1868) pp. 27-29.
10. NA. Statistics Canada, RG 31. Census of 1871. Industrial Schedule. Reel C-10044.
11. "Brush, George" DCB. Vol. 11, pp. 120-21.
12. "Brush, George S." Canadian Society of Civil Engineers (hereafter CSCE). Transactions. Vol. 11, (1907) p. 13.
13. "Cantin, Augustin" DCB. Vol. 12, pp. 158-59; Tulchinsky. The River Barons. pp. 209-10.

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APPENDIX 1
ENGINE FOUNDRY EQUIPMENT

<u>Bennet & Henderson 1835¹</u>		<u>Ward Brothers 1839²</u>	
Steam engine, blast cylinder, cupola, shafting, pulleys	£700	Steam engine & blowing apparatus	£400
Foundry & portable cranes	£ 50	3 furnaces & cranes	£200
1 boring mill	£300	2 boring mills	£200
40 boring bars	£ 35		
6 lathes	£290	1 planing machine	£100
1 punching machine	£ 15	1 punching & bending mach- ine & 2 pairs of shears	£ 75
1 cutting machine	£ 15		
1 drilling machine	£ 45	Drilling machine, vices, anvils, bellows, purchase blocks, machinery, tools	£1415
7 anvils	£ 32	1 trip hammer	£100
Smith tools	£ 60		
Finishing tools	£ 20		
1 Bolt roller	£ 20	1 nut machine, loam mill & portable forge	£160
Old files	£ 20	Files	£ 50
Patterns (engine & non-engine)		Sundry patterns	£400
	<u>£1195</u>		
TOTALS	£2765		<u>£3100</u>

¹ ANQ-M. Greffe de G.D. Arnoldi, no 3884, 2 jan. 1833.

² ANQ-M. Greffe de N.B. Doucet, no 25796, 31 dec. 1838.

APPENDIX 2

EARLY STATIONARY STEAM ENGINES USED OR BUILT IN MONTREAL 1811-1839

<u>Date</u>	<u>Builder</u>	<u>User/Place</u>	<u>Purpose</u>	<u>Details</u>	<u>Source</u>
1811	B&W	J. Molson, Mtl	Brewery	--	Wilson 225, Belisle
1822	British	Handyside Bros. Mtl	Brewery	10hp 15 t.	Wilson 225, Denison 153
1823	Eagle F.	Wm. Wilson, Mtl	Distillery	--	MBHP Griffin 4729
1826	Eagle F.	T. Molson, Kingston	Brewery	33 hp in 1835	Denison 145, 161
1828	Eagle F.	G. Brouse, Matilda, UC.	Grist Mill	--	Leung, 283
1831	B&HF.	T.B. Wragg, Mtl	Nail factory	20 hp	MBHP Griffin 9434
pre 1832	Eagle F.?	Eagle F., Mtl	Engine Foundry	8 hp	Gazette 16-7-1831
pre 1832	?	Phoenix F., Mtl	Foundry	Small	Gazette 16-7-1831
pre 1832	?	Hart Logan & Co. Mtl	Smut and Cribbing 16 hp Mill	16 hp	Gazette 16-7-1831
1832	B&HF.	A. Ritchie, Etchemin, LC.	Saw mills	--	MBHP Griffin 9669
1833	B&HF.	J. Molson, Mtl	Brewery	750	Denison 153, 178
pre 1834	B&H F.	Handyside, Mtl	Brewery	16 hp	ANQM Arnoldi 3884
pre 1834	B&H F.	Government at Quebec	--	10 hp	ANQM Arnoldi 3884

14	pre 1834	B&M F.	B&H F. Mtl	Engine foundry	--	ANQM Arnoldi 3884
15	1836	St. Mary's F.	Wm. Price & Co. New Liverpool, LC.	Saw mills	--	MBHP Griffin 13629
16	1839	St. Mary's F.	Water Works, Mtl	Pumping Water	Low pressure	MBHP Griffin 16525

Abbreviations

ANQM Archives nationales du Québec à Montréal followed by name of notary and number of act.
 B&HF Bennet & Henderson Foundry
 B&W Boulton & Watt
 Belisle Information from Jean Belisle
 Denison M. Denison The Barley and the Stream
 Leung F. Leung "Grist and Flour Mills in Ontario..."
 MBHP Montreal Business History Project of McGill. Notes from notarial files
 Wilson G.H. Wilson, "The Application of Steam to St. Lawrence Valley Navigation"

APPENDIX 3

MACHINE TOOLS OF ENGINE FOUNDRIES ON THE LACHINE CANAL - 1856¹

<u>Company</u>	<u>Lathes</u>	<u>Planers</u>	<u>Drills</u>	<u>Other</u>
Bartley & Dunbar	10	4	5	2 pinchers, 1 shears
T. Redmond	4	1	1	1 bolt cutter
W. Burry	8	1	2	1 bolt cutter
Milne & Milln	<u>8</u>	<u>2</u>	<u>2</u>	1 pincher, 1 punching & shaping
Total	30	8	10	

¹ Province of Canada. Journals of the Legislative Assembly.
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APPENDIX 4

FOUNDRIES IN MONTREAL, QUEBEC AND ONTARIO, 1852-1871

		<u>No.</u>	<u>Capital</u>	<u>Employees</u>	<u>Value</u>
1852 ¹	Montreal	7	--	--	--
	Quebec	96	\$ 71,212 (25)	197 (18)	\$ 50,850 (25)
	Ontario	94	4,398,875 (54)	925 (48)	3,738,375 (54)
1861 ²	Montreal	14	169,580 (9)	427 (11)	263,500 (9)
	Quebec	60	380,070 (23)	665 (27)	481,380 (23)
	Ontario	124	1,780,300 (121)	1,691 (98)	1,435,300 (121)
1871 ³	Montreal	16	--	724	681,900
	Quebec	111	--	1,862	1,607,464
	Ontario	258	--	4,686	4,631,850
	Canada	430		7,653	\$7,325,531

ENGINE BUILDING IN MONTREAL, QUEBEC, ONTARIO AND CANADA, 1871

1871 ⁴	Montreal	4	--	452	328,175
	Quebec	5	--	457	333,525
	Ontario	6	--	502	671,000
	Canada	12	--	1,007	\$1,044,525

¹ Canada (Province). Census of the Canadas for 1851-52. Vol. 2, Appendix 13, pp. 264-65; Appendix 14, pp. 386-94.

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⁴ Ibid. Table 46, pp. 420-21.

APPENDIX 5

MONTREAL ENGINE FOUNDRIES - 1861¹

NAME	CAPITAL	POWER	WORKERS	WAGES	RAW MAT.	VALUE
Bartley & Gilbert	\$49,600	Water & Steam	190	\$5000/mo.	\$78,350	\$200,000
J. McDougall		Water	80	\$2000	\$12,720	\$ 52,800
C. Brush	18,000	Steam	50	\$1200	\$ 7,500	--
T. Redmond	16,000	Water & Steam	60	\$ 800	\$15,700	\$ 40,000
R. Gardner	9,600	Steam	13	\$ 296	---	---
TOTAL	\$65,600		330	\$7800/mo.	\$106,700	\$292,800

MONTREAL ENGINE FOUNDRIES - 1871²

NAME	CAPITAL ³	POWER	WORKERS	WAGES	RAW MAT.	VALUE
J. McDougall ⁴	\$ 37,000	40 hp	167	\$67,500	\$ 51,000	\$131,000
W.P. Bartley	150,000	160 hp	225	49,200	\$ 66,400	\$128,175
G. Brush	50,000	20 hp	80	25,000	\$ 25,000	\$ 80,000
L.E. Gilbert	35,000	40 hp	145	50,000	\$ 46,500	\$120,000
R. Gardner		12 hp	32	12,000	\$ 9,000	\$ 60,000
TOTAL	\$272,000	272 hp	649	203,700	\$197,400	\$519,175

¹ N.A. RG 37. Census of Canada 1861.

² N.A. RG 37. Census of Canada. Industrial Schedule 1871.

³ Includes only fixed capital.

⁴ Includes only McDougall's Caledonia Foundry and Boiler Works.

APPENDIX G

SAWMILLS IN QUEBEC AND ONTARIO 1851-1871¹

	No.	Capital	Employees	Value
1852 Quebec	1065	\$1,473,961 (723)	3634 (451)	\$210,685 (320)
Ontario	1567	1,804,648 (1146)	3670 (305)	104,589 (133)
1861 Quebec	797	3,074,248 (682)	4891 (555)	3,681,741 (521)
Ontario	1164	5,554,901 (1057)	7703 (1001)	4,461,994 (897)
1871 Quebec	1708		11848	9,518,810
Ontario	1837		13851	12,733,741

GRIST AND FLOUR MILLS IN QUEBEC AND ONTARIO 1851-1871²

	Number	Capital	Employees	Value
1852 Quebec	511	\$1,405,957 (386)	807 (209)	\$160,542 (222)
Ontario	612	2,856,379 (439)	1150 (179)	57,348 (72)
1861 Quebec	450	2,403,350 (389)	756 (299)	2,882,730 (256)
Ontario	501	6,408,010 (471)	1579 (420)	9,096,246 (323)
1871 Quebec	810		1506	9,871,714
Ontario	951		2759	27,115,796

¹ Census of Canada. 1852, 1861, 1871. The number of establishments giving returns is given in the brackets. The totals are far from complete.

² Census of Canada. 1852, 1861, 1871. The number of mills in both provinces are gravely undercounted.

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