Felicity L. Leung

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FROM MILLSTONES TO ROLLERS, 1780s-1880s

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Cover: Watson's Mill, Manotick, Ontario. (*Rideau Valley Conservation Authority*.)

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GRIST AND FLOUR MILLS IN ONTARIO; FROM MILLSTONES TO ROLLERS, 1780s-1880s

Felicity L. Leung

ABSTRACT

In this study I examine the changes made in methods of milling wheat in Ontario grist and flour mills from the 1780s to the 1880s. I describe machinery and mill furnishings available during five overlapping periods of technique and touch generally on some of the political, economic, social and geographical influences that affected the flour-milling industry.

Submitted for publication 1976, by Felicity Leung, National Historic Parks and Sites Branch, Parks Canada, Ottawa.

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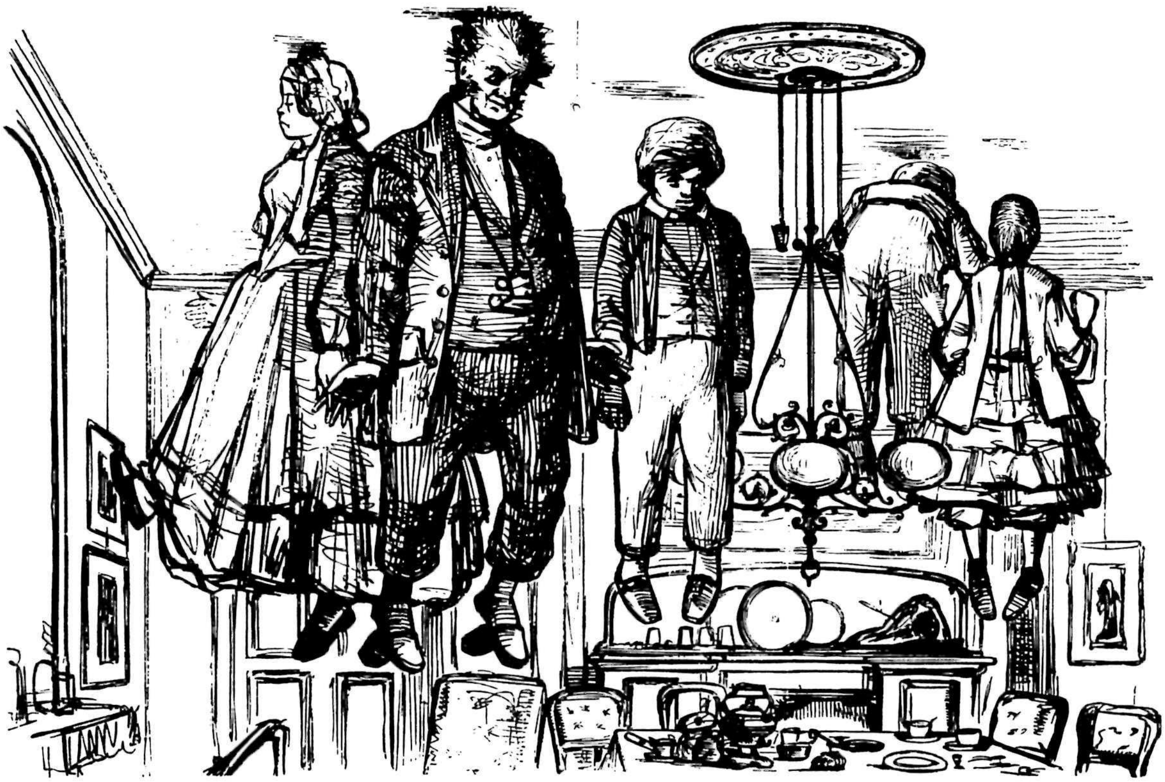
200 PUNCH, OR THE LONDON CHARIVARI. [NOVEMBER 17, 1860.



A RISE IN BREAD-STUFFS!—EFFECTS OF EATING AËRATED BREAD.

Poor Cocker having been Recommended to try the "Aërated Bread," does so, and is Discovered, along with his Family, Floating about the Ceiling of his Parlour, in an utterly Helpless Condition.

Cartoon from *Punch* in 1860 commenting on the high price of aerated bread manufactured by Dr. Dauglish's patented process of 1859.

INTRODUCTION

As the growth and quality of wheat improves, no doubt the flour manufactory will take a favorable turn, and then a mill, the only one in the country that abounds in dry seasons, will be a valuable profession...it is the most solid pursuit in the country....and the Country is one of the healthiest in the world.[1]

This report of the evolution of Ontario water-powered grist and flour mills from 1782 until the 1880s when rollers replaced millstones is divided into five parts, each corresponding to important changes in wheat-milling techniques. Part I deals with mills operating by the low grinding, fast reduction process as they existed in the 1780s and 1790s. Part II describes the introduction of automatic devices for milling in the United States in the 1780s and later in Upper Canada about 1800. Part III specifies some of the many improvements, including automation, made to mill machinery and furnishings from 1800 to the 1860s, the period when mills operated mainly by the automatic, low grinding process of fast reduction. An account of two phases of the European process of gradual reduction as they occurred in Ontario in the 1860s and 1870s is given in Part IV. Part V records the first use of roller mills in the 1870s and the subsequent decline of millstones.

While the report is divided into five chronological sections according to milling technique, not every mill existing in the 1860s, for example, employed the new process of that period. The techniques overlapped in time. Sometimes improved devices were designed to work with an earlier process rather than the most up-to-date one. For example, as late as the 1880s when roller mills were replacing millstones, millstone patents were still being granted.

The information is based largely on 18th- and 19th-century millwright guides, and on Canadian manuscripts, patents and secondary sources related to flour milling. Though primarily a technological history, the study also includes some of the social, political and economic events that affected the grist- and flour-milling industry in Ontario. The report ends with a glossary, but lists of mill machinery manufactories supplying Ontario mills and Canadian milling patents, a chronological arrangement of events affecting flour milling, a brief study of breadstuffs, and biographical summaries of men involved in the Ontario milling industry are available as appendices in Manuscript Report Series Number 201, Parks Canada, Ottawa.

This compilation is intended to contribute background knowledge to those engaged in restoring grist and flour mills, and to provide sources and subjects for further research of the many facets of the Canadian flour-milling industry.

Part I. Old Process or Fast Reduction Mills, 1782

GOVERNMENT MILLS

the diminution of the Article of Flour
is what they [the Loyalists] most feel.[1]

The first water-powered flour mills built in Ontario were King's mills, built by and for the Loyalists and owned by the Crown. General Haldimand and his successors took personal interest in establishing flour and sawmills essential to the new settlements. Surveyors were instructed to take special note of potential mill sites; millwrights were sought to supervise mill buildings; millstones and mill machinery were provided from the King's stores; seed wheat was purchased for the settlers. Because of the predicament of the Loyalists, the Quebec laws governing mill construction were altered to accommodate Loyalist needs. In 1782 by the civil law of Quebec, the building and ownership of a mill was a right and obligation given first to the *seigneur*. *Habitants* residing in the *seigneur's domaine* were legally bound to help build the mill from materials on the *domaine* and to have their grain milled there and at no other place. A toll of 1/14 of the grain brought to be milled was paid to the *seigneur*, who then paid his miller a percentage. If the *seigneur* failed to begin a mill within a year after the creation of the *seigneury* this *droit de banalité*[2] could be transferred to any petitioner who would erect a mill. In the Loyalist settlements west of Pt. Bodet in present-day Ontario, the first mills were owned by His Majesty (who assumed the role of *seigneur*) and were built by his subjects. The Niagara mill was ready by 1783, the Cataraqui mill by 1784, the Napanee mill by 1787 and the Mohawk mill by about 1791.

Niagara Mill

The fort at Niagara, where Loyalists had been gathering since 1778, was the first settlement to have a government grist and sawmill. Although the government intended to provide a mill, the impetus to actually build one came from Peter and James Secord, farmers from New Jersey, whose leased land on the Four Mile Creek near Niagara contained a suitable mill site. In the summer of 1782, Colonel Butler wrote Matthews, Haldimand's secretary, of the Secords' intentions about the mill "which I think will be a great acquisition to this Post, they mean to purchase the Stones and Iron work in Canada but beg his Excellency's assistance by permitting them to be sent up on the King's Batteau."[3] Matthews replied that no private mills, only banal mills, were allowed according to French law, that General Haldimand would provide and send materials, and that the Secords would be paid for building the mills and allowed a "reasonable" profit for working them. He asked that the most "intelligent" Secord be sent to Quebec as soon as possible to inform them where the mill was being built, the materials needed and an estimate of the cost. Because it was harvest time, however, neither Secord made the trip and the required estimate was communicated by post. It amounted to £500 New York currency for "cutting and hauling boards and timber, building and filling in both dams, nails, iron, stones, bolting cloth and saw excepted."[4] Sergeant David Brass, one of Butler's Rangers and a skilled millwright (also from New Jersey), was made "director" (sometimes referred to as "principal undertaker" or "principal workman"), and subsequently promoted to lieutenant. His assistants included the two Secords as "millwrights" and about six others, including squarers hired at the rate of six shillings a day. Work of cutting and squaring the timbers was finished in February 1783. In March, Captain Twiss of the Royal Engineers was asked to give the "necessary orders to have the Iron works made and forwarded to Coteau du Lac"[5] for shipment to Niagara in the spring. Despite an order (occassioned by the peace treaty of 1783) forbidding the carrying on of fortifications or public works, construction on the mills continued, and after a long wait for irons and millstones, both mills were finally completed in 1783 - the grist mill milling the farmers' surplus stores of wheat before winter set in. The final cost was £465 New York currency, within the original estimate and "worth the sum" by all accounts.

Kingston Mill

The second Ontario grist and sawmill, built for the convenience of settlers along the St. Lawrence, Bay of Quinte and the shores of Lake Ontario, was situated on a site chosen by surveyors at the mouth of the Cataraqui River, about six miles from old Fort Frontenac. John Ross, commander of this fort at Cataraqui, communicated with General Haldimand regarding the planning of the grist and sawmill. Because no millwright was available in July 1783, only the collection and preparation of materials was carried out. Ross's wish to have David Brass, described by Ross as a remarkable American genius, to superintend the building was unfulfilled since Brass was busily engaged at Niagara. Instead, Captain Twiss of the Royal Engineers delegated Robert Clark, a newly arrived Loyalist born in 1744 in Dutchess County, New York, a farmer and millwright by trade and one of Jessup's Rangers. By February 1784, the grist mill was reported ready to raise, but due to harsh weather and slowness of the artificers who felt they were entitled to discharges as a result of the peace treaty, the mill took longer to erect than expected. By 28 September 1784, three months after the completion of the sawmill, Ross reported that the grist mill was finished. For three or four years it was the only grist mill in the eastern region of Ontario.

As time went on and other mills were built, the Cataraqui mill earned a poor reputation due to the negligence of those leasing it. When Lieutenant Governor John Simcoe arrived in 1792, it was in the possession of the venturous Richard Cartwright who had repaired it but who subsequently had to surrender it to the Crown. A Mr. Bell was the tenant for a term of one year from 1792 to 1793 and he paid a rent of £64.0.0. The following year a Mr. W. Allen paid an annual rent of £66.0.0 for the grist and sawmill. By 1796, however, the mill was again in need of repair and farmers were complaining that there was a lack of good mills in the area. John McGill, the commissary for King's stores, suggested as a solution that Simcoe either lease the King's mill for a longer period than customary, or else dispose of it altogether so that some enterprising person would be able to make it a productive mill. From 1797 until 1800 the mill was leased to Joseph Allen at the rate of £88.0.0 per year, but by 1799 the solicitor general was instituting an action against Allen because he was three years in arrears on his rent.

About 1805 the mill burned down, and in 1807 David Brass who had built the Niagara King's mill (and who had moved to the Kingston area in 1784 to build the King's sawmill in the Bay of Quinte) petitioned to rebuild it. He proposed a frame building, 30 feet by 40 feet, two stories high upon a stone foundation with the necessary appendages for grinding and bolting, using the remains of the old mill when possble. He asked permission to lease the mill and lands for 21 years at £15.0.0 per annum. In addition, he wanted to erect and rent a sawmill for the same period promising to return the mills to the Crown at the end of 21 years. It was probably these mills Going reported had to be relocated in the 1830s for the construction of the Rideau Canal.

Mohawk Mill

The government also took responsibility for building a mill for the Six Nations Indians on the Grand River. One of

Haldimand's last letters to Lieutenant Colonel de Peyster in November 1784 listed the assistance he was preparing for the Indians. A saw and gristmill was included, to be built by a person understanding the construction of mills who would be sent there especially for that purpose. This mill was built about 1791 during the tenure of Lieutenant Governor Hamilton. Various millers were appointed by the Indian Department at a daily rate of four shillings, Halifax currency. From 1799 until 1803 Jonathon Burch and John Meyers were listed at different times as millers and were paid from the military chest. In 1804, the position of miller was vacant, possibly because the mill had burned down. At a council meeting of the Six Nations in 1809, the Indian leaders asked that a new mill be built so they could grind flour and make bread as before.

Napanee Mill

The Napanee River grist and sawmill was built by the government under the supervision of millwright Robert Clark one year after Clark had finished the Kingston mills. The preparation of the timbers was done during the winter of 1785-86. According to millwright Clark's account book, the sawmill was raised at a bee in March 1786, and the grist mill two months later. In July three pints of rum were charged for "raising the fenderpost and bringing on the carriages."[6] The final accounting in December 1786 showed that payments were made for clearing 1 1/4 acres of land around the mills, and to Mrs. Clark and Mrs. Bell for making the bolt cloth. From 1787 until 1791 the sawmill with two saws, and the grist mill with one run of stones and a bolt machine operated by hand, supplied the settlers with timber and flour.

Sometime in 1791 or 1792, the enterprising Richard Cartwright bought the mills from the Crown for £1,000 and began to set up probably the first merchant-custom mill in eastern Upper Canada. Such a mill produced merchantable flour for export and commerce as well as for the local farmer. Hiring Robert Clark as millwright, he erected a new grist mill near the old one, and as grain produce and trade increased, had the mill improved with the latest machinery. Perhaps as early as 1799 when John Grange, a Scots millwright, was in his employ repairing the mill, the automatic inventions of Oliver Evans were installed. Certainly by January 1804 Evans' grain and flour elevators, his drill and hopper boy operated in Cartwright's mill where they were sketched by Lord Selkirk in his diary; the mill wheel was housed in a wheelhouse with a stove beside the wheel to keep it ice-free; a fanning machine cleaned wheat, and a bolter graded the flour "into three species of flour and two of offal."[7] If in fact the automatic devices were in use as early as 1799, then merchant millowner Richard Cartwright was among the first in Canada to utilize the new designs that Evans had published in 1795 in the *Young Millwright and Miller's Guide* in Philadelphia. One of the first sketches of Cartwright's mills was made by Mrs. John Simcoe around 1795 (Fig. 1), possibly the new mill rather than the original government mill.

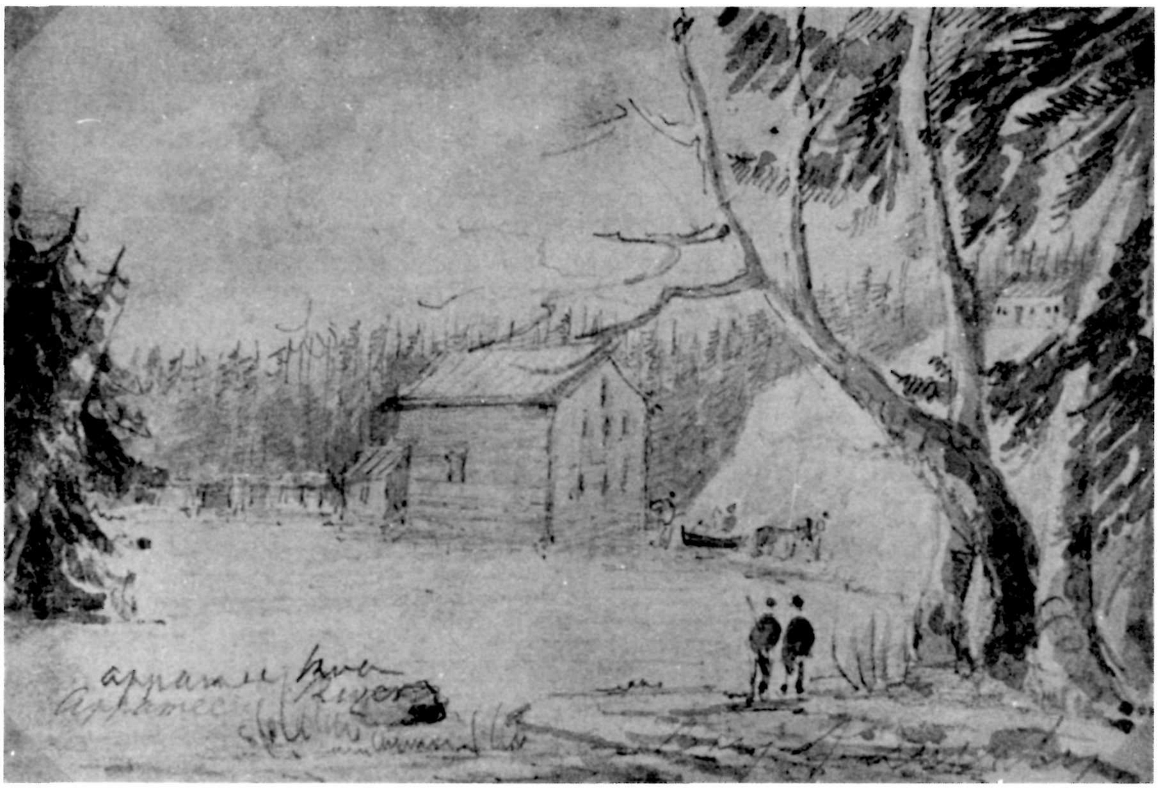


Figure 1. The grist and flour mill at Napanee as sketched by Mrs. Simcoe in 1795. (*Ontario Archives.*)

THE MOVE FOR PRIVATE OWNERSHIP OF MILL SITES

Although King's mills performed a valuable service to the first settlers, there were too few, and the terms for building seigneurial mills were unprofitable and backward by the standards of American Tory capitalists who were accustomed to freehold land tenure. From the beginning dissatisfaction over the restrictive French laws was expressed among the more enterprising Loyalists. As early as February 1784, Sir John Johnson reported to Haldimand's secretary that "evil designing persons" were trying to dissuade Loyalists from taking land in Quebec by telling them of better terms in the neighbouring states where they were "not prohibited from erecting mills."[1] Finally, in 1786, as a result of constant expressions of discontent from the inhabitants and applications for permission to build mills immediately on the plentiful waterpowers, a notice[2] was published by Governor Hope containing an amendment to the restrictive regulations. According to it the rights of *seigneur* would be granted to an individual for 15 years (instead of 10 years) as a reward for erecting a mill. Fifteen mill sites had been picked out for development by a water or windmill, at least one in each township. The first choice of seigneurial right would go to the holder of the lot on whose land the site had been chosen. Certain conditions were binding according to the notice: the mill, sufficient in all respects for the use of the settlers in the township, had to be erected before "November next" - presumably 1787;[3] it had to be kept in constant repair; at the end of 15 years, the owner's rights were to be given back to the Crown with no right or claim by the builder to more compensation. Moreover, if the Crown found it expedient to resume the right of *banalité* before 15 years, it had the right to do so and just and equitable compensation would be made. "For greater encouragement," however, "one batteau properly manned"[4] was allotted to carry the millstones from Lachine to the mill. Any person willing to undertake such a contract was to inform the inspector of his district. His contract had to be approved by the lieutenant governor and the commander in chief, and he had to give sufficient security before 10 May 1786. It was posted that a Mr. Coffins was already building a water mill on Lake Township No. 3, Lot 18.

As a result of this notice, two more mills were built, both in the Niagara area. One by Mr. Burch (legally bound in the sum of £200 to build a saw and grist within two years), was on Lake Township No. 5 between the Great Falls and Chipeway Creek. The second, also on Lake Township No. 5 at the falls above Twelve Mile Pond, 10 miles from the lake and 16 from the garrison, was begun by Duncan Murray who died before they were completed. They were finished by Robert Hamilton who obtained special permission.

The new amendment to the regulations, particularly the clause requiring the mills be returned to the Crown after 15 years, resulted in "much uneasiness and created much discontent among the inhabitants," wrote Richard Cartwright reviewing the history of mill-seat grants in a letter to the land board at Kingston.[5] It appeared the only satisfactory terms the inhabitants would accept were those that had been given to the people of New Brunswick and Nova Scotia - the right to private ownership of mill sites contained in land grants. These terms, sought for by Quebec Loyalist petitioners since 1783, finally were assumed granted when Lord Sidney's statement was published in the Quebec *Gazette* on 3 September 1788.

> It was the King's intention that new settlers in new lands west of Pt. Bodet who now hold their lands upon certificate of occupation shall at all events be placed upon the same footing in all respects as their brethren in Nova Scotia and New Brunswick by having all their lands granted to them in free and common soccage.

From this time, 3 September 1788, argued Richard Cartwright, this statement "fully authorized every Proprietor of land to avail himself of any advantage it possessed as a proper situation for mills."[6] Subsequently, between 1788 and 1792, at least 14 grist mills (and many more sawmills) were built in the Quebec settlements west of Pt. Bodet by landowners who had certificates of occupation. Sir John Johnson's mill on the east side of the Gananoque River ran all year and was accessible by small vessels and *batteaux* that could go up to the mill door (Fig. 2). Jepthaw Hawley's mill on Hawley's Creek near Ernestown was supplied with water for only two or three months and boats could land within a few yards of the mill.

This minor boom in mill building may have been helped by the government's plan for supplying flour to the troops. Beginning in 1786, at the request of settlers themselves, flour for the upper posts was manufactured from Loyalists' surplus grain stores. The government bought the surplus flour and paid the settler at the going market price in Lower Canada plus a bonus for the settler equal to what would have been the cost of transporting it from Lachine to the upper settlements. This form of encouragement must have stimulated the growth of grain as well as the milling industry.

In 1789, new regulations (drawn up at Quebec for the conduct of the Land Office Department) put another restriction on mill building. In an effort to protect mill seats on land yet to be granted from land jobbers and slow development, article VIII of the new rules and regulations for the district land boards on 17 February stated

> and to prevent individuals from monopolizing such spots as contain mines, minerals, fossils and conveniences for mills and other advantages of a common public nature to the prejudice of the general interest of the settlers[7]

the surveyors and their agents were allowed to grant only those lands good for "husbandry." All others mentioned above were to be reserved for the Crown. Land granted containing an unsurveyed mill site had to be reported to the surveyor who would compensate the grantee usually by offering him another grant. If the owner agreed to build a mill, however, he could do so after making special arrangements through the governor in council. It is difficult to know whether this ruling had any restrictive effect on mill building, but evidence suggests it did not. Mills continued to be erected from then until 1792 according to the terms promised by Lord Sidney in 1788. As well, one by John Green near Grimsby was built on lands supposed to be fit only for husbandry in 1789. Others were built on "unsurveyed" land, presumably by people who were unaware of the land board ruling.

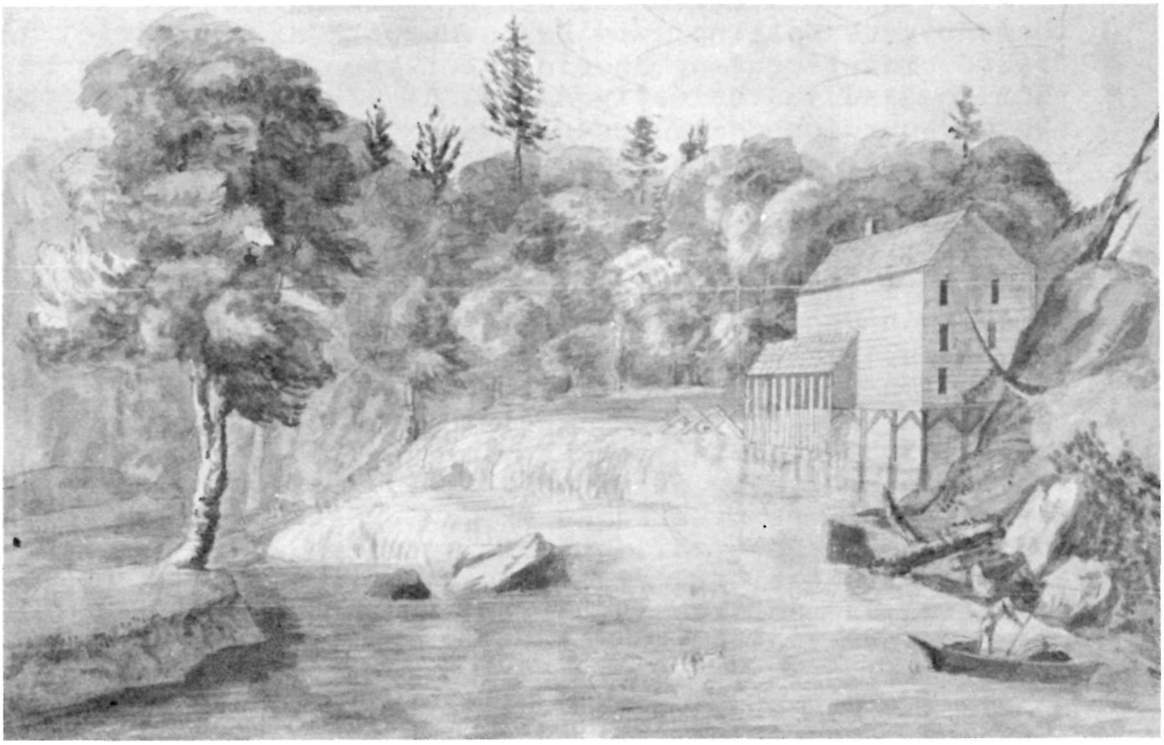


Figure 2. Sir John Johnson's mill on the Gananoque River as sketched by Mrs. Simcoe in 1792. *(Ontario Archives.)*

GOVERNOR SIMCOE'S INFLUENCE ON THE FLOUR-MILLING INDUSTRY

Lieutenant Governor Simcoe was concerned about milling as he was about every facet of settling the Province of Upper Canada. In February 1791 he wrote Lord Grenville from London, England,

> I have to propose that the government shall also furnish the necessary materials for some grist and sawmills to be erected in spots carefully selected for that purpose and of which the government shall become the proprietor and shall be let by public auction for such terms and under such stipulation as shall appear most proper - The Grist mills are universally necessary and will be a great inducement to speedy settlement of lands in their vicinity.[1]

He also informed Lord Dundas the same year that he planned to build sawmills, flour mills and inns as the first step to form different settlements at the navigable heads of all those rivers falling into Lakes Huron, Ontario, Erie and St. Clair. Manufactured materials for the mills were to be sent from England in the early spring of 1792. These, shipped on the cargo ships *Scipio* and *Henniker*, were from the Albion Mill Company and included millstones, mill irons, flour bolts and wire bolt material costing a total of £441.15.4.[2]

It is not certain how far Simcoe was able to fulfill his plans; in fact, evidence indicates that after his arrival in Upper Canada and actual contact with the situation, his proposals were modified. Soon after he arrived in Upper Canada in the summer of 1792, and throughout his tenure, he and his wife visited many of the mills in Upper Canada, often dining with the owner and staying overnight. In October 1792, not long after his installation, he ordered Surveyor General David Smith to conduct a return of all the mill streams in the province, asking for details "whether occupied, by whom, on what condition, authority, tenure, since what period, together with all other circumstances relative thereto."[3] One wonders whether the result of the census (which showed that most mills had been built under private ownership), together with the opinions of mill owners such as Richard Cartwright and the fact that there was a surplus of grain and not enough mills, provided the grounds for the change in the land board's restrictive rules regarding mill seats. On 30 May 1793 it was ruled and published that all proprietors of land with mill seats were authorized to make use of mill sites provided fish and navigation were not blocked. The reasons stated for the change in rule were the increased population and the wealth of the province. Only an area above Niagara Falls was reserved for the Crown because of its military importance.

During the first session of the legislature of Upper Canada, an act to regulate the toll taken in flour mills was passed 6 October 1792 and became effective 1 January 1793. The act increased the toll from 1/14 of the grain (levied in Quebec) to 1/12 of the grain brought to be milled. The fine for exacting more was £10 Quebec currency.

The text of the act ends with an interesting paragraph. Because of the "confusion" that had arisen due to the custom of bringing bags of grain without any distinguishing mark of ownership, it was now law that millers did not have to mill, or be charged with the loss of, any bags of grain or flour unless they had been marked wth the initial of the Christian name and whole surname of the owner. Such distinguishing marks had to be communicated beforehand to the owner, occupier or servant attending the mill. Early accounts of pioneer days[4] tell how groups of settlers would join together to deliver 40-50 bushels of grain by *batteaux* to a mill miles away. With such large quantities of grain, it is not difficult to imagine the miller's quandary in trying to decide which flour belonged to which settler when bags of grain had no name. Then too, unmarked sacks of grain (or flour) belonging to the settler might be confused easily with the miller's own sacks of grain (or flour) which the miller had accumulated from the toll or other supplier and not marked. Some of the poundage was screened from the grain as dirt, some was lost to "sweepings," some transformed into flour dust, and a small proportion was left in the millstones and flour bolt. The finished product, bolted, might include about 63 per cent flour, 13 per cent middlings (for biscuit and mush) and 20 per cent bran or offal (for cattle) making a 4 per cent loss, not counting the toll of 1/12. Throughout history, millers had been liable to suspicion by farmers, who justly or unjustly imagined the various ways a miller could cheat by secretly channelling off grain or flour. In general, however, Upper Canadian millers have enjoyed a good reputation and few cases of fraud have been documented.

Except for the above act and another establishing the Winchester measure as a standard for weights and measures (1 bushel = 60 lbs), no other major laws were passed by the legislature in 18th-century Ontario directly affecting milling of flour. Instead necessary reservations, such as milldam requirements, were stated in land deeds and patents issued by the attorney general or by special orders of the governor. Beginning in 1801 with the act authorizing flour inspection and throughout the 19th century, however, much necessary legislation was passed that influenced flour milling. A great deal of it concerned milldams. Standardization of weights, of the Winchester bushel, and the specification of safety guards in mills were the subjects of some of the laws enacted as time went on.

Flour and Grain Trade

The flour and grain trade of Upper Canada was born during the last decade of the 18th century when sufficient flour and grain surpluses first began to accumulate. By 1792 several thousand bushels of grain were stored at Kingston. A new government flour supply contract was drawn up because the amount of grain being milled was more than needed by both the troops and the settlers, and the government decided it could save money by dropping the bonus. A new contract lasting for about a year beginning in March 1793 engaged Richard Cartwright at Kingston, Robert Hamilton at Niagara, and Askins and Robertson at Detroit as suppliers of flour and peas for the garrisons. Cartwright, Hamilton and Askins were politicians as well as merchants and mill owners, and one wonders what the other mill owners and settlers thought about this apparent favoritism on the part of government. An outlet was provided for other millers' and settlers' flour, however, when permission was given in July 1793 to all inhabitants to exchange their flour, carried to Oswego in their own boats, for masts, cattle and like provisions from the United States.

Governor Simcoe's plan for the export flour trade of Upper Canada stressed the importance of Montreal from which flour would be shipped overseas. He proposed that a principle storehouse be built below the rapids of the town of Montreal, and that a principle flour inspector paid an adequate salary reside there. Smaller receiving houses should be built and staffed with inspectors at points along the lakes and rivers to facilitate the Upper Canadian trade. Simcoe also proposed that British consuls communicate with his proposed Upper Canadian "Company ... the means of rendering the flour suitable" to the market in which the consul was stationed.[5] This plan, plus strict attention to the quality of manufactured flour, would promote the Canadian trade ahead of the American trade. The United States, he wrote, was losing its markets "for want of principle in the manufacturers"[6] - presumably the lack of quality control. While a Quebec ordinance of 1785 set rules for flour exported from Quebec which after partition applied to Upper Canadian flour shipped via Montreal, not until 1801 was flour inspection legislated for Upper Canada. Simcoe's prophecy that Montreal might become "the seat of the most extensive and useful commerce" to Great Britain[7] began to be realised in 1794 when the first official exports from Kingston to Montreal and thence abroad were shipped, - some 896 barrels of flour, 83 barrels of middlings and over 12,000 bushels of grain.

In 1794, too, a new impartial flour contract to supply the troops was drawn up, ending government favoritism shown Cartwright, Hamilton and Askins the previous year. Early in 1794, commissary John McGill wrote Simcoe about conditions of the forthcoming plan which he aimed would benefit both the inhabitants and the government. McGill advised that instead of accepting only quantities of ten barrels or more from the settlers, it would be better to follow a practice used in Detroit for some years - that of accepting flour into the King's store by the single barrel, and even by the bag. This, urged McGill, would encourage the poorer class of settler, speed up settlement and improve the colony in general. A different price would be given for flour by the barrel, equal to the cost of the barrel. Perhaps because McGill's plan necessitated (at Kingston at least) the costly construction of specially built flour magazines with inside walls fitted tight with seasoned board or lath and plaster to keep out insects and dampness, it was not adopted. Instead, a compromise course was decided upon. Public notices from the commissary office advertised that tenders were called from all persons inclined to supply the garrisons - only first-quality flour, properly packed in barrels containing 200 pounds net and guaranteed to last for a year, was acceptable.

Almost from the beginning of this plan, flour sold to the government from the inhabitants was expensive and supplies meagre. When McGill was sent to the Kingston area in May 1796 to discover why, he was informed that attacks from the "Hessian" or "Independent" fly (*Oecidomyia destructor*) had affected crops. But another important factor was that farmers and merchants hoped to get their own terms from settlers and garrisons in the United States (where the few crude existing mills ground for a higher toll of one-tenth). Mill owner Joseph Allen (of North Marysburgh township, Prince Edward County) had sold 200 barrels of flour at New Rotterdam, New York, while at Gananoque 100 barrels were waiting to be dispatched to Oswegatchie. As McGill pointed out to Simcoe in his explanatory letter, this - the lack of government magazines to store grain and flour as a hedge in bad years - plus the exports meant there could be no guarantee of supplies from the Kingston area for a while.

The same trade with the United States existed between settlers and garrisons in the Detroit area and was cut off on one occasion at least, in May 1796, near Fort Miami, by Commanding Officer England of Detroit. England reported his surprise to Simcoe's secretary when his order to stop flour on its way to the American garrisons was termed an illegal act. Because of the flour shortage, England had ordered it sold instead in Upper Canada. The limited supply of flour, made worse by dry summers, continued until 1800 when exports to Great Britain increased, and (Jones states) trade with the United States decreased owing to the construction of new mills there.

Merchant and Custom Milling

Merchant milling began as soon as the surplus of grain permitted the manufacture of flour for commercial as well as local use. The early merchant mills of the 1790s carried on custom milling at the same time: indeed, the grain taken as toll for custom milling the settlers' grain provided the mill owner with some grain to mill for commerce and export. But the toll of 1/12 was rarely enough to establish a merchant mill. In addition, the would-be merchant mill proprietor had to have private capital, not only to hire skilled millwrights and millers and procure the best machinery, but also to buy the local grain. The latter was often achieved by the proprietor setting up a store near the mill where settlers could trade their grain for the necessities of life. Merchant mill owners thus became traders, shippers, storekeepers and even innkeepers. Often their profits plus private capital enabled them to expand and add related enterprises such as cooperages, distilleries, piggeries, farms and woollen mills.

The flour produced in merchant mills was required to be "merchantable," generally a higher standard than custom flour (which was whole wheat or else mixed for the farmer and consumed quickly so that its lasting quality was not as important). Although there were no Upper Canadian laws governing the quality of flour being manufactured for export in merchant mills in the late 1790s, a Quebec ordinance of 1785 applied to flour being exported via Montreal. Such flour had to be "of a proper fineness and merchantable." It had to be packed in casks bound with ten hoops and made of well-seasoned staves. The tare (or weight of the barrel itself) was marked on it together with the name of the proprietor and the place of the mill. Barrels containing four differing amounts of flour were permitted: one quintal and one-quarter (140 lbs), one quintal and two-quarters (168 lbs), one quintal and three-quarters (196 lbs), and two quintals (224 lbs) (one quintal weighted 112 lbs, English weight). The quality of the flour was not specified in the ordinance but it was probably one of three grades: first quality or superfine, second quality or fine and third quality or middlings. These were the grades of the times and the ones specified in the 1801 flour inspection act of Upper Canada and the 1806 act of Lower Canada.

Merchant mill owners such as Richard Cartwright realized the importance of keeping mills in good repair and well equipped so their flour could compete profitably. Merchant mill machinery was generally larger and better constructed than custom milling machinery to handle larger quantities and produce higher quality flour. The changeover from a custom mill to a combined merchant-custom mill usually meant, if not a new building, additional runs of good quality millstones, a special merchant bolt, up-to-date grain cleaners, and any other latest improvements available.

Until the mid-19th century most mills were equipped to do merchant as well as custom work. After this, specialized merchant mills and "grist" mills began to be common, the former manufacturing for export and commerce only, and the latter for the local farmer.

Flour

What was the flour of Upper Canada like before 1800? Reports vary, some settlers describing it as wholesome, others as indigestible. Both evaluations are probably accurate since flour's quality depended on the miller whose job was to do his best with whatever grain and machinery he had.

One of the first problems discussed by the government in 1794 was the lasting quality of flour, a very important subject when flour was to be exported. Some Upper Canadian flour became musty and sour in instances where the miller had not allowed the grain or flour to dry sufficiently. Most millers of the 1790s knew that moisture contained in wheat - and some winter wheat varieties were more moist than others - had to be evaporated either before or after milling so it would not sweat out at some importune time (such as when it was packed in barrels) and sour the flour. The usual solution was to allow the meal to cool and dry sufficiently in a special area of the mill before it was packed. It was reported, however, that some millers lacked the room and packed the flour hot from the bolt so it soured immediately.

John McGill, commissary of stores in Upper Canada, writing to Governor Simcoe suggested that kilns be erected to dry the grain sufficiently before being milled. He pointed out that American flour made from wheat not kiln-dried lasted only two months in the West Indies while that made in England from kiln-dried wheat lasted over two years. If future grants of valuable mill sites were allotted on the condition that the grantee erect a kiln, the colony would benefit. A decided market preference for kiln-dried flour would induce other mill proprietors to follow.

Along with his proposal to erect kilns (which apparently was not favored because kilns were too expensive), McGill suggested other ways to improve the quality of flour being manufactured. He suggested an act requiring brands on flour casks describing the quality of flour (that is, superfine, fine or middlings) together with the manufacturer's name. This requirement would encourage settlers to pay attention to wheat cleaning and persuade millers to keep their mills in good repair. Since neither the size nor quality of barrels had been attended to (often old barrels had been used to pack new flour causing loss and damage) he suggested their size be regulated to contain 196 pounds net weight as was followed in the United States, "an exceeding good size for flour manufactured from wheat not kiln dried."[8] Although these suggestions were considered by 1801 when the first flour inspection law was ratified, until then flour sold to the government was only required to be "properly" packed in barrels of 200 pounds net weight, of the first quality and warranted to keep for 12 months.

SOME PROBLEMS ESTABLISHING EARLY MILLS

Lack of manpower, supplies and facilities were major problems that beset the Loyalists in establishing mills, causing delays and requiring special solutions by the government.

Millwrights

There was a dearth of millwrights during the first years of settlement in Loyalist Ontario. Supervising millwrights like Brass and Clark were found from Loyalist ranks and sent from site to site by the government. Artificers from the Engineer's department such as carpenters, axemen, sawyers and squarers assisted. Often millwrights were busy on other civil projects. In the eastern region in 1784, Sir John Johnson requested Haldimand to direct "Muchmore the Mill Wright" to superintend building his grist and sawmill on the Raisin River "upon my paying him and his finding a proper person to attend in his absence" (at the Cedar Rapids canal) "and to bring with him such tools as may be necessary out of the King's store."[1]

Encouragement was given to some like Martin Tofflemire, who was an "American millwright" among the Loyalists in the Detroit area and was granted land in 1789 "on the express condition of building a mill within one year."[2] Some were brought from the disputed border area south of Lake Ontario. Nicholas Miller, who built grist mills around Markham beginning in 1794 was a Genessee millwright brought to Upper Canada by Governor Simcoe to build the King's sawmill on the Humber. Similarly, the Berczy settlers left the Pulteney area (south of Lake Ontario) during the hostilities of the 1790s and came to take up land and build the Parliament buildings, roads and mills near York. They carried their mill machinery with them. Phillip Eckhardt erected the German mills on Lot 4, Concession III of York County beginning in 1794. Ebenezer Allan was another American who was granted land in Upper Canada in Delaware County near London on the condition that he build the first grist and sawmill. An enterprising business man, Indian trader and coloniser, Allan may have been a millwright as well. He is credited with having built the first grist mill at the Genessee falls (later known as Rochester, New York) in 1789-90; this mill was described as a roughly hewn structure, about 26 feet by 30 feet.

The architecture and plant layout of the first government mills must have been similar to contemporary American "country mills" or grist mills familiar to the men building them. They were relatively small, built of square or round timbers on stone foundations, probably only 1 or 2 1/2 stories high to lessen the work of hauling during milling. The water wheel might have been overshot, undershot, tub or breast, depending on the mill stream, site and skill of the millwright. Built primarily to mill the settler's grain they contained one run of French buhr stone or "country" stone and perhaps another run of ordinary stones.

Some privately built mills seem to have been on a larger scale than the government mills, but this depended on the owner's resources. Sir John Johnson's mill on the Gananoque was sketched by Mrs. Simcoe with three stories in the 1790s (Fig. 2). Later as grain supplies and trade increased, mills were renovated and improved by their progressive proprietors. One of the first examples of this expansion was the Napanee government mill which, when taken over by Richard Cartwright about 1792, was rebuilt and constantly improved so that by 1804 it was among the first in the province with the latest automatic gadgets. Mrs. Simcoe's sketch of Cartwright's mill about 1795 may show his three-storey improved mill rather than the original government mill of 1786.

Mill Supplies

Mill irons and furnishings for early Ontario were supplied mainly from Great Britain, the United States and Quebec. Shipments of machinery were brought from Great Britain by the government during the first years of settlement. One of these was in 1792 at the instigation of Governor Simcoe who planned to establish mills as the first step to settlement. The supplies, consisting of two dozen four-foot French buhr millstones, a corn machine, a flour bolt machine, screens, sieves, wire mesh material, wrought iron spindles and damsels, and cast iron crosses amounted to £441.15.4. Bought from the Albion Mill Company, England, and shipped in the spring along with other heavy cargo on the *Scipio* and *Henniker*, they arrived in Upper Canada in damaged condition due to the slender material used to package them. Twenty of the millstones (ten pairs) forwarded to Niagara were reported to be in a much damaged condition as were a rusty and damaged flour machine and a wheat cleaning machine. Fortunately the other two pairs of millstones remained in good condition and these or others subsequently sent, together with mill irons, were issued from the King's stores as an encouragement to Isaiah Skinner for his mill on the Don, and to John Lawrence for his mill on the Humber, in July 1796.

Much of the first mill machinery was brought from across the American border by settlers bringing their personal effects or by traders who had special permits from Governor Simcoe. Bolt cloths, millstones, grist-mill irons, bars of iron and steel were some of the items allowed to pass to Upper Canada. Permission to barter flour at Oswego in 1793 and the Treaty of Amity, Commerce and Navitation of 1794 no doubt encouraged trade between the United States and Upper Canada, some of which included much needed mill supplies.

Good millstones were valuable items - old millstones from defunct mills were used again in new mills. A Mr. Garner in Niagara was permitted to use the millstones originally donated by the government for the Servos mill providing he paid a nominal acknowledgement of one shilling annually to the receiver general to keep them in the province.

Mill iron work was forged in the province of Quebec. In 1795 Governor Simcoe asked Dorchester's permission for Joel Stone of Gananoque to have the condemned cannons in the area of New Johnstown recast at Three Rivers for Stone's millwork. Stone believed the iron of such guns was more malleable than any other then obtainable.

Millers

Aside from a genial and honest temperament which was a decided advantage when dealing with his public, a good miller possessed a great deal of technical knowledge and skill that has been summed up as sharp eyes, ears and feel. His eyes not only kept him aware of the condition of the gears, milldam and machinery, but also insured his physical safety in a potentially dangerous mill. His ears were constantly attuned to the rhythmical sounds of each mill device so that he knew their progress. His sense of touch or "miller's thumb" was indispensable in discerning the quality of flour issuing from the millstones. It was this feel that dictated how fast the millstones should run, how fast the grain should pour and how close, sharp and dressed the millstones should be. In fact adjustments were made to the entire mill on the basis of this feel. Millers have also been described as forever sweeping. Many were the cures for miller's asthma caused by clouds of flour dust wafting from millstones, flour cooler, bolts and flour packer. What was not inhaled settled on the floor to be swept up with the grain "sweepings" so it would not be trailed wherever the miller walked attracting vermin.

Although in Upper Canada the term "miller" usually described the operator of a mill, it was often used to mean the mill owner, similar to the British usage. Not only because of the shortage of millers and millwrights but also because the trades were related, some millers were millwrights as well, and some eventually became mill owners. The first millers in Ontario appear to have been the Secords who were also farmers, millwrights and as time went on, mill owners in the Niagara area. In 18th-century Ontario, more information is available about prominent mill owners such as Sir John Johnson, and merchants Richard Cartwright and Robert Hamilton who hired millers. Until the 19th century, hired millers received a daily wage of about four shillings, or a monthly wage of four to five pounds. Some early mill owners' income was derived from payments in grain from the farmer for goods and rents as well as from the flour sold. The toll for gristing of 1/14 (or 1/12 from 1793 on) formed a minimal part of the owner's income.

The government offered positions to "millers" in King's mills. Candidates were encouraged to petition for the lease of a mill and the best man was chosen.[3] Providing the mill was kept in good repair, good flour was milled and no better candidate applied, the same "miller" was awarded a new term if he wished. The length of terms varied as time progressed; until 1786 leases lasted 10 years, after 1786, 15 years, and later in a few cases, 21 years. In practise, however, this did not always work out. "Millers" changed sometimes after two or three years. Rents of government grist/sawmills ranged from £66.0.0 to £88.0.0 per annum which was sometimes paid to the Crown in flour or grain. The lessee received his pay in the form of grain taken as toll from the farmers, which he then ground into flour and sold or exchanged.

Mill Owners

Not every grist-mill enterprise was a successful venture, especially for early mill owners lacking capital. The experience of Samuel Ryerse, who erected the first grist mill in the Long Point settlement on Lake Erie about 1796, was burdensome. The lands Ryerse chose to settle were allotted him on the conditions he build a grist and sawmill on the valuable mill seat contained in them. To secure the necessary capital, he had to sell some of his land. Once built, the grist mill required costly repairs, improvements, new bolting cloths, a new dam, constituting a "constant draw upon my father's purse" according to his daughter, Amelia Harris.[4] In summer the mill was often idle because most gristing was done in winter when farmers could sleigh their grain to mill. Hiring a miller to run such a mill was costly, the toll of 1/12 insufficient. Thus "the flour mill pecuniarny [*sic*] speaking was a great loss to my father;

the sawmill was remunerative."[5] At one stage of the mill's existence, a store, 14 feet by 14 feet, was partitioned off in the mill. Shelves, a counter and a desk were put up, goods from Montreal were arranged attractively, and "STORE" was written above the door. Payment was accepted in cash or flour. But this venture failed too, owing to the lack of experience of Samuel Jr. who was put in charge. In 1814 the mills were burned by the American army.

Omitted in Amelia Harris's account were other factors which thwarted her father's enterprise. During the first 12 years of settlement at Long Point, some 11 grist mills were erected. Such competition in a newly settled area, relatively remote from the beaten trade routes of St. Lawrence and Lake Ontario, no doubt added to their difficulties.

METHOD AND TECHNOLOGY OF GRIST AND FLOUR MILLS

The fast reduction method of milling in the 1780s was known as "low" or "flat" grinding because the millstones were run close together to mill as much flour as possible in one passage of grain across the stones. First the settler's grain was received by the miller or servant in the mill who weighed it and extracted the toll. Next it was cleaned to remove extraneous material and seeds - some millers insisted on cleaning before extracting the toll. The mill was started (if not already turning) and the farmer's portion of the cleaned grain poured into the hopper above the millstones and milled into meal. As the floury meal poured out the mouth of the stones it was collected in tubs or sacks and carried (depending on the layout of the mill) to an area or loft for cooling and drying. Often a young boy or "hand" would rake and shovel it to speed the cooling. Once cool, the meal was transferred to a flour bolt, if there was one, which graded the flour into "superfine," "fine," "middlings" or "carnel" (an anglicization of the French *canaille* meaning coarse), the number of grades or qualities depending on the number and quality of bolt cloths. The largest and coarsest particles of bran and flour, called "offal" or "tailings," poured out the tail end of the bolt and were bagged. Each grade was returned to the settler in sacks, according to the mill's capability; flour for export was usually packed in barrels, each quality in a different barrel.

Much of the transporting work in the mills built before 1800 was done by manual labour in contrast to those mills built with automatic devices sometime after 1795. Rope hoists, often operated by waterpower, could be used to lift sacks of grain and flour to the top storey, depending on the plan of the mill (Fig. 3). However, usually the miller required a strong helper to carry each variety of bag up and down the two storeys of the mill, and from machine to machine. The American Oliver Evans (who automated mills in the late 1780s) noted seven tasks performed manually in merchant mills of the last quarter of the 18th century: carrying wheat, hoisting it, taking it from the granary to the hopper, shovelling grist onto tubs, hoisting them, feeding the bolter and mixing the bolted material. These required seven workers or the stopping of some operations to carry on others.

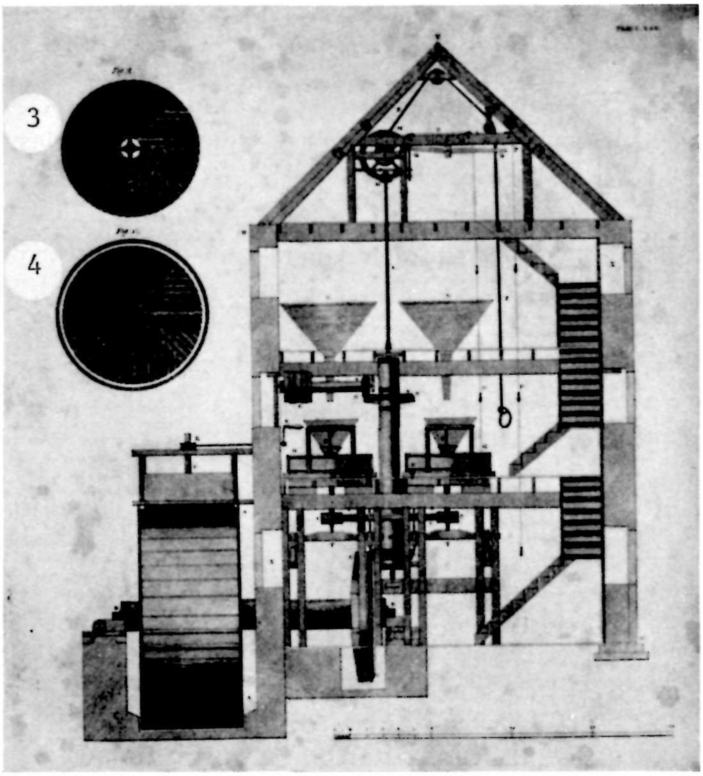


Figure 3. Plan for an old process mill (non-automated) in which manual labour performed much of the hauling of flour and grain. Ropes moved by waterpower lessened man's labour by raising sacks of flour to the loft for cooling. Figures 3 and 4 are the faces of the runner and bedstone, respectively. Each is dressed with eight quarters; six auxiliary furrows lead from each master furrow (Andrew Gray, op. cit., p. 30). (*Courtesy Norman Ball.*)

Grain and Grain Cleaning

The varieties of grain grown by the first settlers in Ontario were generally known as "spring wheat" (also called "summer wheat") and "fall wheat" (also called "autumn" or "winter wheat"). Fall wheat, sown in the fall, prospered well in areas having mild winters. Under protection of light snows, it developed a root system; in early spring it grew high and was harvested in the early summer. Its soft, moist, starchy, usually white kernels with tough skins that did not break up were relatively easy to mill into a white flour providing the stones were sharp; consequently, it was the preferred wheat along the southern areas of early Ontario. Each Loyalist family was allotted three bushels of autumn seed wheat by the government. Spring wheat (sometimes an alternative when fall seed wheat was unavailable) grew readily in northern areas of Ontario where fall wheat would not; spring wheat also thrived in southern areas. It was planted as soon as the frost left the soil and harvested in the late summer. The grains of this wheat were dry and hard, and although they had the asset of being protein-rich, they also had the drawback of a dry brittle husk that was easily crushed into tiny particles by millstones, and a hard kernel difficult to mill into fine white flour. Greater pressure and speed was used for hard wheat, sometimes scalding and discoloring the flour. Thus, the early flour from spring varieties of wheat was "specky" and dark in colour compared with the flour from fall wheats, and so it sold for less. It was mainly because of the dificult milling qualities of spring wheat that new methods were devised and new machinery invented by hard wheat millers. In fact, the effort to produce a white lively protein-rich bread flour from spring wheat to sell at a price equal to or more than that from fall wheat led eventually to the milling methods of the 1880s.

It was necessary to clean wheat before milling because it was subject to a great many impurities that would injure the quality of the flour. The type and variety of weeds reaped with grain depended on the locale, season and year in which grain was sown and reaped: wild onion, wild garlic, thistle, cockle and wild peas are a few mentioned in early accounts. The methods of threshing with a flail on the ground or barn floor (Fig. 4) or by treading horses or oxen over it increased the amount of dirt adhering to the kernels. Sticks, sand, dust, chaff, all the dross had to be removed. Grain shrivelled by diseases, insects and unfavourable weather affected the flour as did overripe wheat and pests that attacked stored grain. During the early days, not all these imperfections were separable as Evans' directions for milling "wheat mixed with garlic" bear out.[1] Weiss wrote that pioneer mills in New Jersey[2] used no grain cleaners, and early backwoods mills in Ontario probably operated without cleaners for a while. Lacking

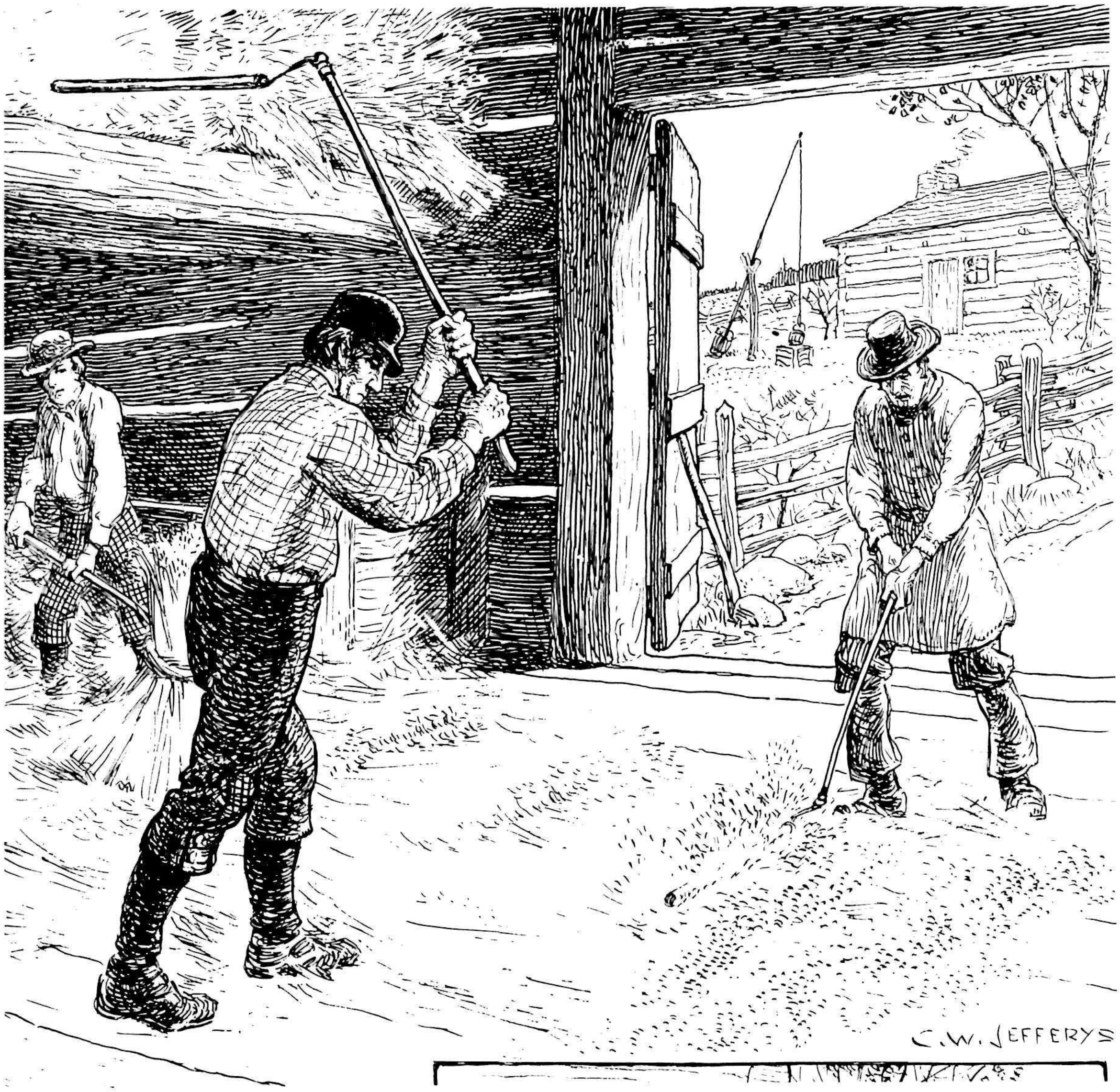


Figure 4. Threshing with a flail on the barn floor, one of the manual methods of threshing wheat in the 18th and early 19th centuries (Jefferys, op. cit., Vol. 2, p. 227). (*Public Archives Canada.*)

machines, there was a variety of hand methods for cleaning grain. In addition, there were mechanical devices to which early millers might resort:

1) The simplest method of cleaning grain was winnowing, performed by the farmer (Figs. 5, 6). Grain was exposed to the air so that the wind would blow away straw, chaff and dust, and the heavy grain would be caught in a container below. This was done after threshing and was rarely sufficient if good quality flour was desired. Not all the light dross was removed and much of the heavy dross was caught and remained with the grain.

Figure 5. Winnowing grain from the light chaff using a shaking screen and the wind, principles reproduced in machines designed for cleaning grain in mills (Jefferys, op. cit., Vol. 2, p. 277). (*Public Archives Canada.*)

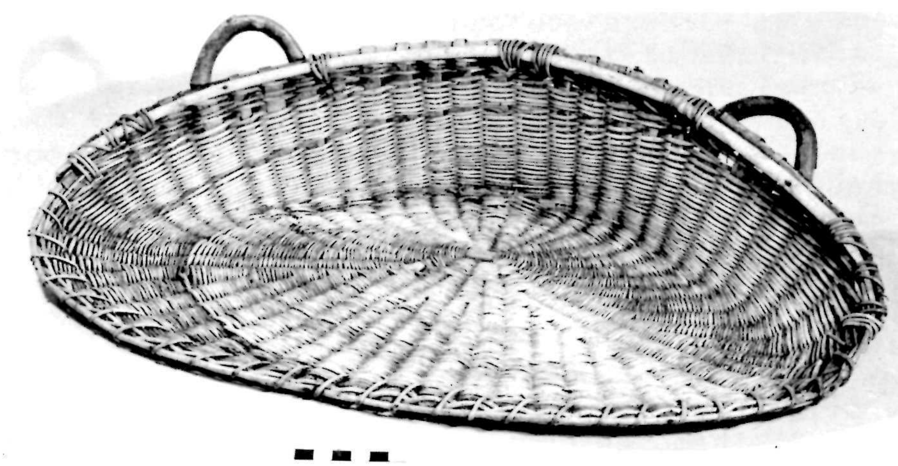


Figure 6. Type of wicker winnowing-fan, ca. 1800, in which grain was thrown up into the wind and caught again after being separated from chaff and light particles. (*University of Reading, Museum of English Rural Life.*)

2) A second cleaning usually took place in the barn or mill. Here a type of hand screen (wire or wicker) might be used to shake out the bad material from the good. One variety made of two layers of wire mesh, the top coarser than the bottom, would retain the good grain in the middle, the dross on the top and let the heavier particles of dust and broken grain fall through.[3] "Cockle skreens" to separate cockle seeds which grew and ripened with wheat in many areas were sold in 1763 in New York to "all concerned in cleaning grain."[4] Mill supplies from the Albion Mill Company, England, sent by Simcoe in 1792, included six wire sieves of three different meshes. Three of the sieves were of No. 24 wire, two were of No. 10, and one was made of No. 30 wire (probably the finest mesh of the three). Possibly these were hand sieves, or else made into sieves for shaking out the material from grain.

3) The invention of the fanning mill in 18th-century Europe combined the two manual methods of winnowing and shaking. There were many kinds imported to America. The first fanning mills used in New France were sent in 1732 in response to Intendant Hocquart's request to the King, and were described as *cribles cylindriques et de fil de fer à la façon d'Hollande*.[5]

4) In the 1780s, "Dutch fans" were used in merchant and country mills of the United States.[6] Operated in conjunction with a revolving wire mesh cylinder of one or two layers of different size mesh through which grain was sieved, the Dutch fan blew dust and light stuff from the wheat as it fell from the rolling screen. While this fan was moved by waterpower in American mills, it is probable that the *à la façon d'Hollande* variety of 1732 was turned manually; it was after 1750 that ways were devised to turn more of the mill machinery by waterpower.

5) George Allsopp, *seigneur* of the seigneury of Jacques Cartier, Quebec, used a variety of grain cleaners in his merchant custom mill, partly because he milled a variety of grains. Describing losses when his mill of eight runs of stones burned down in May 1793, he wrote, "in two hours the covering and all the floors fell in together with... cribbles, screens, cylinders with brushes for cleaning wheat,...all worked by water."[7] The cribble, an anglicization of the French *crible*, or sieve, was a screen. Of special interest, however, is the description of the cylinder with brushes for cleaning wheat, probably an early type of British grain cleaner like the design of Milne's and at that time one of the latest improvements.

6) Manufactured patented machines of John Milne, England (Append. B, Manuscript Report No. 201) were sold in New York and New Jersey, or at John Milne & Sons of Manchester, England, as early as 1773. In America, the cost of Milne's grain cleaners was £12 New York currency. These

machines were wire cylinders with brushes inside, probably similar to those used in George Allsopp's mill.

7) Oliver Evans, the American inventor who published his *Millwright's Guide* in 1795, described grain cleaners in use before then. Three kinds of rolling screens (as well as the Dutch fan) and a shaking sieve (none of them using a brush), along with the method of setting them in motion, were reported to be commonly employed.

8) Another method of cleaning grain was by rubbing it between "ending stones," also called a "sheeling mill" in Scotland.[8] An ordinary pair of millstones, or special stones, set wide enough apart just to rub off the beards and bran and loosen the germ, cleaned the grain without grinding it into meal.

9) Some millers washed and dried the grain which helped loosen and toughen the outer bran covering so it was less likely to break up into unsiftable particles when milled.

Once the grain had been cleaned to the miller's satisfaction it was ready for the millstone hopper to which it was carried or channelled and poured. There was a number of types of millstones available to millers of the 1780s.

Millstones

Millers and millwrights of all times searched for stones that would last and mill a high quality flour. Certain properties were necessary: hardness ensured a lengthy service; the stone's tenacity kept it from crumbling; porosity (caused by the granular structure) provided sharp edges or natural "buhr"; stone structurally uniform wore evenly and laid bare an equally rough surface as the old one wore off. Natural stones that had the above four properties included certain types of quartz, porphyry, granite, sandstone and volcanic rock.

1) Many millstones used by early millers were hacked from the most suitable boulders and rock outcrops near the mill site. These solid local "common" or "country stones" were often flinty conglomerates or granite.

2) So important was it for millers to get the best stone that they or the government were willing to import them. The best millstones of all time were "French buhr stone." These were composed of one-foot-square stones quarried "from time immemorable"[9] near Paris, at Ferté-sous-Jouarre, France. The rock was a fresh-water quartz, porous, homogeneous, very hard and long lasting. Various methods were followed to make different types of millstones, but the type imported to America was made by cementing choice pieces together on a backing of plaster of

Paris and then shrinking an iron hoop around the outer edge (Fig. 7). A number of French millstone manufacturers exported their stones.[10] In 1795, George Allsopp at Quebec city wrote that he had just bought a pair of "French buhr millstones" for his new mill. Such stones cost as much as £60 (two to three times the price of local sandstone millstones) and were installed in most of the best merchant mills. French buhr millstone manufactories began to be established in America as early as 1774. James Webb of New York advertised that he was the "first person in the province" to import and promote the manufacturing of French buhr millstones.[11] In Upper Canada in 1792, 12 pair of French buhr millstones were shipped from the Albion Mill Company, England, as part of the King's stores to be issued to mill builders free as an encouragement to the erection of mills for the accommodation of settlers. The cost to the government for one pair was £22.

Figure 7. French buhr millstone of unknown date showing the porosity of the rocks composing it. A sickle dress remains faintly apparent on its face. (*Black Creek Pioneer Village, Toronto, Ontario.*)

3) Sometimes a combination of French buhr and local stone was made up, either by a millstone manufacturer or by a millwright. The outer portion or skirt where the important grinding was done was made of French buhr, and the central "eye" area was made of local stone.

4) The Esopus quarry on the Hudson River just north of Poughkeepsie, New York, produced solid millstones. The rock was made up of "small white pebbles congealed together in a darker matrix which completely filled the interstices and left no empty cells."[12] This type was popular before and after 1800. Sometimes called "Soper" or "Yankee" stone, it was soft and had to be dressed often. Similar pebble grit stone was available from Virginia quarries.

5) Other stones available to early millers of the 1780s were imported and known variously as "Dutch blue stones," "Cullin stones," "Andernack," "Lavastein" and "Blue stones," all quarried along the Rhine River from the bluish basaltic stratum. These were considered to be the best until the French buhr replaced them.

6) In England, a millstone quarry in the Peak district of Derbyshire where solid millstones known as "Peak" were made may have supplied early Canadian millers with millstones. They were particularly good for milling corn and oats.

With the exception of stones used in portable mills the sizes of millstones in the 1780s tended to be large, anywhere from four feet to seven feet in diameter, and from eight inches to two feet thick. A large stone might weigh up to two tons. The problem of transporting them was solved by using *batteaux* and teams of oxen. Some pioneer mills in the backwoods where merchant work was out of the question used small millstones closer to the size used in portable mills. Ebenezer Allen's mill which was built in the late 1790s was described by Lord Selkirk in 1804: "the stone 20 or 21 inches diamr has been lifted in one hand - it does 15 or 16 bu Ind[ian] corn - 18 or 20 wheat or Rye in 12 hours work."[13] It was used to make chop for distilling as well as to mill flour.

Millstone Dress

The grinding surface of millstones was divided technically into areas: the hole in the centre was called "the eye," the area surrounding it was "the bosom" and the outer area was "the skirt" (Fig. 8). The back of the stone was "the backing" and the grinding surface was called "the face." The face was "dressed" or grooved to create sharp edges with main channels called "furrows." The ungrooved flat areas were called "lands." Sometimes the lands were "cracked" with tiny chisel marks if more sharp edges were needed on the grinding surface. There were two types of furrows: main or master furrows that led from the eye to the skirt, and auxiliary furrows that branched off the main furrows. Both were about as deep as a grain of wheat at the "back edge" while the other edge was sloped to a "feather edge" (Fig. 9). Every main furrow and its related auxiliary

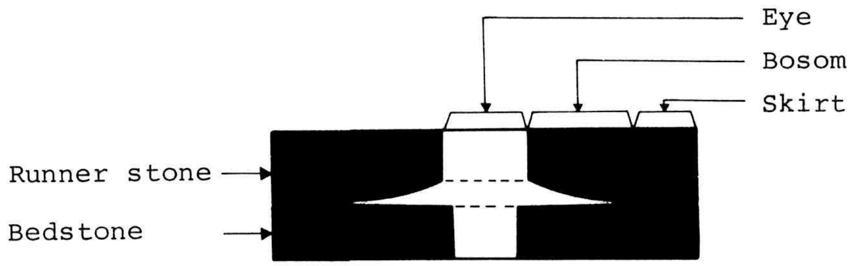


Figure 8. Diagrammatic view of a run of stones showing the main areas: the eye, bosom and skirt (Kozmin, op. cit., p. 164).

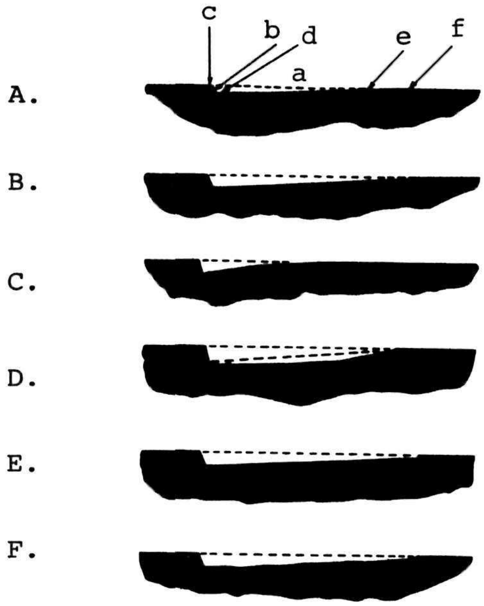


Figure 9. Cross section of furrows in a millstone dress shown in various conditions. A) is in perfect dress showing a, inclined bottom; b, back; c, back edge; d, heel; e, feather edge; f, land. B) is gouged at the feather edge, C) is rounded, D) is dished, E) has a blunt fore edge and F) is humpy; each of these imperfections was corrected by skilled stone dressing (Dedrick, op. cit., p. 271).

furrows and lands made up a section or "quarter" of the millstone dress (Fig. 3).

Millstone dress varied according to the size of the millstone, the quality of the stone and the type of grist being ground. Hard and dry wheat required a dress with less furrows and more plane parts or land so that the brittle bran would not be crushed and speck the flour but be separated in large flakes that were easily bolted out. On the other hand, damp wheats required sharper stones, more open and porous, with more cracks and less plane areas, because the grain was tough and rubbery and difficult to break into meal. Some of the French buhr millstones were so porous that millers considered they needed no dress at all. Choice of a particular style was up to the head miller who (taking into consideration the variety of grain and his type of millstone) knew from experience which dress produced the best quality flour.

Ellicott described how to dress 5-, 6- and 7-foot stones: 16, 18 and 20 quarters, respectively, were made.[14] Craik in 1870 stated that "in the early days" there were fewer quarters and more bosom, and that odd numbers such as seven and nine were preferred.[15] Millstone dresses changed as time progressed because of the changes in stone size and quality, the purpose of the stone, the increase in power and the type and quantities of grain being milled.

At least 12 mill picks, varying in size, weight and sharpness and made of the best tempered steel were used for stone dressing. When soft and dull, picks were taken to the blacksmith to be properly hardened. Once the picks were sharp and ready for use, they were fitted into wooden thrifts or handles made of suitable wood such as ash, beech or chestnut.[16]

Preparations for dressing the stones required that everything be ready to save time so milling could resume quickly. As many as 12 mill picks, tempered and sharpened, were laid out, grease was on hand, the necessary tools were available. The mill was brought to a stop. The runner stone was raised by the crane and turned face up. First a test was made with the red staff (a straight edge painted with ochre to colour uneven areas) to discover where the millstone was "out of face." The coloured high areas were then "dressed down" by cracking and light facing with the lightest and sharpest of the millpicks. Next the bosom was staffed with a shorter bosom staff and dressed down. Then the furrows were deepened by the use of heavier furrowing picks. Starting at the feather edge, the dresser skilfully picked toward the back edge so the pick became sufficiently dulled for the heavier blows required to deepen the back edge. A first-class stone dresser could make 25 cracks per inch with machine-like precision and join each series with the other, making a continuous line. Both runner and bedstone were dressed with the same style. After dressing, the spindle foot and gears were oiled, and the spindle put "in tram" (that is, made truly perpendicular). When the stone was positioned over the bedstone, the patterns were reversed so that as the runner stone turned the furrows crossed each other like blades of shears. The softer the stone and the more use it had, the more often it had to be dressed. Evans believed in dressing his stones twice a week when the mill ran day and night. The most successful miller took great care to keep his millstones properly sharp and dressed because this was the best guarantee of good quality flour.

Stone dressers, especially of hard French buhr millstones, were sometimes known by the blackness of their hands. This blackness or "metal" was caused by pieces of badly tempered steel pick which flew out and became embedded in the back of the hand as the pick struck the hard rock. In England it is said itinerant millstone dressers were required "to show their metal" (that is, their blackened hands) as a guarantee of their skill before being hired - and this was the derivation of the saying "show your mettle." Evans' remedy to prevent black hands was to place a piece of leather over the hand, but this type of aid was considered a hindrance by some.

How Grain Was Milled

In the process of low grinding, grain entered the eye of stone, rolled along the main furrows by centrifugal force over the lands to the skirt or flouring area and was finally flung out as meal. The furrows acted as cutters, conductors and ventilators while the land served as grinding surface (Fig. 10). The distance between the upper and lower stones

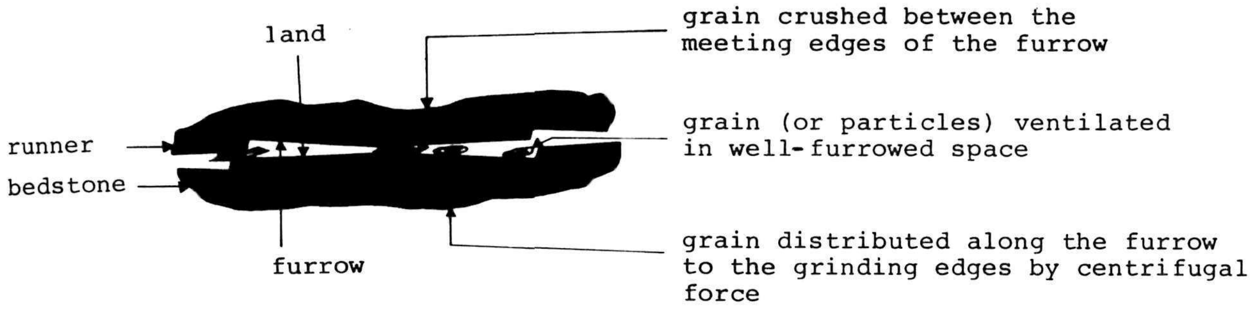


Figure 10. Simplified view of a segment of two millstone faces working together showing how grain was broken, crushed, distributed and ventilated by the furrows as the runner stone revolved over the bedstone (Dedrick, op. cit., p. 265).

gradually lessened from the bosom to the skirt (where the stones almost touched). As the grain rolled toward the skirt, it was reduced more and more by the closeness of the stones and the sharpness of the cracked edges. As well as grinding the grain, the millstone dress aimed to clean the flour from the bran and keep the bran as whole as possible so that it would not speck the flour. Millwrights' tables indicate how the speed of the runner millstone was regulated by the size of water wheel and gears and the size of the stone. Generally a large stone did not need to turn as fast as a small stone. Speeds from 60-150 rpm depending on the grain and stone size were considered satisfactory by early millers. Higher speeds heated and killed the flour, lower speeds produced coarse flour.

Flour Cooling and Bolting

Once the meal left the millstones it had to be cooled if it was to be bolted effectively. Millstones generated heat, and the grist leaving millstones was often hot, damp and sticky. Various methods of cooling and drying were employed. In some mills a boy shovelled it around in a large shallow bin or tub, whereas in others it might rest on the floor of the loft for as long as 12 hours. Whatever the method, if not cooled the bolting cloths clogged quickly and flour was apt to sour early.

Early flour bolts were cylindrical wooden frames around which were stretched a number of bolting cloths of varying mesh depending on the size and purpose of the bolt (Fig. 11). The bolt or reel turned by millpower and was slightly inclined so that as the cooled meal entered the top end it was tumbled around and down. Usually the cloth at the head of the reel was of the finest mesh, that in the middle less fine and that at the end most open so that flour of three grades or qualities was sifted through ("the throughs") into separate holders, while the largest pieces of bran and middlings fell out the tail end of the reel ("the tailings") into a container. Manufactured bolt machines were available from Europe and America during the 18th century. Often, however, from choice or necessity, the miller or millwright constructed his own machine. If the machine was custom-made, a variety of bolt materials, either manufactured or homemade, was available to tack onto the cylindrical frame.

Bolt Material

1) Mill supplies shipped from the Albion Mill Company, England, to Upper Canada in 1792 included a total of 105 feet of wire of five different meshes numbered H64, H42, H32, H20 and H9, in order of the finest to the coarsest. Pieces of this wire would have been tacked on wooden bolt frames according to the millwright's specification. This British wire mesh material was a favourite among millers in

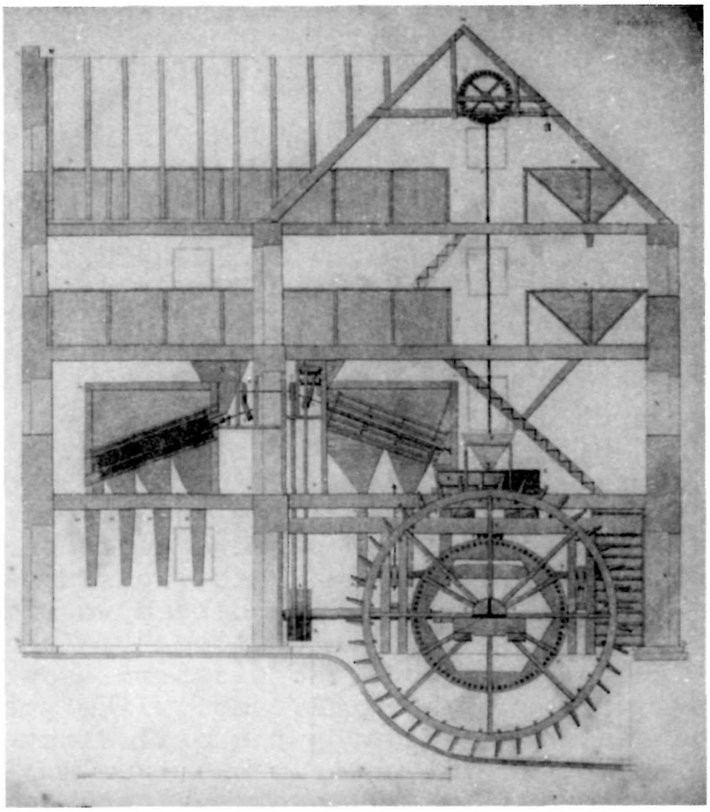


Figure 11. Multiplane view of an old process mill with two flour bolts; the left is covered with wire and the frame of the right would be covered with bolting cloth. From the benches on the upper storeys the cooled flour fell into the flour bolt hoppers, was bolted, then bagged in separate containers from the spouts in the basement level (Gray, op. cit., p. 26). (*Courtesy Norman Ball.*)

colonial America, because although it rusted, it was less likely to clog and was more durable than cloth.

2) Bolting cloths were among the several improvements ordered by Richard Cartwright for his merchant mill between 1795 and 1800, just before the first flour inspection act of Upper Canada (1801) when grades known as "superfine," "fine" and "middlings" were specified. It is interesting that Cartwright returned some fine cloths he had recieved in late 1800 because they were "finer than ... wanted" - probably No. 7. In their stead he ordered No. 6 which "would be fine enough, or at least No. 5." These, he wrote, could be procured by a Mr. Scheiflin in the United States. Possibly these cloths were what was known as "Dutch silk bolting cloths." During the War of Independence, Americans persuaded the Dutch fishnet manufacturers to weave a superior silk cloth with twisted thread that prevented the

meshes from spreading, and this was imported to the United States in lieu of British wire mesh from 1789 to 1815.[17] Eight grades of silk bolt material were manufactured at first, ranging from No. 0 with 324 openings per square inch (for coarsest matter) to No. 7 with over 7,500 openings per square inch (for "superfine" flour). It was expensive, six dollars an ell, but it was said to last five years which was longer than the common bolting cloth of France or England.

3) The English and Dutch also manufactured bolt cloth of flax, and hemp.[18] Other materials aside from cotton used in bolt cloths were wool and horsehair. In 1781, seven yards of "superfine cloth" were shipped to Canada by the firm of Whitily and Duperoy, London.[19]

4) Homespun cloth covered the flour bolt at the Napanee King's mill in 1786. The millwright's wife, Mrs. Clark, and a Mrs. Bell used 24 skeins of thread to weave the cloth, probably according to millwright Robert Clark's instruction, perhaps into two different cloths of varying fineness. These, with 3 1/4 yards of Russian sheeting also bought "for the boult"[20] would have been wound around the wooden frame and tacked into place. This bolt machine was turned by hand. Many of the first mills probably employed homespun bolt material. Most likely the entire bolt machine was custom-made by the millwright himself.

Bolt Machines

1) Ellicott gave instructions on how to build bolts in Evans's *Millwright Guide* of 1795. Common country bolts (such as those used in custom mills) were about 10 feet long and 2 1/2 feet in diameter with a chest the same length, 3 feet wide and 7 1/4 feet high. Six yards of cloth would cover a 10-foot reel. Bolting reels for merchant mills had to be longer and stronger.

2) Manufactured bolt machines were available from the United States and from England. One of these was patented by John Milne, a British millwright, and consisted of a wire mesh cylinder with revolving brushes inside to force out the flour. In 1773 it was advertised that Milne's bolts were available at Daniel Neil's near Acquaknack, New Jersey, or at Templeton and Stewart's in New York for £33.0.0. In Manchester, England, they were sold at John Milne and Sons.

3) Part of the mill machinery shipped from the Albion Mill Company, England, to Upper Canada in 1792 included "a flour machine complete with carriages, brushes"[21] costing £12.0.0 (government price). An additional 130 feet of extra hair brushes at 8d. per foot were included. It is not known whether this was one of Milne's machines, but from the description of Milne's patent it appears to have been similar in design, having brushes that swept the flour out of the bolt.

Once bolted, the process of manufacturing flour was complete. The chore of packing remained. Custom flour was sometimes bagged without bolting (if there was no bolt or if the customer requested it). Depending on the mill, various services for customers were performed. For example, one customer might prefer all the superfine quality separated from the fine; another might prefer mixtures of superfine with middlings, or with fine, or a mixture of fine with bran. Usually custom flour was returned in sacks. Flour for export or commercial use was packed in sacks or barrels.

Water Wheels

As a result of experiments in 1752, John Smeaton, the well-known British millwright, discovered that the overshot water wheel transmitted about 60 per cent of the total waterpower, the undershot 30 per cent of the total waterpower and the breast wheel between the two. But even after this, some millwrights disagreed because many other factors such as wheel size, water supply and bucket shape could improve the efficiency of any of the types. One wonders how much the first Loyalist millwrights knew or had discovered about water wheels. Certainly the pioneer setting had taught them resourcefulness.

Few facts are available regarding water-wheel construction in early Ontario, and the researcher is forced to resort to handbooks of the day. Evans's *Millwright Guide*, as well as reporting Smeaton's experiments, outlined the advantages and disadvantages of different wheel types. It described how to build and gear them to millstones of the proportionate sizes. From Evans and others it is deduced that the following water wheels were employed before 1800 in Ontario:

1) One of the simpler applications of water to power a mill was the use of a current or stream wheel (a primitive form of undershot), in which floats dipped in and were turned by a fast-moving constant stream or river. Because this sometimes required no dam or race, it was less expensive than other types; but a mill so powered risked flooding by being exposed to the whole body of water. Dry seasons left such a wheel high and dry.

2) Another simple method of harnessing waterpower was by the use of a horizontal tub-wheel. Suited to small falls and often requiring no dam, the tub-wheel had a vertical shaft that carried a millstone on top. According to Evans "its exceeding simplicity due to having no cogs to repair"[22] made it preferable to the undershot, providing the water was plentiful and fell more than eight feet

(Fig. 12). The tub-wheel and other horizontal water wheels of the 18th century were used considerably in America, France and Scotland and were the forerunners of the 19th-century turbines.

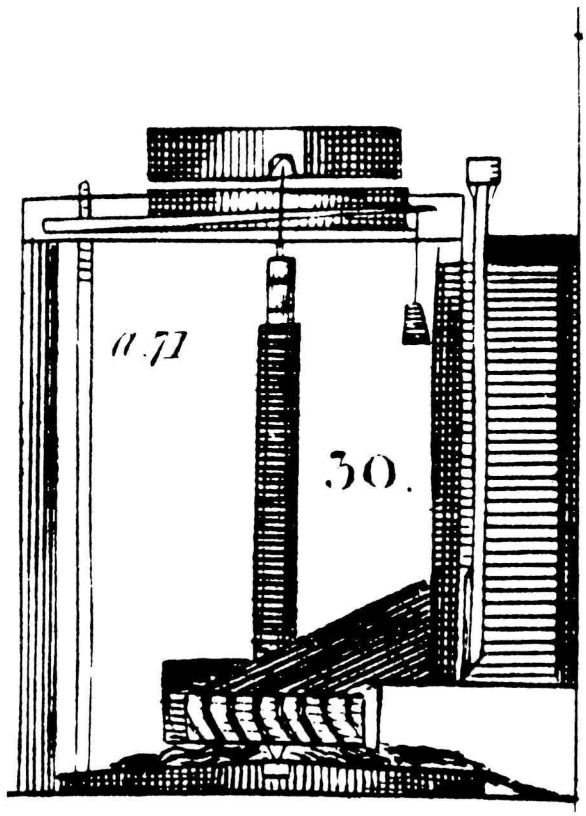


Figure 12. A tub-wheel, simple and cheap compared to a large vertical wheel. It was applied directly to the millstone spindle without the need and expense of cog gearing (Evans, op. cit., Pl. 4).

3) Although use of the undershot wheel began to decline in England during the late 18th century as a result of Smeaton's experiments, in early Ontario the undershot was practical for a small fall and a large supply of water. Turned by water channelled from a dam to the wheel in a specific type of water course, the floats were spun around by shock or impulse (Fig. 13).

4) The breast wheel, which gradually replaced the undershot wheel in 19th-century England, was suited to falls of about five feet and over, or wherever an overshot was not practical. It moved initially by the shock of water hitting the floats, and second by the weight of the water filling the floats which were constructed with rising boards (Fig. 14) or buckets. More skill had to be used in devising the wheel so the maximum use of water was achieved. Evans advocated ventilated floats that filled and emptied easily.

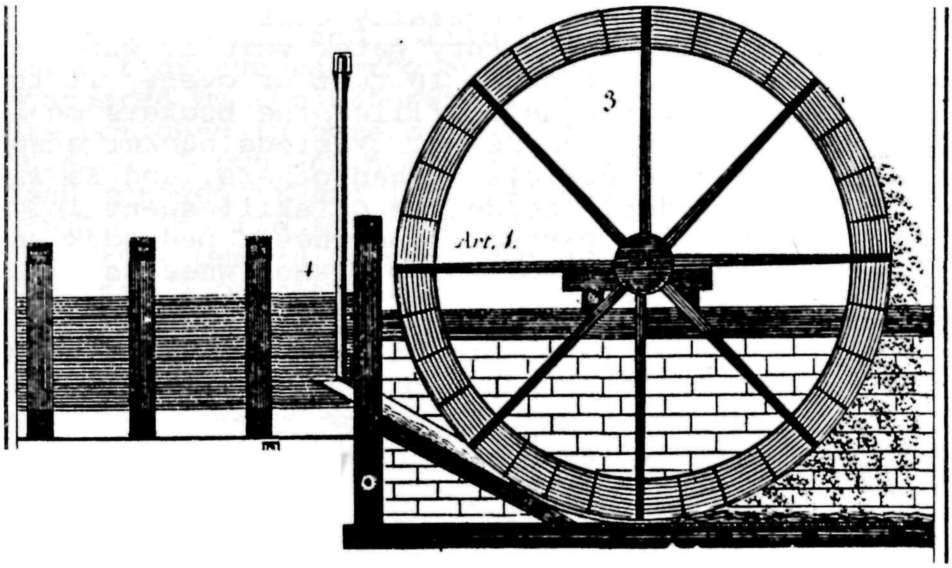


Figure 13. Ellicott's design for an undershot wheel suitable for a head and fall of 7 feet of water. Its diameter was 18 feet and its width was to be equal to the diameter of the millstone (Evans, op. cit., Pl. 13).

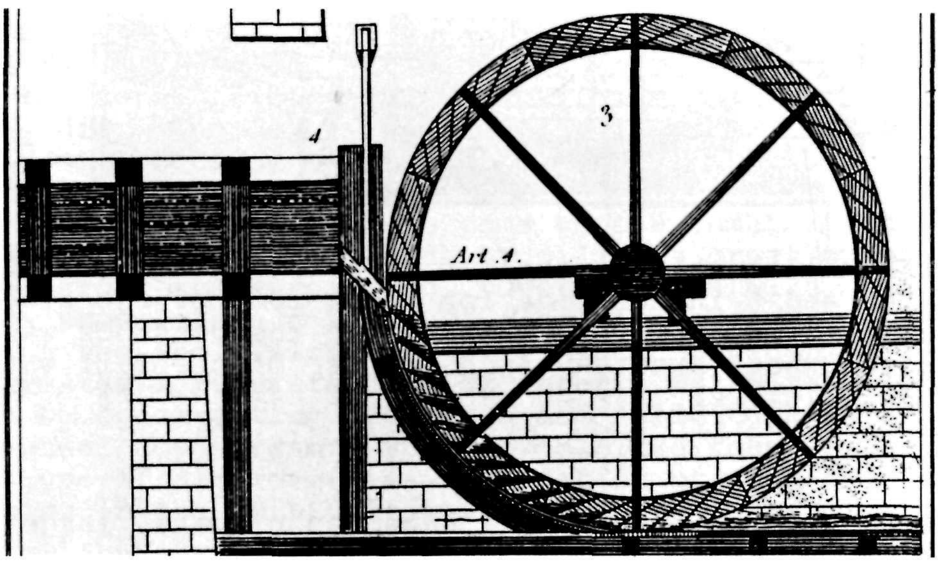


Figure 14. Ellicott's design for a middling breast wheel suitable for a head and fall of 12 feet of water. The diameter of the wheel was 18 feet and its width was to be 9 inches for every foot of the diameter of the millstone (Evans, op. cit., Pl. 14).

5) The overshot wheel, generally considered to be the most efficient of all 18th-century water wheels, was suitable to a high fall of about 10 feet or over. It turned by the weight of the water which filled the buckets on the rim of the wheel and emptied below. Various bucket shapes were devised, some more efficient than others, and as with the breast and undershot, the degree of skill spent in constructing the various parts of the wheel, penstock and spout determined the degree of the overshot wheel's effective power (Fig. 15).

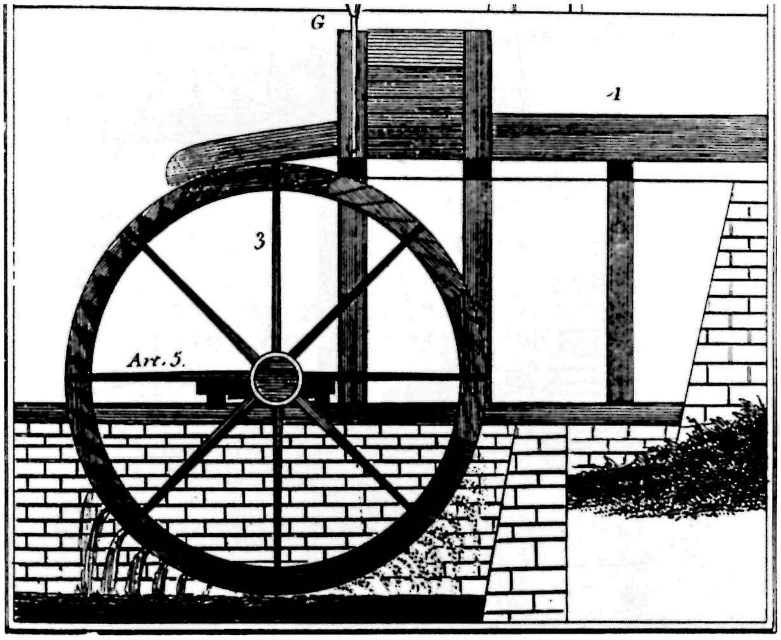


Figure 15. Ellicott's design for an overshot wheel 18 feet in diameter and 6 inches wide for every foot of the diameter of the millstone. The head of water in the penstock was 3 feet and the wheel hung 8-9 inches clear of the tail water (Evans, op. cit., Pl. 15).

Wheel Housing

Because of the harsh Upper Canadian climate, large vertical waterwheels were enclosed in a "waterhouse" or "wheel house." In winter, this might be heated by a fire to keep the wheel completely ice-free. Several heating methods were tried, some better than others. George Allsopp, writing of the fire in his large merchant and custom mill in 1793, mentioned the method of warming which resulted in the devastation of his mill:

> a fire place or kind of open brick stove built on purpose in a thick wall was suffered to

> fill with ice, and a fire made on the wall itself of the waterhouse to thaw the ice gathered by the waterwheel, - this last method is followed in some mills, but aware of the risque, I projected the fireplace in the wall and renewed it and improved the same last fall, even the fire so made the contrary to positive orders was yet neglected and rolled against a partition.[23]

Craik wrote of another, possibly 19th-century method where a stove or fireplace discharged "smoke and fire into the wheel" so that the wheel circulated the smoke and hot air preventing the entry of cold air and melting the ice. In this case, the wheelhouse was sealed off from the rest of the mill.[24]

Milldams

The building of milldams made great demands on a millwright's ability and experience. No one solution applied in every case. The situation and circumstances largely determined the materials and method. The depth, width, banks and current of the stream had to be considered. Winter ice and spring freshets had to be taken into account. While the current and horizontal wheels often required no dam, the more efficient undershot, overshot and breast wheels did. The dam was considered to be a most vital part of the mill because it stored power and sometimes raised the level, increasing the power.

1) Some early Ontario dams were a combination of brush, rock and gravel, made by piling a great quantity of brush across the stream bed, covering this with a layer of coarse stone, then a layer of fine stones and finally topping the whole with carefully placed boulders. Such a dam created a moderate head of water. Extra fall could be added by constructing stop logs and building a race to the mill wheel downstream. Verschoyle Blake found evidence that this type of dam formed the foundation of some dams still existing in the 20th century.[25]

2) Craik described 11 ways of building dams, some of which may have been followed by the first millwrights. One, made of timber, moss, bark and gravel, was suitable for a site with plentiful timber on a stream with a rock bottom and a constant supply of water.

3) Another, for a small stream with a good bottom that dried up in the summer, was made of rafters or planks and sawdust.

4) A dam with piles, timber cribwork, stone centre and

fascines of brushwood was suitable for mud and sand-bottomed streams.

5) The building and "filling in" of the dams of the Niagara King's mills in 1783 imply, perhaps, that cribworks were made and filled in with rocks or other materials. Generally it was better not to use earth-fill in case muskrats and beavers chose to build their homes inside, thereby undermining the whole buttress.

6) Repairs made to the King's sawmill on the Humber in 1794 shed light on dam construction; the front of the dam had been planked and in the following spring it was planned to build an apron on the dam. An apron was a reinforced slide fronting where water spilled over the dam. It protected the dam and its foundation from the vertical fall of logs, ice and other objects that overflowed. By 1829 aprons were specified by law on all streams where there were log rafts and fish. Before this, however, its construction was left to the builder, the inhabitants' will and special orders of those in power - in 1796, petitioners asked that the dam of Sir John Johnson's mill on the Raisin River of Williamsburg be opened to allow fish to pass upstream in the spring.

Water Course

It was safer when feasible to build the mill away from the dam because of floods, and to build a lead or race to carry water from the dam to the mill, (mill-race or head-race), and back to the river, (mill-tail or tail-race). A channel might be cut into the earth and reinforced with timber or stone, or a flume either on timber trestles or laid on the ground, open or closed, might be built. In 1794, the race of the King's sawmill on the Humber had one side "raised by posts and planked with several places logged and banked up from the bottom," and it was planned that the "lower side" of the race be "logged or framed and planked from the foundation."[26]

The length of the watercourse varied depending on the site and practical considerations. Often early mills were placed "on the dam" in a so-called American fashion, according to Lord Selkirk. Smith's mill, built in 1798 near the present Port Hope, although first constructed with a long lead, had to be rebuilt "on the dam"[27] due to leakage in the race which had decreased the power of the overshot water wheel.

Water gates were placed at the dam, water wheel and perhaps mill-tail (depending on the design of the whole) which opened and closed when necessary. That part of the race near the overshot wheel that held the water gate Evans called a "penstock." The design of the penstock, sometimes with a fore-bay or spout, was important and varied with each type of wheel. Some millwrights advocated slanting the penstock down to the wheel: others preferred it horizontal. The water gate (sluice, shuttle), too, required intricate designing to ensure that the proper shape and quantity of water was ejected at the correct angle onto the floats or buckets.

At some position along the race, sometimes in the penstock, a trash rack was placed to keep objects from injuring the gates and buckets and minimizing the wheel's efficiency. To protect fish, "wicker stops" were specified for the King's sawmill on the Humber in 1799. These were to be placed above the race (probably at the dam), "to prevent salmon from being drawn into the stream and either caught within the race or torn to pieces by the wheels" according to an order of Peter Russell, then the president of the executive council of Upper Canada.[28]

SUMMARY

It is estimated that there were at least 60 water-powered grist mills built in Ontario from 1782 until 1800. Many were combined with sawmills or a sawmill was constructed nearby; often the saw mill was begun and finished first to cut timbers for the grist mill. Except for the first government mills, all were owned by private individuals, many of them with capital, and built often with the help of the government which aimed to encourage settlement.

Flour was manufactured by the low grinding, fast reduction process (later known as the "Old Process") and required manual labour to carry flour and grain from machine to machine. About six bushels of wheat (360 lbs) produced one barrel of superfine flour (196 lbs). Except for the Berczy mills which might have followed a German plan, research shows that most mills were built by native American millwrights, designed at first for custom work and no more than three stories high. The mill furnishings included one or two runs of stones, some sort of grain cleaner (although little mention is made of these) and usually a flour bolt. All machinery might have operated by waterpower though it is said that the bolt of the Napanee mill was turned by hand. As grain surpluses increased and merchant milling took hold in the 1790s, mills were improved. Some, located in more settled areas close to grain sources and ports and owned by men with capital, progressed at a faster rate than others at less advantageous locations. It was these favourably located custom-merchant mills that were the first to employ the automatic mill inventions published by Oliver Evans in Philadelphia in 1795.

Part II. The Automatic Mill of Oliver Evans, 1795

THE GENIUS OF OLIVER EVANS

> *No manual labour is required from the moment the wheat is taken to the mill till it is converted into flour and ready to be packed.*[1]

A milestone in milling technique occurred as a result of Oliver Evans's automatic milling inventions which Evans first published in *The Young Millwright and Miller's Guide* in 1795. An inventor rather than millwright, Evans had to study every detail of the milling profession. Between 1782 and 1785, with the help and advice of millwright and miller friends, he and his brothers built a mill on Red Clay Creek, north of Wilmington, Delaware, in which he installed his devices. Reported as a "set of rattletraps" by impressed but confused visitors who arrived while Evans was busy in the fields, the mill operated by mechanical carriers arranged to transport stock from machine to machine. After an initial period of reluctance, eased by Evans's salesmanship, every merchant and custom mill in the United States made use of his mechanisms. At least three progressive Upper Canadian merchant millers, Richard Cartwright, Robert Hamilton and Richard Hatt, adopted his milling improvements around the turn of the century. In 1830 a French miller and engineer, P.M.N. Benoit, translated Evans's work into French, adding notes. In England where labour was plentiful, the change to a mechanized mill was not adopted widely until around 1850, even though a description of Ellicott's automatic merchant mill was published in London in 1796 in volume 6 of *The Repertory of Arts and Manufactures...from the Transactions of Philosophical Societies of all Nations, etc. etc.*[2]

The Young Millwright and Miller's Guide remained a practical handbook for the new school of millers and millwrights in America until the 1860s when gradual reduction methods came into use. Its value today lies in its description of milling practices followed before Evans' time, as well as in the new method prescribed by Evans. The book instructs how to build and operate automatic merchant, custom and combined merchant-custom mills. Easy to read, the text is divided into five parts of which the first discusses mechanics and hydraulics and the second, water wheels. The third part describes Evans's own inventions: the elevator, the conveyor, the hopper boy, drill and descender, how they were built and how they were applied. The fourth part tells how flour was manufactured by the most skillful millers in America. Thomas Ellicott, a millwright friend and merchant miller in Virginia, wrote part five which contains "instructions for building mills with all their proportions suitable to all falls from 3-36 ft." Bills of scantling and iron for a mill 32 feet by 55 feet three stories high with masonry walls are included, as well as directions to build all the machinery and furnishings to operate it in the old fashion. The text concludes with 28 descriptive plates and a short glossary of terms.

Fifteen editions of *The Young Millwright* were published in the United States, the last in 1860. The seventh edition of 1832 omits Evans' preface describing the drawbacks of the old milling methods, and modifies the original appendix "Rules for Discovering New Improvements;"[3] however, T.P. Jones adds useful extracts from the *Franklin Journals* on the construction of water wheels, teeth of wheels and patterns for cast iron wheels.[4] The 13th edition of 1850 contains corrections and additional information on mills of the 1830s again by Thomas P. Jones,[5] a professor of mechanics at the Franklin Institute in Philadelphia and a member of the American Philosophical Society in the 1830s.

Evans's mechanisms included his new inventions and other improvements (which improved older types of machinery).

Inventions

With the exception of the hopper boy, Evans's inventions were used to carry grain and flour from place to place, up, down and across the three or four stories of the mill. All of them, properly applied, made the mill "automatic."

1) The *elevator*, designed to raise grain or flour from one storey to another or from ship to mill, was an endless strap made of good pliant white harness leather revolving over an upper and lower pulley by millpower. A number of small sheet iron or wood buckets attached to the leather scooped up stock from the bottom storey, raised it to the upper storey and deposited it in the appropriate container via a crane spout (Figs. 18-21, 26, 47).

2) The *conveyor*, based on the principle of Archimedes' screw, moved flour or grain horizontally from place A to place B. Made of good maple or smooth hardwood, it was an endless screw of two continued spirals put into motion in a trough (Figs. 16, 18, 20, 26, 47).

3) The *drill*, similar in principle to both the elevator and conveyor but less expensive, was practical in small custom mills. An endless strap, to which rakes made of square willow or poplar blocks were fixed, it revolved on two pulleys almost horizontal in a case. Flour or grain was

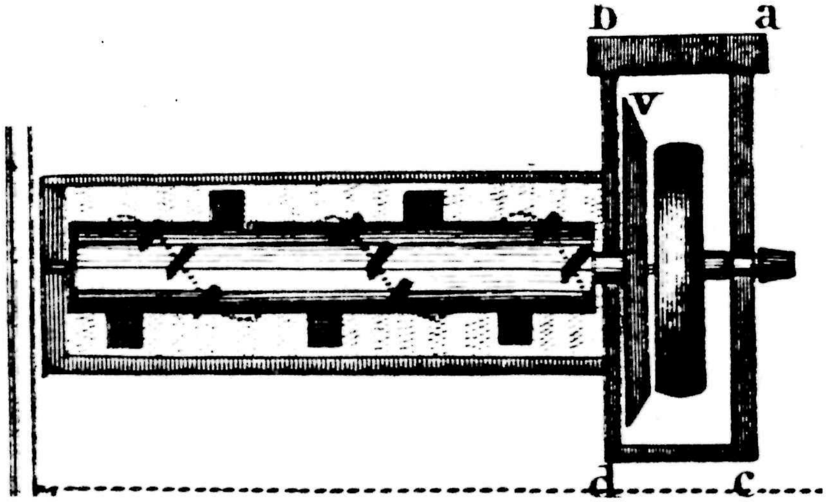


Figure 16. Shortened view of a conveyor used to transport flour and grain horizontally from machine to machine. Based on the principle of Archimedes' screw, it operated by waterpower eliminating the need for manual labour (Evans, op. cit., Pl. 16).

moved by the rakes along the bottom of the case from machine to machine (Figs. 18, 19).

4) The *descender* was perhaps the forerunner of the assembly line conveyor belt. A broad endless strap made of very thin pliant leather, canvas or flannel, moved by pulleys at either end (one lower than the other), it conveyed flour as it fell out of the elevator. This machine operated by the weight of the flour (in the same way as water turned an overshot water wheel) rather than by waterpower.

5) The *hopper boy* did the work of cooling flour done formerly by a boy using a rake or shovel. This invention cooled and raked the meal mechanically, saving labour, time and space, and doing a better job. Dried immediately after being milled both during its elevation to the top storey and during its raking in a hopper boy, the meal did not lie around for 12 hours filling the entire loft and accessible to insects for egg-laying. Natural moisture was evaporated so flour did not sour later. The hopper boy afforded room in the loft for other purposes. Made of a large, circular shallow hopper from 12 to 15 feet in diameter (depending on the mill's capacity) with a vertical shaft in the centre around which arms or rakes of dried soft poplar revolved, the hopper boy spread, cooled and swept the meal to a central spout down which it fell to the bolter (Figs. 17, 20, 21, 26).

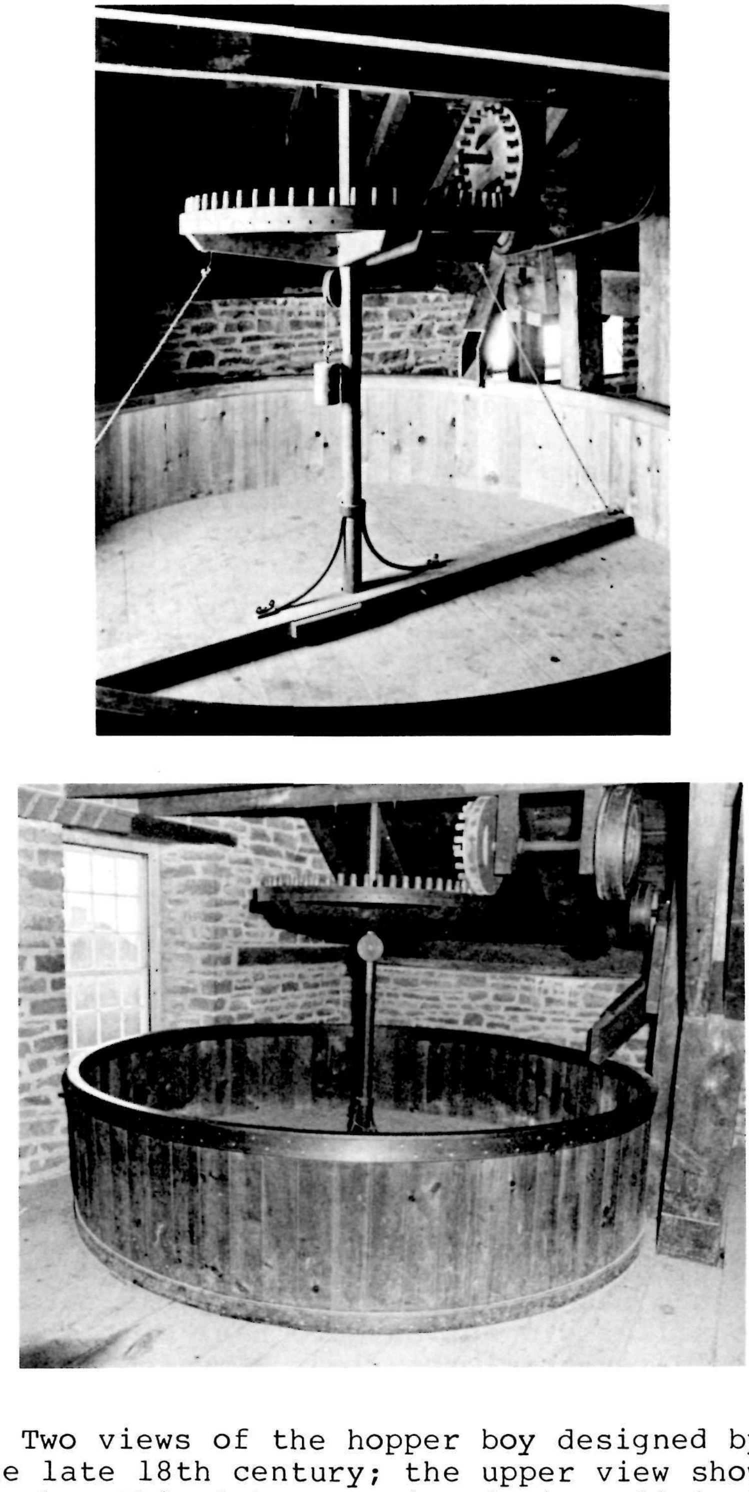


Figure 17. Two views of the hopper boy designed by Oliver Evans in the late 18th century; the upper view shows it ready for work. This labour-saving device eliminated the need of a boy and rake, mechanically cooling the flour by a revolving rake which swept the flour down a central spout to the next stage of processing. (*Black Creek Pioneer Village, Toronto, Ontario.*)

Improvements

Besides his inventions, Evans made improvements to the old types of grain cleaners and flour bolts:

1) His improved rolling screen was designed to clean grain better with less waste in a merchant mill. Grain entered the inner cylinder in a thin stream and was spun around. The inner mesh was open to allow grain to pass but keep out white caps, large garlic amd particles larger than grain. The outside cylinder's mesh was close enough to keep the good grain inside, but sift out cheat, cockle, shrivelled wheat and garlic. The cleaned wheat was then delivered out the tail-end of the shorter outer cylinder, and dropped into a wind tube, at least three feet square, at the head of which was a fan with wings three feet wide and 20 inches long. The end of the wind tunnel led to the outside where dust was carried by wind force. The heavier clean wheat fell nearest the fan into a funnel leading to a stone garner; the light wheat and screenings fell farther away into another special garner, and the chaff settled beyond the screenings garner into a chaff room. Screenings could be rescreened and an inferior flour made, or they could be sold to a distillery or made into feed for cattle, thus eliminating what formerly would be waste, said Evans.

2) Evans observed how to improve the old bolts after experiments. He reasoned that bolts of larger dimensions, both in diameter and length, were best. For example, a reel with a diameter as large as 27 1/2 inches allowed the meal a greater distance to fall and caused the meal to strike the cloth harder, keeping the mesh open; greater length allowed the sifting operation to continue longer so each quality had enough time to be sifted out completely.

Flour-Milling Process

In merchant mills, Evans advocated bolting more of the flour over again, as well as regrinding the coarser grades of flour. This was done most easily by his automatic mill because the miller did not have to haul or hoist the bags by hand but could rechannel the flour along conveyors, elevators, drills and descenders moved by waterpower. His plan provided for resifting the tail flour (along with a little bran to keep the cloth open in sticky warm weather). Middlings were channelled to be remilled with wheat, thereby keeping the middlings from being killed, he said. Earlier millers (especially those millers of hard dry wheats which were hard to break) often had reground the coarser portion separately. Because of the increased speed and pressure required by the stones, the flour was killed or weakened in strength so it would not rise when baked into bread. Evans believed that by regrinding middlings with larger wheat kernels, the middlings particles would be protected from the stone's pressure by the wheat, and a better quality flour produced than before. His was but one of the many solutions advocated by early millers to solve the problem of milling hard wheats into a lively flour using millstones and the low grinding method. It wasn't until the 1860s, when European high grinding came in, that the problem was solved adequately, however.

Millers' Duties

Evans described the duties of millers in a merchant mill. If there were two millers, one was made the master miller who had the "chief direction"[6] during the day. Early in the morning the floors were swept and flour dust collected. Flour packing was begun and finished in the morning - the casks nailed, weighed, marked and branded - indeed, leaving this until the afternoon was "a lazy practice, and keeps the business out of order."[7] In the afternoon, enough grain was cleaned to supply the stones all night. The night was divided into two watches, the first ending at one in the morning and the second at daylight. The master miller arrived at one in the morning for the second watch and first checked the stones to see that they were grinding and the cloths bolting well. Secondly, he reviewed all the "moving gudgeons of the mill to see whether any of them want grease etc."[8] Thirdly, he made sure there was enough grain cleaned to supply the stones until morning, setting the cleaners to work if not. After this his duty was "very easy" - once in an hour he had to see the machinery, the grinding and the bolting, and after this had plenty of time to amuse himself "reading etc. rather than going to sleep which is not safe."[9] At daylight, he was there to direct other hands to work.

Efficiency of Evans's Designs

Not only merchant mill owners, but also custom mill owners were saved money, space, labour and time by using Evans's appliances, which were particularly suitable for mills that ground many parcels brought by surrounding farmers. Individual grain garners for each farmer were designed. By opening and closing the separate garners and allowing one parcel of meal to wait in the loft until the first parcel was bolted, a number of customers could be served with a minimum of trouble (Fig. 18). Evans's improvements were also applicable to grist mills grinding "very small parcels:"[10] a mill with two runs of stones could profit by installing a hopper boy and organizing the mill operations to do merchant work at night and grists in the daytime (Fig. 19).

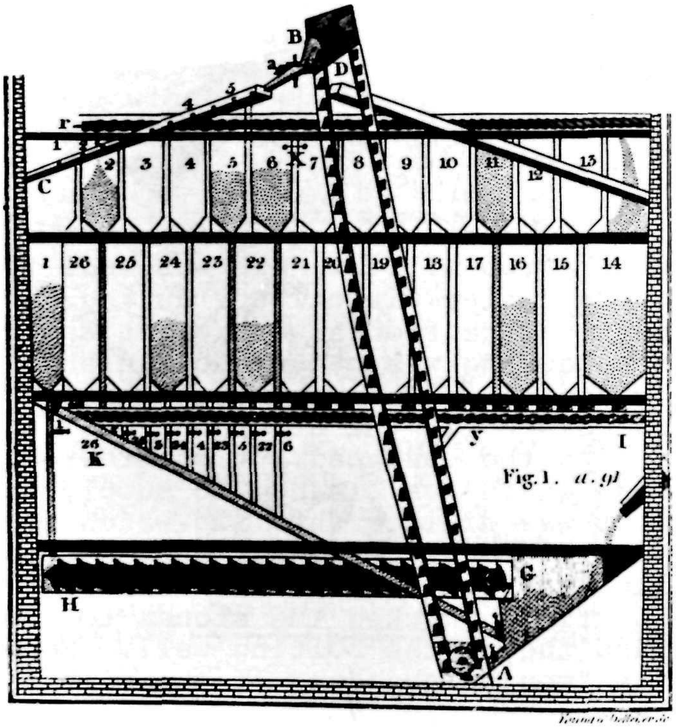


Figure 18. An Evans-designed custom mill showing how garners could be filled mechanically by the use of conveyors KI, drill HG and grain elevator AB. Each farmer's order was stored and milled individually (Evans, op. cit., Pl. 6).

In enumerating the advantages of his methods over the old way, Evans provides a colourful picture of milling in 18th-century America. Because the meal was kept in motion, insect eggs were less likely to be laid and "breed the worms that are often found in the heart of barrels of flour well packed."[11] Flour was better dried and cooled during its journey up the flour elevator. Because of regrinding and resifting, a better yield was obtained. Less waste was made if the machinery was well constructed because there was no

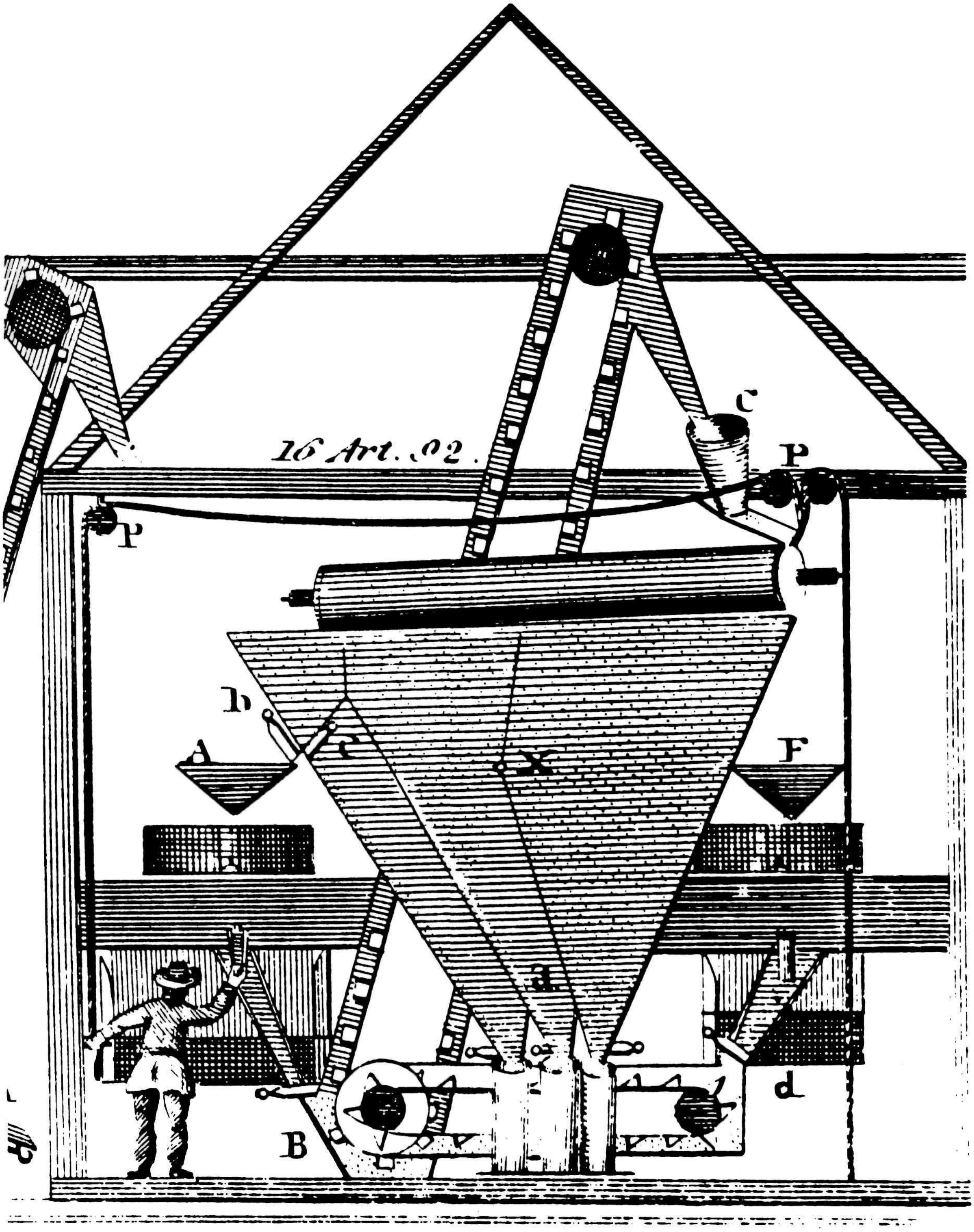


Figure 19. An Evans-designed grist mill showing how the grain elevator B and drill Bd handled small parcels (Evans, op. cit., Pl. 7).

"trampling in it which trails it where ever we walk, nor shovelling it about to raise a dust that flies away."[12] His machinery provided more room in the mill and more time to keep the stones in perfect dress. Less power was needed and less expense in the long run in repairs and attendance. Only half the manpower was needed. Evans reckoned his custom mill would grind 60 bushels of grain in about 12 hours.

While Evans's mill still ground by the old process known as flat grinding, it performed all the operations (grain cleaning, milling, flour cooling, bolting and packing) with his improved machinery and with little manual labour, cheaper, faster and better than ever before. The application of his inventions and improvements varied according to the size, purpose and location of the mill as did the advantages. It is said that Oliver Evans was not only an inventor but also one of the first plant engineers in America. His mill designs, as high as four and five stories for merchant-custom mills, demonstrated the importance plant layout and flow had and was to have in the days of mass production that lay ahead.

THE INTRODUCTION OF AUTOMATIC MILLING TO UPPER CANADA

The inventions and improvements of Oliver Evans were to find practical application in Upper Canada flour mills at a relatively early date. In 1791 settlers had produced a surplus of wheat. In 1793 flour was traded for goods at Oswego. Soon millers would have to be more skillful employing the best machinery to mill flour that could compete profitably. When flour and grain exports to Lower Canada and the northern United States began in 1794, more grain than flour was exported partly because of the lack of mills. Evans's automatic mill was to be a boon to custom and merchant mill owners looking for a solution to the shortage of manpower then in Upper Canada. Within five to ten years after Evans published his inventions in 1795, the first enterprising mill owners who were located in settled areas of Upper Canada and close to grain sources and ports installed the new technology.

More research may determine precisely when Evans's devices were first installed in Upper Canadian mills. By 1804 Richard Cartwright's mill on the Napanee River and the Hatt brothers' mill on Ancaster Creek at the head of the lake utilized automatic machinery, according to Lord Selkirk.

> At Apanée is a fine set of mills belonging to Mr. Cartwright,...with superior machinery. The mill wheels as usual in this country under cover, & a stove beside it to keep it free of Ice - There is a contrivance similar to a chain pump [grain elevator] which carries the Wheat from a trough adjoining the granary to fall thro' a Fanner by which it is thoroughly cleaned, & from whence it passes into the Hoppers - from the stones the flour is conducted into a horizontal trough [drill or conveyor]... pushing forward the flour...[to a flour elevator]... up to a circular floor of 8 or 10 feet diameter [hopper boy]...where a funnel carries it down into the Bolting machine, which is of wire cloth, & divides the flour into three species of flour & two of Offal - The flour coming quite cool into the bolting Ma: [machine] can be packed immediately from it.[1] (Fig. 20)

The cost of building this mill was £500 and it was rented for £300. The rent together with "the grist of the grain which comes into him for payment of debts in the Bay of

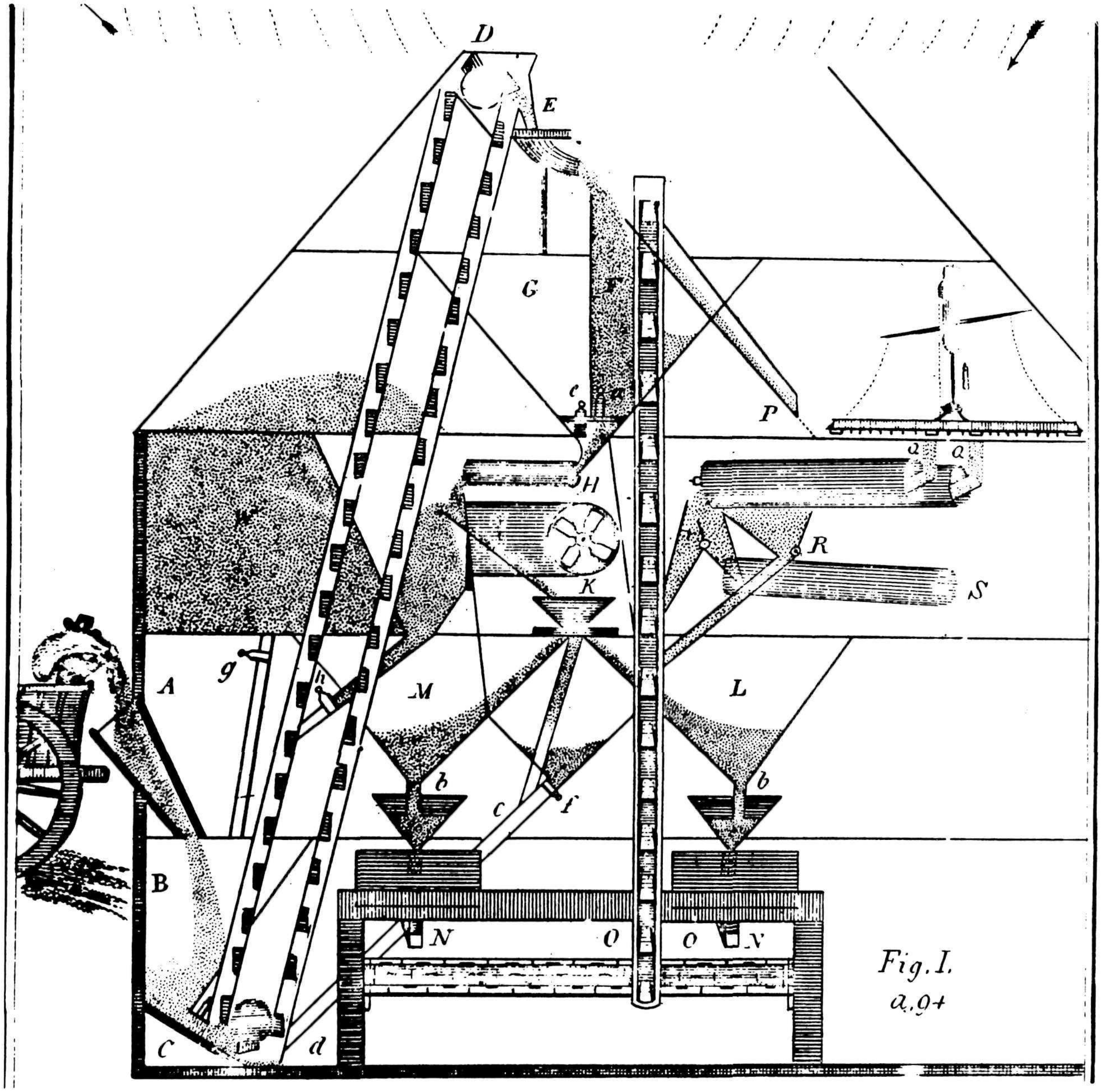


Figure 20. An Evans custom and merchant mill with two runs of stones and automatic conveyors, elevators and hopper boy similar to the description of the Napanee mill recorded in 1804 by Lord Selkirk (Evans, op. cit., Pl. 9).

Quinte" netted Cartwright a profit of £500 some years previously, Selkirk recorded in his diary.

Selkirk also made a special trip from the head of the lake to the Hatt brothers' mill near Ancaster on 30 May 1804. According to the diary, Richard and Samuel Hatt had come from England "seven or eight years ago" and now owned a farm, distillery, a potash works, a store, and very productive mills.

> Their Mills are in a capital style, built by an American now settled in the neighbourhood, - cost about 7,500$ they have all latest improvements of mechanism - still superior to those at Appanêe - conductors, elevators, cooler, & Bolting machinary on the same place. - also a packing machine, which ascertains the exact weight & bursts every barrel which is too small to hold the regulated quantity. ...his mills are chiefly designed for export action, & he considers grinding for Toll (1/12) not worth the expense ...he calculates to have all his exportation ready about this time of year - & is most busy from March - in Febry he receives most of his wheat - during about 4 months or more his miller requires as assistant - but not during the rest of the year - in Summer little is done. - He has two run of Burr stones - four feet diar [diameter] revolns [revolutions] about 60 pr. minute, four bus pr hour each is fair work to do it well - with full water 220 bushels per day in the day 30 to 40 Barrels can be manufactured per day.[2]

The Hatt's grain cleaner consisted of a "wire riddle moving like a [b]olting cloth to sift out dust delivering into a fanner."[3] Sometimes three pounds of dirt was removed from 60 pounds of common country wheat which had been brought in as clean. Hatt estimated that from 60 pounds of wheat (after three pounds dirt and five pounds toll had been extracted) he could manufacture 33 pounds of superfine flour, 16 pounds bran, 1 1/2 pounds shorts and 3/4 pound of middlings.

In 1806 Hatt's mill was described by Charles Aikins as "one of the finest mills in all this part of the country."[4] It was 4 1/2 stories high with an overshot water-wheel in a wheelhouse; the machinery inside included two runs of stones, two fanning mills, four bolts, a flour packing machine, a crane for a man to lift the millstone himself, a machine that automatically stopped the grain from filling the hopper too full, flour and grain elevators, hopper boy and conveyors. The name of the millwright was not given, only the fact that he later built mills for Messrs. Cartwright and Hamilton.[5] It was stated by Aikins that the mill continually ran and still could not grind all the wheat brought in from the neighbourhood.

Not every mill owner in Upper Canada was able to afford or even knew about Evans's devices as early as these, but throughout the 19th century as the province and the flour industry grew, Evans's inventions became better known and needed so that more automatic mills were built and became the rule rather than the exception. The automatic low grinding fast reduction of grain into flour remained basically the same until the 1860s when gradual reduction began to be practised.

SUMMARY

Oliver Evans's cost- and labour-saving inventions devised in the 1780s and published in his guide 15 times between 1795 and 1860 were first installed about 1800 in Upper Canadian mills by an American millwright. Throughout the 19th century when they were known, Evans's improvements fulfilled a need for manpower, mass production, and better machinery for manufacturing flour in mills in Upper Canada. Automatic milling gradually became the most economical mode of milling surpassing methods that were not automated. Evans calculated that about five bushels of wheat (300 lbs) would produce a barrel of superfine flour (196 lbs).

Improvements were made in Evans's and other machinery throughout the first half of the 19th century, and better methods of regrinding middlings were tried in an effort to make more merchantable flour from a bushel of wheat faster than before. An account of these changes to the basic automatic process of fast reduction is given in Part III.

Part III. Improvements to Automatic Old Process Mills, 1800-1860s

THE GROWTH OF THE FLOUR-MILLING INDUSTRY

In all cases endeavour to be near a saw and grist mill, these alone render property of value.[1]

The importance of grist and flour mills to settlers relying on the "staff of life" in the growing province of Upper Canada was elementary. Grist and flour mills were considered to be a basic requirement for existence where flour for daily bread was made. Governors, farmers and capitalists were drawn together in the common goal of making milling enterprises work. The governors thereby encouraged settlement and promoted economic stability, while the farmers and capitalists made a living for themselves and flour for the people. Driven by harnessed waterfalls, mills formed the hubs of villages and towns. Even in the backwoods, lands close to mills were high in value. Centres where farmers and merchants met to barter and sell the necessities of life, mills, if not a lodging place for farmers, were often within a short distance of inns and distilleries. Notices of every sort including bans of marriage[2] were posted on mill doors. It is said that the pattern of roads in Upper Canada was influenced by the location of grist and flour mills on waterpowers.[3]

Most mills began as "custom" mills designed to grind the farmer's grist, usually of wheat, for a toll paid in grain. These became the centres of local commerce. "Millers are obliged to be storekeepers and they must have a general assortment of goods to supply the farmer and give in exchange for grain," wrote Charles Wadsworth, new owner of an old grist mill on the Humber in 1828. (PAC, MG24, I130, Wadsworth Papers, letter of 7 November 1828. Wadsworth uses the term "millers" to mean mill owners. In this study "miller" will refer to mill operator.) As people poured into the country and the frontier rolled back, well-situated grist mills expanded to do additional "merchant" work making flour for sale and export. If the waterpower, local produce and available capital allowed, grist- and flour-mill owners began other water-driven enterprises such as carding and fulling mills. Often sawmilling had been established first and brought in large returns. Distilleries, piggeries, cooperages and farming were all economical adjuncts found associated with grist and flour mills, owned by the "millocracy."

The period from 1800 to about 1865 when mills operated mainly by the automatic, low grinding process was characterized by growth and change in every facet of life in Upper Canada. The population multiplied 24 times, from some 57,000 to over one million. Settlements stretched back from the Great Lakes to points as far north as Georgian Bay and Allumette Island on the Ottawa River. Roads, canals and railways spun out. Grist and flour mills, necessities in the growing settlements, increased steadily in number until 1851 when there were 693 throughout the approximately 350 townships of Upper Canada, more mills than in any other province in British North America. There were three peak periods of growth before 1851; from 1834 to 1838 when mills increased by about 125, from 1844 to 1848 when they increased by 116, and within the next three years, 1849 to 1851 when 140 new mills were established. Between 1851 and 1861 faulty census figures show a reduction of 190 mills, decreasing the total to 502 by 1861. An unprecedented increase (reflecting the faulty figures) of over 450 mills within the next decade brought the total number to 951 by 1871.

There is reason to question these statistics based on the assessment rolls and the census, and to conclude that there were more mills existing than recorded, especially between 1850 and 1860. The Assessment Law of 1819 required that mills with one run of stones be assessed at £150 annually, and additional runs of stones be assessed at £50 annually. It was reported, however, that when the time came for assessment, some mills were not operating and therefore were not included in the assessment rolls. This was understandable since yearly fluctuations in grain as well as waterpower meant that some mills operated for only part of a season in poor years. This explains why some assessment rolls rated only "1/2" a mill or run of stones. Lillie in 1855[4] claimed that it was "to be regretted" that "the late census returns should be so deficient" due to those who withheld from carelessness or "whatever other cause" the returns. He claimed this lack was not chargeable to "the parties employed in collecting them, but the witholders of information."[5] Though Lillie was not writing of mills in particular, W.W. Smith in 1865[6] stated that only four of the 20 mills in Grey county were recorded in the 1861 census due to poor information. It must be concluded then, that the decrease of 190 mills between 1851 and 1861 and the spectacular increase of some 450 mills between 1861 and 1871 according to the census is grossly inaccurate and that the truth lay in the other direction; that there was a steady increase unrecorded for reasons requiring further research (Fig. 54).

It was natural that the number of mills in Upper Canada increased up to the 1880s in a country abounding with waterpower, fertile soil and a constantly growing agricultural population of farmers and citizens dependent on mill products, a country that was governed by leaders who encouraged the milling enterprise and that had natural ties with the United States and Great Britain from which capital, expertise and the latest mill furnishings were available. The Corn Laws up to the late 1840s, the Reciprocity Treaty of the 1850s and 1860s and the Crimean and Civil wars were beneficial to Canada's flour trade. The construction of railways in the 1850s created new sites and spurred construction of mills. The revolution in farm machinery from 1840 on accelerated grain production, and changes in flour milling to cope with larger quantities faster were made at about the same time.

The rate of increase in the number of grist and flour mills depended chiefly on the wheat supply, the number of waterpowers available, the number of enterprising men of capital and expertise to develop the sites and government regulations concerning each of these. Waterpowers were usually plentiful, men of capital and technical skill not always, and the government's role of ensuring the fair and balanced distribution of mill privileges sometimes difficult to play. In the early period of the Long Point settlement, for example, too many sites were developed for the supplies of grain, and some mill owners operated at a loss. More often the situation was reversed, especially during the opening of new settlements, and settlers had to make long journeys to distant mills despite the existence of suitable mill sites nearby. Lack of capital to develop the power was one problem. Another was finding millwrights, and the most convenient source of technical expertise in the backwoods environment was the United States. Some sites were unattainable, frozen on lands owned by absentee landlords, land jobbers or the clergy or Crown. In a few cases the government itself contracted for the construction of a mill and auctioned it to the highest bidder. Despite some drawbacks and injustices, the number of mills throughout the province increased steadily in reponse to the farmer's productivity, and the local and export markets.

GOVERNMENT ENCOURAGEMENT

> *I am under the immediate necessity of sinking for the present more than £2,000 in the erection of saw and grist mills as I found that the first inquiry of those disposed to become settler was 'when they could depend upon having the convenience of mills'*[1]

Colonel Talbot's need for enough capital to provide mills and thereby encourage settlement was similar to that of the government of Upper Canada from 1800 to 1865 when faced with settling the province. Diverse legislation was passed to assist and encourage settlers to erect needed mills. Each new piece of legislation aimed to answer the problems and petitions of the day. While the order in council of 1793 gave all landowners freedom to develop their sites, and another rule stipulated that certain mill-site grants be developed within a year or so, it became apparent that these were not enough and that disadvantages were embodied in the land-granting system in general. Mill seats became monopolised. During the first half of the 19th century, many valuable mill seats remained undeveloped on land owned by individuals, the Crown and clergy, leaving some groups of settlers with no mill in their immediate vicinity. In January 1818, a partial solution was found when the land boards were ordered to prohibit the locating of mill sites unless security had been given for the building of a mill. A period of time was allotted for their construction. In 1823 the proposal to open up clergy and Crown reserves containing valuable mill seats was considered and followed to some extent; some mill sites on reserves were leased for an annual rent. The government resolution to grant townships and reserves to capitalists such as those behind the Canada Company left mill construction to the grantees, but this in some cases constituted a monopoly of mill privileges. For example, the Canada Company established a fair number of good mills which it rented - terms unsatisfactory, however, for some enterprising settlers and others in remote areas. The company's policy of mill ownership discouraged the similar hopes of settlers, only a few of whom owned mill privileges.

The terms under which the government mill at Peterborough was built appear to be similar to those advocated by Simcoe in 1791 (see Part I) in that they were auctioned. In 1826, the government awarded a contract to Horace Perry and he, with the help of the inhabitants, raised what was considered to be a large frame for a sawmill and adjoining grist mill with two runs of stones capable of producing 50 barrels a day. The mills were duly advertised for sale and auctioned off on 10 September 1828 for £2,500 to the highest bidder, Mr. Moore Lee of the firm of Hall and Lee of New York. The terms of sale required that one-third of the price be paid within one month of sale, one-third at the end of the first year and the last third at the end of the second year.

In 1837 the act to provide for the disposal of public lands, section XX, stated that the lieutenant governor might allow £1,000 in any township for the erection of a grist or sawmill paid via the commissioner of Crown lands. Such mills were advertised, sold, and the proceeds given to the commissioner who furnished an annual statement of sales. The act also allowed private sales (arranged through the commissioner) to a lessee or occupant of Crown lands if that individual was liable to injury by the disposal of the land to another person. A form of this type of consideration was recorded as early as 1802, as evidenced in the case of Joshua Booth. Booth, out of four applicants, was awarded the lease of the King's sawmill at Ernestown (near Kingston) because his grist mill downstream on the next lot might have been adversely affected had any other person been allowed to operate the sawmill. It was reasoned that because Booth was in the unique position of being able to benefit the community by improving both waterpowers, he, of the several applicants, was awarded the lease of the sawmill.[2]

The numerous petitions to the lieutenant governor in council requesting assistance to construct mills in newly inhabited areas reveal how often groups were left without mills.[3] An interesting plea, different because it arose from the relatively well-established township of Chatham in 1840, illustrates how the government was expected to help. The reason for the petition was the fire at Joseph Wood's steam grist mill in the Louisville area which had left the inhabitants with no grist or sawmill nearer than Detroit, 22 miles away. Petitioners asked that money be provided to build a new mill on the land of Mr. Gee who had formed a mill seat by digging a mill-race two miles in length which benefitted adjacent lands as a drain as well. A second group of petitioners explained that the race of Mr. Gee could not supply water to keep a mill in operation four months of the year. They asked instead that Joseph Wood be given the means to rebuild his steam flour and grist mill. Both groups referred to the Statute of 1838 which authorized the expenditure of £1,000 for building a mill in a township. Regrettably the council advised both groups that there were no funds in the hands of the government, "the amounts received for Crown Lands having been fully absorbed in covering, and have ever been found insufficient to cover the Land Rights returned by the sale of Clergy Reserves."[4]

The type of assistance given by the government throughout the period under review varied from time to time. Free millstones and mill irons were distributed from the King's stores during the early part of the 19th century. Duty-free importation of machinery not manufactured in Upper Canada from the United States was allowed sometime within the first quarter of the 19th century and again during Reciprocity. A mill was built for the Indians at Coldwater by the government.

It is believed that a deeper study of land policies and records in Ontario trade tariffs and trade agreements will reveal more information regarding encouragement given by government to grist- and flour-mill entrepreneurs.

MILL ARCHITECTURE

From 1800 until 1860 there was great variety in the architecture of mills based on functional demands. Perhaps the greatest difference was between those longer established, larger grist and flour mills at the "front" and the "backwoods" grist mills. The first mill in a newly settled area was usually small, made of local materials to suit local needs. Some were "squatters," hastily built on waterpowers which dried up in summer. Sometimes a mill was built merely as a token of encouragement to settlers, sometimes to claim land rights, but more often it was a well-planned operation which improved with time or was replaced with a better edifice if the waterpower proved adequate and other factors were favourable. A very small mill, the first in Peterborough, was built by Adam Scott in 1821, 18 feet by 24 feet with one run of very common millstones and an upright saw. For about five years it provided 500 settlers with flour and lumber, and then the government contracted for a larger frame combined grist and sawmill for the convenience of the Irish settlers pouring into the area after 1826. Scott's mill continued under a new owner who added a brewery and distillery, but these burned down in 1835.

Dimensions of mills grew in height due to the economy of Evans's automatic devices, and in width and breadth as additional millstones and improved machinery were installed once grain surpluses permitted expansion. Competitive mills at the "front" were in the best position to take advantage of the new technology and adopted it early. Richard Hatt's mill on the Dundas-Ancaster road in 1804 contained superior machinery and in 1806 was described as one of the finest mills in the region, being 4 1/2 storeys high, the lower partly of stone (see Part II). That mills of the period grew significantly in height can be attributed to the method of milling that made use of gravity (at no cost), and the economical automatic devices patented by Oliver Evans in the United States. Foremost in importance to architecture, perhaps, was Evans's elevator that raised grain and flour to any height by waterpower. Once raised, the natural force of gravity was gainfully used so flour and grain were channelled down via chutes from storey to storey and machine to machine. Evans's horizontal conveyors and hopper boy, together with his elevators, were used profitably, reportedly cutting labour costs in half in both grist and flour mills in Upper Canada. Throughout the 19th century wherever these were installed they were described with fascination by observers:

> Whilst Dick was unloading we looked at all the contrivances about the mill which is very complete. It is five or six stories high, and the wheat and flour are carried up and down from the stories in which it is first deposited in little strings of buckets raised by the waterwheel which also works the axle by which the sacks of wheat are lifted in.[1]

Writing of Benjamin Thorne's new mill built soon after 1828 for a cost of £2000, Mary Gapper expressed her interest on 28 January 1930 in her diary. In 1842 the Louth Mill at present-day Balls Falls was designed with Evans's devices (Fig. 21). Another example of an even later use of Evans's

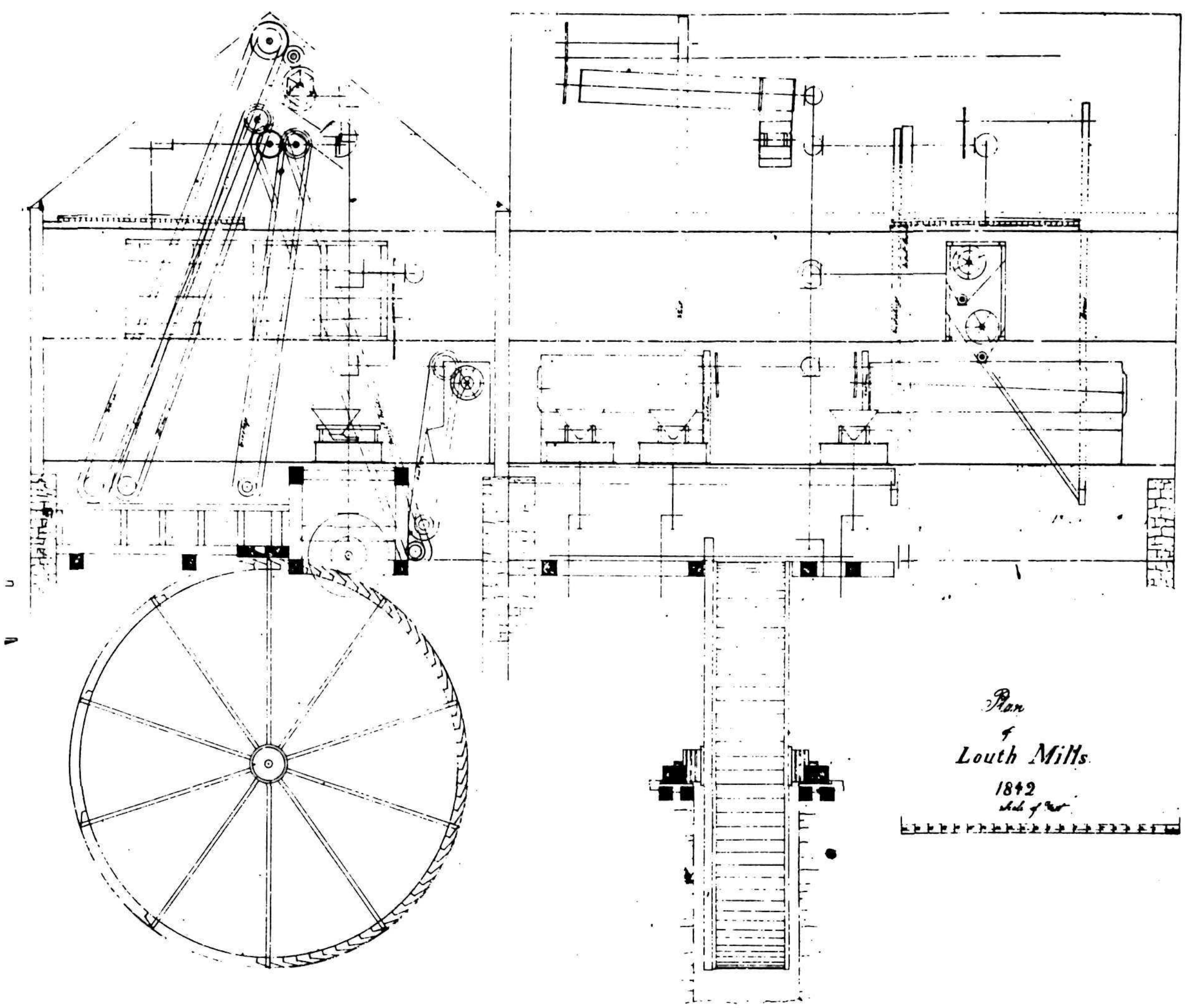


Figure 21. Cross section of an automated grist and flour mill at Louth, Canada West, in 1842. The plan for the new mill shows five elevators for wheat, bran, middlings, merchant meal and custom flour, and a hopper boy for cooling the grist. (*Niagara Peninsula Conservation Authority.*)

inventions is found in the Wadsworth Papers. Mill manager William Wadsworth wrote of the improvements he hoped to make to his mill at Weston in 1847 in a letter to his daughter Betsy who was attending boarding school in Suffolk, England. He explained that while his mill's capacity was then 60 barrels per 24 hours milling day and night for export and local use, he hoped to build a new mill in which the labour would be cut in half, all done by machinery "even to the packing of the flour."[2] In this way their business would be larger while the amount of labour was the same. By 1856, a five-storey mill with six runs of stones was erected south of the old building.[3]

As the above examples attest, grist- and flour-mill architecture was based on functional considerations. Craik,[4] writing of mill construction before the 1870s, stated there was no definite rule for water-powered grist mills because the site would be different in different situations. A great deal of common sense was used by the millwright who studied the numerous variables of each mill site: the height and features of the bank; the height, entrance and exit of the water; the road or approach for convenient loading and unloading of grist; whether the mill was to do custom or merchant work and how much; the type, quantity and position of machinery required for the particular head and quantity of water, and the material of construction. Not until turbines came into use was more uniformity possible.

The best foundation was stone, at least as high as it was exposed to water, but this depended on the type of water wheel. For example, a turbine required only a low basement, while an overshot wheel placed inside needed stonework extending as high as the wheel because wood siding decayed under usual operating conditions. Another important factor in building a mill was to have the main floor level correspond with the road and mill yard so that it was convenient to load and unload teams at the door. Each storey varied slightly in height depending on height of the machinery occupying each floor. Craik described how to make an ordinary custom grist mill "more fireproof" by building it of stone or brick and placing the timbers so that once aflame they would fall away without prying down the walls. The interior walls would be plastered with mortar upon stone without lathing. The stone lintels were placed over each door and window outside, but extended inside of wood.[5]

The most important structural feature of the basement was the "husk," the extra strong frame that supported the heavy millstones on the floor above. Hughes (1855) wrote that errant millwrights framed the husk to the main building when it should be separate so the stones would stay level and power not be lost. He warned that husk posts be no longer than 12 feet long lest unnecessary tremor result and cause the machinery to work off pitch.[6] Pallett recommended cast-iron husks in 1852.[7] Craik advocated husk timbers be placed in such a way as to be removable (when decayed) without disturbing the walls or upper portion of the mill.[8] Mill gearing occupied the basement and sub-basement levels and its design depended on the number of stones, the type of water wheel and the site. Most variation in gearing occurred with overshot wheels whereas the more modern turbine-type wheels allowed uniformity of construction and less cumbrous gearing, according to Craik.[9]

On the first floor or stone floor the millstones were hung. A small room was partitioned off as a mill office where a desk, chair, shelves for catalogues, business correspondence and mill accounts were filed. The upper floors were open, arranged with machinery according to the flow plan of the millwright. Grain cleaners, flour bolts, hopper boys, grain and flour storage bins and flour packers were all strategically located. Linking one machine with another and storey to storey were flour and grain elevators, spouts or chutes, conveyors, drills, and so on if the mill had been automated. Trapdoors improved the passage of furnishings since stairs were too narrow and steep. Guards were required by law after 1838 to protect the public from accidents caused by revolving pullies, belts, shafts and gears.

Normally rectangular, many mills had additions made to them as their output increased and technology changed. One important irregular feature of the normally rectangular mill was the wheelhouse, a necessary appendage for Upper Canadian mills where the climate was extreme. Sealed off from the mill, they were heated by various methods to keep the water wheel ice-free. With turbine-type wheels, however, a wheelhouse was not necessary and sometimes was torn down after a mill had been "modernized" with the installation of one of the new vertical shafted wheels. Auxiliary steam engines were also housed in additions, as were dust rooms. Grain storage houses were separate or attached to the mill.

Construction materials used for mills varied; often the first mills were wood on a stone foundation. Round or squared timbers, plank, clapboard and later board and batten were used. Building materials became more varied as time progressed. One well-known example of a stone mill was described by Robert Gourlay in 1818 in the village of Stone Mills (now Delta) as "unquestionably the best building of the kind in Upper Canada."[10] An early use of brick "baked right at home" was made by John Bowman in 1844 when he built his grist and woollen mill at Almira, York County.[11] An example of an early patterned brick mill is found in Brooklin, Ontario County, erected about 1848.

The style of mills during the period was governed by functional considerations. Roofs were usually gabled, sometimes gambrelled or hipped. Often dormers were included to illuminate the loft, and sometimes a clerestory was incorporated. Windows were casement or double-hung for light and ventilation. When there was no water-wheel house enclosing vertical wheels, fewer windows were located on the side facing the wheel to shield the mill from dampness and cut down noise from the wheel. A pulley hoist was usually located at or near the roof's ridge on the side where delivery wagons unloaded grain and machinery. This facade and sometimes another contained doors on each storey through which machinery was hauled since mill stairs were narrow and impractical.

Early accounts often referred to the erection of "grist and saw mills," a "grist-saw mill," a "combined grist and sawmill" or a "grist and adjoining sawmill," terms which led one to imagine that in some cases both mills were enclosed in a single structure. Further research sometimes revealed that they were two separate structures on one waterpower, situated either beside each other or across the fall. In some cases, however, grist and sawmill were within a single structure. Craik in 1870 wrote of a small overshot grist and sawmill owned and geared by an "old Scotch millwright" who installed cast-iron cog gearing and extended drive shafts horizontally from the grist mill with two runs of stones to "an adjoining workshop...at the other end of the mill" where circular saws and a lathe turned.[12] There were other grist and sawmills combined within a single structure. Herron Mills in Lanark County operated as a flour and sawmill in the 20th century, though originally the two were separate in the mid-19th century.[13]

WATERPOWER PLANTS

Chosen methods of harnessing Upper Canada's abundant waterpowers chiefly depended upon the nature of the site, the skill of the millwright, the availability of materials or manufactured wheels and the capital of the owner. By the 1860s a multitude of water wheels had been invented. Divided into two broad categories of vertical wheels and horizontal wheels, the latter turbine-type, most water wheels required a dam. Not enough detail has been found about wheels actually used in Ontario mills during the period under review, and one wonders about the practicality of some of the Canadian patents. American manufactured horizontal wheels were employed as early as the 1840s. The use of steam engines alone and to supplement waterpower began in the 1820s, but up to the 1860s the majority of mills were moved by cheaper and plentiful waterpower.

Dams

> *The Mill dam, 100 yards long, 13 feet high, 30 feet at fan & 8 or 10 at top may cost 100£ & employ 2 axmen & 8 labourers for 2 months. The dam is framed of large Hemlock logs, between which earth is filled in.*[1]

Millwright Hayden's method of filling a dam with earth in 1803 was an invitation to muskrats to move in and undermine the dam, according to some later millwrights. Hughes[2] gave details of how he built his muskrat-proof dam in the 1840s. Framed in wood, filled with coarse gravel, with an apron and flashboards, the dam was recommended for all sites with soft bottoms. Craik gave detailed descriptions of 11 different plans each to suit a specific site.[3] Log dams built where timber was plentiful and water supply was constant (Fig. 22); dams of rafters and sawdust on small rock-bottomed streams that dried up in summer; a dam suitable for soft or mud-bottomed streams requiring piles, timber cribwork, stones, rafters, planks and fascines; another for a similar site requiring no piles; two types of stone dams, one for a soft bottom and the other for a firm foundation; two cribwork dams of earth fill (or rock fill if the stream's bottom was unequal); a frame dam for a rock bottom, and lastly the most durable

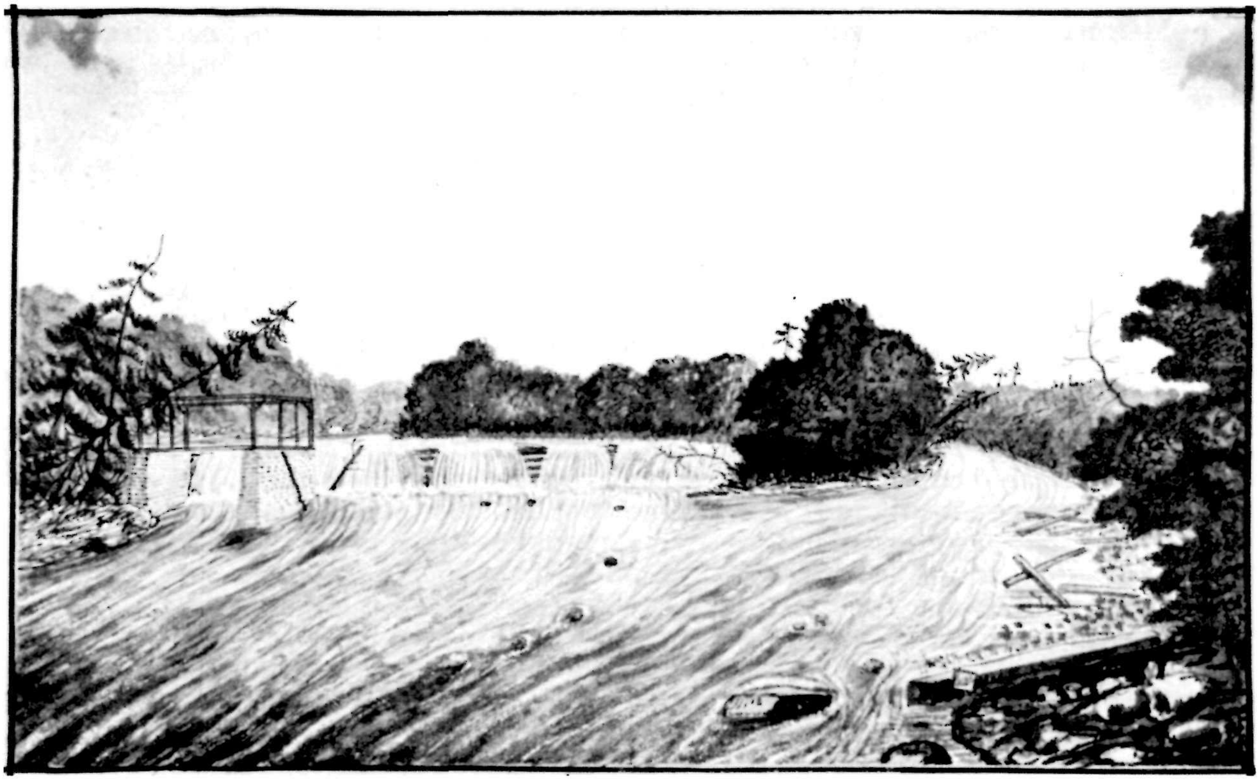


Figure 22. An 1827 sketch by Burrowes of a log dam on the Rideau River at Long Island, Upper Canada. (*Ontario Archives.*)

type made of cut stone fitted together with waterproof cement, were all detailed in Craik's chapter on milldams. Methods of making booms and breakwaters (to channel logs, timber and ice), aprons, slides and flashboards ended Craik's account of methods of dam construction to 1870. James Leffel first published his book on dam construction in 1874; over 20 types of dams were detailed (Fig. 23).

During Lord Selkirk's travels across North America in 1803 and 1804, he observed the position of the dam in relation to the mill. He referred to two different ways, the Scottish fashion and the American method, layman's terms perhaps for what was actually workable. Selkirk claimed the Scottish fashion for an overshot wheel placed the dam distant from the mill so a long lead was necessary, while the American method was to build the mill close by the dam so little raceway was needed. He wrote of the mill in Port Hope:

> Smith at first brought his water in a lead according to the Scottish fashion for an overshot - but the leakage obliged him to remove his Mill & Build it on the Dam in the usual American method.[4]

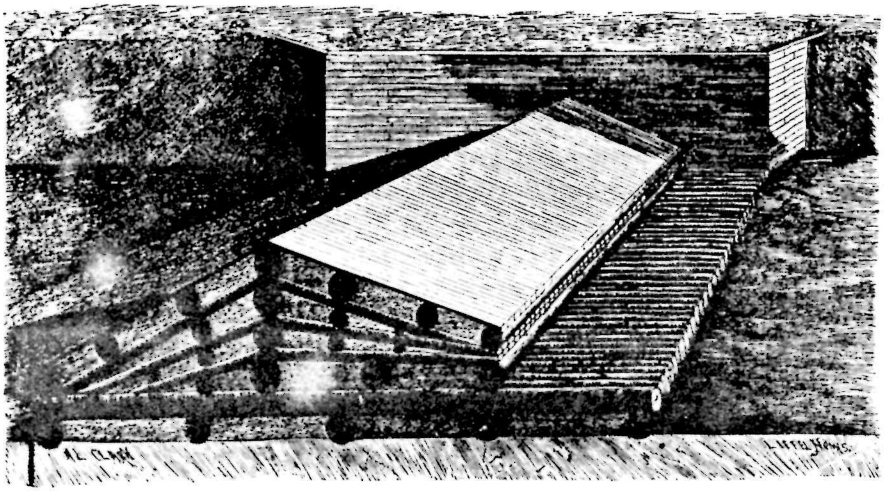


Figure 23. A log and plank dam, ca. 1848, for a gravel-bottomed stream with sandy banks. Filled with stone and gravel, the economical dam had a planked apron (Leffel, op. cit., p. 127).

Selkirk's descriptions of mills usually included the reason for each method of construction. In New York, near Onondaga, he wrote about a mill where

> there is a lead of some length from the Dam - a proof perhaps of the mildness of the Climate - Eastward they find it necessary to cover the wheel with a case of wood - & to place it close below the Dam to avoid the effect of Frost - with these precautions Mills can be kept going in the severest weather when the supply of water is powerful.[5]

Of a mill and dam in Prince Edward Island, Selkirk recorded millwright Hayden's ideas.

> The mill is always set close to the Dam or actually forms a part of it, the reason for this is that the soil is so porous that a Mill Load cannot be made without great difficulty - It also enables the mill to work all winter.[6]

All of these observations together make it obvious that mill and dam construction depended to a great extent on each millwright's consideration of site conditions and practical actualities rather than national ideas. Indeed, what Selkirk called the Scottish fashion was the same as the American Oliver Evans had advocated in 1795: that the mill be erected far from the dam to prevent it from being swept away with the dam during spring floods.

Water Wheels

The great variety of water wheels documented between 1800 and the 1860s offered knowledgeable millwrights a wider choice than ever before, providing they had the means at hand to make or procure them. The large conventional vertical wheels with horizontal shafts predominated, overshot, undershot, high and low breast wheels undergoing improvements that increased their efficiency. A variety of wood and cast-iron "whirl wheels" (most of them horizontal on vertical shafts and some of them applicable vertically) began to be patented in Canada in the 1840s, and evidence that an American version was used in 1846 in Upper Canada is found in Keefer's journal.[7] Evolving from the European horizontal and American tub-wheels, these early turbines generally were classified as central discharge wheels and reaction wheels but also by a multitude of other more specific names. They came to rival the usefulness of the large vertical wheels for a number of reasons. Craik's guide as late as 1870 recommended the use of his improved overshot and undershot wheels for mills in areas isolated from machine shops, but he also described experiments made with central discharge wheels and spiral discharge wheels.[8] The mill of Dickinson and Currier, erected on a relatively low fall at Manotick near Ottawa about 1859, was powered by five of Tyler's Patent Outward Pressure central discharging water wheels made at the Victoria Foundry in Ottawa,[9] while the 1863 grist and flour mill at Ancaster near Hamilton, erected on a high head formed by the Niagara escarpment, ran by a double arrangement of wooden overshot water wheels about 18 feet in diameter.[10] It may be that the period from the 1840s to the 1860s was a time when the high efficiency of the overshot water wheel was difficult to beat by the whirl wheels then available, and that it was the progressive mills on low falls that made use of the early turbine-type of wheel.

Millwright's guides, scientific journals and encyclopaedias of the day report the numerous improvements made to larger vertical wheels from 1800 to the 1860s. In 1824 M. Poncelot of France advocated curved buckets on the undershot wheel, an improvement which lessened the water's shock and increased the wheel's efficiency from about 30 per cent to about 60 per cent of the total waterpower.[11] Ventilated buckets, an improvement of William Fairbairn the celebrated British engineer, were applied to overshot and breast wheels.[12] More use of iron parts (first advocated by John Smeaton and John Rennie in late 18th-century England) was made in both wheels and smaller gearing. In the United States in 1852 all-metal overshot water wheels, a patent of Samuel Fitz, began to be manufactured in shops in Martinsburg, West Virginia.[13] British millwright John Rennie had devised a sliding hatch in 1784 for the high breast wheel but applicable to all water wheels,[14] and in 1824, William Fairbairn improved these. An Upper Canadian patent of 1842 described an improved way of constructing penstocks at a more efficient angle to the bucket; it was granted to millwright Jacob Baker of Vaughn in the Home district.[15]

Turbine-type wheels of every variety began to be patented in Canada in the 1840s. Some made of iron which could be moulded into curved and screw-shaped blades lasting longer than wood, and some of wood, only a few of these claimed to be as efficient as the overshot water wheel which might utilize up to 75 per cent of the total waterpower. But even the less efficient varieties had advantages over the larger vertical wheels. Being smaller, they allowed mills on waterpowers before unusable; in fact they could be used on falls of almost any height, some requiring no dam. It was said they were less expensive being easier to repair and longer lasting. The great advantage of the enclosed types was that they were unaffected by freezing weather and thus ice-free in the Canadian climate.

Canadian water-wheel patents from 1800 to the 1860s began after 1840 and were mainly for turbine-type wheels. The summary descriptions found in the lists of Canadian patents give an idea of their construction. The first, on 1 September 1841, was the improved "submerged anfractuous" water wheel of Harvey Tripp of Haldimand township "in the form of a cylinder" which could be applied where "great power is required with a small supply of water," perpendicularly or horizontally, raised or depressed to any angle in the range of 90 degrees and "altogether immersed."[16] The second, also in 1841 by a patentee in Haldimand township, was granted to George Rogers, gentleman. His "vertical percussion reaction waterwheel" consisted of two vertical percussion wheels encased in a tight-fitting frame, water serving "both buckets at right angles" and discharging "by reaction apertures at the end of each bucket."[17] John Lamb of Hawkesbury claimed his "new waterwheel" of 3 October 1842, a downward flow type, was frost-proof and unaffected by being entirely immersed in water.[18] One variety of central discharge wheel was patented by millwright Elias Nichols of Sherbrooke, Quebec, on 4 April 1845,[19] titled "a new method of constructing waterwheels." On 14 December 1846, carpenter John Livingston of Cavan was granted a patent for his new waterwheel with "flying plates" on a slanting upright shaft.[20] The best description in the lists giving dimensions and material was that of Thomas Brill's "screw right and left reversed" cast-iron wheel, 25 inches to 30 inches in diameter with eight to ten 15-inch long screw-shaped buckets placed on an upright or horizontal shaft encased in a cylinder. Its superiority lay in the fact it could run well under water with less quantity of water than any other.[21] On 12 September 1848, Walter Perkins Newman of Elora, Ontario, was granted a patent for his "hydro-pneumatic waterwheel" different "in that the prime mover is the pressure of the atmosphere."[22] In 1851 and 1854 central discharge wheels, the first a "whirlpool" wheel patented by wagon-maker Benjamin Fuller, and the second an invention of mineralogist John N. Gatiss were patented.[23] The first "turbine" patent, "Turbine Helicoide," was granted on 10 August 1855 to N. Lacroix of Montreal;[24] it and another in 1863, the "Improved Turbine" of O. Kendall,[25] were the only patents for wheels defined as turbines, although the 15 other water-wheel patents granted from 1855 to 1865 were for turbine-type wheels.

In the United States one of the earlier patents for a water wheel defined as a turbine was granted to U.A. Boyden in 1853, an outward flow type based on the principle of Fourneyron of France whose turbine in 1827 is claimed to be the first ever perfected. Hughes in 1855 recommended a number of horizontal wheels: Howd's direct action water wheel (patented in 1838 and 1842) improved by Robert's shute (patented in 1854), Jagger's Improved Turbine, the Jonval turbine, and a central discharge wheel made of wood or a combination of oak and iron.[26]

Steam Power

Steam-powered flour mills were first established in Great Britain in 1783, in the United States in 1808 and, it is reported, in Upper Canada in 1823 at Chippawa near Niagara. Operated by one miller and one fireman working 16 hours a day, the Chippawa mill was powered by a six-horsepower engine consuming two cords of wood per 24 hours and grinding 25 barrels of flour every 24 hours.[27] In the same area at St. Davids a steam grist mill built "on a large scale" owned by Richard Woodruff, merchant, was scheduled for completion by October 1824.[28] By 1827 Joseph Pickering wrote there were two steam mills in Chippawa,[29] one of them possibly the Telferton Steam Flour Mill.[30] In 1828 farther east, George Brouse of Dundas county, Matilda township, petitioned for duty-free machinery from the united States for his planned steam grist mill.[31] The Eagle Foundry in Montreal established by the Ward brothers of Vermont may have manufactured the engine used by Brouse.[32]

Available evidence points to the United States as the source of the first steam engines used to power grist and flour mills in Upper Canada. In 1811 a small engine, useful for the distilling, grist or saw-milling business was brought into the province by Almarin James of Whitestone, New York. On 1 March, James' petition for its sale was read in the House of Assembly with a certificate from Richard Cartwright, M.P. who had seen it operating for a distillery "on a small scale in wooden vessels by steam."[33] James' price for its application to a grist or sawmill was $35.00. Even by 1831 no steam engine had been manufactured in Upper Canada with the exception of one begun in 1830 by an "enterprising American"[34] according to Cattermole. The lists of Canadian patents show that the first patents for steam engines were granted to residents of Lower Canada near Montreal where there was a number of large foundries. On 25 June 1830, Robert Hoyle was granted a patent for his "improved hydraulic steam engine," and not until 1845 were the next steam engines patented, again by Montreal area inventors.[35] Evidently not patented, various steam engines were manufactured at the York Steam Engine Works in the 1830s (see Append. A, Manuscript Report No. 201).

Up to the 1860s the majority of mills were run by waterpower which was still abundant and cheap in comparison. W.H. Smith recorded in 1846 that 18 mills were steam powered, these mainly at ports.[36] Lillie reported 41 grist mills were impelled by steam and 569 by water in 1854.[37] Users of the early engines ran the risk of explosions, by 1870 described as events as common as a freshet to a water mill or a hurricane to a windmill.[38] Steam's decided advantage was the facility with which it could be set up in the most lucrative site, close to transportation, markets and sources of supply. Especially as railroads were established distant from waterpowers, men of capital made use of steam. More constant than wind or water, though costly because of fuel, steam engines were particularly useful as auxiliary motors when water was low. It was claimed that established mills could expand without the cost of an extra building by using a steam engine in addition to wind or water. In 1833, an auxiliary steam engine purchased from the York Steam Engine Works for some £300 was installed in the Gooderham and Worts windmill on the Toronto shoreline.[39] Hughes in 1855 cautioned against the "old method" of a single engine because it required "nice calculation" to avoid backlashing; he promoted instead the use of two engines which gave a steady even power without the need of a fly wheel[40] and gave specific dimensions for an engine to drive a mill of two runs of stones.[41] Craik by 1870 still preferred a good waterpower provided the site was close to markets, grain supplies and transportation,[42] while some mill owners enthused about the greater amount of flour produced from steam-driven belt-geared mills.

Gearing

From a study of millwrights' contracts, newspaper advertisements, catalogues and guide books, it is evident that more cast iron was used for gearing as time progressed, and later, "belt gearing" became popular. In 1809, for example, a bill of scantling for a mill 36 feet by 45 feet containing two runs of stones specified an oak water wheel 20 feet in diameter, an oak cog wheel 9 feet in diameter with 74 cogs made of maple or beech, an oak spur wheel 8 feet in diameter with 100 cogs of beech or maple, a bull nut 4 1/2 feet in diameter (no material given), two cast-iron stone pinions, an oak crown wheel 4 1/2 feet in diameter and bolt gearings (for bolt machines) totalling 10 feet in diameter plus 150 cogs for these and the crown wheel. Another list of materials given by Lord Selkirk in 1804 for his small one-run mill at Baldoon included only one cast-iron pinion, presumably for the stone.

By the 1830s more cast iron was being used for mill gearing, particularly at sites close to good foundries. In 1830 founders at Black Rock Foundry near Fort Erie in the United States presented an estimated bill of iron and brass castings to Messrs. Hamilton and Warren for a mill of three runs of stones which was under construction across Lake Erie at Kettle Creek (Port Stanley area), Upper Canada. Included in the estimate were two cast-iron pit wheels with 112 cogs each and eye diameter of 30 inches, two cast-iron crown wheels with 36 cogs each and eye diameter of 20 inches, two spur core [or cone] wheels with 104 cogs and eyes of 20 inch diameter, "one of them to be made after the light pattern for one run of stones,"[43] and three millstone pinions of 23 cogs. For the smut machine a five and a half foot long shaft with four flanges, two core wheels with 88 cogs and eye diameters of 12 inches, two pinions with 26 cogs, the eye of one 11 inches in diameter and the eye of the other to suit the shaft, were listed. Three bevel wheels, one of 60 cogs and two of 48, the eye of the larger with a 10-inch diameter and the two small ones with 9-inch diameters, completed the cast gearing for the Kettle Creek mill. Other castings in the bill were gudgeons with steel points (one for the main shaft 17 inches in diameter), wings, couplings, journals, bridge pots for upright shafts, spindles, plumb blocks and composition boxes. This trend toward the use of iron in place of wood was seen in an 1834 advertisement in the *Canadian Correspondent* reporting the sale of a grist and sawmill "and machinery run by metal gears,"[44] but further research revealed that this included only the pinion gears and stone pinions. In 1842 mill castings noted for sale included spur, bevel, mitre and bull wheels as well as stone pinions and gudgeons.

In 1870 Craik described a mill he had seen, probably in the 1850s or 1860s, geared by an old Scotch millwright who had used cast-iron cog gearing and no belts. A segmental gear 14 feet in diameter was bolted on the 20-foot pitchback water wheel. Spur gears, pinion gears, bevel gears and stone pinions were cast iron, as perhaps were the shafts since Craik described the mill's movement as being "wholly of iron."[45] In his opinion, however, the mill was overgeared; the pinion fitting into the segmental gear was too small and being close to the water caused trouble and constantly had to be greased.

Belt gearing "introduced several years ago by Columbus Smith, a celebrated American millwright" according to Craik in 1870, had advantages over cog gearing.[46] Though cog gearing was cheaper, less troublesome and more durable than belt gearing, it was less preferred by millers and mill owners who had tried both because belt gearing produced a much smoother motion less wearing on millstone dress, and therefore manufactured more flour from a bushel of wheat. An undated catalogue (ca. 1872) of the Brantford, Ontario, foundry of C.H. Waterous and Company listed the reasons why belted grist mills were preferred to "geared" mills. They produced a more even motion, steadier stones and exerted less strain on engines (presumably steam). With no noise or rattle, belted mills were simpler and easier to keep in order. Millstones and machinery could be better placed, and the mill's settling did not affect belts as much as gears. Because of differing opinions, however, the Waterous company was ready to build any style of mill, "belted, geared or half-belted."[47] In 1868 Lewis Baxter wrote that his mill with two runs of stones 4 feet in diameter, powered by a 30-horsepower steam engine with belt gearing (which he preferred) ground 10 bushels of wheat per hour per run of stones, and 50 bushels of his chop stones per hour.[48] It is believed that belted gearing worked well with steam power, both of which became more popular as they were improved during the last half of the 19th century. One improvement for gears in steam-driven flour mills, according to Pallett in 1852, were steel springs. Placed on the stone pinion, a steel spring took off the backlash of the engine. Pallett preferred elliptical-shaped springs similar to carriage springs rather than other forms of coil springs.

MILLWRIGHTS

> *There probably never existed a more useful and independent class of men than the country millwrights. The whole mechanical knowledge of the country was centered amongst them; and, wherever sobriety was maintained and self-improvement aimed at, they were generally looked upon as men of superior attainments and of considerable intellectual power.*[1]

It was said that the best millwrights, like poets, were born. They came into the profession sometimes from mechanics, carpentry, milling or sawyering, but usually after serving as an apprentice under a master millwright. The apprenticeship of seven years requisite in Great Britain did not apply in Canada, however. Possessing a knowledge of drafting and the fundamental principles of power and machinery, a millwright knew how to harness the correct amount of power, how to erect a mill proportionately strong and how to arrange all its machinery efficiently. Experience, coupled with tact and ingenuity, were qualifications needed to deal with the diverse conditions found in each mill site and defined by each owner.

Next to farmers, millwrights were the most needed in Upper Canada according to Cattermole,[2] who reported that "most mechanical operations" were carried on by Americans "so sensible of the superior advantages we enjoy."[3] The need for millwrights and mechanics not only to design, draught and construct new mills but also to repair and improve established mills in both the new and older settlements that mushroomed from 1800 to the 1860s continued throughout the 19th century.

The scope of millwrighting changed as soon as foundries began to cast machinery parts and manufacture mill furnishings. Whereas before most of the machinery was handcrafted of wood near the site by apprentices and journeymen millwrights under the supervision of a head millwright with the help of a blacksmith, later more parts were foundry or factory made. The millwright in charge of the project consulted with mechanics at the foundry and mill furnishers to buy the necessary parts. As time progressed, too, costs and wages increased with variations in different areas. More complex machinery on new principles challenged millwrights to keep up with the latest inventions. Millwright's guides and handbooks, catalogues, scientific journals and rare accounts in mill owner's papers reflect the changes made in the millwright profession.

Lord Selkirk's diary recorded consultations held in 1804 with a Scots millwright, McQueen, a resident of the United States, on the subject of erecting mills for Selkirk's settlement at Baldoon on Lake St. Clair.[4] To build a threshing mill, oil mill and grist mill, McQueen proposed sending one head man to Canada and hiring others locally. His final estimate for the grist mill alone was calculated in dollars: one man's labour for 80 days ($1.25 per day), board ($1.50 a day), travelling expenses ($2.00 a day), materials (one Esopus stone and one buhr stone costing $90.00; a cast-iron stone pinion costing $10.00; one spindle, bail and driver costing $30.00) and haulage ($5.00 per cwt). The board and shingle structure was to be 30 feet by 24 feet and 12 feet high, and once in operation the mill was to grind four to five bushels of wheat per hour. There is no evidence in the diary that the mill was ever constructed.

From Selkirk's conversations with McQueen and other millwrights in Canada and the United States, it was obvious there were at that time a number of ways of paying millwrights in Upper Canada. A daily rate or so much per foot diameter for each wheel and cog was paid in dollars or sterling.

> McQueen (a Scots Millwright) calculates his workmen at 1 1/8$ per day besides provisions - he reckons it equivalent to this to pay them 2 1/2$ per foot diameter for an undershot water-wheel of 3 or 4 feet wide - or 5$ for a Cog wheel - besides material. Iron comes to from 1/- to 3/6 lb. N.Y.C. - in general 1/2 or 1/3 of which 6d for the raw Iron - the rest for the work.[5]

The papers of Alexander Hamilton of Queenston provide later documentation of mill construction and show an increase in wages. In 1817 Hamilton and Benjamin Canby together contracted with millwright Joseph Wilder from Ithaca, New York, to build a grist and sawmill at Canborough to replace those destroyed during the War of 1812. Wilder's estimate for a two-storey mill 34 feet by 28 feet with two runs of stones, a separate sawmill with two saws, a race and dam "all in a complete manner tight from leakage"[6] warranted to keep for a year, amounted to $3,000.00. Two-thirds was to be paid while it was building and the last $1,000 was payable after the year warranty was up. Wilder's estimate may have been based on calculations found among Hamilton's papers regarding the cost of grist-mill work. Running gears and water wheels were charged by the diameter and amounted to 24/- ($4.80) per foot diameter (almost twice that quoted by McQueen in 1804), plus 8d ($.13) per cog. Rounds required for the trundle wheel were 2/6 each. Bolting wheels "by the piece" were 8/- each plus 4d. per cog. Shafts for the large wheels cost $10.00 each, sawed, and $14.00 "not sawed."[7]

In 1827 a letter from a young surveyor in York to friends in Great Britain recorded that millwright's wages ranged from 7/6 ($1.50) to 10/- ($2.00) per day, board and lodging given in addition.[8] This was slightly more than Cattermole who promised engineers and millwrights not less than £6.0.0 to £8.0.0 ($24.00-$32.00) per month boarded "especially in all the new towns and settlements" in 1831.[9] In 1830 Cattermole had heard of one millwright earning £10.0.0 ($40.00) per month boarded "but that was an extreme case"[10] (though closer to the surveyor's report). Although wages varied in time according to region and the nature of the job, one wonders why 20 years later they had decreased. According to a colonial circular of 1851, the average daily wage for a millwright not boarded was 7/6 ($1.50), or 6/3 ($1.25) boarded.[11]

There was a great deal of variation in the total cost of building a mill. Mill manager William Wadsworth of Weston Mills on the Humber in 1831 estimated that the cost of building a "common grist mill with one run of stones" was from £200 to £250 ($800.00-$1,000). A "good merchant's mill" cost from £800 to £1,000 ($3,200-$4,000), probably with two or three runs of stones. Unfortunately Wadsworth neglected to mention whether the figures included the cost of the dam, and whether the mill was made of wood or stone. Rental value ranged from £40 to £50 ($160-$200) per annum for a grist mill and from £140 to £150 ($560-$600) per annum for a merchant mill, depending on the water supply and the mill's distance from market. Sawmills, because of their simple machinery, cost about £100 ($400) to erect and would readily rent for the same amount per year.[12]

A graphic account of the work and materials involved to erect a five-storey merchant flour mill with four runs of stones in 1847 is recorded in Jacob Keefer's journal written from 1846 to 1853.[13] Owner of the "Welland Mills" at Thorold, Ontario (Fig. 24), Keefer kept a daily record of the progress in building the mill until about 1850 when he lost control of it. Built at an estimated cost of $20,712, the mill was capable of producing 200 barrels daily in addition to shorts and bran. The cost included a ship's elevator capable of discharging 1,000 bushels of wheat an hour, and storage for 70,000 bushels of wheat and 5,000 barrels of flour. The journal recorded step by step the mill's construction and Keefer's transactions with his workers. Hauling stone from the quarry at nearby Slabtown was begun on 13 November 1845. A trip to New York City and Boston in April 1846, to Oswego in May to see the head millwright, and to the Dundas foundry of Gartshore and Company with the head millwright to agree on millstones and gearing,[14] were made before 23 June 1846 when the first stone was laid by the masons. Four months later the walls were finished and work began on the flume and inside plastering. On 24 April 1847, within 10 months of laying the first stone, the mill was operating. But millwrights continued their operations, probably checking the works and

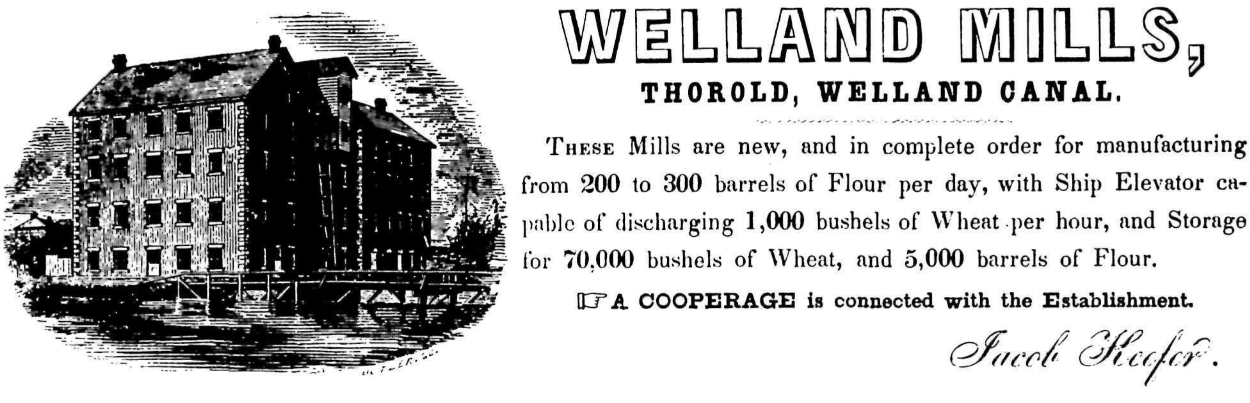


Figure 24. Jacob Keefer's merchant mill constructed 1846-47 on the Welland Canal at Thorold, Canada West. (*Public Archives Canada.*)

repairing various imperfections and breakages until 27 September 1847.

The head millwright, Samuel Taggart, was employed by Keefer from May 1846 until August 1847 when he and his family moved away. Taggart drafted the plans and specifications which were mailed to Gartshore in Dundas on 2 December 1846. Mill gearing and millstones from Dundas were duly delivered to St. Catharines and Queenston where they were picked up by Keefer or one of his carters beginning on 13 January. These "loads of castings" included two spur wheels and their shafts, four water-wheel shafts, three pairs of millstones, a box of gudgeons, lighter screws, a small wheel, a bevel wheel, an upright shaft, steel steps and other items not detailed. After a close inspection of the stones, Taggart discovered the runners were unsafe and reparation by Dundas millwrights insufficient so that new stones were hauled to the mill. It was Taggart who kept a record of all the working hours of the hands in the mill. As head millwright, he discussed with Keefer the best way of dividing the bolting cloths as soon as they had arrived from the firm of Platt in New York City. He made trips to Gartshore's at Dundas during the mill's construction, returning to report the progress of their work for Keefer. Taggart's second estimate of the time the mill would start grinding was correct, but the first was two months premature, the delay seemingly caused by the slowness of Gartshore's work. A long "parliament" was held between Gartshore, Keefer and Taggart soon after the mill began operations to arrive at terms of payment.[15] Keefer recorded a number of figures,[16] none of which indicated the individual wages he paid his head or other millwrights, unfortunately.

Owner Keefer's relationship with his head millwright at points seemed to be authoritative even in the field of millwrighting. Soon after the water was run through the race for the first time, he suggested to Taggart that a gate be made in the main trunk below "to draw off the water necessary instead of drawing through the wheel" which Taggart then approved.[17] Keefer also bought the mill machinery himself, making trips to adjacent towns in the United States and Canada. Though not stated, it is presumed the buying was directed by Taggart. In Buffalo Keefer purchased nails, locks for the mill door, tin and wire cloth, hinges, screen wire, door handles, screws, copper (to make brands), scale beams and a Fairbanks scale. In St. Catharines he purchased draughting sheets, white sewing silk to make up his flour bolts, rope, cherry lumber, maple wood, 3,000 hoops for flour barrels, cooper's adzes, tacks, screws, bar lead, zinc, round iron, iron, a 10-inch tackle block with friction roller, 8 scoop shovels, spring balances, a marking iron, towels and sheeting, scrapers and millstone feeders made from a pattern. In Port Dalhousie at the north end of the Welland Canal he purchased a box of cogs. Keefer also wrote or telegraphed manufacturers in New York City, Oswego, Rochester and Toronto for important items. Platts in New York sent bolting cloths and Brown's Patent Balances (possibly for the millstones); from Oswego Springer sent a proof staff costing $30.00. Other Oswego purchases included a smut mill, and possibly central discharge wheels to power the mill. Spaulding in Rochester delivered a feed duster costing $200.00 for a trial use. Dusters were then a new type of bolt aimed to separate and save the flour dust clinging to coarser grades of bran, middlings and shorts, but Keefer returned it after two years as unsatisfactory. Unnamed sources provided ships elevators, fanning mills, tallow, and a box of patterns.

After the departure of his head millwright to a Rochester job, Keefer hired other millwrights to work in the mill. H. Burgogne replaced some of the spouts, one Ward repaired the feed duster and some of the elevators. Correspondence with Taggart continued to 10 December 1849 at least, when Keefer sent him three letters he had received in 1846 from "the Oswego manufacturers of the central discharge wheel." Throughout the period of the journal it was evident that a relationship of respect was maintained between the two. Keefer usually referred to his millwright as Mr. Taggart, in contrast perhaps to his references to his millers who were rarely termed Mr. in the diary, partly because of their poor behaviour.

MILLERS AND MILL OWNERS

The word "miller" derived from "mill" is ambiguous and is and was used indiscriminately even by census takers to refer to owners of woollen, saw-, grist and flour mills as well as operators and hands inside these mills. In this report the term "miller" will refer to the operator of a grist or flour mill, sometimes known as a "grinder." Some millers were or eventually became owners, but because the work of running a mill required two or more hands, miller-owners, unless in partnership or willing to hire clerks and managers, found it necessary to hire millers while they did the managing or went on to other things. It was mainly the small automated grist- or custom mill and late 19th- and 20th-century small flour and feed mills that were operable by the mill owner and his family.

Early references to millers are found in mill owners' journals and letters, since few day books or mill records from the first half of the 19th century survive. Much of the data about millers, recorded by proprietors, was restricted to the miller's good or bad behaviour. One tends to form the view that hired millers were liable to drunkenness, and that there must have been a difference in performance between the hired miller, the miller who leased a mill and the miller who owned his mill. Unfortunately, owners' accounts ommitted the miller's side of the story including the many unreasonable demands made by owners on millers. If positions in mills were filled by millers matching the requirements given in advertisements, however, they were men of good character, sober habits and strict integrity, some of whom understood the management of grist as well as sawmilling. Some ads stated that married men were preferred, or a young man, with the advice that none needed to apply who smoked or chewed tobacco.

Milling guides outlined the separate duties for head millers, second millers, third millers and mill hands known as "dusties," "boys" and flour packers. The number of these depended on the number of millstones in the mill, and the amount of grain arriving for grinding which varied seasonally - which was why some millers were paid by the day or week while head millers were hired for a longer period. Hughes in 1855 outlined some of the duties and proper help required for a mill with four runs of stones using the automatic, low grinding method. The head miller or superintendent took charge of the mill's business, examining each stone's progress and making necessary improvements. He came on duty after breakfast and worked until 11 at night.

The second miller was capable of taking charge in the absence of the head miller. He, with the third miller, dressed the stones by four o'clock each day, swept and followed the instructions of the head miller. Hands to oil the journals daily, a clerk to carry on the retail business, someone "competent to take in wheat," and a careful person "expressly" for packing flour were necessary in such a mill. Pallett's guide of 1853 was more specific about the head miller's duties. The head miller ensured that there was enough clean grain for night grinding, tested stones and appointed someone to dress them, if necessary, each day. The second miller tended the mill until one in the morning while the third miller took over from then until one in the afternoon.

In a small grist and flour mill of one or two runs of stones the head miller's responsibility was great and included not only operating the mill, keeping it clean and in good repair, stone dressing, accounting and managing the hands, but also maintaining a good relationship with the farmers as well as the mill owner. Successful millers gained a reputation for being gregarious, friendly, discreet individuals whose skill, character and integrity won them an important place in the community. Foremost in importance was the miller's "thumb" or skill which, coupled with his honesty, won the confidence of both farmers and the mill owner. "If the owner of a mill is not a practical miller himself, yet he may form some idea of the capability of the miller from examining the quality of flour made," wrote Pallett.[2] A miller's knowledge of grain, his tact and honesty in cleaning and extracting the toll, his skill at grinding and bolting to suit each customer were all scrutinized by the farmer who, once satisfied, returned seasonally to the same mill with a constant income for the owner.

Some millers with mechanical and inventive abilities devised and improved mill machinery to suit the needs of the mill. Some, like those in Great Britain where stone dressing was a long standing trade in itself, specialized in stone dressing. As the milling industry grew and mills with four and more runs of stones were more numerous, they were kept busy dressing stones. By the 1860s mechanical dressers, some using diamond cutters, began to be patented. In the 1880s when rollers replaced stones, the stone-dressing skill was less needed and experienced dressers became difficult to find, many of them employed in roller mills as millers.

Accounts from manuscripts portray the roles played by millers and mill owners during the days of low grinding in Upper Canada.

> The people are pleased with Mr. Scribner, the Miller, but...Mr. Scribner says if he continues at the mills we must put in another run of stones next spring, that he cannot grind all sorts of grain with one run of stones and do the people justice.[3]

Elias Smith, owner of Hope Mills (Port Hope, Ontario), in 1800 was fortunate to have hired a responsible miller like Mr. Scribner, whether he appreciated the cost or not. Especially in the early days mill owners found it an expensive and lengthy business transporting millstones, flour bolts and grain cleaners from manufacturers in England and the United States. Many millers capable of good work were often handicapped because of inadequate machinery. Another expense mill owners sometimes were not willing to pay was the time it took to dress millstones. Pallett warned millers not to be "governed by the Mill Owner as to the time the stones should be dressed"[4] since owners "often" wanted them to run a long time without dressing so no time was lost, even when it resulted in spoiled flour. "A miller should have it in his own power to take up stones and dress whenever necessary."[5]

Some of the qualities sought for by mill proprietors when hiring millers were revealed in the letters to Robert Nelles, M.P., proprietor of a small grist and flour mill at Grimsby in the early 19th century. On 17 February 1816, Henry, son of Robert, informed his father why he had employed Philip Sparrow (or Sparn) as second miller in their mill with two runs of stones. Sparrow had been an assistant in the mill for a while, knew how to dress stones and had promised not to drink.

> It will be necessary to have two in the mill this spring as the quantity of grain to grind will require the mill to be drove night and day and one miller cannot grind every night, likewise the customers have great confidence in Sparrow's grinding.[6]

The daily journal kept by mill owner Jacob Keefer from 1846 to 1850 during the time his merchant mill of four runs of stones was erected and operated is interesting in that he hired three millers and other hands similar to the suggestions given above in Hughes' guide of 1855. Keefer's head and second miller were from Oswego, New York, a flour-milling centre, and were described as family men accustomed to work together. Snyder, said to be the best stone dresser in Oswego, was the head miller hired at a wage of $45.00 per month. Keeler, the second miller, was hired at $35.00 per month while there was business, or $30.00 per month for a year. A third miller, Jas Rymer, was hired later at $28.00 per month but there was no further mention of him or his work. At least one flour packer was paid 2 1/4 cents per barrel.

It was Snyder as head miller who advised the owner Keefer to replace the country bolt with a merchant bolt, making the mill entirely devoted to merchant milling. Snyder, too, was asked by Keefer to examine samples of grain from two competing grain boats to choose the better one for milling - a choice that earned Keefer abusive language from the owner of the unwanted cargo. It was Snyder who estimated the daily profit of the mill, and who advised on the number of extra hands to hire. One wonders what drove the head miller to go on a drunk less than half a year before his contract was up. When forced by Keefer to sign an oath of temperance, Snyder immediately broke it, occasioning his employer to underline in his journal *Keeler on, Snyder off*.[7] As the new head miller, Keeler's duties appeared to be different from Snyder's chiefly because the quantity of wheat available for milling had dwindled. He is reported to have searched the neighbourhood for shorts and bran which, once purchased, were run through a fanning mill and duster and the products eventually sold. After Keeler's term ended, Mr. Tewsley, a good stone dresser, became the head and only miller. Due to the lack of grain coming to the mill via the Welland Canal in the spring of 1848, Tewsley actually rode out among the farmers to see if they would bring in their wheat. Tewsley had also been employed as a stone dresser during the time the mill was being built and he and his helper George Elliott had offered to dress Keefer's millstones for $30.00 per run, presumably for the initial dressing of the new stones. In 1849, new millers were hired as grain supplies improved, but little reference was made to their work other than they were grinding middlings.

About 1850 Keefer appeared to have leased or sold his mill, having accumulated heavy debts. One wonders whether the high salaries he paid were one of the reasons, aside from the repeal of the Corn Laws and increased competition, that his venture failed. A comparison of miller's wages given by Keefer and William Wadsworth of Weston mills north of York in 1847 shows that the Welland millers were extremely well paid. Wadsworth[8] reported paying only £6.0.0 per month for a head miller ($24.00 compared with Keefer's $45.00) and £5.5.0 per month for a second miller ($21.00 compared with $30.00 to $35.00 given to Keefer's second miller). Even Keefer's third miller at $28.00 per month was paid more than either of Wadsworth's. The fact that Keefer's mill was a larger, up-to-date merchant mill in a competetive milling centre close to the United States may account for some of the difference in wages, and neither account mentioned whether board was included or not. Often millers were given a house and the expense was deducted from the salary. In 1851 the average wage of a miller boarded, according to a colonial circular,[9] was 4/- a day or £35.0.0 per year, equivalent to about $20.00 per month (one shilling equal to $0.20). The average for a miller not boarded in 1851 was 5/- a day, or about $26.00 a month, which was close to what Wadsworth paid his miller.

Millers' houses appear to have been adequate structures built for family use near the mill. One rare account was found, a reference to the "airy and beautiful" situation of Samuel Ryerse's miller's house which was occupied by the Ryerse family after their own burned down about 1804. With a few alterations and improvements it was made more comfortable than their own, while the miller and his family were moved to a "smaller tenement."[10] Interestingly, although Ontario millers were housed in separate structures, in Lower Canada millers often lived in rooms or apartments in the upper storeys of the mill itself.

THE AUTOMATIC FAST REDUCTION PROCESS OF MILLING

To understand the problems of milling wheat by fast reduction, it is necessary to understand the structure of the wheat kernel (Fig. 25). In general, a grain of wheat is and was a small seed with a troublesome crease in the middle and a bothersome brush or beard at one end. The crease contained the darker cells of the dried pollen tube and any foreign material that managed to lodge there. Beards varied in size, some balder varieties of wheat being without them. There were three main parts to each seed. About 13 per cent included the six layers forming the coat of the seed: three were the pericarp or outer husk later known as "beeswing," and three were the inner layers which adhered tightly to the endosperm giving the seed its colour and some protein

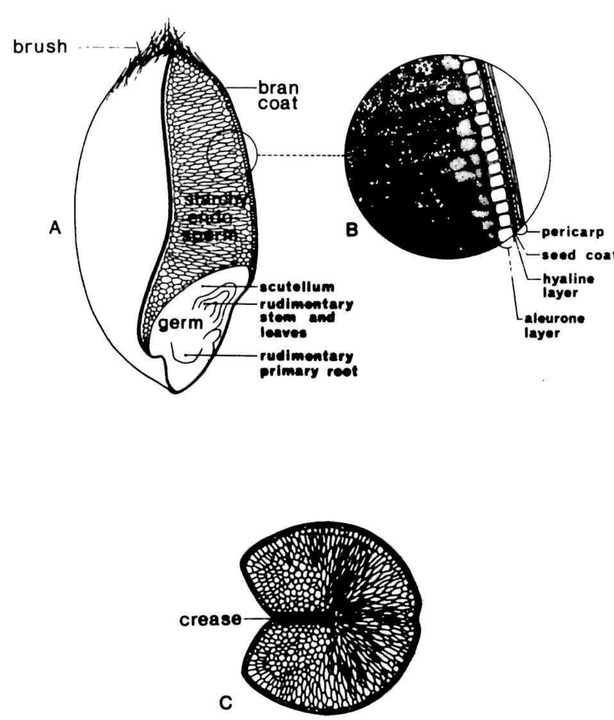


Figure 25. Enlarged view of a wheat kernel. A, Longitudinal cut showing the three main parts of the seed: coat, endosperm and germ; B, magnified section showing the layers forming the seed coat and the endosperm; C, transverse midsection showing the crease (Alcock, op. cit., p. 5).

content. The last hardest layer made up of protein-rich aleurone cells was botanically part of the softer endosperm, but during milling it was separated with the outer layers of the seed because of its toughness and colour. The second and major part of the wheat kernel was the endosperm composed largely of starchy cells which made up about 85 per cent of the seed. Gluten, which made "strong" flour, was concentrated in the outer starchy cells of the endosperm, those nearest the hard, sweet aleurone layer. The third main part of the seed was the germ or "chit" which contained a vitamin-rich oil important for nutrition. It was this oil that created problems; it was liable to become rancid which spoiled the flour, and it preserved moisture within the seed, moisture which "sweated" out importunely and created sour flour unless the grain had been kiln-dried or the flour dried. If rubbed too thin by millstones, the germ disintegrated and formed a greasy coat glazing millstones.

The different varieties of grain required special consideration by the miller. The greatest difference in seeds was between the soft wheats, generally fall wheats, and the hard wheats, generally spring wheats. The fall wheat made a weak white flour suited to make cake and pastry. Fall wheat contained less gluten than spring wheat, which was best suited for bread flour. Both varieties of grain were used for making flour for every purpose, however, because the fast reduction method of milling made little distinction between the unique qualities of hard and soft wheats. The main effort of millers grinding low was to make as much fine white flour as possible from a bushel of wheat, whatever its type.

This was more easily done with soft fall or winter wheats. Being moister their tough rubbery husks did not break up readily and were easily separated as bran from the white flour. Soft wheat usually had a white inner seed coat and a white starchy endosperm which was easily reduced to a white flour - or to a starchy hot paste that coated millstones and clogged the bolts if the miller and stone dresser lacked skill. The higher moisture content of winter wheat which varied according to the season, soil and way it was stored, could be reduced by kiln-drying or else by drying the flour before bolting.

Hard spring wheat, on the other hand, was dry and often amber. Its brittle husk was milled into fine particles not easily sifted from first-quality flour. Greater pressure was used to break the hard seeds, and often the naturally amber flour was further discoloured by the scalding heat, in addition to being specky from the bran. It was unfortunate that whiteness of flour was considered valuable, since the darker spring wheat flour, being richer in protein and gluten, was best for bread making. Millers seeking to overcome heated flour milled higher to reduce the pressure.

This left a large percentage of "middlings," coarse granules containing the hard glutinous and protein-rich part of the kernel. Regrinding the middlings created a second-quality flour graded "fine" and later "superfine 2" which was often "killed" or further scalded during the second grind by hot close millstones. Killed flour with injured gluten would not rise when baked having lost its "liveliness" or ability to contain air bubbles. Not until the "new process" of gradual reduction, practised sometime after 1860, did millers know how to make the best flour from hard spring wheats.

From the 18th century to about the mid-19th century, the traditionally British process of low or flat grinding, so called because the millstones were run relatively close together, was practised in North America. After 1800 in Upper Canada the process became automated wherever mill owners installed the inventions devised in the 1780s and published in 1795 by the American genius Oliver Evans in his *Millwright's Guide* - but the method remained the same. With sharply dressed millstones running fast and close, as much flour as possible was milled in one grinding. Three basic steps were necessary: cleaning, grinding and bolting. In actual practice and especially among millers of hard wheats, the coarser portion was reground to make a sometimes fine, sometimes superfine addition to the first, main grinding. But the flour from the second milling was generally poorer having been killed by the hot close millstones. The trend in milling methods from Evans' time until the adaptation of the European high grinding or gradual reduction in the 1860s, was toward a better, gentler treatment of middlings so a higher quality of flour could be produced from them. This higher yield of livelier flour brought profits to the mill owner.

Regrinding of Middlings

To avoid the loss when middlings were sold as third or lower quality flour, many methods of regrinding them were tried, and these were improved as time went on. Evans in 1795 recommended middlings be reground alone lightly,[1] or along with the grain on regular millstones so they would not be overheated and the flour killed.[2] In the 19th century as the flour trade became international, effort was made to keep up with European millers who had long ground and reground hard wheats into excellent bread flour. One American solution was offered by "mealman" David Bonnell who in August 1849 in the United States[3] and in 1850 in Upper Canada patented his "improved process of flouring"[4] (Fig. 26). Bonnell employed special

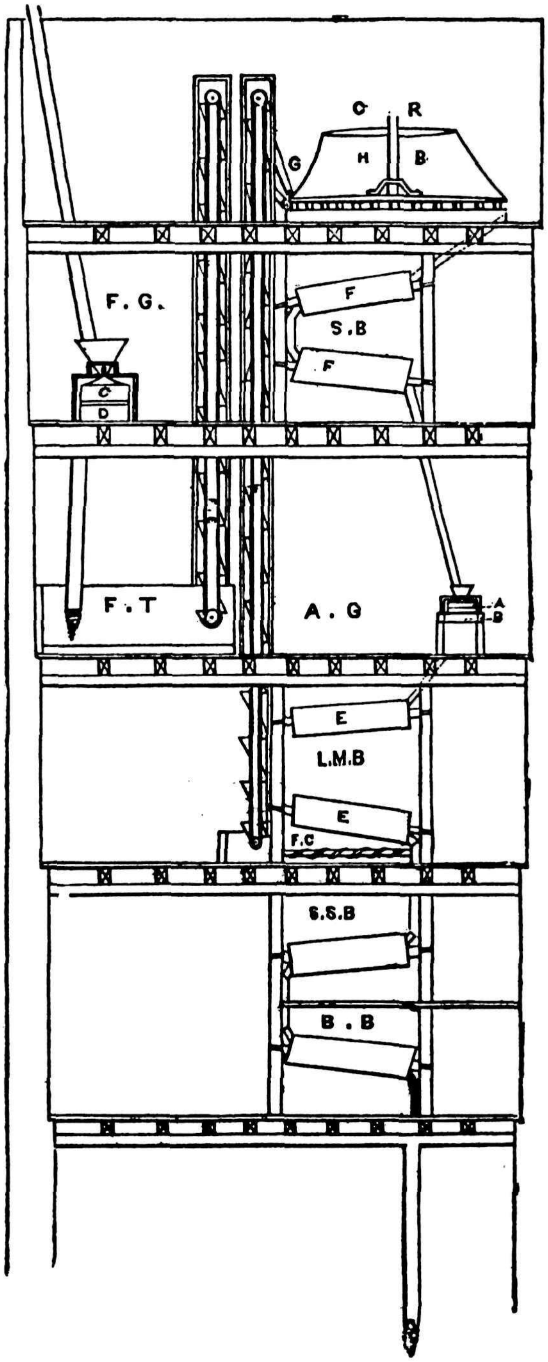


Figure 26. Simplified plan of David Bonnell's process of making flour by regrinding the middlings. Patented in 1849-50, his method used millstones CD for the first grinding, a hopper boy HB in the cooling room CR, scalping bolts SB for removing flour, auxiliary stones AB for grinding the tailings and an assembly of flour bolts for separating merchant flour and bran (Patents of Canada 1849-1854, patent 279).

"auxiliary stones" three feet in diameter run at 300-500 revolutions per minute to regrind everything left over from the first grind, thereby producing more superfine and saving "the glutinous saccharine and most nutritious and valuable portion of the grain."[5] Evidence shows that this patented method may have been quickly communicated to progressive merchant mill owners. Jacob Keefer, owner of the Welland Mills at Thorold, Ontario, recorded in his journal on 21 September 1849 that he had been called on by "Mr. Bunnell ... about grinding."[6] Three months earlier Keefer reported that a "New Miller" had begun work,[7] and subsequent entries stated that middlings were being ground. Whether or not Keefer's new miller followed Bonnell's patented method is not certain, but he may have been in contact with one of the latest "improved" processes. Although Bonnell's process was similar to European methods utilizing special smaller stones to regrind middlings, it was, nevertheless, harsh by European standards, because his stones were run at such a high speed.

Henry Pallett's milling guide of 1853 advocated three methods of remilling middlings, two similar to Oliver Evans' method and the third similar to but less harsh than David Bonnell's patented process. Pallett's third method was an improvement over his first two and promoted the use of special stones for middlings, 3 or 3 1/2 feet in diameter.[8] The texture of the stones was close, the dress specifically different and the speed as slow as 130 rpm, all measures that treated middlings more gently with less pressure and heat than Bonnell's so flour was less likely to be killed.

David Craik's guide of 1870 stated that "the greatest trouble in all large mills appears to be the working of the middlings."[9] In good times, owners could afford to grind high and make one first-class grade of flour and then make two or three grades from middlings. When flour was cheap, however, there was little demand for inferior flour,[10] and so the object was to get as much first-quality flour from wheat without injuring the colour. To do this Craik advocated using one run of middlings stones to regrind middlings into first-quality flour, and another run to mill second middlings into second-quality flour, or for mixing with lower grades, depending on the quality of the middlings. He described his arrangement of five runs of wheat stones and two runs of middlings stones with a six-reel chest of bolts plus two three-reel chests and three flour coolers.

It is difficult to know which of the several methods of regrinding middlings was used by Ontario millers since few details are revealed even in mill owners' diaries. Keefer in 1849 indicated he may have tried Bonnell's process. John Goldie writing about his new mill at Greenfield near Ayr, Ontario, in 1850, only revealed that "our profits [come] from the bran, shorts and middlings, the latter being again ground, and from which second flour is made, but this is only done in the summer after the wheat is all done."[11] It seems, then, that Goldie's miller saved all the middlings from the first grind of the wheat, probably in a special middlings garner or bin in the upper storey of the mill, and these were reground after the wheat had been ground once. "Second flour" referred to flour made by the second grinding branded "superfine 2" the newly defined third quality of flour according to the flour inspection act of 1850. Since Goldie's miller waited until wheat was milled, he probably used ordinary wheat stones to remill middlings since in fact the mill only had two runs of millstones in 1850, one for "chop" and one for "flouring."[12]

In 1856 Welland Canal millers were publicly censored for the way they mixed their reground middlings in their large, well-equipped mills receiving large consignments of western wheat from the United States.[13] It was claimed they mixed their reground flour with "superfine 1" and branded it "superfine 1." In this way they and "any such large perfectly constructed mill" were able to grind one barrel of "superfine 1" flour from four bushels of wheat, which was unfair to "ordinary" mills which took four and one-third bushels to make a barrel of "superfine 1."[14] The objection was made that the "superfine 1" flour from Welland Canal mills was not "intrinsically" worth as much as the "superfine 1" flour from other mills, which was why informed bakers paid more for the country mill grade of "superfine 1." The writer and many in the trade queried whether "any flour mixed with middlings ground over again should be stamped Number 1."[15] He concluded that there was no harm in manufacturing it that way, but asked that it be distinguished in inspection from other flour "made in the usual manner" costing considerably more.[16]

Increased Yield and Rate of Production

Not only because of regrinding middlings but also because of other improvements made in mill machinery, the capacity of mills increased between 1800 and 1860 so more flour was manufactured from a given amount of grain faster than before. Force flour bolts and dusters were designed to separate flour and flour dust from coarser particles more effectively so more flour was saved. Flour exhausts and new types of flour coolers replaced the hopper boy, speeding up production. The automatic devices of Oliver Evans continued to be installed and saved time as well as labour. Kiln-dried wheat yielded more flour per bushel, and new methods of powering mills, especially improvements ensuring a constant even power, produced more flour. Craik wrote that belt-geared mills, because of their smoother motion, produced an extra 1 1/2 pounds of flour per bushel of wheat.

Lack of details regarding milling methods and machinery used in Upper Canadian mills from 1800 to 1860 make it necessary to study mill capacities recorded in census records, directories and guides which directly or indirectly reflected the improvements made. A mill's capacity and its output were different, the latter being its actual production and the former its capability. For example, many mills did not operate at full capacity due to low grain supplies or poor waterpower. Capacities of mills were reckoned by the number of bushels of wheat the mill was equipped to grind every hour or 24 hours, or by the number of barrels of flour the machinery and men could produce every hour or 24 hours. Often, however, the "day and night" operation was irregular and every mill closed by 12 o'clock midnight Saturday. From 1800 to about the 1830s the capacity of an up-to-date merchant mill was between 100 and 150 bushels of grain per run of stones every 24 hours, or about 20 or 30 barrels of flour per 24 hours. From about the 1840s on, mills claimed capacities of about 240-450 bushels or around 60 barrels of flour every 24 hours per run of stones. In 1853 Pallett stated that millstones 4 1/2 feet in diameter run at 160 rpm ought to grind eight to ten bushels per hour and do good work.[17]

The standard yield of one barrel of superfine flour from five bushels of wheat was allowed as the basis of the grain and flour trade from about 1830 until sometime in the last quarter of the 19th century - by 1889 the government allowed 4 3/4 bushels to make a barrel of flour. In fact the actual yield from mill to mill varied and was more than the allowed standard to permit a small profit for the mill owner. Every good miller tried to improve his yield. David Bonnell in 1849 claimed his patented process produced a barrel of "excellent superfine flour" from 210 pounds of good dry grain, the equivalent of 3 1/2 bushels[18] - a questionable feat. Similarly, the well-equipped Welland Canal millers in 1856 were reported to mill a barrel of superfine 1 from four bushels of wheat while small country mills ground a barrel from 4 1/3 bushels. The secret behind Bonnell's and the Welland millers' high yield lay in their method of grinding and mixing middlings flour, though the condition and cleanliness of their grain made a difference too.

In the early part of the 19th century or wherever simpler methods were practised, the yield of white flour was lower. A barrel of superfine was produced from between five and six bushels of wheat. Various mills advertised their terms of exchange, terms, however, that allow for profit and therefore mask the actual yield. For example, in 1810 Clark and Street, owners of the Bridgewater Mills at Niagara, published a handbill[19] stating their terms of exchange for grain brought to their mill for storage. For 5 1/2 bushels of grain (330 lbs), they would give 70 pounds of bran, 8 pounds of ship's stuff and one barrel of superfine flour (196 lbs) or a total of 274 pounds of produce. Barrels furnished by Street and Clark cost 3/6 York currency, packing cost 6d. and if nailed and lined, 6d. more. Apparently the firm made their profit by selling or using the 56 pounds of leftovers. In 1832 Gooderham and Worts made contracts with grain suppliers and farmers in which they would return four barrels of flour for 20 "good bushels" of wheat (64 lbs to the bushel).[20] In other words, for 1,280 pounds of grain, 784 pounds of flour (presumably packed in free barrels) was returned, leaving the remaining 496 pounds for Gooderham and Worts to sell or distill as profitably as it could.

Little is written about the 19th-century gristing trade; more is available about the merchant trade, but it is clear that the matter of yield was less urgent for the farmer than it was for the merchant miller. Farmers and settlers received the main part of their wheat back in produce of some grade - flour and meal plus bran and shorts. The main loss to the farmer from the grain he brought to be milled was in the form of screenings in the grain cleaner, and tailings and sweepings, plus the toll. The latter, by an Act of 1792, amounted to 1/12 of the grain he brought to the miller for grinding. The best way a farmer could increase his yield was by harvesting a crop of clean plump grain, and this would net him one or two pounds more flour per bushel of wheat, especially if it was ground at a skillfully run and efficiently equipped grist mill.

Gristing and merchant work became two separate businesses as 19th-century improvements made milling an expensive undertaking. Despite petitions of mill owners for an increase in the toll of 1/12 to pay for rising costs, the toll remained the same. Gristing was meant to be a service to the farmer whose supplies of wheat, whether by toll, barter or cash, provided merchant millers with the source of their flour. Less sophisticated machinery designed for custom work produced less fine and fancy flour for the farmer. Custom flour was never liable to inspection except by the farmer himself.

While machinery in the merchant section of the mill was improved to keep up with the growing competition in the flour trade, less costly improvements in the grist mill were made to suit the farmer's needs. Custom mill machinery was designed to take into consideration the varying needs of each farmer and the varying quality and quantity of his grist. Millstones and flour bolts were designed to produce grades that would satisfy. Some grist mills were equipped with chopping stones to break grains for livestock feed. Custom bolts separated flour of either mixed or pure grades to suit the request of individual farmers. Wherever gristing became competitive, millers found ways of attracting farmers, if not with expensive machinery then with tact. Squair very clearly stressed the equal importance of tact and skill as qualities making a successful grist miller and fitting him for the "delicate matter [of] providing the material for the making of the daily bread of the community."[21] Leaving out the matter of machinery he wrote:

> It was no easy matter for the miller to make sure that, with more or less inferior wheat, he would always send home with the farmer a full quota of good, sweet flour, which would rise well, and come out of the oven, brown and crisp, to the delight of the good housewife, then, and now, and ever, a most fastidious person.[22]

The yield to the farmer from Squair's mill in 1854 was calculated at 40.83 pounds of flour plus bran and shorts for every bushel of grain.

Mill owner Squair also conducted a small merchant business from his mill with two runs of stones. In 1854 he entered into an agreement with Messrs. Tucker and McCoy at Port Newcastle. From every four bushels and 24 pounds of grain delivered to him by Tucker and McCoy, Squair promised to deliver one barrel of superfine 1 flour at a rate of 200 barrels of flour a week. As his share Squair received all the offal which included screenings, bran and shorts, plus 1/2 for every barrel of flour. Not enough details are available to discover the actual profit of the mill. The cost of a barrel (2/-) plus teaming to Port Newcastle (-/5 per barrel of flour) cut down profits. The returns for merchant work in November 1854 equalled $186.60, and this added to the return from gristing, $26.50, totalled $213.10 for the month's grinding.

Many mill owners like John Goldie of Ayr realized that gristing or country work would not pay and chose to do merchant work only. In 1850 Goldie received a commission from flour merchant James Brown of Dundas who paid Goldie the price of five bushels of wheat in exchange for one barrel of superfine flour. With the cash Goldie bought wheat (supplemented by his own crops), and his profits were made from the leftover middlings, shorts and bran after one barrel of superfine had been milled. He reground middlings making "superfine 2" flour, and sold this, the bran and shorts (smaller middlings) so he could pay for labour and barrels. Goldie calculated that by employing one son to act as second and sometimes first miller, and his two other sons elsewhere in the mill, he would make profits up to five dollars a day with which to pay for the cost of his machinery and mill construction.

The flour inspection laws between 1841 and 1860 reflected the better use made of middlings by regrinding (Table 1). In 1841 there were two grades of middlings known as "fine middlings" rated third quality, and "middlings" rated fourth quality. In 1850 a new third quality was added, "superfine 2," and evidence shows that this was one in which reground middlings flour had been mixed. By 1856 the law defined five qualities of flour and only one grade "fine middlings" in sixth place existed, presumably as a result of the practice of regrinding middlings down into flour. In 1860 "fine middlings" was in seventh place next to the lowest quality known as "Ships stuff or pollards," and there were six grades of flour rated "fine" and higher.

Table 1. Qualities of flour defined in the flour inspection acts passed in Ontario between 1801 and 1889. The increase in qualities resulted from improved methods of milling, particularly the invention of finer bolt cloths through which flour was sifted into various grades.

Year	First Quality	Second Quality	Third Quality	Fourth Quality	Fifth Quality	Sixth Quality	Seventh Quality	Eighth Quality	Another Quality	Other Brand
1801	Superfine	Fine	Middlings							
1820	Superfine	Fine	Fine middlings							
1841	Extra superfine	Superfine	Fine	Fine middlings	Middlings	Pollards				Farine entière*
1850	Extra superfine	Superfine	Superfine 2	Fine	Fine middlings	Middlings	Pollards			Farine entière
1856	Extra superfine	Fancy superfine	Superfine	Superfine 2	Fine	Fine middlings	Pollards			Farine entière Kiln dried
1860	Superior extra	Extra superfine	Fancy superfine	Superfine	Superfine 2	Fine	Fine middlings	Pollards		Farine entière Kiln dried
1873	Superior extra	Extra superfine	Spring extra	Superfine	Fine	Fine middlings	Pollards		Strong bakers'	
1874	Superior extra	Extra superfine	Fancy superfine	Spring extra	Superfine	Fine	Fine middlings	Pollards	Strong bakers'	
1887	Patent** roller	Straight roller	Extra superfine	Superfine					Strong bakers'	
1889	Patent roller	Straight roller	Extra superfine	Superfine	Fine				Strong bakers'	

* Whole-wheat flour.
** The law specified two types of patent roller flour: one made from "spring wheat" and one made from "winter wheat."

These methods of regrinding middlings were only a partial solution to the problem of saving gluten-rich middlings from waste or sale as low-grade produce. An even better solution was yet to come from Europe where gradual reduction and middlings cleaning - or "purifying" as it came to be known in North America in the 1870s - was commonly practised. A special flour bolt arranged to grade and clean middlings into different sizes before regrinding, and "granulation" to make middlings first instead of flour, were two steps distinguishing this European method from the methods of high grinding and middlings regrinding used by Upper Canadian millers during the major part of the 19th century.

Hopefully more information regarding Canadian grist- and flour-milling procedures will be found, perhaps in milling periodicals that aimed to exchange information about the industry and which did not begin to be published until the late 1860s in the United States. One of these, *The*

American Millers founded in 1873, was popular in Canada and included correspondence from Ontario millers and mill owners. The low grinding process was as good as each miller made it, and good millers found ways of improving their grind, ways that died with them if not recorded in some fashion. In 1887 M. McLaughlin wrote that the aim of milling had not changed since the 1830s - to make a purer flour, a larger yield of it and at a decreased cost of manufacture.[23] Scientists knew that the pure white flour was less nourishing than whole meal or coarser grades. Even in 1850 it was written that the "controlling influence of custom" made efforts to change the notion that whiteness was a mark of goodness, a vain occupation.[24]

GRAIN VARIETIES

Farmers were always interested in acquiring varieties of grain best suited to the climate and soil, high yielding, insensible to pests and diseases, and profitable at the mill and market. Harvesting of winter or fall wheats was confined to a few temperate areas of Upper Canada - the Bay of Quinte, the western peninsula and a strip 12 miles wide along Lake Ontario from Cobourg to Niagara. Elsewhere in Ontario fall wheat was winter killed three years out of four.[1] Planted between the end of August and 10 October, it was reaped the following summer and was said to yield an average of 20-25 bushels per acre.[2] Until the 1830s a smooth red variety of winter wheat, possibly Red Chaff, was popular along the Bay of Quinte. West of the bay, along Lake Ontario, White Flint and later White Bearded, a plump favourite, were cultivated and sold for sixpence more per bushel when exported, probably because they were white and produced a whiter flour than Red Chaff milled.

Further north in regions where winter wheats were killed by frost, tillers turned to spring wheat. Sown in the spring between 20 April and 15 May, it was known to yield an average of 18-30 bushels per acre.[3] The first variety to gain notice in Upper Canada was Mediterranean or Italian, brought from the United States about 1830. Because it succumbed to rust, however, Siberian wheat, originally brought from England to New Hampshire in 1780, supplanted the Italian and was popular north of Lake Ontario in the 1840s. Other varieties such as Bald Club and Black Sea were tried but all these in time became subject to rust and midge which shrivelled the grain and reduced its yield.

The most important grain introduced into Upper Canada and North America in the 19th century was Red Fife, named after David Fife of Otonabee County.[4] Originally from Galicia near Poland, the grain was part of a sample of unidentified wheats picked by Fife's friend from a grain boat docked at Glasgow, Scotland, in 1842. When sown by Fife in the spring, it alone of the other grains sent with it survived through the season. In time Red Fife was hailed by northern farmers in Canada and the United States as the best. It was easy to thresh, productive and free of rust. It could be sown as late as 10 June to escape the worst attacks from the wheat midge, in strong clay or in lowlands. Although like most spring wheats it was more difficult to mill than winter wheats, it produced a good flour with better bread-baking quality than any other variety of the times. By 1860, Red Fife, also known as "Scotch" or "Glasgow Wheat," superseded all other spring wheats sown by farmers in Upper Canada.

GRAIN CLEANING AND DRYING

After threshing, winnowing and extracting wheat for seed, the farmer packed his cleaned grain in sacks ready for the mill or market. Transportation began as soon as possible following the harvest, but where roads were bad, many farmers preferred waiting until winter for the sleighing season. Long lines of vehicles loaded with 40 or 50 bushels of grain en route to a mill or market were common sights in every season in Upper Canada.

Grain considered clean by the farmer was rarely considered clean by the miller. Merchant mill owner Hatt reported to Lord Selkirk that his miller removed three pounds of dirt from a bushel (about 60 lbs) of "common country wheat...brought in as clean" in 1804.[1] Some wheat teamed to the Bridgewater Mills of Clark and Street in 1811 was smutty and could not be "receipted."[2] Instead of being milled with receipted wheat, it was set aside with 17 other similar parcels, all to be ground by themselves.

By the 19th century most of the methods of cleaning grain in a mill were done mechanically by waterpower rather than manually, though not always. "I have got...the wheat washed and drye and put with the rest,"[3] wrote Mrs. Nelles from Grimsby to her husband attending Parliament at York about 1800. Washing grain was perhaps one of the few manual methods used to clean grain in the 19th-century mills. It was a tricky process because of the drying necessary afterward. Care had to be taken to dry it just enough so that the kernel was not too moist (and therefore susceptible to fungal growth and fermentation), and the husks and bran were sufficiently tough to be milled in large particles that were easily separated from the flour. Though condemned by some later millers because it distributed impurities throughout the grain, washing achieved two ends - lighter dross and chaff were skimmed off the top of the water, and adhering mud, dirt, mould and smut on the kernel were washed off.

The idea grew among millers that the better the grain was cleaned, the better the flour and the less grain wasted. It became the practice of progressive millers to use a number of grain machines, each designed to do a different job. The choice of cleaners depended on the aims and resources of the proprietor and his miller, and the type of grain as well as the weeds and dirt harvested, threshed and accumulated in the grain. Henry Pallett gave five steps for cleaning wheat in his millers guide in 1853. First, grain was run through a rolling screen (10 feet long, 28 inches in diameter, covered with coarse No. 4 wire, and run at 18 rpm) which rid it of straw and sticks so it would feed regularly during the cleaning process. A second rolling screen, larger and faster, with finer wire mesh (16 feet long, 30 inches in diameter, run at 22 rpm and covered with No. 10[1] wire mesh to screen out dust and finest particles as well as four feet of more open No. 4 wire) received grain from the first rolling screen. Thirdly, a "shaker" was used to rid grain of "rat dung and small sticks" just slightly longer and larger than wheat. From the shaker the wheat was run through a smut mill which broke up the smut and dirt and rubbed the furz or beard off wheat. From the smutter, the crease dust which made flour "gray" had to be removed either by a suction fan, Pallett's combined suction fan and grain separator, or by an ordinary rolling screen combined with a "good blowing fan."[4]

There were two trends of development during the period from 1800 to 1865. From fanning mills which did all of the work, specialized inventions were developed. Different machines were devised such as cockle and smut machines, each to clean a specific weed or particle. Another trend was to combine the new principles of specific machines into one bigger and better machine that took up less room in the mill. The latter type of machine became popular in the last half of the 19th century.

Grain cleaners may be divided into two functionally different types, separators and scourers. The former separated the good from the bad and were popularly known as fanning mills, rolling screens, shaking screens, separators and cockle machines. Scouring machines cleaned crease dirt, wheat beards, husks, smut powder and any other adherents to the kernel. These were known as scourers, hullers, polishers and smutters.

Separators

The cylindrical or rolling screen with a fan known generally as a fanning mill continued to be used in mills in the 19th century, but less as other horizontal shaking screens became popular. Of the eight fanning mills[5] patented in Canada during the period under study, only one employed a rolling screen and this in combination with flat screens. It was patented in 1854 by Richard Lossing of Brantford, and titled "a rolling screen fanning mill."[6] Rolling screens were replaced because flat shaking screens took up less room in a mill and were more efficient. Comprised of a chest of horizontal or slightly inclined flat sieves set one above the other and oscillated by mill power, shaking screens were combined with a fan to blow lightest materials from the grain as it sifted through the screens. Because some of these fanning mills were used on wheat as it was received at the mill off the farmer's wagon they were called "receiving separators" while other similar machines with finer screens used further on in the cleaning process were known as "milling separators."[7]

Fanning mills, especially those made in the early part of the 19th century, were intended to rid grain of most foreign material, including a troublesome weed known as cockle (*Agrostemma githago*). The cockle seed was the same diameter as wheat, ripened at the same time and was especially difficult to screen out - which was why Virgil referred to it as *infelix lolium* alluding to the idea that cockle was transformed into wheat. It was inevitable, perhaps, that specially constructed cockle machines were devised. Storck and Teague wrote that one of the first and most important machines was patented in France by M. Vachon and Son in 1845.[8] Their *trieur* separated grains of different length and same diameter, such as round cockle seeds and elongated wheat grains. Based on a new principle, later adopted in America for various grain cleaners such as the Carter Disk Separator, it employed an inclined revolving cylinder with special grain-shaped indentations along its surface which picked up and carried out only good grain and left the unfittable ones at the bottom of the machine where they were discarded.

In Canada the first cockle machine was patented in 1862 and designated as "a new improved fanning mill for separating oats, cockle and other seeds from wheat."[9] More like the conventional fanning mills of the time and not based on the principle of the trier in any way, it employed almost horizontal perforated flat sieves with different sized and shaped openings for passing the different kinds of grain and seeds. William Myers, a machinist in Morrisburg, Ontario was the inventor. It was not until 1871 that the next "machine for separating cockle from wheat" was patented, a device of A. Milloy of Vinto, Ontario.[10]

Scourers

A major problem of farmers and millers was to rid grain of smut, described in 1822 as a "distemper in grain which dissolves the substance of the kernel, turns it to a black dust and bursts the coats of the kernels."[11] To deal with smut, farmers brined wheat and millwrights designed special machines, the early ones rolling screens. In Great Britain the first 19th-century machine "for eradicating smut from wheat" was patented in 1803.[12] The first patent in the United States was granted in 1805 to T. Pierce of Fishkill, New York.[13] In 1812 mill owner Richard Hatt of Dundas Ontario, wrote to George and Alexander Hamilton of Queenston asking about their "wire cylinder ... for cleaning smutty wheat."[14] Hatt, whose merchant mill was reported as one of the best in the province (see Part II), was interested in purchasing the device providing it was "entire ... not very rusty" and in a reasonable state of preservation.[15]

About the 1830s smut became a serious problem in the United States and a great many different machines began to be designed. The aim of a good machine was to break the smut accretions and immediately blow away the dust and particles before they could mix with the good grain falling to the bottom of the machine. The action took place in a revolving cylinder which by various means battered and broke the brittle smut fragments while a fan quickly blew away the powder with the husks. Some of the earlier machines were harmful because they delivered a severe battering which broke even the good grain. Some contained ineffective fans. One highly rated American invention used in Canada was F. Harris and Sons patented Improved Smut and Scouring Machine and Fan, manufactured and sold at Elizabethtown, New Jersey, in the 1850s.[16] It was unusual in that it employed stones revolving like millstones but four times as fast to scour and clean grain while the fan blew away the dust. Craik wrote that between 1830 and 1870 hundreds of smutters were devised, some running horizontally and some vertically. Hughes' guide of 1855 gave directions for making a smut machine to clean 30-40 bushels of wheat per hour.[17]

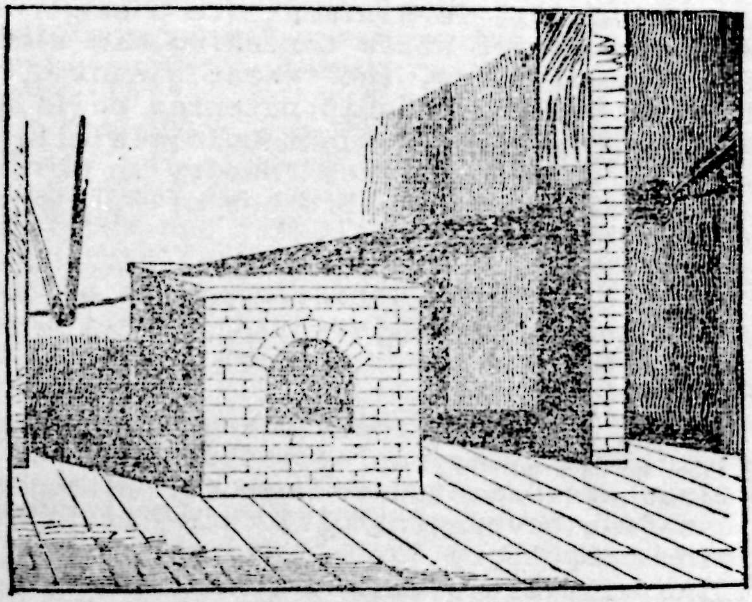
In Canada during the period under review only five patents were granted for devices specifically to remove smut. The first was granted in 1837 to William White, a miller in Newcastle District, for his "new and useful machine for removing smut from wheat."[18] It was a wooden cylinder 30 inches long with wrought iron rods against which grain was projected to pulverize the smut which was then blown away while the sound grain passed out the bottom. In 1842 the second patent was granted to William Arms of Sherbrooke whose machine used beaters, grooves, a sieve and a fan to purify grain.[19] Thomas Brown, a miller of Dunham near Montreal, patented his smut mill in 1848 which consisted of an upright frame 2 feet 10 inches square containing heads, spikes, wings and beaters to loosen the dust while four fans drove the smut powder into a smut room as the grain fell into a box.[20] John Gartshore of Dundas in 1857 patented a fan and other improvements to Grimes Patent Smut Machine,[21] and in 1858 T.C. Gleason of Hamilton patented an "improved grain cleaner and smut mill."[22]

Machines known as scourers, hullers, or polishers which rubbed the wheat grains were in the same category as smut machines - and sometimes the same invention though known by another name. For example, the "triple action vertical scourer and separator" patented in 1855 by F. Bowen of Port Ryerse, Ontario, consisted of a "scourer or smutter,"[23] a vertical cylinder with beaters, a suction fan and a chess separator. The list of Canadian patents included 25 grain-cleaning patents granted in the 1860s; because of their brief descriptions it is difficult to discern whether they were used by the farmer after threshing, in a mill or in a distillery. One of these, the "wheat cleaning machine" of William Goldie of Guelph township patented on 14 July 1862,[24] may have been used in the John Goldie's mill at Ayr and manufactured in the Dumfries Foundry in Galt, part-owned by John Goldie, Jr., a brother of William.

Kiln Drying

Kiln drying was a process that extracted moisture from wheat so flour would not sour, an advisable measure especially if flour was expected to keep for a long time. In 1795 Upper Canadian government officials had considered making kiln drying compulsory for all those acquiring grants of land containing mill sites where merchant flour mills were to be constructed. But because it was objected that kilns were expensive, and perhaps because the climate was not as wet as in England where kiln drying was a common practise, and because Canadian wheats were generally drier, the drying of wheat, rather than being compulsory, remained an option to be considered by each mill owner. In Lower Canada from 1806 to 1842, "Kiln D" was a brand applicable by law to flour so made and inspected at Montreal for export. In 1856 the flour inspection law for the United Provinces returned the specification "Kiln D" as a brand for flour manufactured from kiln-dried wheat.

There were many advantages to kiln drying wheat. The opinion of Mr. Brondgeest of Hamilton, Canada West, in 1848 regarding kiln drying revealed the extent of his knowledge of grain milling then. The souring of flour was avoidable by the use of a kiln, he stated, "one third to one fifth of the wheat being highly dried makes the whole perfect for years; and that third or fifth may be of the cheap spring grain, making much stronger and better flour, but which, if not kiln dried would sour the whole."[25] Brondgeest was a merchant and president of the Board of Trade of Hamilton concerned with the preservation of food; he also proposed the shipment of grain in barrels rather than bulk to keep it dry. Interestingly, he, like others, blamed the souring of flour on spring wheat (normally drier than fall wheat) when, in fact, any wheat was susceptible. The fact that spring wheat was harvested in the fall sometimes in damp condition, and stored during the damp cold winter, sometimes inadequately covered, sometimes frozen, so it contained more moisture than normal by the time it was milled, may have led Brondgeest and others to blame spring wheat as the chief cause of sour flour. Another reason may have been that stone-ground spring wheat flour was a coarser article containing more sweet and oily parts of the kernel which in warm moist conditions prompted souring.



REVOLVING DRYING KILN.

THE Subscriber begs to inform the Millers, Merchants, and the Public generally, that he has, at considerable labor and expense, invented and completed a Machine for DRYING Wheat, Oats, Barley, Indian Corn, or any other Grain necessary to be dried before being manufactured: and he assures them, that it is the cheapest and most expeditious mode of Kiln Drying Grain now in use. This Machine will dry from thirty to sixty bushels of grain per hour in a most perfect manner. It is so constructed, that the grain passes through the machine, from thence to the rolling screen, where it is cooled, in a fit state for manufacturing. This machine requires very little power to keep it in motion, and may be driven by a small strap from any wheel in the mill. A quarter of a cord of hardwood will produce heat sufficient for drying a thousand bushels of grain.

The Subscriber begs to inform the public, that he has obtained a Patent for his Machine, which extends through the United Province of Canada, and that he is prepared to manufacture the above Machines to order, or dispose of the right to persons desirous of manufacturing or using the same.

Any further information on the subject may be had, by addressing the Subscriber. All communications (post-paid) will be immediately replied to.

HIRAM BIGELOW.

Tecumseth, Bond Head P. O.,
February 15th, 1844.

DESCRIPTION.

Composed of a Cylinder about ten feet long, and ten inches in diameter, made of Cast Iron, one-half of an inch in thickness, having an iron shaft passing through its centre, on which it revolves with a pulley or wheel at one end, by which it is put in motion. The Cylinder is placed in an oblique position, having about 18 inches fall, and is enclosed either in another metal cylinder, or a brick arch, of thirteen inches diameter, leaving a space of one inch and a half between the two cylinders, through which space the fire is conducted from a fire-place or grate, at the lower end, and passes out by a chimney at the upper end. The grain is conducted by a tube into the upper end of the inner cylinder.

Figure 27. A grain-drying kiln patented in the United Provinces of Canada by Hiram Bigelow in 1843-44 (*British American Cultivator*, Vol. 2, 1843, p. 144).

Miller's guides promoted kiln drying of wheat. Hughes in 1855 wrote that "wheat should unquestionably be dried" if flour was to keep "any ordinary length of time, particularly for export."[26] He enumerated other advantages of kiln drying; more flour per bushel was millable, less machinery was needed, flour quality was improved "at least ten per cent" because "all impurities of a vegetable nature" (fungus and mould) were "entirely consumed," and the flour absorbed more water in bread making and baked a spongier loaf.[27] Hughes promoted his own grain dryer used for corn as well as wheat, made of iron and heated by a furnace placed underneath two cylinders of different temperature in which grain was raked while drying.

The lists of Canadian patents beginning in 1824 included four patents granted for grain dryers up to 1862. The first two were devices of Hiram Bigelow known as "a revolving drying kiln for the purpose of drying wheat or other grain" (Fig. 27) and "a new improved revolving drying kiln."[28] The former was granted in September 1843 when Bigelow was living in the township of Tecumseh in the Simcoe district, and the second improvement was granted when he was a resident of Coteau-du-Lac in January 1844. Two other patents were granted; one in 1850 to Oliver Tiffany of Hamilton,[29] and another in 1856 to J. Parsons of Toronto,[30] both for drying apparatuses that could be used for a variety of purposes.

MILLSTONES

The same millstone rock used before 1800 continued to be used in Upper Canada until the 1860s, French buhr being the best. These stones were imported ready-made or bought from a local millstone manufacturer who had imported the buhr rock in pieces from France. In 1800, because of the war with France, the Society for the Encouragement of the Arts in Great Britain offered a gold medal or £100 for the discovery of a quarry producing stones similar in quality to the French. Many claims were made that such a quarry had been found - one in Conway, Wales, and another at Abbey Craig near Stirling, Scotland.[1] Even in America around 1810 a quarry in Georgia was discovered and reported to be identical in composition and geological position to the French,[2] but there really was no adequate substitute. In France new quarries were discovered in the same general area of the Marne valley near the early quarry at Ferté-sous-Jouarre. About 1840, near Epernon (west of Paris), a stratum of molar quartz with grey, blue and white flint was discovered and the rock exported to America for making excellent millstones.[3] In 1852 in the valley of the Marne as far as Epernay, slate blue to grey and yellow-grey stones began to be quarried. Both these new quarry beds contained less porous stone than the earlier light grey, old quarry beds in the Tarterel region of the Marne River.[4] As milling technology improved, the new quarry stones became more highly esteemed than the old quarry stone.

Canada's mineral sources were reported to yield "millstones of an inferior quality"[5] though useful. In 1804 Lord Selkirk observed in Oxford County "loose stones of red granite" similar to rock seen on the Matchedash River (between Georgian Bay and Lake Simcoe) which were reported to make good millstones.[6] In 1851, the Canadian geologist W.E. Logan wrote that "aside from the numerous and accidental granitic and syenitic boulders strewed about the country," sites for good millstones were found in the Eastern townships at Bolton, Knowlton, Stanstead, Barnston, Barford, Hereford, Ditton and Marston.[7] One highly esteemed site of granite was at the "Vaudreuil Beauce Seigniory, near the band of serpentine" (possibly Rigaud area).[8] Pseudo-granite without quartz strains was found in mountains north and south of the St. Lawrence river at Sainte-Thérèse, Beloeil, Rougemont, Yamaska, Shefford and Brome. Silicious conglomerate rocks *in situ* were located at the Vaudreuil seigniory, the Cascades, and Point du Grand Dêtroit, as well as in the Gaspê at Port-Daniel and L'Ance â la Vieille. Tachê's *Sketch of Canada* stated that the best rock for millstones in Canada was found in the district of Gaspê.

In Upper Canada the first known millstone manufactory was established at St. Catharines by E. and J. Haywood about 1828. In 1829 they announced a branch factory at York where millstones of any size for flouring or country work were available, as well as plaster of Paris which was sold by the bushel, barrel or ton. At Brockville also in 1829, millstones of "superior quality" were available for cash, approved endorsed notes, cattle or other country produce, according to an advertisement in a Perth newspaper.[9] By the 1840s Richard H. Oates and Christopher Elliott were owners of the French Burr Millstone Manufactory associated with the Phoenix Foundry at York where they sold not only stones but bolt cloths and mill furnishings of every description. In Montreal in 1840 William Bury established a millstone manufactory. Smith in 1846 recorded millstone factories at Dundas and Colbourne Harbour in Cramahe township.[10]

Before Upper Canada millstone manufactories were established and even afterward, millstones were imported from the United States. "Oswegatchie stones" (presumably from the Ogdensburg area) though not as good as Soper stones from Esopus, New York, made "excellent flour" according to Elias Smith of Port Hope in 1800.[11] Sometime before 1830 the McDonnell brothers, owners of the Gananoque mill, imported two pairs of stones from Rochester and two from Utica.[12] These were probably bought from the millstone manufactory producing French buhr millstones established at Rochester about the 1820s,[13] and from the Utica factory of Hart and Munson, established in 1825 which provided French buhr stones as well as local stones and mill furnishings for mills in Canada.[14] As settlement spread west, new millstone quarries were discovered in the United States. One was at Muskingum, Ohio, where "flint ridge" blocks were fitted together to make millstones similar in construction to the French buhr but suited for grist mills and coarse grains.[15] Known as "Raccoon burr," the rock was described as a "cellular and amorphous quartz."[16] The reciprocity treaty of 1854-66 allowed the free admission of hewn, wrought or unwrought burr between Canada and the United States.

Some millstones may have been imported from England. Peak stones from the Peak district of Derbyshire were good for milling corn and were made up in one piece of millstone grit. Often a cast-iron ring bearing the maker's name and the year of manufacture was put in the plaster around the eye of the runner stone.[17]

The trend in millstone size from 1800 to 1860 was toward a stone with smaller diameter than before. Previously stones 7 feet-5 feet in diameter were installed in better mills, but sometime around the 1830s stones 4 1/2 feet and less became more popular being more in accordance with the "scientific principles of the age."[18] Hughes' guide of 1855 stated that 4 1/2-foot stones were large enough for any waterpower, even too large for a waterpower of over 10 feet head and fall.[19] Smaller stones required less power to drive them, cost less, took up less room in the mill and were easier to handle and move. By applying the power nearer the centre and increasing the weight of the top running stone, twice to five times the amount of grain was ground with less quantity of water.[19] Smaller stones milling by the old process turned faster, sometimes as fast as 180 rpm. Larger millstones milling by the old process turned more slowly, 60 rpm being considered optimum by some millers of the early part of the 19th century.[20]

Millstone Dress

Millstone dress changed due to the decrease in the size of stones, the less open and porous stone, the increase in their speed, and the greater quantities of wheat milled (Fig. 28). To make use of every inch of space on the smaller closer millstones run at speeds between 160 and 180 rpm, it was necessary to put in more furrows and quarters than before. Hughes wrote about the superiority of his "new quarter dress" with 21 quarters, over the old 16 quarter dress.[21] Craik wrote that the bosom area (the raised

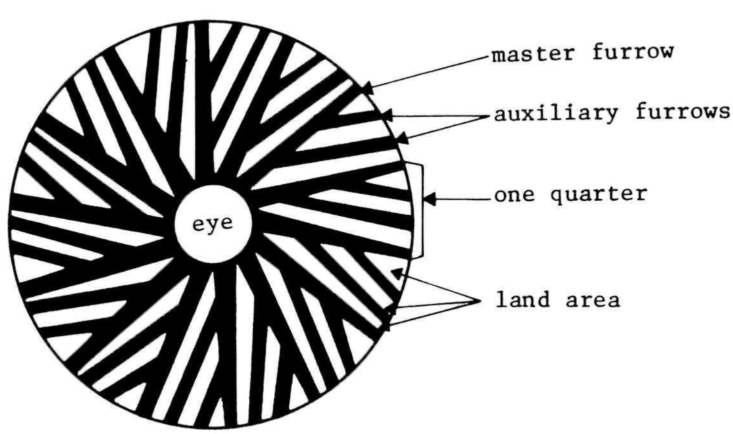


Figure 28. Dress, ca. 1855, for a four-foot buhr millstone showing 14 quarters with three tapering furrows in each quarter, a design specifically for New Stock Stone which was closer and less porous in structure (Hughes, op. cit., p. 256).

area to admit grain at the eye) was discarded which created a smaller stone than before. In its place the increased number of furrows meeting at the eye provided channels for the grain to enter.[22] Whereas before, the face of a five-foot stone milling five to six bushels per hour might be wasted, now every inch was used in a four-foot stone expected to mill 10-20 bushels an hour.

Millstone dresses began to be patented in the 1850s in the United States and in the 1860s in Canada. At the same time in Canada, attempts were made to mechanize the difficult job of dressing stones. John Rourke's "millstone picker" of 1852 could be driven by the millstone spindle and consisted of a hammer and pick moving in various directions across the stone, capable of adjustment in position and strength of blow.[23] In 1859[24] and 1860 two more patents were granted for millstone dressers. The latter, the first in Upper Canada to use diamonds, was the invention of J.T. Smith of Belleville, Ontario.[25] After 1860 many more mechanical dressers were devised using diamonds.

Millstone Coolers and Other "Appurtenances"

The need to keep flour as cool and dry as possible had been solved once by Oliver Evans' hopper boy of 1795. About the 1840s, a new method began to be applied to millstones while the grain was being milled. The first patents were European, designed for merchant mills. Necessary perhaps because of the higher speeds of the smaller millstones that reached scalding temperatures if the pressure and millstone dress were improperly calculated, the first millstone ventilators varied in design and were met with different opinions. The American miller and millwright Hughes, writing in 1855 "on the late invention of introducing air between millstones when grinding," indicated he placed little confidence in them then.[26] On the other hand, William Fairbairn, the British millwright, listed six clear advantages ventilation made in milling flour at Deptford Mills in England. Fairbairn was writing of Bovill's patent of the 1850s as applied in the large government mill.[27]

The first Upper Canadian patent, granted in 1846, appears to have been a comparatively simple method involving specially constructed millstones. Richard Oates, owner of the millstone factory in Toronto and the patentee, advocated drilling a number of holes in the runner stone at an angle against the course of the stone in proportion to the size and speed of the stone. Through these holes air was admitted which cooled the meal while it was milled.[28] Later millstone ventilators were more complex devices.

In addition to the above major improvements, many small but important changes were made to millstones in the 1840s. A machine to test how well the runner millstone balanced was devised by Mr. Munson of Utica in 1849 and used in the process of stone manufacture. This meant that the major chore of balancing stones no longer had to be done by the millwright installing them at a mill.[29] To correct small inaccuracies in balance caused by the change in humidity from manufactory to mill site, Hart and Munson provided a shot balance free of charge.[30] Millwright Munson also devised an improved cast-iron millstone eye and spindle which prevented grain from clogging and allowed the stones to be driven at any speed required. In 1855 a Baltimore firm, Morris and Trumble (originally established in 1815 by Morris and Egerton), was reported to sell millstones finished with cast-iron eyes set into eye blocks.[31] Cast-iron eyes made it easier to keep millstones in tram (perpendicular to the spindle so one side of the stone's face did not wear faster than another); in fact, Mitchell's Philadelphia French burr millstones "made on an improved plan with Kenderdine's cast iron eye, self-adjusting irons, and bedstone bush" were "self-tramming."[32] Specially designed patented grease-collars for mill spindles and shafts kept the spindles from getting loose, a fault which was "a great detriment to millers making extra work every time the stones [were] dressed." Patented grease-collars did away with "greased rags and leather collars"[33] and were another improvement made to millstones noted in the middle of the 19th century.

Pallett in 1853 pointed out that cast-iron spindles were best in steam-driven mills where extra stress was exerted. Due to the unsteady nature of steam power he specified cast-iron spindles as long as eight to nine feet with the circumference of their body between 14 and 16 inches for a four-foot millstone. On the other hand, the spindle of a water mill could be made of wrought iron about 5 1/2 feet long for the same size stone.[34]

FLOUR BOLTS

The improvements made to flour bolts from 1800 to the 1860s were relatively few in comparison to those made after when middlings purifiers, complex flour dressers, graders, scalpers and sifters were designed for the new process and roller process of gradual reduction. Perhaps the most significant advance between 1800 and 1860 was the manufacture of bolt material in finer and finer mesh so finer and whiter flour than before was separable. The type of bolt machine prevailing during the automatic old process days was the cylindrical bolt and later the polygonal reel. A specialized type called a duster began to be used profitably with flour reels in the late 1840s. Sifters employing flat oscillating screens may have been used instead of reels in some mills, but available evidence indicates that the revolving reel was most popular. These were designed for custom as well as for merchant mills. The former were small and covered with about three grades of bolt material. Merchant reels increased in size and number for a given mill and were covered with the finest bolt material available to millers competing to make finer whiter flour.

Bolt Material

The variety of manufactured bolt material increased between 1800 and the 1860s as finer mesh was woven in both wire and cloth. Numbers designating the different mesh were not standardized but seemed to vary according to manufacturer and material. In general, lower numbers indicated fewer openings and threads per square inch (hence coarser flour was bolted through), while higher numbers indicated more openings and threads per square inch (hence finer flour was bolted through), and numbers given to wire material were higher than those given to cloth material. The following list included the types reported in a variety of sources:

1) Wire bolt material was used by millers who were employed in the King's mills. Shipped from England for the government stores in 1792, the material was numbered 64, 32, 20 and 9 (see Part I).

2) "Patent worsted cloths" covered flour bolts advertised for sale by D.A. Grant in 1803.[1]

3) "A silk bolting cloth called Dutch bolting cloth" was "in common use" according to miller and millwright Caleb Edwards of Olmstead's Mills on Irish Creek near Merrickville, Upper Canada, between 1808 and 1818.[2] This was presumably the silk material first imported to the United States from Holland between 1789 and 1815 when hostility between the United States and Great Britain forced the former to find new suppliers of bolt material. Made by Dutch fishnet makers who wove a superior twisted stitch, the cloth was available in eight different grades numbered from 0 to 8 in order of coarse to fine.[3]

4) Bolting cloth numbered 10 was smuggled into Queenston from Buffalo in May 1812 for Alexander Hamilton who had ordered it from the Albany firm of Caldwell, Frazer and Company. Their letter explained that such cloth was scarce, "the only in New York of the quality at the time," and cost $112.50 for 1 1/2 lots or $75.00 for one lot.[4] The type of material was not mentioned but may have been Anchor bolting cloth available in numbers from 00 to 10 in the early 19th century from New York City importers[5] (Fig. 19).

5) Muslin bolt material was used in Joseph Keeler's "mere apology for a mill" the first erected in Norwood, Ontario, in 1821.[6] This may have been "hard book muslin" used by millers which was inferior in quality to Anchor cloth.[7]

6) In the early 1830s Henry Bodmer began the manufacture of silk bolt material in Switzerland, in an area of the Rhine valley above Lake Constance where the atmospheric conditions were best. From about 1832 to 1860, Bodmer's weavers made interlocked bolt cloth numbered as high as 12 from Italian and French silk.[8] This was imported to America and competed with Dutch silk bolt material.

7) In 1836 a factory of Messrs. Tripette and Renaud fils was established at Sailly-Saillisel, France, north of the Somme River where the climate was moist and suitable for manufacturing silk bolt material. Their weaving was based on the "new principles invented in Holland and pracitised there by a few French Protestants in exile."[9] About the 1850s and 1860s they began to weave a patented cloth with a twisted gauze thread placed at regular intervals to reinforce the whole. This was reportedly the "first step" in reinforced cloths which by the 20th century became standard.[10]

8) In 1855 Hughes' guide advised that "Dutch" cloths were the best and were imported by Ritter and Brother of Philadelphia, the oldest importing house in bolt cloths where a good selection of all numbers in two widths, 33 inches and 40 inches, was available.[11] Another company, Defoe and Company of Holland had various agents in leading cities of the United States.[12] Defour's Dutch Anchor Brand Bolting Cloth was another cloth advertised by Hughes.[13]

9) Wire bolt material, advertised as a "late invention" for grist mills, was reported by Hughes in his 1855 guide.[14] Probably a newly patented American method of manufacturing bolt material (since British wire material had been popular in the 18th century), the "superior" iron or brass wire cloth was recommended for custom or grist milling because it was best for short reels and damp wheat. Iron wire was numbered from 2 to 60 and cost between 12 1/2 and 45 cents per square foot. Brass wire, numbered from 2 to 70, was more expensive and cost between 30 and 80 cents per square foot. Both were manufactured and sold by Sterling Smith of New York City.

Bolt Machines

Increases in the length and diameter of both custom and merchant bolt frames were one of the improvements made to reels between 1800 and 1860. Another was the early 19th-century reportedly American invention of polygonal frames to replace cylindrical or round ones. The six- and eight-sided machines tumbled the stock instead of sliding it, an action which was believed to separate flour grades more effectively than the cylindrical bolts. Force bolts, based on the principle of some 18th-century British types, were patented in Canada and the United States employing new and improved mechanical knockers, brushes and beaters to force flour out of the bolt cloths. Although millwrights' accounts are scarce, a few of the types of machines used in Upper Canada have been described.

1) Two early types of bolts (ca. 1820-30) found in "the British Provinces" were detailed by Craik in 1870. The oldest reel was a "wire cloth and brush bolt" made to revolve pretty rapidly with another reel slowly turning inside composed of brushes which swept the flour through the brass wire mesh and kept them open. It was six feet long and about two feet in diameter, and would bolt for two or three runs of stones.[15] This was a force bolt.

2) The second bolt reported by Craik was an English bag bolt used more extensively than the wire cloth and brush bolt above. The reel was the same size but the cloth was different. Made of very strong material comparable to linen said to be derived from the "inner bark" (probably the bast fibre) of a nettle, it was woven without seams into a bottomless bag wider and longer than the reel itself. The great velocity of the reel made the bag bulge out over the reel against two smooth wooden bars placed to help knock out the flour. Flour was fed into the bolt via a shoe struck by noisy iron strikers. The chest, similar to the wire and brush bolt, collected and conducted two kinds of flour (probably superfine and fine), plus the shorts and bran, by funnel-shaped spouts into separate bags.[16]

3) Bran dusters (and middlings dusters) advocated by Hughes were sold in Lockport, Niagara County, New York, at Spauldings Machine Shop and Foundry, in three sizes: No. 1 suitable for a mill turning out 100 barrels a day; No. 2 for a mill producing 200 barrels daily and No. 3 for a mill turning out 500 barrels a day. The saving in a mill producing 100 barrels a day was from one to two barrels of flour.[17] Jacob Keefer in 1847 installed a feed duster in his mill but was dissatisfied with it (see "Millwrights").

4) Another type of bolt was a "sifter" which used horizontal sieves of different mesh which shook or oscillated to separate different qualities of flour. The only Canadian patent for a flour sifter before 1860 (there were none for flour bolts) was granted in 1847 to Edward Sylvester de Rottermund of the district of Montreal for his "new and useful method of constructing flour sifters."[18] Unfortunately the plans have been lost and only a short description indicated that the machine used sieves of different degrees of closeness to make separate siftings.

5) In 1860 Robinson and Jego patented their "improved method of bolting flour" in Canada. They claimed their machine always kept the cloths free (including flour made from damp transhipped wheat) by regulated knockers placed inside a cylindrical reel. According to Robinson and Jego their cloth was freed of clogging oats, chaff, moths and other insects to better allow the flour to pass through. This they considered established the superiority of their machines over the "common mode" of their competitors which drove the flour inside.[19]

6) Craik gave a description of custom bolts used in custom mills using the old process automatic methods of milling, including his method of putting on the cloth, his plan for the numbers of cloth, the gearing, the chest and methods of cleaning cloths.[20] In general, reels were between 12 and 18 feet long with diameters between 30 and 36 inches, and ran at about 32 rpm. Descriptive plates of a merchant bolt designed by Craik formed an appendix to his guide.[21]

Systems of Flour Bolting

In merchant mills it was necessary to use a number of reels together to do the job of separating large quantities of flour into merchantable grades for sale. The number or "system" varied according to the number of stones and the grades of flour aimed for the market. Documentation of arrangements of flour bolts in mills in Upper Canada during the period under review is rare but millers' guides fill the gap.

Hughes' *American Miller* of 1855 described an "old plan," probably pre-1850. Two superfine reels (covered with No. 9 cloth) were placed in the same chest above two return reels (meaning the throughs would be returned to the upper reels via the cooler for rebolting), both covered with less fine No. 8, 7 or 6 cloths. All reels were 18 feet long and 32 inches in diameter. The middlings from the coarser No. 6 or 7 cloth on the return reels were "rich" and therefore reground to produce a "fine" flour unsuited for bread because it was "dry" but better than unground middlings which were good only for feed. This old arrangement, suited to a merchant mill with three runs of stones, was "condemned" by Hughes because it required more wheat to make a barrel of superfine flour, much of the flour wasted in rich middlings.

Hughes described a better new arrangement, about 1855, which made use of four reels all covered with No. 10 superfine cloth, 20 feet long and 3 feet in diameter, plus a fifth reel called a "duster." The duster was used to clean bran of the fine merchantable flour which clung to it and the middlings. "A valuable machine" which no flouring mill should be without, the duster was larger in diameter than the superfine reels and was covered with No. 5 material for middlings and wire cloth (with 18-24 wires per inch) to separate shipstuff from the bran. Such a system was good for a mill with four runs of merchant stones and was capable of dressing up to 200 barrels of flour per day.[23]

A similar but more elaborate plan for a mill producing 100-200 barrels of flour a day requiring six-sided reels was outlined in Henry Pallett's miller's guide of 1853. Two superfine reels, 20 feet long and 32 inches in diameter covered with No. 10 cloth and run at 30 rpm, fed tailings into two return reels of the same size and speed covered with No. 9 cloth. Under these four, two more reels, one for middlings covered with No. 5 cloth and one a duster covered with No. 10 cloth, separated middlings from the bran and superfine flour dust from the bran. Pallett also included directions for cutting up, fitting and sewing the bolting cloth on the six ribbed frame.[24]

R.C. Brown's guide of 1877 describing the new process of milling reviewed old methods of bolting flour which corroborated Pallett and Hughes and added more information. He wrote that the usual size for a reel was 20 feet long and 32, 36 or 40 inches in diameter. The chest might include up to four reels, two side by side above and two below with one conveyor under two reels. In such a case cant boards gathered flour from both reels into one conveyor under the lower reel. Generally another conveyor for middlings and bran (which were channelled upstairs to a duster) was situated under the flour conveyor. Usually flour was taken from the upper reels only and the lower two were return reels, meaning that flour bolted from them was returned to the upper two reels. Brown instructed how to renovate four and five reel chests for use in the new process of the 1870s.[25]

LEGISLATION RELATED TO FLOUR MILLING

From 1800 to the 1860s a great deal of legislation was enacted related to the flour-milling industry. A study of the *Revised Statutes of Upper Canada, 1792 to 1840*, Volume 1, Public Acts and Volume 2, Private Acts, and *The Statutes of Canada* published for each year after 1840 reveals useful information about flour milling not found in technical and historical sources. Most important were the laws concerned with flour inspection and milldam construction since they set standards and reflect the technical sophistication that was evidently attainable some time before practise was set down by law.

Flour Inspection

Eight different flour inspection laws were passed in Upper Canada from 1801 until 1860, each increasingly detailed to keep up with technical, political and economic changes affecting the growing flour industry. Only flour for sale was liable to inspection, custom flour having no legal standard. To ensure that merchant flour met a standard, the government legislated such things as brands, grades of flour, barrel construction and inspection instruments. Various repeals and amendments changed details of when, how and where inspection occurred, the structure of barrels, the nature of brands, how inspectors were chosen and penalties. Perhaps the most interesting change between 1841 and 1860 was the increase from three to eight grades of flour as a result of improved methods, particularly the manufacture of finer bolt material.

The first flour inspection law for Upper Canada was passed on 9 July 1801. It was relatively simple and was passed for the mutual advantage of buyers and sellers of flour, it being up to the seller to call a government appointed inspector. Under oath to impartially execute his duty, the inspector bored the cask with the "usual instrument"[1] to prove if it had been honestly packed, and to judge its quality by marking it fine, superfine, middlings or unsound, all for the cost of 3d. per barrel. Because a large amount of flour from Upper Canada was exported to Great Britain and elsewhere via Montreal, it was subject to reinspection there. The Quebec ordinance of 1785 (see Part I) was repealed in 1806 and a new tighter law enacted in Lower Canada. Upper Canadian mill owners exporting via Montreal thus had to be aware of and abide by the stricter rules of Lower Canada, especially after 1806.

Many of the sections of the 1806 law of Lower Canada were necessary for the export trade. Strict barrel specifications were even more detailed than those enacted in the 1820 law of Upper Canada. Every barrel was to be of new oak, beech or ash ("new" was replaced with "good" in later laws). Well-seasoned and bound with at least ten wooden hoops, three at the end and a lining hoop within the chimes, the barrels were permitted in three sizes: one to contain 98 pounds, one to contain 196 pounds and another to contain 224 pounds of flour. In addition to brands stating the quality of flour, a brand "Kiln D" was applied to barrels filled with flour made from kiln-dried wheat. This drying process prevented flour from souring early and was advisable for exports expected to keep for a year or more. Another brand "ENT" was applicable to flour made from the whole produce of the wheat excepting the coarse bran and pollards, and was the same as *farine entière*." The 1806 law also stipulated the method of appointing inspectors, their duty and oath, and the appointment of flour examiners in case of disputes. Curiously, the rules governing barrel construction and the brand Kiln D were not included in the 1820 law of Upper Canada which was an extension of the 1801 flour inspection law. Not until union in 1841 were barrel specifications by Upper Canadian law as detailed as those for Lower Canada. Moreover, the 1841 act, applicable for both provinces, omitted the definition of the brand for kiln-dried flour, and not until 1856 was "Kiln D" included in the flour inspection act once more. It may be that less strict laws were drawn up for Upper Canada to encourage the growth of a milling industry. It may have been believed that Oliver Evans's hopper boy cooled flour sufficiently so souring was less likely to occur; hence the need for a "Kiln D" brand was ended - until experience proved otherwise. It is also possible that the Upper Canadian laws were in accord with American laws. Other acts were legislated in Lower Canada related to flour inspection in 1818, 1822 and 1839, and study of these together with those of Upper Canada may reveal useful information about the flour trade of each province.

In 1820 the flour inspection act of Upper Canada was extended. Flour inspection was "at the election of any purchaser"[2] and weighing was "from time to time."[3] The expense was split equally between buyer and seller. Fines of 10s. per barrel were levied on the manufacturer if barrels were lightly packed or the quality was incorrect, and these were collected by the district justice of the peace, half going to the receiver general and half to the suer. The initials of the inspector and the district or place of inspection, how the flour was faulty, were put on by the inspector, who was not allowed to deal in flour. In addition to the marks of the inspector, the law of 1820 required every miller with flour for sale to provide a brand for the barrels with the name of the mill in which the flour was packed, the initials "U.C.," the net weight, the tare and the quality. First quality was "superfine," second quality was "fine" and third quality was "fine middlings" (a change from the law of 1801 when third quality was "middlings"). For the first time in Upper Canada a clause was included in the act describing flour barrels: "good sufficient casks, made of staves well seasoned and bound with ten hoops, the tare marked...together with the net weight of flour contained, each cask to contain 196 pounds."[4]

In 1841 the next act to regulate the inspection of flour and meal was the first for the United Provinces of Upper and Lower Canada. It repealed all previous flour inspection laws of Upper and Lower Canada, and provided a more detailed one. Now inspectors and their assistants were chosen by a board of examiners which in turn had been appointed by boards of trade in Quebec, Montreal, Toronto, Kingston and other local municipal authorities. Moreover, two or more people experienced in flour manufacture were to be called in by the examiners to help appoint inspectors who, once chosen, were required to take an oath not to deal in flour and not to purchase it except for self. Flour inspection was required on application being made by a proprietor or possessor of flour, and consisted of boring the head of each cask, probing the contents to the whole depth of the cask by an instrument "not exceeding five eighths of an inch in diameter" then plugging the hole and returning the flour from the bore to the owner.[5] The place, month and year of inspection, whether "sour" or "rejected" (if unmerchantable), and corrections were branded on the barrel, and a certificate of inspection was given to the owner, all for a cost of 2d. per barrel regardless of size and exclusive of cooperage. Penalties included a £20 fine for underloading or adulteration, and 2s. if improperly branded. Branding instruments owned by the manufacturer and packer were to plainly show on one end of each instrument the Christian initial, full surname, place of packing, quality and weight of flour and tare of the cask. This brand mark was to take up a space 14 inches long and 8 inches broad.

Interestingly, since the 1820 law the number of grades for flour had increased from three to six, no doubt as a result of technically improved bolting cloth (Fig. 29). Now the very superior quality was "extra superfine," second quality was "superfine," third was "fine," fourth was "fine middlings," fifth was "middlings" and sixth was "shipstuff" or "pollards" used for biscuit or for distilling. Whole wheat or *farine entière* was to be branded as "ENT." These grades remained the same until 1850.

Tighter specifications for flour barrels were laid down in the 1841 law. "Good and strong of seasoned oak or ash, as nearly straight as may be,"[6] the staves had to be 27 inches from croze to croze and those for half-barrels had to be 22 inches from croze to croze. The diameter of the barrel head was to be 16 1/2-17 inches, and half-barrels

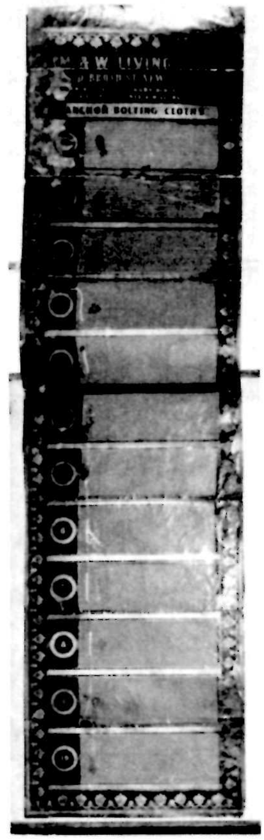


Figure 29. Sample of Anchor bolting cloths numbered in fineness from 00 to 10, ca. 1817. By the 1830s techniques for making finer cloths would be developed. (*Courtesy of Norman Ball.*)

13 1/2-14 inches. The finished barrel was bound with at least ten wooden hoops three of which were at each end with a lining hoop within the chimes, all well secured by nails. A penalty of 2s. was charged for each barrel not meeting the standard.

A new clause in the 1841 law dealt with the penalty for effacing brands and for counterfeiting brands or inspectors marks: £50 was exactable. The entire act was in force until 1 January 1848 when another to continue and amend the 1841 law was passed.

There were two important amendments in the 1848 act; one provided for the inspection of oatmeal, and the other required that all flour grades be equal in quality to those inspected at New York City. It was the duty of each inspector to procure a proper sample of the New York qualities known as extra superfine, superfine, fine, fine middlings and middlings, to guide himself in his task. This clause was repealed by the 1856 act when local boards of trade set standards. Other amendments were a decrease from 2d. to 1d. exclusive of cooperage in the charge paid by owners for inspection, and a fine of 2s. payable for every barrel delivered for sale without brand.

In 1850 the law regulating the inspection of flour and meal was again continued and amended. Once more flour qualities were changed. First quality was "extra superfine," second was "superfine," third was new - "superfine 2," fourth was "fine," fifth was "fine middlings," sixth was "middlings," seventh was "pollards" and *farine entière* was "ENT." All were to be equal in quality to New York City standards and now it was up to the inspectors to keep track of any change in the number of grades adopted in New York and conform to those changes. Millers once again were allowed to include either the name of the mill or the place of packing on their brands; the mill's name had been required by the 1820 law until the 1841 act stipulated instead the place of packing. New York grades were numerous, and perhaps for this reason the new law of 1856 made no reference to the above.

The next important change in the flour inspection law occurred in 1856 when all previous acts were repealed and replaced by an act "for the inspection of flour, Indian meal [cornmeal] and oatmeal" which became effective 1 July.[7] Again inspection was not compulsory. Two new qualities of flour were added, one designating second-quality flour and another designating flour from kiln-dried wheat. Second quality was to be known as "fancy superfine" instead of "superfine" which was now third quality. Fourth quality was "superfine 2," fifth quality was "fine," sixth was "fine middlings," seventh was "shipstuff or pollards" doing away with the "middlings" grade. *Farine entière* or whole wheat was still "ENT," and a "Kiln D" brand indicated grain had been kiln dried. Indian meal and oatmeal were graded into three qualities to be branded "first," "second" and "third," and while Indian meal and rye meal were packed in barrels similar to those required for flour, oatmeal was packed in barrels weighing 112 pounds (half barrel) and 224 pounds net. All barrels were to be "good and strong of seasoned oak, elm or other hardwood...as nearly straight as may be."[8] Inspectors who provided samples approved by the board of trade were to make weekly returns of flour or meal inspections on Monday to the secretary of his board of trade.

An amendment was made to the above law in 1858 which concerned the duties of inspectors. Inspectors became liable to fines if they failed to weigh at least 10 per cent of all flour inspected and make any deficiency good. Flour samples as standards were to be renewed only between 15 August and 15 September and be approved by a majority of the board of examiners appointed by the mayor and board of trade for the year beginning in April. The certificate or bill of inspection furnished by the inspector had to show the gross quantity of flour or meal taken by the instrument. In 1859 the laws of 1856 and 1858 were consolidated.

On 19 May 1860, amendments were made to the consolidated law of 1859 concerning flour and meal inspection. Now the inspector at Toronto was permitted to appoint one or more assistants, and the period of time samples were renewable was lengthened by one month ending on 15 October. Again the number of grades of flour increased. Now "superior extra" was first quality and all the others stepped down a peg making "shipstuff or pollards" eighth quality instead of seventh.

Assessment

According to the act of 1819 to levy and collect rates and assessments in Upper Canada, grist water mills with one run of stones were assessed at a yearly rate of £150. Every additional pair of stones was rated at £50 per year. The assessment records published yearly in the House of Assembly journal indexes until 1850 when the law was repealed are a useful listing showing the growth and decline of the use of millstones in each district, county or township (Fig. 30). Assessments after 1850 were carried out by municipal authority.

Accident Prevention

In 1838 a law was passed to protect the public against accidental injury from machinery used in mills. As of 1 August 1838, substantial guards were required around machinery to prevent contact with people. The justice of the peace was authorized to examine and inspect machinery and guards, notify the owner of any unsoundness and issue a certificate of safety covering a six-month period. The penalty for not abiding by the law was £1 or 30 days in jail.

Weights and Measures

The act to establish the Winchester bushel and a standard for other weights and measures in Upper Canada

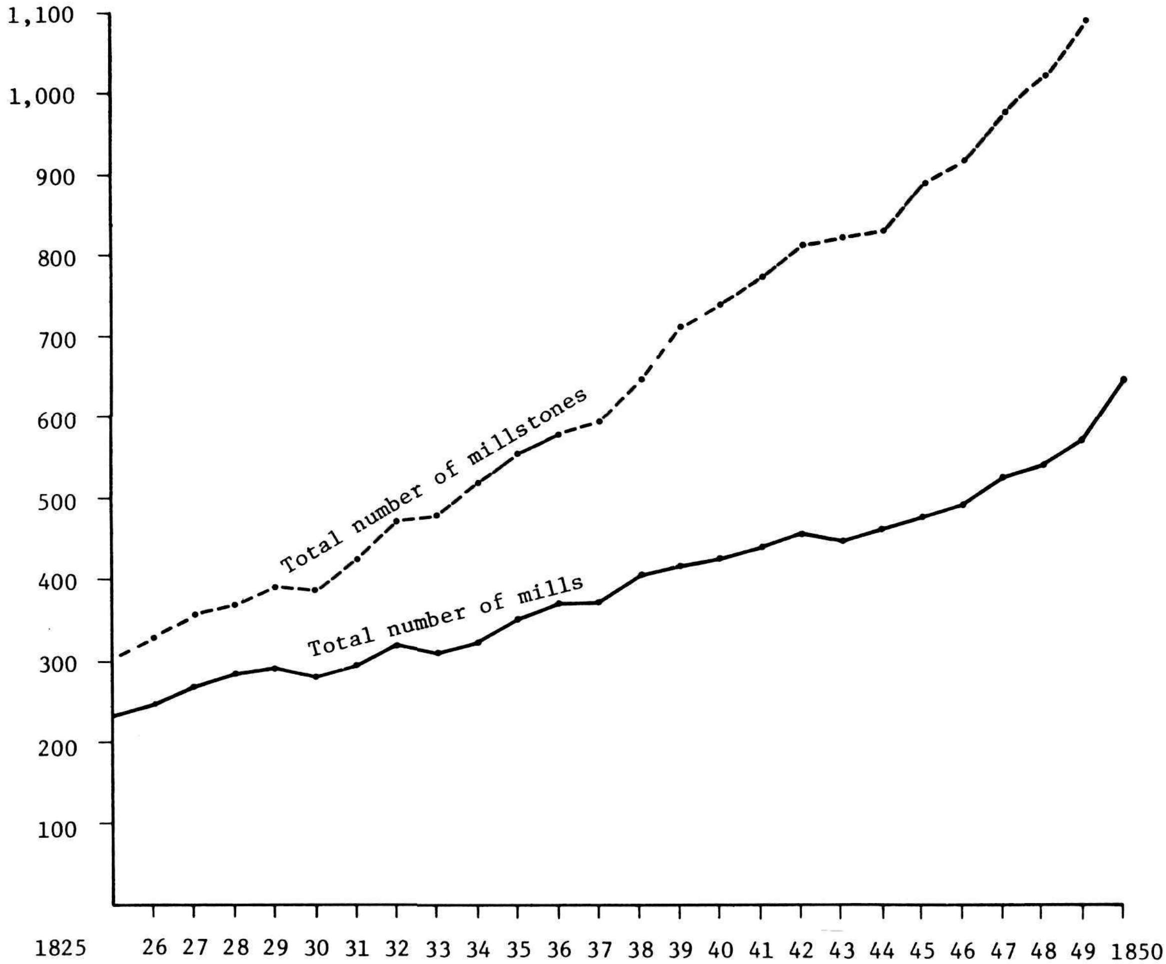


Figure 30. Graph showing increase in mills and millstones in Ontario from 1825 to 1850 despite the repeal of the Corn Laws by Great Britain in 1849 (based on the assessment rolls).

passed in 1792, was repealed 16 April 1835 and a new act passed. A Winchester bushel of wheat now equalled 60 pounds; Indian corn equalled 56 pounds; rye equalled 56 pounds; barley equalled 48 pounds and oats equalled 34 pounds. The word "bushel" was to mean the weight of the bushel. At confederation an imperial bushel of wheat equalled 2150 cubic inches.

Weights and scales used by millers had to be stamped by the district inspector of weights according to an act passed on 19 March 1823 to establish a sum of money for the purpose of obtaining a standard for weights and measures in Upper Canada. On 10 February 1840, this law was altered and amended stating that an inspector for each district had been appointed who would publish in newspapers the different places and times he would examine weights and measures used by all buyers and sellers. Each inspector had copies of standard weights and measures with which to compare local weights, and stamps with which to certify the same.

Milldams

The blocking of waterways by milldams created havoc among inhabitants hindered in carrying on the lumber trade, fishing, transport, farming and rival milling. Although an order in council published in May 1793 stated that the passage of fish, logs and other craft must not be hindered, the law was not heeded as the many petitions from dissatisfied settlers bear out. To solve the problem, several public laws were enacted between 1828 and 1849 requiring aprons on milldams. Aprons of specific dimensions were specified for dams erected on the Moira River and its tributaries, for dams on streams in the district of Huron and for dams on the Otonabee River. Those in each of these areas differed from each other in detail and differed from those required on other streams in Upper Canada where logs were floated. Between 1830 and 1840, the passage of four local and private acts allowed dams on the navigable Thames River according to specific conditions of construction.

In 1828 the first law requiring aprons on milldams was passed to facilitate the lumber trade and the ascent of fish. Unless an apron "not less than 18 feet wide by an inclined plane of 24 feet 8 inches to a perpendicular of six feet"[9] was built onto every dam legally erected on streams where lumber rafts were brought down or where salmon and pickerel abounded in Upper Canada, mill owners were liable to a fine of £25 annually. If such a stream or dam were narrower than 15 feet, the whole dam had to be aproned.

Between 1830 and 1840 four local and private acts were passed authorizing the erection of milldams on the Thames River.[10] The first, in 1833, specified that locks and inclined planes be built for the passage of boats, logs, rafts and fish, that navigation not be obstructed any longer than 20 days, and that building consent be obtained from land owners adjacent to certain falls. Similar conditions in 1834 were spelled out to Richard Tunks who was granted permission to build a dam across the Thames with the admonition that passage through the dam must be free of toll. The people of Kilworth village were granted authority in 1840 to build a dam on the Thames containing locks and inclined planes; but the law stipulated that the dam be 50 yards upstream from the tail race of Ben Woodhull's mill, that the owner of the lot on the opposite side of the stream be entitled to use the water for his mill or machinery, and that the dam be built within two years.

In 1845 a law was passed to provide more effectually for the construction of aprons on dams built on streams in the district of Huron. Here, mill proprietors had neglected the law of 1828. Consequently, as of 1 June 1845, aprons were required at least 28 feet wide (if the stream was narrower, the whole width of the stream) and at least 8 feet in length for every foot rise under penalty of 5s. daily until the apron was erected.

The following year, in May 1846, a law was passed for dams in the district of Victoria on the Moira River and its tributaries. Aprons were to be at least 32 feet wide, at least 8 feet in length for every foot rise of the dam, and the dam's apron was to be at least 2 feet lower than the dam's top. The apron was to be built in the main channel of the stream "with the highest part thereof one foot below the said fall."[11] A fine of 2s. 6d. daily was levied until the law was complied with. Obviously impractical, this law was repealed two years later and replaced with a new one which became effective 1 October 1848. The apron was made steeper - at least 32 feet wide and at least 5 feet in length for every foot rise. It had to be two feet lower than the dam "except where the rise of the dam shall be less than four feet in which case the height of the dam...at the apron...shall not exceed one half its length at any other place."[12] Built in the stream's main channel, the apron's highest part was to be one foot below the level of the dam where it joined the dam. The fine was halved to 1s. 3d. daily until compliance with the law.

On 30 May 1849, the last public act in Canada West concerning dams during the period under review was enacted to amend and further the act of 1828. Except for the river Otonabee, apron specifications given in the 1828 law were to be followed. In general, the apron or "slide" was to afford a depth of water sufficient to admit passage of saw logs, lumber and timber usually floated down streams where dams were. Owners were allowed to construct waste gates and slash boards to prevent unnecessary waste of water, providing they opened them when logs had gained the main channel of the stream. Where no rafting occurred and no pickerel or salmon existed, aprons were not necessary.

Clause II of the act dealt with aprons on the Otonabee River. There, aprons had to be at least 32 feet wide by an inclined plane of 5 feet to a perpendicular of 1 foot in proportion to the height of the dam. Side pieces at least one foot high had to be fixed at the outside of the apron to confine water and prevent timber from falling off the side. The penalty for not abiding by the law was high - 10s. a day. Allowance was given for owners to repair or rebuild dams damaged or carried away. But the law stated that it was lawful for everyone to float sawlogs on all streams in Canada West during spring, summer and autumn freshets, that no one had the right to destroy or injure any dam, provided it had a "convenient apron, slide, gate, lock or opening" for the passage of logs.[13]

The flooding of lowlands by milldams created furor among land owners. Mill proprietors were faced with lawsuits and forced to compensate. Some mill owners had good reason to object to unfair judgements against them. In 1812, flooded lands caused a number of freeholders in Glengarry, Stormont and Russell counties to petition for a law to regulate mill seats. Living in a lowland area where mills were scarce, they were angry at the exorbitant rent exacted by owners of flooded lands from mill owners. Enterprising people who would like to erect mills were discouraged, they complained, and a number of mill owners were actually pulling down their mills because the yearly rent on overflowed land was more than the sale of the same land. Not until 1850 was a law passed to protect mill owners. Persons purchasing lands flooded by milldams at a reduced rate would receive little support in any court action taken against a mill owner.

SUMMARY

The 19th century in Upper Canada was characterized by immense growth. As the population grew naturally and through immigration and agricultural lands and new settlements were created, the number of grist and flour mills increased correspondingly. Viewed by the government as deciding factors encouraging many to settle, mills were constructed often with the government's help, a help that varied, however, and was sometimes slow in coming. Immigrants from the United States, Great Britain and Europe as well as native Canadians contributed capital and technical expertise needed to erect mills. The plentiful waterpowers, even the lack of roads, as well as the growth of railways and mechanized methods of planting and harvesting grain encouraged the building of mills. Favourable trade agreements enacted by the government induced many to invest in milling. With the growth of an international grain and flour trade, more effort was made to keep up with international standards of flour manufacturing. Upper Canadian wheat, both fall and spring varieties, gained internationally good reputations and were much in demand in Great Britain and the United States. The extent of grain trade vs. flour milling and the importation of United States grain to Upper Canada for milling requires further research.

From 1800 to the 1860s and even after, the fast reduction method of milling in Upper Canada was made more efficient so more flour was milled from a bushel of wheat than before. Better methods of regrinding middlings, improvements to grain cleaners, flour bolts, millstones, water wheels and gearing, the use of kilns to dry wheat, and the automatic devices of Oliver Evans contributed to the more complete and faster extraction of flour from wheat. Especially competitive merchant mills at the "front" close to grain supplies and transportation routes were installed with the latest machinery.

In 1863 a new milling process was patented by an emigrant miller from Germany employed by Elias Snider of Waterloo County, Canada West. John Brown's process of gradual reduction was adopted at numerous mills in Canada and the United States until and even after the 1870s, when another process of gradual reduction based on French tradition was adopted in Minnesota and became famous for its treatment of hard wheats. The added quality which the new process brought to flour and the good price for which flour sold (if not in Canada, then in the United States) were

deciding factors that made gradual reduction popular. An account of the two phases of the new process are given in Part IV which follows.

PART IV. The New Process of Gradual Reduction, 1863

THE INTRODUCTION OF GRADUAL REDUCTION TO ONTARIO

Beginning in 1863 and continuing for a dozen or more years in the history of milling in Canada, millstones operating by a new process produced a stronger, livelier, higher quality flour than had been possible by the old process of low grinding and fast reduction. Since the 18th century, Ontario millers had manufactured flour by running the stones relatively fast and close together to make as much flour as possible from the first grinding. From 1863 (when John Brown's method was patented) until the 1880s (when gradual reduction was performed by rollers), the continental method of running millstones high and slow, to make as many middlings as possible from the first grinding, was adopted and adapted by many progressive mill proprietors in Ontario. The process of gradually reducing spring and fall wheat was especially profitable for hard spring varieties that contained more gluten than fall wheats. The harder grains and their middlings which the old method had treated harshly by fast, low millstones were now more gently reduced in a series of grindings so the gluten was not impaired but "lived" in the flour. This "strong" flour made a stronger dough better able to retain air and more loaves were produced from a given amount of flour than before.

The idea of gradual reduction was not entirely new to Canadian millers. Most trying to solve the problem of wasted gluten-rich middlings had milled with stones a little higher, regrinding the increased amount of coarse middlings one way or another; when care and skill were combined, a superior product was manufactured. Perhaps because the major trend in North American milling improvements, partly due to automation, had been toward speed and quantity to produce more flour faster and with less labour than before, it was out of the question for native millers and millwrights to conceive the more time-consuming solution practised in Europe. The principle of the continental method, moreover, was at odds with the traditionally British method of fast reduction, perhaps because the British dealt mainly with soft wheats while the continent milled hard wheats. The North American method, adapted from the British and used for both soft and hard wheats, aimed to produce as much flour and as few middlings as possible in the first grinding, whereas the central European solution produced as little flour but as many middlings as possible at the first grinding.

Gradual reduction of wheat required more steps than were practised in the fast reduction method in Canada. At least three additional pieces of machinery were used in the European system: special small stones to create middlings, a machine to clean and sort the flour and bran from the middlings and special stones to remill the tender middlings. It was the middlings purifier (as it came to be called), used to clean middlings much as grain had been cleaned, that constituted the greatest change. Ignaz Paur of Leobersdorf, south of Vienna, in 1807 had devised one of the first German machines to manufacture flour from a very hard "Banat" wheat. This and his later improved model employing a sieve and fan to clean middlings were widely used in central Europe by the 1860s. Millers in France as early as 1775 used a hand-operated "middlings ventilating machine analagous to that for cleaning wheat," according to Rollet, author of *Memoire sur la meunerie*,[1] and by 1860 a French miller, Perrigault, had patented a popular machine using sieves and an exhaust fan to clean middlings.

In contrast to the North American system of milling, the continental system was not automatic. Storck and Teague wrote

> Hundreds of little buckets stood around the mill, each in position to receive its own particular material; scores of men busied themselves carrying the products in buckets on to the next stage of processing, on the basis on decisions made on each batch of stock by the head millers.[2]

In Europe, where labour was plentiful, the intricate pains taken by workers milling hard wheats were rewarded by the final production of numerous grades of flour ranging from white to the so-called black. The lack of a large labour force, the less stratified society and the automatic machinery in North America were factors precluding the whole-hog adoption of European procedure here. However, the practice of granulation, gradual reduction and middlings cleaning were widely accepted, and in the 1870s came to be known as "the new process" which produced high quality "patent" flours.

Method of the "New Process"

Continental ideas brought to North America by natives of France, Germany and Austria-Hungary during the second half of the 19th century were adapted to local conditions. The patent of John Braun (changed to Brown) in 1863 permitted local practise and modifications in millstones and bolts. The purifiers designed by the LaCroix brothers in the 1870s were adapted from Perrigault's middlings cleaner for wheat milled in Minnesota mills. Individual variations developed from mill to mill and new inventions and improvements adapted to local wheat and automatic systems were devised by local millers and millwrights. As "modern" machinery was manufactured and variations of the new processes patented, millwrights at foundries and mill furnishers under contract to mill owners supplied and converted old mills to the new school. Entire new mills were constructed in some cases. In 1877, a book by R.C. Brown (no known relation of John Brown) was published titled *The New Process Milling, or Practical Suggestions on the Reconstruction of Mills*[3] based on Brown's experience in revamping old mills to the new process. Soon to be out of date with the adoption of rollers already being tried in leading mills, the book encouraged millers to try the superior method despite initial hardships and expense.

The new process practised in America increased the number of basic steps in milling by two. The fast reduction there had been three - cleaning, milling and bolting (then remilling the middlings and rebolting the flour - a method which came to be known as a "bastard new process" by millers who differentiated between the old and new process of the 1870s). Gradual reduction required five basic steps - grain cleaning, granulating, purifying, milling and bolting (then remilling, repurifying and rebolting). Some millers, such as R.C. Brown, preferred to call the new method "granulation" rather than high grinding. Millstones were run higher than before and slower, especially during the first grinding of the wheat, to granulate (later referred to as break, crack or chop) the grain into a mixture of coarse granules known as middlings, plus bran and flour. This granulated meal was purified by being separted from the bran, offal and flour in a purifier so clean middlings were channelled to the millstones to be remilled on specially dressed middlings stones. Flour from middlings was bolted and packed, perhaps mixed with the small amount of flour made during granulation, and often middlings bolted from middlings flour were repurified and remilled into flour.

The increase in the number of steps and the slower speed of the millstones reduced the speed of flour production by the new process. R.C. Brown admonished

> The day has been when the man who could make the most flour per run of stone was considered the best miller; but that day has gone, never more to return. If you desire to make more flour, put in more stone.[4]

Quality rather than quantity became the aim. Whereas at the height of the old process, one run of stones might be capable of milling 20 bushels of grain per hour, now wheat stones milled 5-12 bushels depending on the condition of the grain and the size and dress of the millstones. The profits lay in the increased yield of high quality flour per given amount of grain. R.C. Brown calculated that about 16 per cent more flour per bushel was obtained by the new method and that flour was higher quality than before.

Mechanical Era of Flour Milling

Oliver Master wrote that in the history of Canadian flour milling 1865-95 was the "mechanical era of the industry."[5] Mill machinery improvements and inventions increased to keep abreast of the revolutionary methods being tried in this relatively short time. At least three major changes based on European methods took place in flour-milling techniques. The first of these was the new process of high grinding and gradual reduction in 1863 of which an account follows. The second was the change to gradual reduction using millstones and rollers about 1875, and the third was the adoption of full roller systems about 1880.

Not only new machinery required for the new techniques was manufactured during the mechanical era but improvements were made to these, and to the usual panoply of grain cleaners, millstone exhausts, grain driers and steamers, flour bolts and as well water wheels needed to mill flour. In 1872 the patent law rescinded the requirement that applicants for patents have a year's residence in Canada before their application with the result that many more inventions and improvements than previously from outside Canada, especially from the United States, became Canadian patents. Progressive mill owners needed capital above all during the transition era, for the cost of travelling, hiring millwrights and buying new machinery was high. Richmond stated that "many fortunes had to be sacrified...in the scrapping of machinery as what was installed one year proved obsolete a year or two later."[6]

It was during the mechanical era that more merchant mills separated from custom or grist mills according to Master, not only to make room for new machinery inside the mill but also because of other reasons making it more profitable to operate merchant mills. Urbanization, the growth of international trade facilitated by the extension of canals and railways to new western wheat lands and the construction of grain elevators at transshipment centres permitted mills to operate independently of the farmer.

In fact the separation of merchant from custom mill occurred wherever and whenever the owner considered he could succeed without the farmer, even before 1860. In 1847 Jacob Keefer outfitted his mill at Thorold on the Welland Canal to do merchant work only. There the plentiful supply of Ohio wheat shipped by grainboats through the canal filled his storehouses for a while at least. In the 1860s and 1870s grain dealers and mill owners constructed grain elevators where large supplies of grain brought from distant fields were weighed, sorted (sometimes dried) and stored for milling or export. Mills at such sites no longer had to deal as much with the local farmer as with the grain merchants and shippers. It was mainly at ports, large industrial centres and grain elevator sites, that independent merchant mills could be established, while outlying areas of large cities and rural towns and villages supported combined grist and flour mills. By 1865 a rural town situated on a good waterpower and railway communicating with wheat sources might support a larger merchant mill as well as one or two smaller mills that did gristing in addition to merchant work.

There was always a need for the grist mill during the transition to commercial milling, especially as farmers turned to mixed farming, and it is generally affirmed that as long as milling methods remained relatively simple, the small flour mill (often a grist mill too) had certain advantages over large commercial merchant mills. Smaller country mills, often family concerns, were able to buy choice grain at lowest prices, pay lower wages and operate at lower costs. Machinery prices were the same for large and small mills, and during the period when changes and improvements were rampant, many small mill owners profited by waiting until the "new" had been proven in progressive mills before buying.

Variations of the new process evolved as time went on and improved machinery was devised to mill, purify and bolt. Grain conditioning and millstone exhausts became more popular and were often included in new process mills. There were two phases of new process milling that had historical impact in Ontario: the 1863 process of John Brown based on German tradition and first adopted at a medium-sized family-run grist and flour mill, and the 1871 process of the Lacroix's and G.T. Smith based on French tradition and made famous in the large Minneapolis mills of Governor Washburn. A short account of these two follows.

THE IMPROVEMENTS OF JOHN BROWN OF WATERLOO COUNTY, 1863

German Mills, where John Brown was first employed by Elias Snider, Sr. to try out his new method, might be considered the pioneer mill of the New Process in Ontario. Located on Schneider's Creek in a hamlet a few miles southeast of Kitchener in Waterloo County, the mill was 35 years old when bought for $23,000 by Elias Snider in 1860.[1] Originally constructed in 1825 by Philip Bliehm of Montgomery County, Pennsylvania, it was part of a milling complex that included a sawmill (1812), a woollen mill (1826) and a distillery (1826).[2] Owned by four different proprietors between 1835 and 1860 and used to hold the first Anglican services about 1848,[3] the mill must have been adaptable to the new technique on trial. Elias Snider, Sr., the son of Jacob C. Snider, had been brought up in a milling and farming environment, and in 1853 as a young man had ventured alone in the milling profession when he owned and operated his father's mill in Waterloo.[4] Though this was sold in 1854 to John Hoffman, it remained a family enterprise and later was used to manufacture flour made by Brown's improved method.

It was at German Mills, previously known as Judasberg or Jewsburg, that the new flour was made by John Brown soon after he emigrated from Germany. Hired by Elias Snider, Sr. "in the early sixties,"[5] it must have been there that Brown built and experimented with the new machinery, designed after German ideas, perhaps those of Paur. On 2 October 1862, his application for a patent witnessed by Elias Snider and D.S. Shoemaker was completed. This, together with a model of the machinery and a sample of "grits" and "superior flour" were sent to the Ministry of Agriculture in Quebec on 14 October 1862.[6] Five months later on 11 March 1863, John Brown was granted a patent "for improvements in machinery for the manufacture of flour,"[7] and these represent the first known instance of gradual reduction in Ontario or as it came to be known in the United States in the 1870s, the "new process."

John Brown's improvements included a pair of millstones "not for the purpose of grinding the wheat into fine flour but...to hull or remove the bran from it and to break it up into a sort of coarse granular meal which will be known by the name of 'grit'."[8] These stones, as small as 18 inches or 2 feet in diameter, could be easily adjusted to the proper distance. Contrary to normal North American practise the upper stone was stationary, the lower the runner. By them cleaned wheat was broken into granular meal

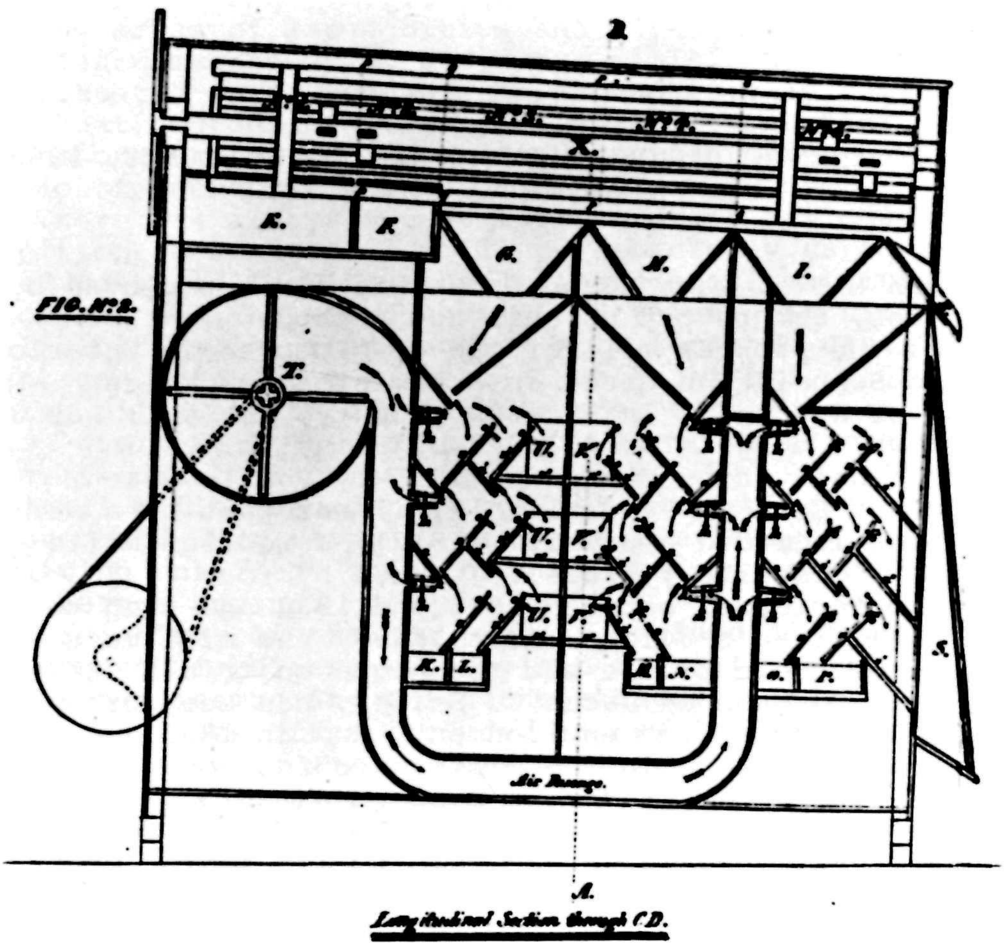


Figure 31. Cross section of the successful flour bolt and separator based on German practise patented in 1863 by John Brown for his gradual reduction process of milling. Granulated wheat passed through flour bolt X and as it descended, a fan at T circulated air through the stock, separating it and sorting it according to its weight into compartments at K, L, U, V, M, N, O, P. Thus heavy grits were blown to K, N, O, while their lighter offal fell into L, M, P. Each stream was spouted from the machine to the next stage of the process. (*Canada. Consumer and Corporate Affairs.*)

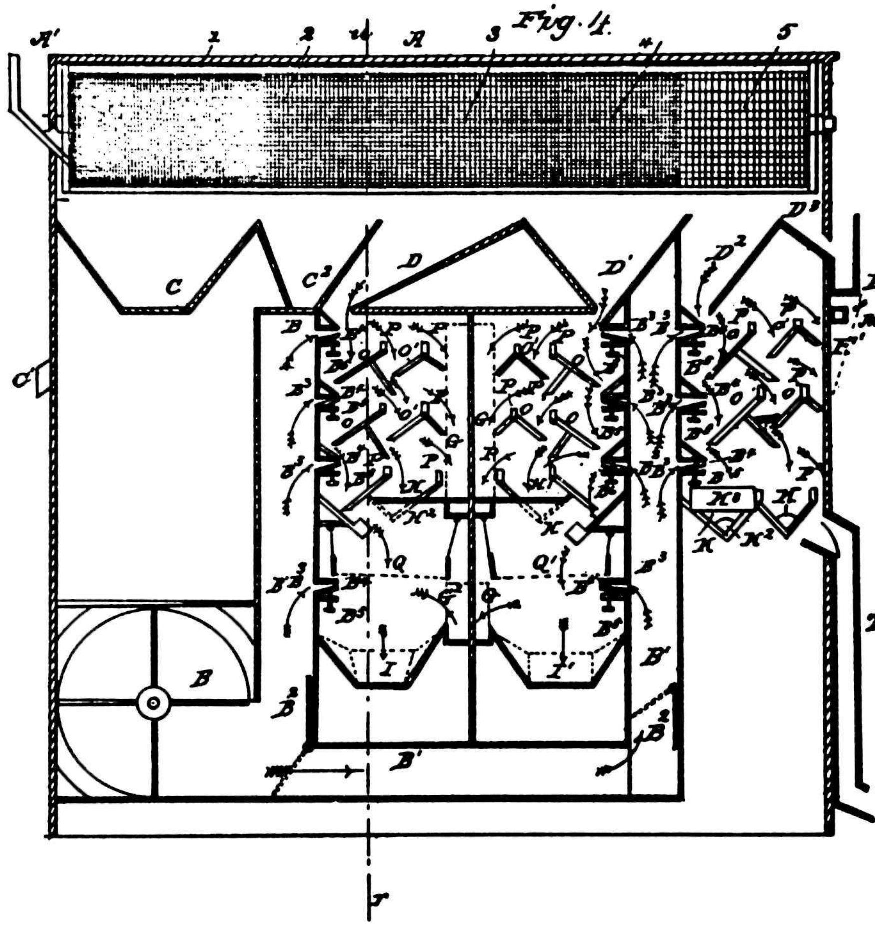


Figure 32. Cross section of John Brown's flour bolt and separator as patented in the United States in 1865, two years after his Canadian patent. By comparison with his original 1863 patent (Fig. 31), changes are apparent in the position of the fan and the arrangement of compartments in the separator. (*United States Patent Office Records.*)

made up of a small proportion of flour and middlings and a large percentage of grits.

Brown's other improvement was his "combined bolt and separator"[9] (Fig. 31) into which the granulated meal was sent. The bolting portion was the same as reels generally used to bolt flour, except that it was covered with an increased number of cloths - five instead of two. The greatest difference between this bolt and others lay in the chest portion of the machine which was made up as a separator (housing a fan, air passages, compartments, hoppers, spouts, adjusting screws and regulators) through which a blast of air separated three grades of grits and their bran into separate compartments. Flour that had passed through the first and finest bolt material was channelled away as third-quality flour. Middlings going through the second bolt material were later combined with the grit offals and reground and bolted to make second-quality flour. It was the grits (sized 1, 2 and 3 as they passed through the next three cloths of the bolt) that made first-quality flour after being "ground over again by common millstones in the ordinary way and dressed in the ordinary bolts."[10]

Interestingly, Brown differentiated between middlings and grits, while most North American millers only referred to different sizes of middlings. According to Brown, grit 3 was the coarsest while grit 2 was a mean between grit 1 and grit 3 and was "very valuable as an article of food."[11] Middlings to Brown were smaller but less prized than the grits. A sample of grits that had been included with the patent application had been described as "wholesome for children and invalids."[12] These may have been the equivalent of "Vienna Grits" or "Weiner Gries" sold in Europe since the late 18th century and manufactured from hard Hungarian wheats. North American millers usually referred to particles the size of grits as "good quality middlings"[13] or large middlings, and sometimes semolinas, a term that today specifically denotes large middlings made from durum wheat.

Whether the method was automatic was not explicit. Brown's patent specification stated only that the ground material be "carried in the ordinary manner"[14] from stones to bolt, thus permitting use of either automatic devices or manual labour. The ordinary method of conveying grain and flour in most Ontario mills of the 1860s was via the elevators, conductors, conveyors and drills originally designed by Evans in the 1780s, while John Brown's native European mills employed manual labour.

Oliver Master wrote that "the method found favour with Elias Snider Sr. and his family with the result that the new equipment was installed by Brown in their various plants."[15] The new flour was called "Haxall" a name chosen by the Sniders (but not registered as a trademark) after the Richmond, Virginia, mill famous for its flour in the early 1800s. Sutherland's gazetteer advertised in 1864 that the Union Flour Mills at Waterloo contained seven runs of stones manufacturing "the celebrated Haxall flour and farina."[16] The mill, powered by water as well as a 45-horsepower steam engine, had cost over $45,000. In 1877 it was again advertised, this time containing eight runs of stones to dress "the best Haxal and Ferina flour"[17] under the ownership of William Snider, another of Elias Sr's. eight sons. German Mills, too, must have manufactured the new flour by 1864, though mention of this was made later in an 1877 gazetteer.

German Mills and the St. Jacobs Mill were two mills producing Huxall flour which were owned by Elias Jr. (hereafter referred to as E.W.B. Snider), a man who was to play a leading role in introducing new flour-milling methods to Ontario. In 1862 at the age of 20, he was made manager of German Mills after having served as an apprentice since 1860, the time when John Brown was working on his new process. From 1864 to 1871, both father (Elias Sr.) and son (E.W.B.) managed the mill on a share basis. Then E.W.B. bought the St. Jacobs Mill north of Waterloo in Woolwich township which had originally been erected in 1850-51 by his grandfather Jacob C. Snider. By 1877 both German Mills and the St. Jacobs mills produced the new flour. Now under the ownership of Tillman Snider, E.W.B.'s brother, the steam- and water-driven German Mills was "engaged in grinding and dressing Haxal and Ferina Flour of very best brand and quality, not excelled in Canada."[18] E.W.B.'s large flour mill at St. Jacobs contained "seven run of stones capable of dressing and packing 120 barrels of Haxal Flour daily."[19]

The flour was at once a success on the market. Oliver Master wrote that the flour sold for as high as $14.00 per barrel on the home market and as high as $17.00 in the United States. "An extremely renumerative business connection with Boston, Springfield and other points in the New England states"[20] was opened. It was not long before curious Americans visited the Snider mills to see how they operated, and induced John Brown to patent his machinery in the United States. In 1865 Brown, as a resident of Utica, New York, was granted two patents, one for "improvements in grinding mills for grain"[21] (Fig. 34), and one for his "improvement in flour bolts"[22] (Fig. 32). Mr. E. Munson, a partner of the well-known Utica mill furnishing company of Hart and Munson, witnessed the patents. Basically the same as his earlier Canadian improvements but with some changes, Brown's United States machines were "used in mills from Buffalo to Providence"[23] after 1865.

It was unfortunate financially that the Sniders chose the brand name Haxall to describe their new flour. In 1873 the Haxall-Crenshaw firm of Richmond, Virginia, took out an American patent[24] on the name Haxall, which "compelled the Sniders to withdraw their brand from American markets."[25] But the superior flour continued to be manufactured and sell in Canada even though Vice-President Philip Haxall registered his trademark in Canada in 1877.[26] As late as 1884 when the Sniders had changed to roller milling, Tillman and Amos, proprietors of the Champion Roller Mills (the old German Mills renamed) advertised "German Hexel" among other brands manufactured at their mill.[27]

THE NEW PROCESS OF EDMUND AND NICHOLAS LACROIX IN MINNESOTA, 1870

Interestingly, Canadians had a role in the evolution to new process milling in Minnesota, as did Fife wheat, which was first grown near Peterborough, Ontario, after being brought via Scotland from its native Galicia near Poland. In 1857 Alexander Faribault, son of a French fur trader, set up mills in Faribault, Minnesota, on the Cannon River. The Faribaults were one of several Canadian families who had emigrated to the new lands where only spring varieties of grain survived. Alexander may have been the leader of mill owners along the Cannon River who became famous for their superior flour (before the milling revolution of the 1870s) by following "the French quality milling process in a slightly modified form to meet American conditions."[1] He may have influenced other Canadian immigrants on the Cannon River, such as brothers John S. and George N. Archibald. They set up mills at Dundas, Minnesota, and milled a superior flour which sold for a dollar more per barrel than flour from Minneapolis. Archibald dressed his stones with greater care, did better bolting and used less pressure, evenly grinding out a whiter, purer flour. Similarly the Gardner mill at Hastings was known even in 1859 for its high-quality flour said to sell for profits of up to three dollars per barrel by following a process of reducing the pressure of millstones, increasing the number of grindings and carefully bolting.

Certainly Alexander Faribault played a part in bringing the new process to the United States. In 1861 perhaps encouraged by the successful partial adoption of French ideas regarding milling, Faribault hired millwrights Nicholas and Edmond Lacroix, then in Montreal, Canada, to build a new mill for him at Faribault.[2] The Lacroix brothers were skilled engineers and millwrights, born in France and educated at the *Ecole des Arts et Métiers* where they had become familiar with current European inventions; while living in Montreal in 1855 Nicholas had taken out a patent for his "Turbine Helicoide"[3] similar in principle to French-designed wheels.

When the brothers came to Minnesota (Nicholas brought his wife and family consisting of a son, Joseph, and three daughters), they set up their own mill about 1866. Here they designed purifiers adapted from the design of Perrigault of France. Using horizontal sieves that shook (instead of a revolving reel as John Brown had used), Nicholas earned for himself the name "Shaker miller." It is said the Lacroixs made purifiers for Faribault and Archibald about this time.

Edmund Lacroix left the Faribault settlement sometime after his milldam was carried away by a freshet in 1868, and went to Minneapolis to sell his ideas to millers there. He was hired about 1870 by George Christian, a new employee of Governor Washburn of Minnesota who managed the Washburn B, a 600-barrel mill with 12 runs of stones. Christian in his previous occupation as a flour broker had seen the Archibald mill in operation and had learned some of the secrets of its success which he was anxious to apply in the Washburn B. He hid Lacroix in a locked room supervising the construction of a new purifier which was completed in March 1871. Because the bolting cloth of this machine clogged badly, a brush was used manually to keep it clean. With the help of George T. Smith, previously the head miller of the above noted Gardner mill at Hastings, a mechanical brush was designed to solve the clogging problem. Both Lacroix and Smith claimed credit for the improved machine by individually patenting it in the United States and Canada. Edmund's American patent of May 1872 (Fig. 33) was later modified and manufactured in Minneapolis at the Minnesota Iron Works owned by C.M. Hardenburgh and Company where it sold for $300.00.[4] His first Canadian patent, titled "Improvements on flour bolts"[5] was granted to himself and to W.T. Archibald of Moulinette, Ontario (possibly related to the Archibalds of Minnesota), in November 1872, and was the same as his first American patent. Lacroix's second patent for a "middlings separator and purifier,"[6] possibly an improvement of his first, was granted in September 1873.

The Lacroix brothers did not patent their process of milling. Passing mention in Edmund's purifier specification described this procedure as "the best process known;"[7] wheat was granulated, bolted and the middlings were purified before being remilled. Whatever the details of their method, the Washburn mills realized a profit of $0.50 a barrel in 1871, $1.00 in 1872, $2.00 in 1873 and $4.00-$4.50 in 1874.[8] The price was forced down within 10 years but not before the rapid adoption of the purifier. Nicholas too patented a purifier in the United States in 1873. Unfortunately neither Lacroix realized much in profit; both are reported to have died suddenly in 1874, Nicholas in Milwaukee and Edmund a week later in Rochester, but not before they had made purifiers for other mill owners in Minnesota, New York and Michigan. It was said that Joseph Lacroix's efforts to manufacture his deceased father's and uncle's machines failed because "the greed of the patent sharks had resulted in the formation of a gigantic combination which crushed Lacroix and left him bankrupt."[9]

Though Edmund had not patented the new method of milling using the purifier, his astute co-worker George T. Smith did. Patented in Canada on 4 June 1873 a few months

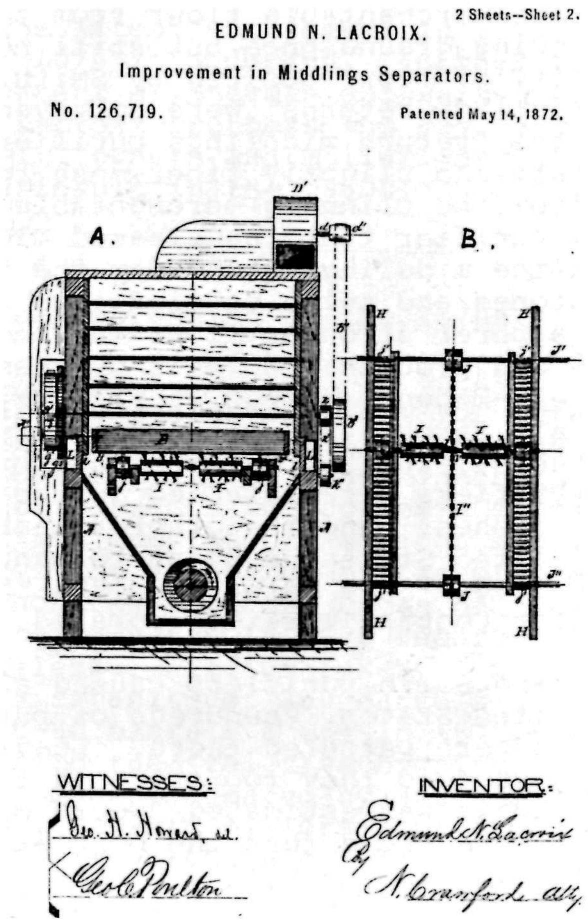


Figure 33. Middlings separator of E.N. Lacroix patented in Canada in 1872. Based on French practise, it caused a revolution in milling technique in America. A, View showing fan D', shaking screens B and travelling brush I; B, view showing the mechanism of the travelling brush I. (*United States Patent Office Records*.)

after his purifiers, George T. Smith's method claimed to use "a novel...order of purifying, grinding, and bolting the middlings as well as automatically returning the 'middlings returns' to be repurified, reground and rebolted."[10] The first step was to high grind the wheat so that 30-45 per cent middlings were produced. This grind was then bolted to separate the merchantable floury portion (which was conveyed to the packer) from the middlings (described as a mixture of specks of cockle, fuzzy fibrous material separated from the skin of the berry, and coarse grains of the kernel lying close to the skin which were gluten-rich). These middlings were transferred to the purifier, the third step. The fourth step was to grind the purified middlings and the fifth to bolt their product in a special "middlings bolt" which separated the merchantable flour from the middlings - now finer after being ground once but still not fine enough to make the quality of flour desired by Smith. For this reason these "middlings returns" were conveyed to a second purifier called the "return middlings purifier" which used slightly less draft and slightly finer mesh to separate the fine middlings from the clinging merchantable flour. It was from this second purifier that the cleaned middlings again were conveyed to the middlings stone for the third grinding (once on wheat stones and twice on middlings stones). Thus with less waste a purer stronger flour was made than had been made by the old process. Smith's process allowed use of "any of the well-known machines [purifiers] which used an upward draft of air through the shaker"[11] (presumably Lacroix's and others), but he preferred his own machines. Two of Smith's purifiers were patented in Canada on 18 April 1873, one using brushes[12] and the other a shaking bolt.[13] In the United States he began to manufacture his purifiers in 1876,[14] and later, in 1884 the G.T. Smith Purifier Company was incorporated in Stratford, Ontario.[15]

The Lacroix and Smith purifiers caused a revolution in milling in the United States. Hundreds of purifiers and improved purifiers were patented there. Leading millers renovated mill systems so they too produced the new flour, one barrel of which it was estimated "would make twelve and one half per cent more bread than the best winter wheat flours."[16] Especially in the United States spring wheat became more valuable than winter wheat and its flour, reversing positions in the old value scale. To aid millers changing from the old to the new, R.C. Brown, an American miller familiar with the method, wrote his *New Process* guide.[17] Though the book made no mention of Lacroix or Smith it described the new process as it had evolved in United States mills up to 1877. Various arrangements of machinery were feasible, some arising from the old set-up employed previously in the mill.

Jones stated that leading Canadian millers did not adopt the patent process of grinding flour introduced at Minneapolis until 1874.[18] They may not have used Smith's Canadian patented process of 1873 until then but there is reason to suppose that Montreal millers were using an adaptation of the Minnesota process before 1874. In November 1872 a "middlings separator", similar in design and purpose to the LaCroix purifiers, was patented by Willard H. Sherman and James Parkyn (an engineer and owner of flour-mills at Côte Saint-Paul on the Lachine Canal). That this was a popular machine was evidenced by the fact that the patent was renewed in 1877 by Parkyn and other assignees, including John Ogilvie, a partner in the A.W.

Ogilvie and Company which established mills (probably equipped with the latest machinery) in 1872 at Seaforth, Ontario, and in 1874 in Goderich. Further research may show that the 1872 patent of Sherman and Parkyn was based on designs of the Lacroix brothers who may have kept in touch with Montreal mill owners and millwrights after their departure to Faribault in the 1860s.

The Depression of the 1870s

The general depression of the 1870s affected the flour-milling industry probably limiting the adoption of the new process in Ontario mills. The Minnesota phase of the new process contributed to the economic slump since one of its results was the dumping of American flour on the Canadian market. The select committee of the House of Commons which inquired into the cause of the depression in the flour-milling industry in 1876 reported the opinions of two merchant millers. William Lukes, owner of a mill at Newmarket with a capacity of 200 barrels a day but which had produced only 70-80 barrels a day in 1875, ascribed the cause of the dip to the "relative high price of wheat," and the limited home market created by excessively keen competition among Ontario millers; but the situation was made worse by the importation of cheap American flour at a time when a large part of the population, the agricultural community, was provided with custom flour.[19] Speaking as a member of the Dominion Millers' Association and the Manufacturer's Association of Ontario, Lukes asked that a reciprocal tariff be levied on American wheat and flour entering Canada. Since about 1867, the United States had levied a tariff of 20 cents a bushel on Canadian wheat and 20 per cent *ad valorem* per Canadian barrel of flour, while American wheat and flour were admitted free.

James Goldie, a merchant mill owner in Ayr, believed the depressed state of the milling interest was "gradually getting worse for the change in the manner of milling in the United States, which throws a large quantity of flour on this market."[20] The handsome profits American new process millers made on their highest grades allowed them to sell their inferior or lower grades cheaply in Canada - more cheaply than Canadian millers could afford. Canadian consumers preferred the good though lower grades to paying the high cost of the superior grades, even those manufactured by Canadian new process millers, according to Goldie, which was why he mixed his new process grades to suit the wants of his customers. While Ontario and Maritime customers happily devoured good cheap American flour, Ontario flour manufacturers suffered. Goldie believed that some of his costs could be cut if bonding charges were minimized. As a member of the Dominion Millers' Association, he petitioned that the government do something to alleviate the high rates which were a "great impediment to the trade."[21]

The poor reputation of Canadian flour due to souring in the 1860s, the high cost of American northwestern spring wheat as a result of the new process in the 1870s, plus the demand by bakers for flour made from spring wheat by the new process, the deterioration of Ontario crops of Fife spring wheat, the influx of cheap, duty-free American flour on the Canadian market, the high and unequal freight rates and the troubles and delays Canadian merchant millers experienced in bonding flour from inland mills to the seaboard were some of the factors that affected the Canadian flour-milling industry in the 1870s. In the midst of the depression the Dominion Millers' Association was formed in 1875 to look after the interests of the milling trade. Especially during the last quarter of the 19th century, the association had a great and beneficial influence on the Canadian flour-milling industry (see Part V).

GRAIN AND METHODS OF PREPARING IT FOR MILLING

By the 1860s over half the grain lands of Upper Canada were sown with spring wheat[1] and this harvest increased as time went on for a number of reasons. New settlements after 1860 were situated in more northerly climatic regions where mainly spring varieties survived. Lands in southern, older settlements became exhausted where farmers had not paid more than the average attention to crop rotation and fertilization, so mixed farming was resorted to which cut down the quantity of winter wheat being sown.[2] Particularly between Kingston and the head of the lake, winter wheat was replaced by barley crops after 1860.[3] To escape the wheat midge that ravaged fall wheat, farmers turned to spring varieties which ripened too early or late for midge attacks.[4] Fife wheat was still a favorite grain of Ontario farmers, but by 1876 it had to be strengthened by new seed from Manitoba.[5]

The first grain inspection act in Canada was passed in 1863 specifying standards of quality for grain.[6] Inspection was not compulsory but at the request of the buyer who paid the fee; the whole transaction took place at a grain inspector's office set up near the trading centre. Mainly aimed at the grain dealers and international grain trade, the law may have affected those merchant mill owners who bought large quantities of grain from shippers, but its impact was probably nil on the majority of grist- and flour-mill owners who bought or traded farmers' local supplies uninspected except by the miller. Jones wrote that the law had little effect until the 1880s.[7]

According to the act of 1863, grain was graded by its inherent goodness, its type and its cleanliness. White and red winter wheats were each divided into two qualities: No. 1 was "sound and plump and free from admixture of other grain, No. 2 was "sound and good but less free from admixture of other grain."[8] Spring wheats were graded into "Extra Spring," No. 1 and No. 2. Extra spring was the top grade, sound plump, free from other grain and weighed 60 pounds per Winchester bushel. No. 1 spring was similar but drier, weighing 59 pounds per bushel. No. 2 was drier still, weighing 57 pounds per bushel, and was sound but less free of other grain. Unsound, damp or dirty wheat was "rejected."

In 1873 a new general inspection law was passed specifying standards for all produce of the Dominion and this was amended in 1874. By the amended law, winter wheats were divided into No. 1 and No. 2 white (pure), No. 1 and

No. 2 red (mixtures of red and white, or all red), and No. 3 winter wheat (56 1/2 pounds per Imperial bushel). Spring wheats were classified as No. 1, No. 2 (58 1/2 pounds per imp. bushel) and No. 3 (55 1/2 pounds per imp. bushel). Each of the No. 1 grades had to be "sound and plump and well cleaned," while the No. 2 grades were "sound and reasonably clean."[9] Two new definitions were added to the 1874 law reflecting practises since the 1863 law; all admixtures of spring with winter wheat were to be graded as spring wheats, and Black Sea and Flinty Fife wheats were "in no case" to be inspected higher than No. 2 spring wheat.

There was no increase in the price of Ontario spring wheat as a result of the new process unlike that experienced in the United States in the mid-1870s when the price of spring wheat rose above that of winter wheat. Ontario spring wheats continued to sell for slightly less than Upper Canadian white and red winter wheats until the 1880s for a number of reasons. Those Canadian millers using the new process milled both winter and spring wheats. They could not make the high profits American millers made because it was said the majority of Canadian consumers were not willing to pay for it, cheap American flour allowed in duty free being preferred, and custom flour serving the needs of the large agricultural community. Duty-free western American grain including spring wheat was milled at progressive merchant mills well situated on transportation routes, and though this rose in price in the mid-1870s, it was probably preferable to the deteriorated Fife spring wheat grown in Ontario.

Grain Drying and Conditioning

During the 1860s Canadian flour earned a bad reputation by souring early before it could be sold. A report of the Toronto Board of Trade in 1863[10] blamed this on spring wheat, hot summers and the slowness of railways in getting flour and grain to its destination. The Toronto board allowed that the only practical means of alleviating the problem was to get the grain to market in the fall and first two months of the spring. Curiously the report singled out spring wheat as the cause of souring, when in fact any grain, spring or fall, if exposed to inordinate amounts of moisture and milled before sweating without conditioning, was manufactured into a flour that soured early. Presumably spring wheat in this case had been inadequately stored during the winter and spring so it absorbed moisture from rain and snow and was in poor milling condition by the summer. The hot summer months of June and July hastened the souring process, according to the board of trade. Even in 1867, millers who "took most pains to sustain the reputation of their brands suffered equally with those less careful, and a doubtful reputation became attached to Canadian flour."[11]

Because of the poor reputation Canadian flour was earning, in 1867 the president of the Toronto Corn Exchange, Thomas Clarkson, promoted the sale of Sutton's Grain Dryer by forming a company with James Brown Jr. and its designer, Robert Twiss Sutton, engineer, who had been granted patents for his apparatuses to dry and cool grain in 1863 and 1866. The aim of the company, published in an 18-page pamphlet titled "The Commerce of Canada Considered, and the Character of its Breadstuffs exposed"[12] was to appeal to millers to prepare their flour by Sutton's patent process and thereby make it reputable for the trade with the Maritimes, West Indies, Mexico and Brazil. The company was prepared to install their brick towers at mills in any part of Ontario; E. Peplow and Son's mill at Port Hope and Boulton's Steam Mill in Toronto were two of the first to use Sutton's dryer at a cost of $800.00.

Clarkson, Brown and Sutton's pamphlet, in berating the apathy of Canadian millers whose actions had shown them to be less concerned about flour's long lasting quality than Canadian bankers, capitalists, farmers, merchants, consumers - even their American competitors - stated that only "until recently" it was "supposed" there was no remedy for souring.[13] One wonders how much the writers knew of practical milling, for from the beginning of merchant milling in Upper Canada in the last decade of the 18th century the good effects of kiln drying had been extolled and grain drying encouraged by the government (see "Merchant and Custom Milling") as well as by makers of grain dryers and millstone ventilators. There was no doubt, however, that the writers were serious in believing their machine to be more effective than others.

Sutton's grain dryer worked by conveying grain along a series of eight or more perforated floors in chambers supplied by air heated by hard coal. Cold air exhausts opposite hot air registers drove off dampness and vapour rising from grain as it dried. Controls to regulate the grains' velocity, the degree of heat, and the draft in proportion to grain's dampness were provided. When grain reached the bottom floor it was "perfectly clean, dry and free from any foreign smell whatsoever,"[14] ready to be conveyed to whatever part of the mill was necessary (see Append. D, Manuscript Report No. 201).

The principles inherent in this grain-drying patent of 1866 were similar to those recommended by R.C. Brown in 1877 for new process milling. Air rather than steam or water was best for grain conditioning, according to R.C. Brown who objected to past practices of dampening wheat with hot or cold water because it left the kernel damp and in bad condition even though the bran was toughened. Washing, too, was bad practice because impurities dissolved in the water were redistributed throughout the grain. The use of steam left the innermost part of the kernel damp and musty or tainted with other impurities and imperfect flour was produced.

For new process milling, R.C. Brown recommended that properly conditioned grain be milled. "Ask a first class miller which is the best time in the year to mill wheat, and he will invariably answer you the months of June and July."[15] But because grain was milled year round, Brown reasoned much of it had to be "forced" into the right condition. To accomplish this he promoted the use of a heater to dry wheat. Grain was passed over a coil of pipe or a corrugated cylinder heated by steam to the proper temperature - blood warmth. One heater per run of stones successfully drew the moisture from the wheat into the bran toughening the bran (so it was less likely to fragment during milling), and drying the flouring portion so it milled easily. Used in conjunction with a millstone exhaust, the heater contributed toward a dry flour that would not sour.

Eight Canadian patents were granted from 1863 to 1875 for grain-drying machines. The first two were granted to William Sutton of Brantford in 1863,[16] one called "an improved grain drier" and the other "a combined hot and cold air mechanical grain dryer." Robert Twiss Sutton of Lindsay was granted the third patent described above: "a machine or apparatus for drying and cooling grain."[17] The dessicator patented in 1863 by G.H. Fourdrinier of Lyn, Leeds County, was usable for manufacturing malt or "for drying and improving grain."[18] Bemis's Canadian grain drier of 1866 was a device of B.B. Bemis of Winterbourne, Waterloo County.[19] Thomas Lawrie (the millwright who superintended construction of Cope's mill at Ancaster in 1863) was granted a patent for his "compound adjustable revolving grain drying machine" in 1867.[20] A process to prepare grain for flouring devised by O.F. Cook of California[21] in 1874 appears to be the type condemned by Brown because it used steam or water to soften the husks and then hulled them between revolving surfaces. In 1875, a "wheat steamer" patent was granted to E.H. Gratiot of Wisconsin,[22] made up of a steamer and a dryer employing various types of coils.

GRAIN CLEANING

Articles written as late as 1880 about grain cleaning bemoaned the difficulty of eradicating cockle seed (*Agrostemma githago*) and wild garlic (*Allium sativum*) from grain at the mill. The problem of cockle was older than Virgil and caused by the fact that both cockle and wheat ripened together and were roughly the same size and density. Milled with wheat, cockle imparted a bluish cast and slightly bitter taste to the flour. Garlic contributed its characteristic pungent odor "obnoxiously apparent when the bread [was] taken from the oven, or during the process of mastication."[1] To produce a reputable and therefore profitable flour, millers, millwrights and mechanics continued their efforts to improve cleaners based on various theories and practices. Finer manipulation with more gentle action to keep the bran whole precluded use of some of the older harsh beater-type machines according to some millers. Much depended on each miller's grain and the impurities expected; because these varied regionally and seasonally, adjustable machines were a necessity.

R.C. Brown[2] promoted gentle cleaning machines that did not break the wheat, scratch the bran or pulverize the kernel, because these were actions impeding the aim of new process millstones, granulation. It was better to use a number of machines, each doing a little well, than a few attempting to do a great deal. From the hundreds of machines on the market, it was up to the miller to choose those best adaptable to their grain depending on whether the wheat was spring, winter, hard, soft and even the season in which it grew since some years produced harder wheats with thicker bran than other years. Such a machine should be adjustable while running and with adjustments easily accessible. First a separator was needed to remove sticks, straw, oats, seeds; then a cockle machine to remove cockle seeds; then a scourer, and after that a brush and polishing machine. For some wheats such as Michigan wheat, the scourer could be omitted because its action was unsuitably harsh and the same work was achieved by the brush and polishing machine.

B.W. Dedrick, author of *Practical Milling*,[3] described another arrangement of grain-cleaning machinery suitable for new process mills. Eight different machines were employed in the following order: a receiving separator, a milling separator, an oat separator, a cockle separator, a magnetic separator, a scourer, a brush machine and a chit (germ) screen. Dedrick's work, written in 1924, made it obvious that he remembered the new process as it was in or after 1878[4] (when magnetic separators were first patented) and perhaps indirectly points out the fact that many mills continued to operate by the new process after leading millers were using rollers.

Canadian patents for grain-cleaning apparatus during the period of new process milling in Canada were more numerous than for any other mill machinery, but it is probable half of these were used by the farmer during the threshing process in the field. About 50 machines described as fanning mills, grain separators, grain cleaners, grain scourers, grain polishers, smut mills, grain hullers or combinations of two types were listed in the Canadian Patent Office Records. In 1873 patents from inventors outside Canada increased; of the 21 patented machines from 1873 to 1877, 16 were American and 5 were Canadian, a trend that continued. Most of the cleaners were for separator-type machines, ones that dealt primarily with impurities that were mixed with grain but formed no part of the kernel; these were fanning mills, cockle machines and separators. Thirty-five in all were listed. Eleven other patents were granted for the type of machine that dealt with impurities adhering to or forming part of the kernel such as furze (beard) and chit (germ) and dirt. These were listed generally as grain cleaners, smut mills, polishers, grain hullers and scourers. Because of the large number of cleaners, only those of each type likely to have been used in mills are described briefly, and the other patents are listed in Appendix A, Manuscript Report Number 201. There is no evidence that any of the cleaners were devised specifically for new process mills, though they may have been used in new as well as old process mills.

Separators

The patent of J. Morningstar of Waterloo, Ontario, titled "the self regulating grain separator" granted in 1866[5] may have been the type adjustable to the type of grain being milled. O. Jull's "grain cleaner" of 1867 may have been used in his father's mill in Orangeville, Ontario.[6] Most of the separator-type machines employed horizontal screens and a fan, but a closer look at the specifications for fanning mills and separators will determine the principles used and whether they were for farmers or millers.[7]

Three machines used in mills to remove cockle seed were patented during the period under review. These were granted to A. Milloy of Vinto, Ontario, in 1871, and to F.A. Balch of Hingham, Wisconsin, and J. Gordon of St. Catharines, Ontario, in 1874.[8]

No magnetic separators were patented in Canada from 1863 to 1875.

Scourers

In 1874 possibly the first scouring machine using brushes was patented in Canada, a "machine for polishing and scouring grain" of H.P. Becker and N. Underwood of Illinois.[9] Another was the cleaner of E.W. Johnson of Foreston, Illinois, granted in 1875. Its description stated that it consisted of an upright cone cylinder containing screens and brushes to scour the grain.[10] A "wheat scourer" using brushes or stones was patented by G.W. McNeil of Akron, Ohio, in 1875.[11] American brush machines became a favorite type of cleaner in United States mills and were exported abroad.[12] Though brushes had been used for separating impurities in 18th-century rolling screens (see patent of John Milne of Manchester, England)[13] their use in the last quarter of the 19th century in scouring-type machines proved popular and more gentle than beaters. Often they were used after the smutter or even instead of it. In 1881 the first grain cleaner *called* a "brush grain cleaner" was patented in Canada.[14]

Only two machines *called* smut machines were patented in Canada from 1863 to 1875. These were the "smut mill and grain cleaner" of B.T. Trimmer of Rochester, New York, granted in 1872, and the combined separator and smutter of M. Deal of Bucyrus, Ohio, in 1875.[15] A closer look at specifications for other grain cleaners of the scouring type may prove that they used smut removing devices as well.

United States Cleaners

In the United States the number of grain cleaners patented was more than double those patented in Canada. Improvements were constantly being made and the new models manufactured and sold locally as well as in Canada. Storck and Teague wrote that the advent of the wire binder in 1878 brought the need for magnetic separators to extract pieces of wire lost in grain. Cleaners that broke the grain (sometimes called disintegrators) were tried and although the harsh action wasted power, the machines were sometimes used to make large middlings. Some were designed to split the kernel so the crease dirt could be removed more easily, but many millers believed this action was too harsh and favoured brush machines.

MILLSTONES OF THE NEW PROCESS

Millstones for gradual reduction differed in size and dress from those for fast reduction because their purpose differed. Though Abernathey (1880) advocated only a change in stone dressing and made no mention of a change in the size of stones (he allowed that old mills could be changed to new process mills merely by redressing and properly manipulating the stones), John Brown (1863) and R.C. Brown (1877) differentiated between two types, generally smaller than before, one for granulating wheat into middlings and the other for regrinding middlings into flour. Both types of stones tended to be less porous than those formerly used, and the favorite rock still came from quarries in France. Stones for hard wheats tended to be larger than those for soft wheats.

Stones for Granulating

"Wheat stones," as they came to be called by the 1870s, to granulate wheat into middlings were various sizes and dress depending on the wheat and the system in which they were installed. John Brown's Canadian patent of 1863 specified unusually small stones for wheat because these made more middlings whereas large stones ground out more flour. Brown recommended stones "eighteen inches or two feet in diameter" though he allowed "any size that is found to be most suitable to the circumstances"[1] (presumably the nature of the grain, or perhaps the existing mill set up) and he gave no directions for dressing them. Brown's American patent of 1865,[2] however, specified slightly larger stones (possibly for harder wheats) 30 inches in diameter, and prescribed a dress made of equal parts of furrows and lands (many more furrows than used for old process stones). The furrows were laid tangential to the eye which was five inches in diameter, and began some distance from the eye or bosom area (Fig. 34). Both his American and Canadian patents made the upper stone stationary and the lower stone the runner, contrary to normal practice but typical of European stone design.

R.C. Brown's guide of 1877[3] gave more details about size and dress of wheat stones than John Brown did. For hard spring wheat, R.C. Brown advocated a four-foot stone dressed with many smooth, relatively shallow, narrow furrows

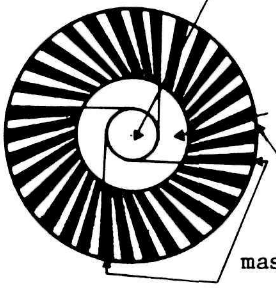


Figure 34. Dress for a 2 1/2-foot millstone designed for the new process by John Brown in 1865. This did not mill grain into flour in one step but gently hulled and granulated grain as a first step in gradual reduction. (*United States Patent Office Records*.)

(or fewer wider), covering two-thirds of the face; the other third contained smooth land surface with no cracking. Hard winter wheat required slightly smaller stones, 3 1/2 feet in diameter, dressed the same as for hard spring wheat. Soft winter wheat was best ground on smaller, three-foot stones containing even less land surface than the former. For all of the wheats, stone texturally close was better than the more open stone used in the old process.

The speed and rate of feed for wheat stones was slower than for stones of the old process. Though both depended on the type of wheat and millstone dress to some extent, generally four-foot stones ground only five to eight bushels per hour at 140 rpm. Smaller stones revolved faster than larger stones. The aim of wheat stones was to granulate, not grind, to roll, not slide. Flour and middlings were rolled out of the bran. Ideal stones produced middlings of even size. Three or four grades of middlings, some flour and some bran was a better mixture than one with eight or nine grades of middlings, less bran and less flour, according to R.C. Brown.

Stones for Regrinding Middlings

Stones used to regrind middlings varied according to the system and the wheat. Both John Brown's Canadian and American patented processes allowed large stones, or "common millstones in the ordinary way,"[4] presumably the 4-4 1/2-foot stones of the old process. In direct contrast to John Brown, R.C. Brown (1877) prescribed middlings stones small in comparison to wheat stones, based on the principle that less surface treated tender middlings more gently. Stones three feet in diameter were the best according to R.C. Brown[5] although he knew of millers using four-foot stones. The same dress was put on these as was put on the wheat stones, except that the furrows were shallower to correspond with middlings smaller than wheat. Dedrick concurred with R.C. Brown that stones to grind middlings were smaller than wheat stones and referred to them as middlings "ponies."[6]

Stone Dressing

Although R.C. Brown believed the pick would always be needed for changing from one dress to another, for putting in a new dress and for the heavy work of facing, he allowed that the new and different types of emery or corundum wheels and diamond dressers being devised were useful to finish the work and keep the stone in order. In fact, such wheels were well suited to treat new process stones whose smooth natural grit was necessary for granulation. All millers advised great care in dressing the middlings stone so that the face was true and the cracks clean, sharp and regular. Abernathey knew of some millers who preferred small shoulders on the feather edge, a form of cracking within the furrow, but the value of this he believed was to "irregularly murder the grain." Knowledgeable millers like himself "universally conceded that the bottom of the furrow be made as smooth as possible."[7]

During the early part of the period under review, two mill picks used manually were patented in Canada. These were granted to J. Gibson of St. Marys and A. Linton of Brockville in 1864 and 1865 respectively.[8] Seven millstone dressing machines were patented between 1868 and 1875, two being diamond dressers.[9] Three millstone dresses were patented in 1864, 1868 and 1875.[10]

Millstone Exhausts and Other Devices

By 1877 millstone exhausts, which had first been patented in Canada in the 1840s, were applied successfully in leading mills to draw off moisture from the stones as flour was milled, leaving it in a better condition for bolting. This form of flour cooler took the place of the hopper boy. Dedrick's plan for flour milling shows he applied exhausts on both wheat and middlings stones. Only one machine "producing cold air around millstones" was patented in Canada during the period under review and this patent was granted to C. Walling of Port Perry, Ontario,[11] in 1875.

Millstone feeders to regulate the rate of speed for feeding grain into the stones were devised, some specifically for middlings. The slower speed of the stones, the new nature of the grind and the different dress required new feeders. Three of the four patented during the period under review were for middlings.[12] Other millstone devices patented in Canada from 1863 to 1875 were "a millstone test" in 1869,[13] a machine for staffing millstones (to make sure the stone was perpendicular to the spindle) in 1872,[14] two "equilibrating" machines (to balance millstones) in 1874,[15] a "running gear" (to raise or lower the runner) in 1874,[16] an improved spindle step (adjustable to compensate for wear),[17] and a "face tester" (composed of a circular metal plate covering the entire stone) in 1875.[18]

Two recipes for millstone cement to fill cavities in overporous millstones were published in 1866[19] for the benefit of millers. One was a mixture of powdered buhr block, alum and borax melted together, and the other was a mixture of equal parts of powdered alum and pulverized broken china melted together and poured into the cavities.

PURIFIERS

> *Up to this date [1877] about three hundred patents on purifiers have been taken out. The result of this extraordinary activity of the inventive mind in this field, is, that we now have a simple, small, compact and easy running Purifier, that is found to do the work better, with less waste, less room, less attention and less expense, than the large cumbersome machine of eight or ten years ago.*[1]

Writing of purifiers in the United States, R.C. Brown evidently was promoting the "Garden City Purifier," patented by Louis Gathman of Chicago in 1874 and 1875 in the United States (Fig. 35), and in 1876[2] in Canada. Sold widely in Great Britain and Canada, it was highly practical, being adaptable to large and small mills, for winter or spring wheats. Brown's biased comments are useful because they point out the direction of what he considered were the better improvements made to purifiers. Improved even after 1877, purifiers were standard equipment in new process and roller mills to clean and grade middlings. Known in the early patent records by such names as "the combined bolt and separator" (John Brown, 1863), "improvements in flour bolts" (John Brown, 1865 and Edmund Lacroix, 1872), "Middlings separator" (Sherman and Parkyn, 1872), "machine for dressing flour" (G.T. Smith, 1873), they became known as purifiers because they rid middlings of impurities such as bran and fibrous material, germ, and flour dust so a whiter purer flour was millable. R.C. Brown discerned that the best purifiers were constructed on the "only principle on which to successfully purify middlings" which was to grade them first and purify them in grades using a bolt and air. Those that employed only air, or only a bolt, were inferior.

The machines devised to grade and to purify varied greatly. The bolt or separator portion might be a revolving cylindrical or polygonal reel, or a flat set of screens or slightly flat set that shook horizontally, vertically or in a circular motion. Brushes or knockers sometimes were applied to thoroughly force the stock through. Bolt cloths covering reels and screens varied according to mesh and the number of different meshed cloths on each reel or screen. Air was applied by the use of an exhaust or suction fan or both, usually below the screen but sometimes above and below, and sometimes inside a reel.

Figure 35. A popular middlings purifier patented by Louis Gathmann in the United States in 1875. This was advocated by R.C. Brown as one of the simplest and most efficient machines to date (R.C. Brown, op. cit., p. 69).

The list of Canadian patents shows that from 1863 to 1877 about 26 purifiers were patented in Canada; nine were granted to Canadian residents, one to a British resident, and the rest to Americans. The purifier of John Brown (different from later ones because it used a reel instead of horizontal screens) and those of Edmund Lacroix and George T. Smith (using horizontal screens that shook) have been described already. The "middlings separator" of Willard H. Sherman and James Parkyn of Montreal, granted on 14 November 1872,[3] was similar to the Lacroix machine in that it used shaking horizontal screens and a brush. It separated middlings into about three grades which were then purified by a blast of air. Judging from the fact that the patent was renewed in 1877[4] for another five years by John Ogilvie, Parkyn and T. Pringle, another assignee of Sherman, it was probably used successfully in Parkyn's mill at Côte Saint-Paul on the Lachine Canal and at the Ogilvie mills nearby.

On 30 October 1873, G.W. Glen and G.T. Barclay of Oshawa, Ontario, took out a patent[5] on their improved "middlings and flour purifier" which claimed the novelty of using a wind spout above and below screens which were moved by vibrators and knockers. There is reason to suppose that this may have been the purifier on display at the Provincial Exhibition in Toronto in 1874. Described by an exhibition reporter as "an apparatus for procuring a superior quality of flour with a larger yield to the bushel than usually obtained,"[6] a middlings purifier was entered by the Joseph Hall Manufacturing Company of Oshawa whose "spirited and enterprising president and manager"[7] was W. Glen - possibly one of the patentees of the 1873 machine.

Other purifier patents included one granted to William Petch of Brantford, Ontario, on 18 March 1874 for a purifier which used a reel as well as screens.[8] On 7 November 1874, J. Gregory of Wingham, Ontario, took out a patent on his middlings purifier which used a revolving reel, an air blast and revolving fluted rollers.[9] The seventh purifier patent granted to a Canadian was the machine of W.H. Gibbs of Oshawa used to blow the flour and impurities off middlings after they had been graded in a separate flour bolt.[10] This was the type condemned by R.C. Brown (1877) because it only purified and left the separation to another machine - the bolt. W.H. Gibbs was a member of the dominion Parliament like his brother Thomas N. Gibbs; both were partners with a third brother F.E. Gibbs in the Gibbs and Brothers millers and grain dealers firm.[11] In 1874 they registered their maple leaf trademark, still used today by the Maple Leaf Flour Mills.[12] Presumably the purifier patent granted to William Gibbs on 17 April 1875 was used in their Oshawa mill to produce flour marketed under their eight[13] trademarks first registered on 11 April 1874. H.M. Charlesworth of Egmondville, Ontario, patented his middlings purifier on 24 April 1876.

American Benjamin Barter patented three purifiers during the period under review, the first when he was a resident of Minnesota in 1874 and the others in 1876 when he was stated to be a resident of Toronto.[14] His first purifier granted on 20 January 1874 was "a machine for dressing flour" using a fan and a shaking bolt with brushes reminiscent of LaCroix's.[15] Storck and Teague write that it was used for winter wheat, which may have been one reason why Barter came to Toronto, a locale where good quality Upper Canadian winter wheat was milled, and the place where Barter set up a mill furnishing firm about 1876.

Other purifiers patented by Americans included one on 1 October 1874 by S. Howes and Company of Silver Creek, New York (a mill furnishing firm established in 1856),[16] and others granted to residents of Rochester,[17] Silver Creek,[18] Shibley (New York),[19] and St. Louis, Missouri.[20] On 17 June 1875, A. Crabtree of Backup, England, was granted a patent for his "middlings separator"[21] (see Append. B, Manuscript Report No. 201 for complete list).

FLOUR BOLTING FOR THE NEW PROCESS

Flour bolting for the new process varied immensely from mill to mill depending on the phase of the process (John Brown's early phase required a simpler procedure), the assembly of machinery, particularly the millstones, and the type and condition of grain being milled. Some millers like R.C. Brown (1877) advocated bolting the wheat crop as well as the middlings grind, and others like John Brown (1863) only after grinding middlings.

John Brown's Method

Perhaps because Brown's early purifier or "combined bolt and separator" acted as a flour bolt, other bolting machines were not necessary to further separate material made by the first granulation. Only after middlings had been reground did Brown specify that the resulting meal was to "be dressed in the ordinary bolts" to make first-quality flour.[1] Brown left bolting up to each miller, which allowed room for variety. Presumably bolts of the old process continued to be used.

R.C. Brown's Method

Flour bolting was necessary at two stages according to R.C. Brown: after milling on wheat stones and after milling on middlings stones.[2] The trend was toward more bolting surface, meaning an increased number of reels of smaller size rather than a reel of larger size. These were enclosed in a large chest; "modern chests" as distinct from old process chests had two conveyors under each reel (presumably because each reel was covered with two different bolt cloths), which meant they had to be more commodious than the old which only housed one conveyor. Now the usual number of reels in a chest was three or six whereas before it had been two or four and sometimes five. If more bolting surface was needed, an extra chest was added. Brown gave directions for converting an old chest to a new chest. He also described his own design for new chests, smaller than the usual old size of 20 feet long by 32 inches in diameter, though the mode of construction was the same as the old. He preferred reels 16 feet long and not over 30 inches in diameter because "in nine cases out of ten the full length of the reel is never used." An even better bolt was to place three reels in a chest 12 feet long one above the other, an arrangement suitable for one run of wheat stones.

Bolt cloths continued to improve in fineness of mesh. By 1877 fine cloths were numbered to 14 according to Brown's descriptions; in 1860 the finest cloth was number 12. The finest cloths were used on reels to bolt middlings after they had been reground. Brown differed with many millers because he believed that sometimes coarser bolt cloth should be placed at the head of the reel whereas old process millers had usually put the finest at the head.

Bolting Arrangements for Meal from Wheat Stones

Brown outlined half a dozen methods of bolting in his chapters on "Bolting," "Successful Examples" and "The Reconstruction of Mills." In the last[3] he took examples of reels in a mill of the old process and showed how to update the whole arrangement. Because he believed in "overcoming the miller's prejudices and working him up gradually" rather than in discouraging him by the troubles arising from making the change all at once, Brown outlined three new arrangements, one of which was intermediate to adopting the new process entirely.

The examples of a successful miller of Brown's acquaintance is useful here to illustrate reels necessary in a new process mill with one pair of wheat stones and one pair of middlings stones. Hard, kiln-dried winter wheat granulated on wheat stones was bolted in a chest containing four reels; one scalper, two flouring reels and one duster, each 16 feet long and 30 inches in diameter. The scalper was covered with number 9 cloth and three feet of number 2 at the tail to take off the bran and middlings. The two flouring reels (one evenly divided into cloths 10XX and 11XX and the other into cloths 12X and 13X) produced flour, some of which was returned to the second flouring reel, while the tailings were sent to the duster. The duster, also clothed in number 12X and 13 cloths, removed the floury portion from bran, middlings and tailings before they were conveyed to the purifier. Brown postulated that if an additional wheat stone were added to the mill, an extra dusting reel would be necessary as well as an extra purifier, one to deal with middlings and one for tailings. If the same mill ground spring wheat, Brown recommended the same number of reels but each covered with fewer and finer cloths; the first flouring reel would need 11X and 12 cloths and the second, number 13.

Bolting Arrangements for Meal from Middlings Stones

For flour from the single run of middlings stones in the above successful miller's mill, a chest containing two flouring reels was used in addition to the duster portion of the chest for bolting wheat chop. In the two-reel chest, the upper reel was covered with 12X and 13 cloth, and the lower with cloth 14 and three feet of cloth 10. The throughs of number 10 cloth (some of it middlings) were conveyed with middlings from the wheat stones to the duster in the wheat chest and dusted before being returned to the purifier. In this way the miller manufactured a "patent" flour from the middlings, as well as a "straight grade," meaning a mixture of flour made up of flour ground on wheat stones and flour ground on middlings stones.

In summary, R.C. Brown wrote that the secret of successful bolting lay in common sense. "If there are any secrets, they must lie in the arrangement of cloths and the manner in which the material (was) manipulated"[4] and experience had taught him that the rational approach was the best. Both the size and number of reels and the arrangements and mesh of the cloths varied depending on the composition of the meal or chop, and this depended on the type of grain, whether it had been kiln dried and whether it had been ground on wheat or middlings stones. It was requisite that every bolting arrangement be adapted to each run of stones, since no two pairs milled exactly the same.

Only one Canadian patent was granted from 1863 to 1875 and that was to J.R. Currey of Windsor, Ontario, on 23 December 1869 for his "improved flour bolt knocker."[5]

FLOUR DURING THE PERIOD OF THE NEW PROCESS

There were many descriptions for flour during the 1860s and 1870s, some general and some specific and few revealing it was made by the new process. The grades or qualities defined by law, individual trademarks and flour advertised publicly were sometimes difficult to correlate. For example, "family flour" or flour for "family use" was a general term used by flour millers and dealers since the 1850s probably coined to distinguish this flour from flour milled for bakers. Family flour occasionally was further described by a quality set by law such as "extra" (the top quality), and by a note that it was made from pure or choice white wheat (winter wheat). The term had little to do with the process by which the flour was made, but more with its purpose and market.

The first trademarks for flour were registered in the 1860s when trademark laws for Upper Canada were first enacted (1860, 1861 and 1868), and showed no evidence of having been designed for flour made by the new process of gradual reduction but instead for "patent prepared flour" sold by Toronto flour dealers. Directions for making small cottage loaves, French loaves and pastries by mixing the flour with water, or sometimes with "common flour," indicated the process involved adding a leavening agent to ordinary flour. F.A. Whitney and Company in 1861,[1] and Edward Murdock and Company in 1864[2] registered trademarks for the same self-raising recipe acquired from Jones of London, England.[3] "Flexman's Prepared Flour" was another trademark registered by three different proprietors between 1869 and 1870[4] (see Append. D, Manuscript Report No. 201).

The flour inspection act of 1860 designated standards for eight different qualities of flour manufactured at Canadian mills. These qualities, in order of highest to lowest, were known as Superior Extra, Extra Superfine, Fancy Superfine, Superfine, Superfine 2, Fine, Fine Middlings and Pollards. From 1865 on, efforts were made to draft a new flour inspection bill, a regular practice during the 1850s when sections of the law were changed in 1850, 1856, 1858, and 1859 as well as 1860. New changes were needed in the law because new grades were being manufactured by the 1860s, and a motion to make the inspection compulsory was under consideration.

The Move to Change the Flour Inspection Law

As early as 1863, the Montreal Corn Exchange began to record sales of a new type of flour described at first as "strong fresh-ground superfine."[5] Much in demand it sold for "exceptional prices,"[6] more than the highest grade, superior extra, at times. From 1864 to 1867 the flour was graded as a superfine from Canada wheat and further defined as "strong Canada super," "strong brands for Bakers' use" and eventually "strong Bakers' flour" always selling at a price above that of ordinary superfine, sometimes with the note that favorite brands brought the highest exceptional prices. More research may prove that some of these brands were the result of John Brown's improved machinery of 1863 and that one of the favorite brands was "Haxall." On 13 September 1867,[7] for the first time strong bakers' flour was listed along with other legal grades of flour in the Montreal Corn Exchange listings. Even though it had not been recognized by law as a quality subject to inspection, strong bakers' flour may have been approved as a grade by the Montreal Board of Trade's flour examiners. Partly because of its scarcity and strength, the price of strong bakers' flour was always above the price of ordinary superfine and often above fancy superfine, extra superfine and superior extra. In 1869 mention began to be made of "medium bakers' flour" as well as "good to ordinary" and "choice" brands of strong bakers', the medium valued just below the choice brands.[8]

The debates of the House of Commons of 14 August 1865, reveal that a new bill respecting the inspection of flour and meal was ordered and presented by Mr. Rose, M.P., which, on second reading was referred to a standing committee on banking and commerce. A petition of the Montreal Board of Trade, and the Corn Exchange Association of Montreal praying for a bill to amend the old law was read before the house of 28 August 1865, but nothing more was recorded in the debates about the matter that year.

After Confederation, efforts were renewed to change the law, this time for one to apply across the Dominion. In May 1869, the Montreal Corn Exchange again proposed a new bill amending and consolidating the law regarding flour and meal inspection. This bill was presented to the Montreal Board of Trade which passed it on to its board of examiners responsible for choosing flour standards. The flour examiners were to review and amend if necessary the Corn Exchange's proposal so an acceptable bill could be submitted to the Dominion Parliament in the 1869 session. The Board of Flour and Meal Examiners, however, considered the proposed changes "too sweeping" and reported that the old act had given satisfaction in Great Britain and the lower provinces.[9] In particular the standard for white wheat flour was considered too high, the quality of white wheat having deteriorated. Instead the board suggested that the fancy superfine grade be omitted and the standards for superior extra and extra superfine be graduated to meet the requirements of the trade. They also proposed that because of the Maritimes' objection to the term superfine 2, this grade be retermed superfine, and that the old superfine grade be retermed spring extra, containing a portion of fall wheat.

The process of changing the flour inspection law continued to concern the Montreal Board of Trade in the 1870s. In January 1871 a committee of the president, John Yonge, and Messrs. Azan and Henshaw (appointed to consider the necessity of a new general inspection law for the Dominion) submitted their report that a uniform law was requisite and that inspection be compulsory as an advantage to producers and shippers. The meeting moved that their report be submitted to the Dominion Board of Trade. By 1873 the Montreal Board of Examiners considered further specific changes in the qualities of flour to be defined in the new law after a meeting in Ottawa with representatives of flour examination boards across the Dominion. The grades or qualities amended by Montreal examiners and telegraphed to the Minister of Finance in Ottawa ten days before the new law was passed were Superior Extra, Extra Superfine, Fancy Superfine, Spring Extra, Superfine, State Superfine, Fine, Middlings and Pollards. Not all of these were included in the new inspection act, however.

The act "to amend and consolidate and to extend to the whole Dominion of Canada the laws respecting the Inspection of certain staple articles of Canadian produce" was assented to on 23 May 1873.[10] Under the new law flour grades were to be Superior Extra, Extra Superfine (made from pure fall wheat), Spring Extra, Superfine, Fine, Fine Middlings, Pollards or ships stuff, and Strong Bakers' Flour (to include flour made from choice spring wheat "extra high ground").[11] While this law recognized strong bakers' flour made by gradual reduction, it omitted fancy superfine, and perhaps partly because of this and other omissions, the entire act was repealed the following year. A new act "to make better provision extending to the whole dominion of Canada, respecting the Inspection of certain staple articles of Canadian produce" was assented to on 26 May 1874.[12] By this act flour was designated as Superior Extra, Extra Superfine, Fancy Superfine, Spring Extra, Superfine, Fine, Fine Middlings, ships stuff or Pollards, and Strong Bakers'. Inspection was not compulsory and provision was made that standards for the whole Dominion were to be fixed at Montreal by delegates from the boards of examiners at Quebec, Montreal, Toronto, Hamilton, London, Ottawa, Halifax and St. John, New Brunswick, between 15 August and 15 October of each year; not less than three places had to be represented to establish dominion standards and if members were not present, standards would be set by the governor in council. The Ministry of Inland Revenue would distribute the chosen samples to inspectors and the council of the Montreal Board of Trade would send notices of meetings to the flour examiners across Canada. The general inspection law of 1874 regarding flour and meal standards remained unchanged until the new law of 1887 recognizing roller flour.

Beginning in April 1874, spurred perhaps by the new inspection law and by the new process of milling, a number of mill owners registered trademarks for flour, most to be stencilled on barrels and some for bags of various sizes. The Gibbs Brothers of Oshawa, Ontario, for example, registered seven different marks.[13] Three, "Maple Leaf," "Ellesmere Eagle," and "Plough Brand for family use," designated flour made from winter wheat. Two, "Gibbs' Best Expressly for Bakers'" and "Extra Strong Bakers'" were directed toward the baking trade, the two latter made by the new process of high grinding. Two others, "Our Brand" and "Paragon," specified neither the wheat from which the flour was ground nor the quality of flour.

Patent Flour of the New Process

Literally "Patent flour" meant any flour made by any patented process, but after the middlings purifier and gradual reduction patents in the 1870s, the term "patent flour" came to mean flour made from purified middlings which had been gradually reduced. "Bakers' flour" was flour ground from the first granulation of wheat, and "straight flour" was a mixture of bakers' with patent. The general inspection law of 1874, however, did not recognize patent flour as a quality in the way it recognized strong bakers'. Some Canadian millers using the new process reported that they mixed their highest patent grades with bakers' and lower grades because Canadian consumers were not interested in paying the high price patent flours demanded. Not until 1887 (when the law was changed to apply to roller flour) did the law specify brands for "patent" and "straight" flours gradually reduced on rollers. Though not recognized by law or even a registered trademark, much of the Canadian new process flour of the 1870s was probably marketed, like the Snider's flour of the 1860s, under unregistered brands.

SUMMARY

Beginning in 1863 a number of mills in Ontario manufactured flour by a new process that produced between 50 and 75 per cent superior flour. A portion of it known as "strong bakers'" was much in demand by the baking trade. Another portion finer, whiter and highly priced was known by the 1870s as "patent flour" in the United States. While some millers were able to realize large profits from the various grades so made, others claimed that Canadian consumers were unwilling to pay for the highest grades, and so they mixed them with lower grades to suit the wants of their consumers.

New machinery was needed to produce the new flour. Special millstones to granulate middlings, a special middlings cleaner known as a purifier, and special millstones to regrind the middlings into high-quality flour were the chief innovations required for the new process of gradual reduction. Millstone dress changed to suit the new method. Machinery improvements, some for the new process and some not, continued to be made in flour bolts, grain cleaners, flour exhausts, grain dryers and purifiers during this period.

About 1872 when some mills were beginning their conversion to the new process of gradual reduction, E.W.B. Snider became interested in roller milling, a successful European method in which rollers were used to reduce grain into an even whiter, purer flour in a series of grindings. The invention in 1874 of porcelain rollers and their successful application in Budapest mills led Snider to inquire about them late in 1875. An account of the subsequent successful introduction of roller milling to Ontario is given in Part V which follows.

Part V. Roller Milling in Ontario, 1875

DIVERSITY OF ROLLER-MILLING SYSTEMS

> *It is intelligible that in so composite a system of reduction and separation as we have in milling, with wheats of such different characteristics, with trade conditions so many and various which entail a corresponding variety of demands on the part of consumers, diverse systems of mill building and operation should come into being.*[1]

Writing in 1891, Professor Kick, the well-known German milling authority set forth the main factors that had produced the variety of roller mills and methods in Europe and his statement applied to roller milling in North America as well. In Canada during the last quarter of the 19th century, rollers and the necessary machinery used for roller milling were imported from Europe and the United States or else manufactured locally. Feasible methods were found to roll local wheats into meal which was separated into flour products suiting the differing tastes of Canada and her foreign markets. European "long systems" which produced unsaleable grades in Canada were modified to shorter systems designed for local soft, medium and hard wheats grown in the 1870s and after. In some mills, rollers and millstones worked together in combined systems until full roller systems were installed. In others, millstones were discarded altogether to make room for rollers. Part of the diversity of Canadian roller-milling systems during the early phase was due to the diverse influences reaching Canada from Europe and the United States.

The invention of successful roller milling, generally credited to Hungary by North American millers of the 1880s, was originally the work of a Swiss engineer, Jacob Sulzberger, who improved a design of another Swiss in a mill at Frauenfeld, Switzerland, in the 1830s. Sulzberger's rolls were grooved iron arranged in sets of three pairs placed one above the other in a cast-iron frame, and were used only to break grain into grits and middlings while millstones were used to reduce grits and middlings into flour. In 1839 this system was installed in Pesth, Hungary, at the Josef Walzmuhle. Though other mills in Europe installed Sulzberger's system, few succeeded as the Pesth mill owing to the determination and capital of its owners, one of whom was Count Stefan Szechenyi. Despite prevailing prejudice against roller mills because their intricate workings were difficult to learn and early designs were less than perfect, the mill at Pesth continued production and was improved. In 1868 larger rolls, an improvement of F. Naeff, increased the rate of production, and in 1874 F. Wegmann's porcelain rolls replaced millstones so an all-roller system was successfully established at the mill. Each of these successes at the Pesth mill gave impetus to new improvements across Europe, some of which reached North America. But it was due to the continued success of the Pesth mill and others in Hungary that credit is given to Hungary for roller milling.

Bennett and Elton[2] wrote that in Great Britain in 1862 an improved version of Sulzberger's system known as the Buchholz partial system was adopted at an Ipswich mill; under-runner millstones were used to mill middlings into flour. In 1868 a Liverpool mill adopted the same system but improved it in 1870 to an all-roller system claimed to be the first in Great Britain. From the late 1860s on, a number of mills were fitted with partial systems of various designs and by the late 1870s, owing to the push given to all-roller systems as a result of Wegmann's porcelain rollers, various all-roller systems were installed at many of the large merchant mills in Great Britain. By 1881 the first automatic all-roller mill in England was designed on the Simon system for F.A. Frost and Sons of Chester.

Roller milling was introduced to the United States in the 1870s. On 11 October 1870, G.A. Buchholz's partial roller system was patented, and between 1870 and 1874 John Stevens of Neenah, Wisconsin, reportedly worked on his roller designs patented in 1880 and after. In Minnesota from 1872 to 1873 A.G. Mowbray of Winona experimented with large marble rolls for crushing wheat, and in late 1873 a committee of Minneapolis millers visited Europe to investigate French and Hungarian methods. One of the committee was George H. Christian who on his return in 1874 ordered 36 pairs of smooth chilled cast-iron rollers based on European design to be manufactured by the Farrell Foundry in Ansonia, Connecticut. These were tried out in the Washburn A mill in Minneapolis. By 1879 a feasible automatic, all-roller system operated at the Washburn C mill.

It was inevitable that Canadian merchant mill owners competing on international markets with British and American mill products would bring roller milling to Canada. In 1871 A.W. Ogilvie reportedly imported a set of rollers from Hungary, but little is known about these. The Snider experiments and ultimate success with Austrian rollers between 1875 and 1877 revealed in E.W.B. Snider's family papers is described below. From the latter source, milling journals, guides and newspapers of the day, it is possible to reconstruct some of the events that make up the history of roller milling in Ontario (Fig. 36).

From the beginning Ontario roller milling went through many changes. First were combined partial systems where

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Figure 36. Typical advertisement hailing the advent of rollers in an Ontario mill in 1883. (*Huron Expositor, May 1883.*)

millstones were used to hull and break the grain into granular meal made up largely of middlings and which rollers then reduced to flour. Another partial roller system was one in which rollers were used to break the grain into middlings and millstones were used to remill the middlings into flour. Sometimes millstones were used to hull the grain, rollers to break it and stones to mill middlings. Though partial systems worked adequately in their time and place, improvements were the order of the day and competition was keen especially among mill owners with capital and a broad outlook. It was the all-roller system that eventually superseded the others.

A partial system using millstones to break grain and rollers to reduce middlings was adopted at the St. Jacobs mill of E.W.B. Snider between 1875 and 1877, and was based on Austrian methods and used Austrian rollers. On what might be called a medium-long system, clean grain was hulled and broken on millstones to produce "grits" or large middlings known as grit number 4. These were then further reduced to flour (after purifying and bolting) by running through rollers five or six times. Though the use of stones to break wheat eventually was dropped because stones tended to decimate bran that specked flour, they could be used effectively when they were suitably dressed, designed and run to suit the wheat. If the variety and condition of wheat was right and the assembly of machinery - bolts, purifiers, grain cleaners - right, good flour was manufactured. The Snider mills had been installed with under-runner small millstones especially designed for hulling and breaking wheat so this Austrian-type partial system was more easily adopted at their mill than at other Ontario mills equipped with the normal run of stones. Once better alternatives were available to the Sniders, however, millstones were replaced.

A second type of partial roller process - the opposite of the above - was popular in many of the smaller mills in Ontario during the 1880s. Corrugated rollers used to break wheat had an action that twisted the endosperm out of the bran so little decimination took place, and the bran was rolled flat so it was easily scalped from the middlings and white flour. The great advantage of millstones for reducing middlings was their large capacity, greater than porcelain or iron rollers. Again, much care had to be taken in dressing stones and running them high. As time went on and reduction rollers were improved, the use of millstones waned. Knowledge of the care required to dress millstones for middlings reduction gradually disappeared, partly because the expense of such care in time and money was too much compared to that needed for rollers. It was a fact that the grinding action of stones decimated any bran that happened to be left in middlings, and as the germ was included with the bran, the flour was further darkened and susceptible to souring. If millstones were retained, careful bolting was necessary and extra care at every stage of milling was needed to mill a flour that could compete with all-roller flour. Regrinding of second middlings resulted in overheated or second-rate flour, and to solve this drawback, some mills installed smooth rollers just for second middlings. Generally, however, it was claimed that millstone flour could never be as white as roller flour. By 1887,[3] one miller wrote that combination mills could be quite successful in areas where roller-mill competition was limited and high quality milling not in the field.

The all-roller systems, once perfected, had many advantages over millstone and partial systems. In milling flour, roller machines did not demolish the woody hulls of the grain as much as millstones did, did not get as hot as millstones, required less power, were not dressed as often and required less surveillance. They did 37 per cent more work requiring 47 per cent less power, ran for months without changing, increased the yield per given amount of wheat and made a whiter flour with fewer fragments of hull and germ. Larger mills were possible because rollers required less power, less space and were more economically run on a large scale. By the 1880s rollers were made in sets of two or more so that two breaks could be done with less machinery.

Roller machines were improved and local adaptations made and later designs were usually better than earlier ones. Early machines were heavy, gear driven rather than belt driven, and less adjustable than later ones. Feed devices for spreading stock evenly along rollers, mechanisms to adjust the space between rolls and keep it constant, differential speeds, new types of corrugations and many other betterments were applied to rollers during the transitional period so millstone millers found fewer reasons to keep their stones.

The Hungarian milling industry had evolved their "long system" of many breaks and reductions suited to their hard grain and public demand for many grades of flour. North American millers devised their "long system," never as long as Hungarian long systems. Used to mill hard wheats, local long systems involved three to five breaks on wheat, and eight to twelve on middlings. "Medium systems" which the majority adopted required three to four breaks and five to seven reductions. Shorter systems were generally for soft wheats which broke down more easily than hard. A very short system suitable for a small mill might use two breaks on grain and three reductions on middlings. The number of breaks and reductions required in any system also depended on other considerations than the wheat: the amount of roll surface needed for a given capacity, the corrugations used, the speed of rolls and the differential speed between fast and slow rolls.

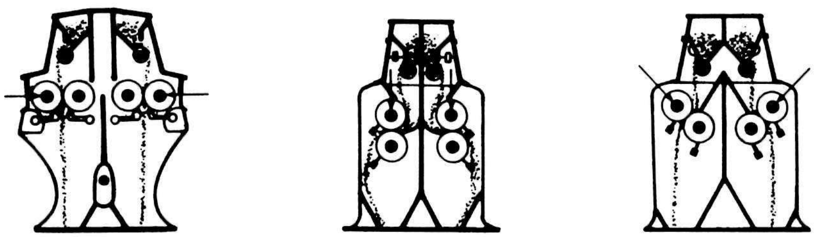
Corrugations of rolls might be sharp, dull or medium. They might be shallow or deep, fine or coarse, and the practicality of these depended on wheat and one's experience with various wheats. Sharpest corrugations milled soft, damp, tough wheats, while the dullest milled hard brittle wheats. The form and number of corrugations and the depth of their cut varied with each break. The first break rollers had the deepest and coarsest corrugations, and each succeeding pair of break rollers had successively finer corrugations so that as the meal became finer it was treated less harshly. Corresponding to the smaller size of flour particles running through each successive pair of rolls the distance between the rolls lessened. The action of the corrugation was affected by the speed of the rolls. When both rolls of a smooth pair were run at the same speed, grain or stock tended to be crushed or flattened. It was found that differential speeds produced a tearing or rending action that twisted endosperm out of the bran.

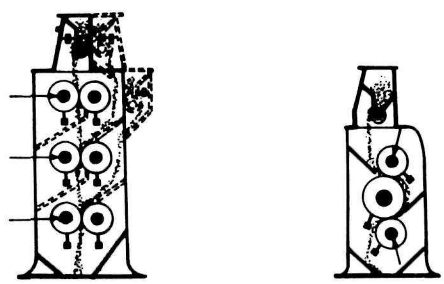
The material of the earliest rolls was cast iron but this wore too quickly. Chilled cast iron became the accepted mode. Porcelain (sometimes referred to as "glass") rolls were an improvement in the 1870s over some smooth iron rolls for middlings reduction. Made from the finest potter's clay, unglazed and fired once into a biscuit ware, they were porous and therefore similar to the surface of French buhr stone. Compared to smooth iron rolls of the day they were light and exerted less pressure. In 1878 grooved porcelain rolls for breaking wheat were tried in the Washburn C mill in Minneapolis, but were replaced with corrugated cast iron. As better designs for chilled cast-iron rolls for reducing middlings were devised, use of breakable porcelain diminished.

The size and speed of rolls varied, early designs being generally smaller in diameter and length and slower than later designs. Dedrick's text, *Practical Milling* (1924),[4] outlines the history of roller-milling in the United States and gives some idea of the various sizes and speeds of later standard rolls. Diameters ranged from six to ten inches, nine inches being more or less standard; optimum speeds varied from 600 rpm for a six inch to 450 rpm for a 10-inch roll. Optimum length for 9-inch diameter was 30 inches, 36 inches for a 10-inch diameter, 20 inches for a 7-inch diameter and 16 inches for a 6-inch diameter. But manufacturers made rolls of assorted lengths for each diameter. Arrangement of rolls into sets also became standard. There were "two roll mills" of a single stand or pair, "four roll mills" or double stands, "three roll mills" where the middle roll was the mate of the other two, and a "three high" roller mill (Fig. 37). The latter was arranged with three pairs of rolls above each other, each pair distinct with its own feeder and discharge spout so the set was able to make three distinct breaks or reductions. The same arrangement might serve as a feed mill, the grain passing from one pair directly to the next. These were some of the various designs for roller mills and there were others during the last quarter of the 19th century.

With the advent of rollers, the accompanying assembly of machinery required in the milling process was adapted to

Double stand roller mills (3 types)





Three-high roller mill Three roller mill

Figure 37. Different arrangements of rolls in stands that became standard by the 20th century. (*Drawings by S. Epps after the original in B.W. Dedrick, op. cit., p. 98.*)

suit rollers. Like rollers, these were imported, modified and improved for local systems. In the area of grain cleaning and preparation, new processes for conditioning, washing, debranning, separating and scouring were tried. In the field of bolting, centrifugal reels were an innovation designed to break up flaky flour (pressed together by rollers) so it could be bolted economically. New types of scalpers specially clothed to separate middlings and coarse material from floury stock, dusters to remove fine dust from middlings and sharps, and graders to sort middlings all became requisite for roller-milling systems. Flour dressers, purifiers plus the other bolting equipment created so much flour dust that dust collectors were needed to prevent explosions. Rollers became differentiated for specific uses. Some were specifically designed to split grain and were known as "cracking rolls"; "sizing rolls" broke middlings down to the proper size for given systems, and "scratch rolls" removed the floury matter from bran. Each roller-milling system varied according to the machinery needed for it and was designed to mill a specific wheat or mixture of wheats into a saleable product suiting a particular market. It was the assembly of machines, not just the rollers, that made each system and produced the new high-quality products known as patent and straight roller flours.

The variety in roller-mill designs, then, was also due to the variety in individual machines making up a system. Since each worked within a whole system, the design of each unit was determined partly by the design of the other units. Some imported rolls were modified or improved to work in Canadian systems if the accompanying assembly of machines had not been imported or was too unfeasible. Because of the various millstone set-ups in Ontario mills, room for more variation was allowed owing to the variety of millstone set-ups. The mill owned by E.W.B. Snider at St. Jacobs, Waterloo County, was probably the first to successfully adapt to roller milling in Ontario when iron rollers from Vienna, Austria, were imported. But the Snider combined roller system of the 1870s, since it used Austrian rolls to work in a system using under-runner German-type millstones, was different from most combined systems that followed it. By the 1880s American-manufactured as well as Canadian-manufactured rolls and machinery were available and easily accessible for the majority of mill owners wanting to convert. Credit should be given to the pioneers of roller milling however, whose energy, money and experience was spent not only for their own benefit, but for the benefit of those who followed and profited from the pioneers' mistakes as well as their success.

THE SNIDER PIONEER ROLLER MILLS

> *To transform the milling industry..., was a stupendous task, and many millers fell by the wayside in the struggle, but those whose vision was clear and efforts tireless were amply rewarded.*[1]

The change to roller milling in Ontario was not an easy transition. It required more than the importation of rollers from Europe before marketable flour could be manufactured. A great deal of time had to be spent experimenting with the foreign machines to adapt them to local grain which differed from European grain. In any mill a number of machines worked in an integrated fashion to handle the succession of grinding, cleaning, bolting and purifying operations. Ontario millers would discover that the introduction of one new machine to this assembly necessitated adjustments or changes in the others. It would require a knowledge of foreign languages as well as milling to deal with ambiguous English translations, let alone German, French or Hungarian instructions. Once a workable process was developed, roller-mill machines and other necessary devices could be manufactured locally. It was a time-consuming business requiring the backing of energetic men with tenacity and conviction as well as a large amount of capital.

Such a man was E.W.B. Snider who, in 1862 as manager of German Mills, had risen to his father's challenge of making their milll prosper. In 1863 with German miller John Brown, the mill was adapted to Brown's patented improvements based on a German practice of gradual reduction using under-runner millstones and his improved bolt or purifier. Their success with this method led others in Ontario and the United States to follow them. Thus, from the age of 20 to 30, E.W.B. Snider had taken part in a minor milling revolution. Awake to the possibilities of European procedure as a result of Brown's successful process, the young Elias in 1872 was ready to explore the new roads already being travelled by leading merchant mill owners in Europe and Great Britain.

It is said that his meeting "about 1872" with W.M. Stark, a representative of the London, England, firm of Stark and Bruce, Flour and Grain Merchants, a firm that represented some of the big roller flour mills of Vienna and Budapest, led E.W.B. to explore European roller milling.[2] Stark, sent in 1871 to establish a flour business with Canada based at Toronto, showed Snider samples of the finest Viennese and Budapest flour ever produced. These interested Snider so much that he obtained the address of the mills making it which eventually led to his receiving a milling journal. Finding out the process he then wrote to the manufacturers of the milling machinery.

It is evident from his correspondence with Hoerde and Company of Vienna that Snider wanted to import porcelain rollers, the patent of F. Wegmann that had proven so successful in 1874 in the Pesth mill in Hungary. There, porcelain rolls were used to make flour from middlings after iron rolls had broken grain into middlings. The advantages of Wegmann's rollers over millstones had been published in *Die Muhle* in December 1874 and Janury 1875, probably the journal Snider had read. It must have been a disappointment to E.W.B. when he learned from the Hoerde company in January 1875 that the porcelain rollers had "proven badly because in the first days of work they cracked, for by the circulating, the iron axis grows warm and porcelain mantle is forced to break."[3] As alternatives to porcelain, Hoerde and Company described in detail two other types of "hard cast iron" rollers (probably chilled iron), the first type designed to "bruise, dissolve and grind the meal" (probably to break, granulate and reduce the stock into flour), and the second type "for dissolving the grit" (reducing middlings), all patents of Escher, Wyss and Company of Leesdorf, Austria, a reputable firm that had equipped paper mills in America.[4]

From the beginning of Snider's correspondence with this and other European manufacturers it is clear there was difficulty in understanding the milling terms of the other. Though written in English, the European letters contained unusual renditions easily misinterpreted. Since the porcelain rollers had broken, E.W.B. requested the second type of iron roller for dissolving the grit. But these were advised against by Hoerde and Company who had examined the sample of middlings Snider had enclosed with his request. Instead they suggested their other roller machine which, they explained, would be more profitable because it was able to make middlings into flour as well as "bruise, dissolve and grind the fruit."[5] Their brief explanation of why the second machine was not good enough to mill flour from middlings was "you cannot dissolve middlings but only the usual grit."[6] Presumably the small size of Snider's middlings were not the proper size for the rollers; grits tended to be large middlings.

It was in September 1875 that the set of rollers (Fig. 38) arrived at the St. Jacobs mill with directions in German for its installation and operation. This *Walzenstuhlung* was a set of four rollers, one placed vertically upon the other driven by toothed gears. The motive wheel, a pulley, was one meter in diameter and turned at 100 rpm. The machine occupied a space three feet square and five feet high, weighed 30 quintals (three tons) and

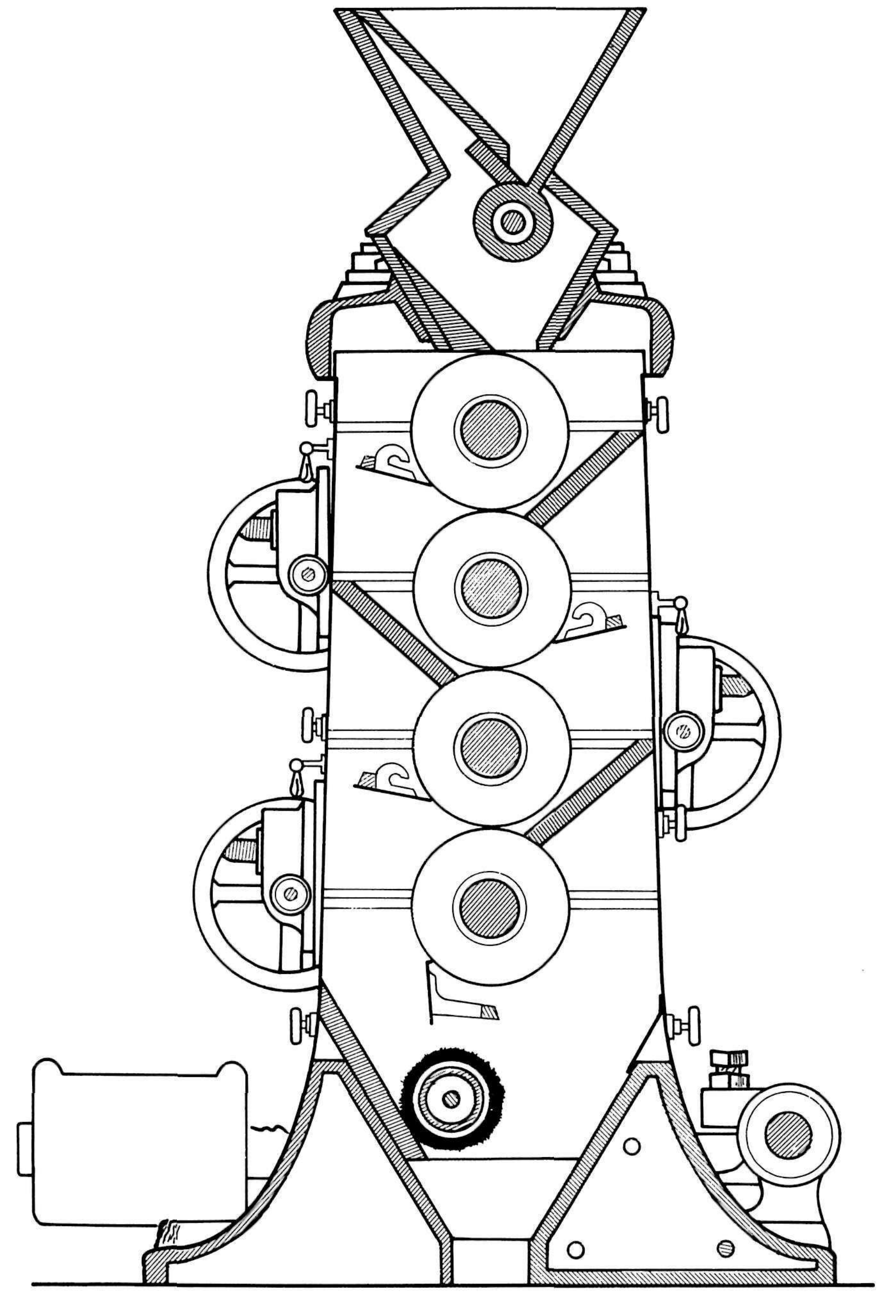


Figure 38. Cross section of the first roller mill imported from Austria to St. Jacobs, Ontario, in 1875. (*Drawing by S. Epps after the original in the Archives of the Waterloo Historical Society.*)

required three horsepower to run. Flour or meal passed through three pairs of rollers before it left the machine, the space between the rolls growing narrower and narrower so the good (as opposed to the bran and germ) was not "crushed all at once but bruised by and by," and the "heating of the fruit" and the "tearing of the sheath" was avoided.[7] The set would produce about 45 quintals (50 barrels) of flour every 24 hours.

The *Walzenstuhlung* had the advantage of being adaptable to the usual panoply of machines employed in Viennese mills - though in Ontario this was different. Here was another difficulty that had to be overcome by Snider's millers accustomed to different machines. First "a good machine for cutting off the top" was needed to remove the beard, split the kernel and separate the germ. The "usual cylinders for meal and separating the grit" (scalpers and bolts), "a machine for cleaning the grit" (purifier), and millstones "for the first breaking of the fruit" and "for the grinding of the bran" were the "by-machines" needed to work in this system.[8] It would take time to make adjustments in the St. Jacobs mill before workable units could be assembled.

With their letter[9] accompanying the machine, a prospectus[10] of their newest roller named the "Universal Walzenstuhle" for making grits (breaking wheat into grits) was included. It could be combined profitably with the machine Snider had just imported. Though there is no evidence that Snider purchased it, it may have been one of the many considered by him and his millers in subsequent trials. The company also sent patterns of wheat, flour and bran requested by Snider as a guide.

Experiments and trials with the new roller continued into 1876. On 13 January, Hoerde and Company replied to Snider's letter of 30 November 1875 in which he had sought advice. It was "of no importance that you drive the machine with a belt drawing downward" but "we beg [you] to freight the level not too strongly, for exceeding pressure is no use by grinding, it is an obstacle because the good must go repeatedly through the rollers"[11] and too much pressure would harm the stock. Snider's suggestion that the rollers were not true was denied and the problem of "shocking" ascribed to the poor alignment of the rolls. It was suggested that a "mechanism" be ordered to ensure that the rolls lay in a parallel bed.

Other helpful information included in the letter was a description of how to make "grit number 4," the size of grit required for the rollers. A pattern of this grit and the middlings, flour and bran made from it was proffered with an explanation of their process. After the fruit had been "pointed" or separated from the beard and germ it was milled high on stones (*hoch geschroten*) for the first break which made a high percentage of grit number 4. These were sent to the roller machine and the result to the meal cylinder or bolt. The "resting" in the cylinder (the tailings made up of the coarse grits and middlings) was sent to the grit cleaning machine or *Griesputzmachinen* (purifier) and the cleaned grit was returned to the rollers and reduced to flour which was bolted. Bran was "dissolved" on millstones, perhaps into the dark flour made into European "black" bread.

A large part of Hoerde and Company's last letter of January 1876 in the Snider family papers provided a solution to another problem common to millers of the day using iron rollers: the problem of caked meal. Because of the roller's great pressure, germ and flour often caked together so good flour was wasted with the germ. To remedy this situation, the use of a centrifugal bolt was advised. Hoerde's *Schlauch centrifugalsichter doppelt mit Schalencylinder* was described as their best machine.[12] The left half was the centrifugal cylinder covered with cloth material in which the good but caked flour and middlings were loosened and the "coarse middlings" (germ) separated. The right half was the *Schalencylinder* clothed with silk through which flour was bolted. This machine they strongly urged Snider to order if he wanted to mill roller flour economically. Storck and Teague (1952) wrote that the centrifugal reel invented in 1861 by Gustave Lucas of Germany first became known in America at the Cincinnati Milling Exposition in 1880.[13] There is no evidence that Snider imported Hoerde's best machine, though a description of a *Centrifugal-Sichtmaschinen* patented by Martin was among the family papers (Fig. 39), and possibly he did order it or one of the others in Hoerde's catalogue.

Hoerde's last letter of 13 January 1876 ended with their wishes to Snider for a happy New Year and their hope that now he would be able to "harmonize" his method of grinding with their country's method - a difficult feat still since one of the tasks remaining was to make the mill automatic. Richmond wrote that one of the "pioneer miller's difficulties" was to produce more grits.

> In those days there were no elevators to lift and discharge the products from the various machines, and the product was caught in bags and put through the same machine five or six times before the reduction was of the right fineness for the best quality of flour. In other cases the product was caught in bags in the basement of the mill and carried up several flights of steps, and poured into a hopper feeding the next machine.[14]

Most Canadian mills of the 1870s using millstones were automated, but not so Austrian and Hungarian mills where manual labour was cheap and expected. One of the many tasks of North American millwrights installing roller systems was to devise a way to economically automate the process without injuring the quality of flour.

Unfortunately there is no more information telling how the system was automated and how the mill was equipped to

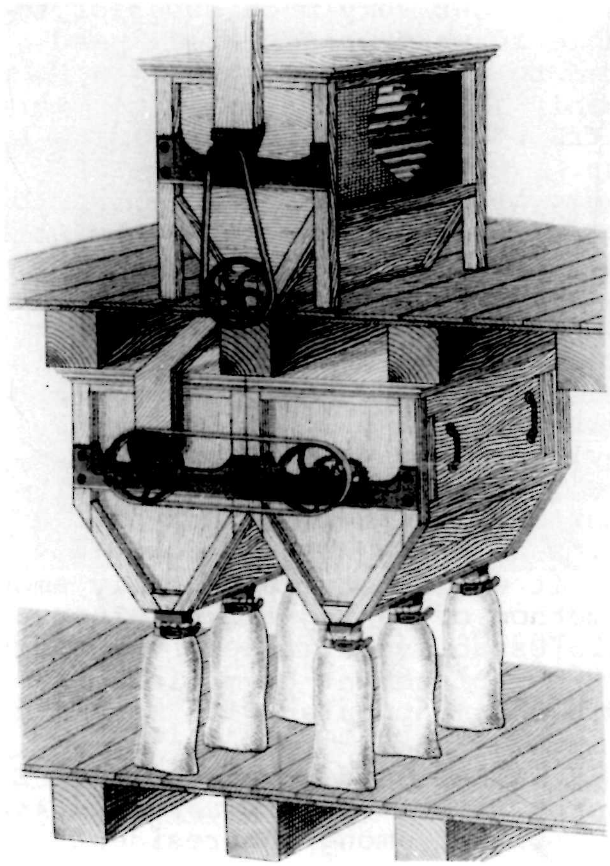


Figure 39. Centrifugal flour bolt patented by Martin ca. 1875 and manufactured by Escher, Wyss & Co. of Leesdorf, Austria. (*Archives of Waterloo Historical Society, Snider Family Papers.*)

produce merchantable flour by this combined system. There may have been a similarity between the rollers installed at the St. Jacobs mill and the first Canadian manufactured rolls turned out by a Waterloo foundry in 1876 for William Snider,[15] one of E.W.B.'s brothers. William became an owner of the Union Mills in Waterloo in 1879, a mill previously owned by a group of people one of whom was his father, Elias Sr.[16] Considering the co-operation between members of the Snider family, it was possible that William's rollers manufactured in Waterloo, presumably for his Waterloo mill, were based on the Austrian design of those imported by his brother, E.W.B., or they may have been quite different. Perhaps some of these locally made rollers were tried out at the St. Jacobs mill or the New Dundee mill during the experimental period.

W.M. Stark stated that after E.W.B. had experimented with the imported rollers and gotten them to work, he was able to produce "a flour very much superior to what he had hitherto been able to make on stones,"[17] and some of this was exported to Stark's London firm. No date was given but it was probably sometime in 1877, the year that Snider registered his trademark *Walzen* (roller) for his choice new roller flour.

Interestingly, the gazetteers and directories of Waterloo County of 1877 and 1878 made no mention of the rollers installed in the St. Jacobs mill but merely stated that it was "a large flour mill with seven run of stones capable of packing 120 barrels of Haxal flour daily."[18] This was the flour made by John Brown's patented machinery using the gradual reduction method with millstones. Even E.W.B.'s new mill at Dundee, acquired on 4 July 1876, was described as having four runs of stones, being 100 feet by 40 feet and five stories high.[19] The omission of roller milling at Snider's mills in these directories possibly reflected E.W.B.'s unwillingness to advertize the new technique before it was recognized locally among consumers as an approved method of making flour. Innovation, especially in old established trades, was often met with suspicion, and the replacement of millstones, time-honoured in the Bible, would be unpopular with many millers as well as citizens.

By 1881 only Samuel Snider, an uncle of E.W.B., was noted as a roller miller in the *Illustrated Atlas of Waterloo County*. Listed among the residents of Bridgeport, very small print acknowledged Samuel S. Snider and Peter Shirk as "Merchants, millers, flour made by the roller gradual reduction process."[20] Among other illustrations was a large engraving of their mill, previously known as the Lancaster Mill but now bearing the name "Lancaster Roller Mills."[21] The Snider Family Papers contain the original engraving, dated 1877[22] (Fig. 40), evidence perhaps that the mill was fitted with rollers even then. On 29 April 1878 Shirk and Snider registered a trademark for their roller flour naming it "Deutsche Buda"[23] after the town in Hungary, Buda, where roller flour originally was made famous. It may have been this flour that won a diploma in 1878,[24] made from winter wheat.

Though the atlas divulged the secret of rollers at the Bridgeport mill in 1881, it made no reference to those in E.W.B.'s mills. Except for an engraving of the St. Jacobs mill and Snider's home,[25] (Figs. 42, 43) and a biographical sketch of E.W.B. - his milling "success" and political career[26] - there was nothing to suggest that revolutionary techniques were in progress (Fig. 41).

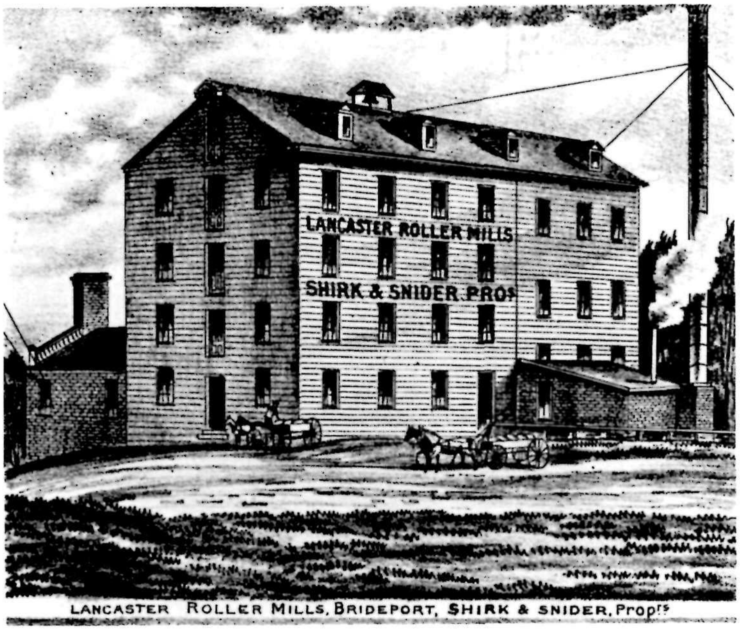


Figure 40. Flour mill at Bridgeport, Ontario, ca. 1877, owned by Samuel Snider and Peter Shirk. Before long many Ontario mills newly installed with rollers would be renamed to include the word roller (Cumming 1972a, p. 29).

Figure 41. Portrait of E.W.B. Snider published in 1881 when he first served in the provincial legislature (Cumming 1972a, p. 29).

Figure 42. Residence of E.W.B. Snider, St. Jacobs, Ontario, in 1881 (Cumming 1972a, p. 18).

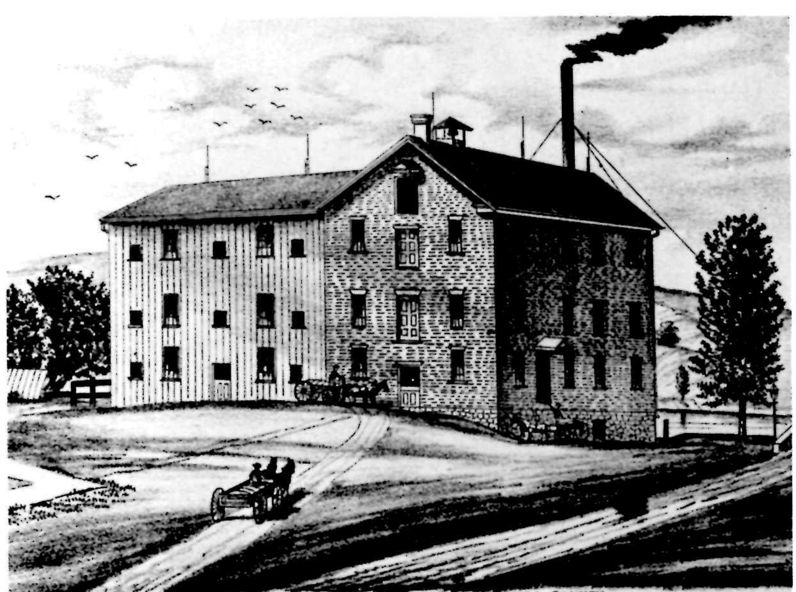


Figure 43. The Pioneer Roller Flouring Mill on the Conestogo River at St. Jacobs, Woolwich Township, in 1881 (Cumming 1972a, p. 18).

THE ALL-ROLLER SYSTEM OF E.W.B. SNIDER

> *It must not be assumed that the importation of this machine from Austria overcame the flour milling problems. It only opened up greater possibilities. Improvements were the order of the day for years to come, and Mr. Snider, ever on the alert for further advancement, always installed the latest improved machinery.*[1]

It has been written that by 1878 E.W.B. had "as near as possible a full roller flour mill"[2] and that in 1881 he had a "full roller mill."[3] Undated data among his family papers make it difficult to known exactly when E.W.B. succeeded in getting porcelain rolls, which together with iron rolls would make an all-roller system. As his correspondence with Hoerde and Company bears out, ever since 1875 he had wanted to import porcelain rollers. Sometime between 1878 and 1881 he succeeded in getting them.

The source of Snider's porcelain rolls is not certain; he solicited information about them from three different manufacturers after 1877. The E.P. Allis firm of Milwaukee, Wisconsin, was one of these, and their brochure provides a glimpse of how porcelain had fared since their initial trial in Budapest in 1874.[4] In 1877, the Allis firm obtained sole rights to manufacture Wegmann's rollers in America. According to prominent American millers (whose testimonial letters of 1877 were included on the back page of the Allis brochure), Wegmann's porcelain rolls were vastly superior to the iron rolls they were using to mill flour. The superiority of porcelain, some wrote, lay in their economy of power and their greater capacity than iron rolls of the same size. Light in weight, with self-acting pressure, differential motion and convenient adjustability, they were more controllable than heavy iron rolls. Whereas iron flattened and caked a part of the middling so they were passed off with the germ wasting a great deal of good flour, porcelain produced flour and fine sharp middlings, easy to separate in bolting. Flour from porcelain rollers was whiter than flour from millstones could ever be, though it was confirmed that millstones had the advantage of a larger capacity.

Dimensions of the machine depicted on the Allis pamphlet showed that it was 5 1/2 feet high, 2 feet 10 inches wide and 3 1/2 feet long. The driving pulley was not quite 2 feet in diameter and revolved at a recommended speed of 180 rpm. The capacity of the mill varied according to the size of the middlings being milled, but ranged from 2 1/2 to 3 1/2 cwt (up to 350 lbs, not quite two barrels) per hour. It required 1 1/2 horsepower to drive and weighed 13 cwt or half a ton (Fig. 44).

Information on a slightly different model of porcelain rollers, larger and heavier with greater capacity, was also solicited by E.W.B. from a Swiss mill furnishing firm, Weber and Bunzli of Uster, just east of Zurich, which had an office in Vienna, Austria.[5] Undated, their brochure depicted a different view of what may have been a later design of Wegmann's rollers in which the rolls were moved by belt rather than toothed gears (Fig. 45). Other differences between it and the Allis machine were obvious in the frame. Because of these differences or improvements, it is likely the Weber and Bunzli model was a later design than the 1877 Allis model. By 1880 another improved design with a solid frame and belt gearing was manufactured by E.P. Allis and Company (Fig. 46).

It was from the letter of Wilhelm Braun, a mill engineer and manufacturer at Carlsbad, Germany (now Kharlovy Vary, Czechoslovakia), that we know Snider had procured porcelain rollers, probably from Braun. Writing on 3 March 1881, E.W.B. expressed his dissatisfaction with the porcelain rolls working in his mill. In reply, Braun urged him not to change to chilled iron rolls and promised to replace the porcelain if there were surface flaws or other imperfections. He asked the differential speed used by Snider's miller and whether he crushed his middlings "only". For a free trial Braun proposed sending Snider his patent roller mills with either two or four rolls. These stands were almost noiseless, required no oil and had a "mechanism" for adjusting the distance of one roll from another "from 1/100th of a line and three or four lines."[6] This would enable Snider to "grind rollers in the very same roller mill without taking them out at all, thus saving great labour and placing of a special machine for grinding." Though unclear, this might mean that the porcelain rollers would be adaptable for grinding wheat or reducing middlings, jobs normally done on two separate sets of rollers. There is no further evidence in the Snider Papers that Braun shipped his porcelain rollers to St. Jacobs or any other mill of E.W.B., but a postscript suggested that further communication between the two, perhaps a meeting in Ontario, might occur; Braun ended his one and only letter in the Snider papers by thanking E.W.B. for his "invitation" which he would consider within the year.

The New Dundee mill where Hillborn stated the all-roller system was tried in the winter of 1880-81, eventually was installed with "12 pairs of rolls, seven were of iron manufactured by the Goldie and McCulloch Company of Galt and five pairs were of porcelain imported from Austria."[7] "Later" the porcelain rolls were replaced by iron rolls, and though no date was given, the 1884 gazetteer and directory of Waterloo County described the New Dundee mill with nine sets of rollers capable of milling 100 barrels a day. The difference between 12 pairs in 1881 and 9 sets in 1884 may reflect the change to iron rolls.

Richmond[8] wrote that the period from 1875 to 1895 was one of transition when improvements installed one year might become obsolete the next, and that fortunes were sacrificed because of discarded machinery and millwrights' wages. Because of these changes it is futile to speculate on any of the mill setups at the Snider mills at any one time, particularly when only a few clues are given. Hilborn wrote that the semolina purifier used with millstones and gradual reduction was no longer needed when porcelain rollers were installed.[9] The Snider family papers contain four undated probably British plans for automatic partial and all-roller systems suited to small and medium mills. The "medium roller mill plant"[10] was depicted with four sets of fluted three-roll mills for breaking wheat, and four sets of smooth three-roll mills for reducing middlings (Fig. 47). A pair of "cracking rollers" for splitting wheat, ten types of centrifugals for separating various stocks and two purifiers completed the machinery requirements for this system priced at £1,420.00. These telling designs may have been planned specifically for Snider as early as 1875, or they may have been handed to him by W.M. Stark, his British connection, in 1872 when they first met.

The *Gazetteer and Directory of Waterloo County* for 1884-85[11] recorded the daily the capacity and number of sets of rollers and runs of millstones in six mills owned by members of the Snider family as follows:

Conestogo Mill of Menno Snider	7 sets	2 runs	80-100	barrels
New Dundee Mill of E.W.B. Snider	9 "	-	100	"
German Mills, "Champion Roller Mills" of Tillman and Amos B. Snider	9 "	-	125	"
St. Jacobs, "The Pioneer Roller Flouring Mills" of E.W.B. Snider	10 "	-	150	"
Bridgeport, "The Lancaster Roller Mills" of Shirk and Snider	17 "	-	200	"
Waterloo, "Union Mills" of William Snider	24 "	3 runs	300	"

Of the six mills, only two were equipped with millstones, perhaps used for gristing or chopping rather than for a partial roller system. Interestingly, the two all-roller mills containing nine sets of roller machines (at German Mills and New Dundee) each had different capacities, possibly because of a difference in machine design. The capacity of the Snider family mills together amounted to about 950 barrels a day in 1884, not far from the 1,100 barrels produced daily at the Norris roller mills in St. Catharines,[12] but very little compared to the 4,500 barrels produced at the largest mill in the world in 1882, the Pillsbury A in Minneapolis.[13]

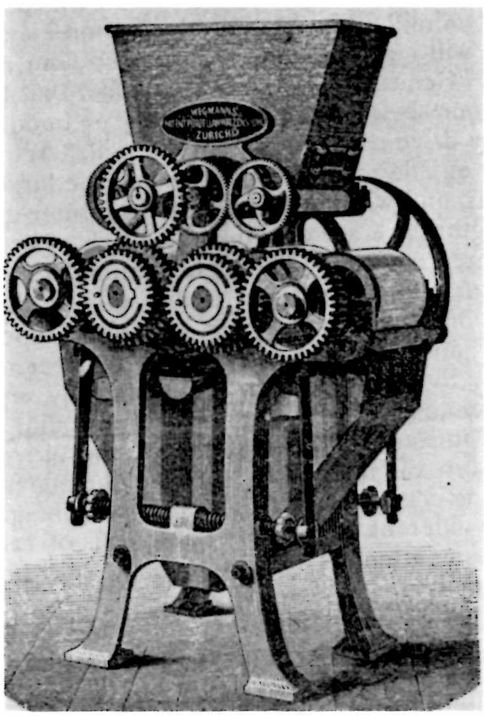


Figure 44. Model of the porcelain roller mill patented by F. Wegmann and sold by E.P. Allis of Milwaukee in 1877. (*Archives of Waterloo Historical Society, Snider Family Papers.*)

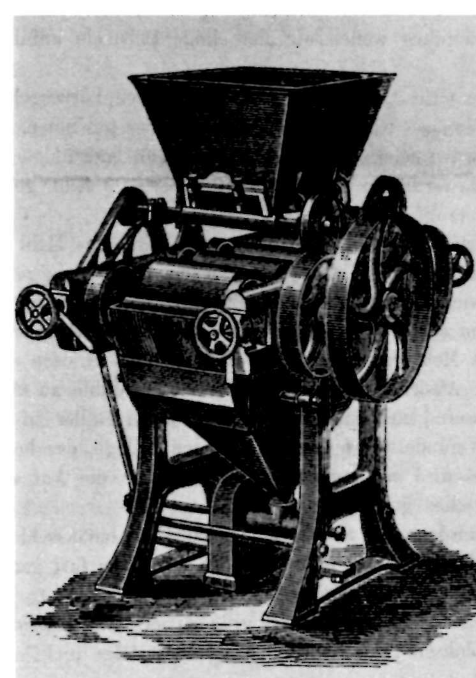


Figure 45. Model of the porcelain roller mill manufactured by Weber and Bunzli of Uster, Switzerland, in the 1870s. (*Archives of the Waterloo Historical Society, Snider Family Papers.*)

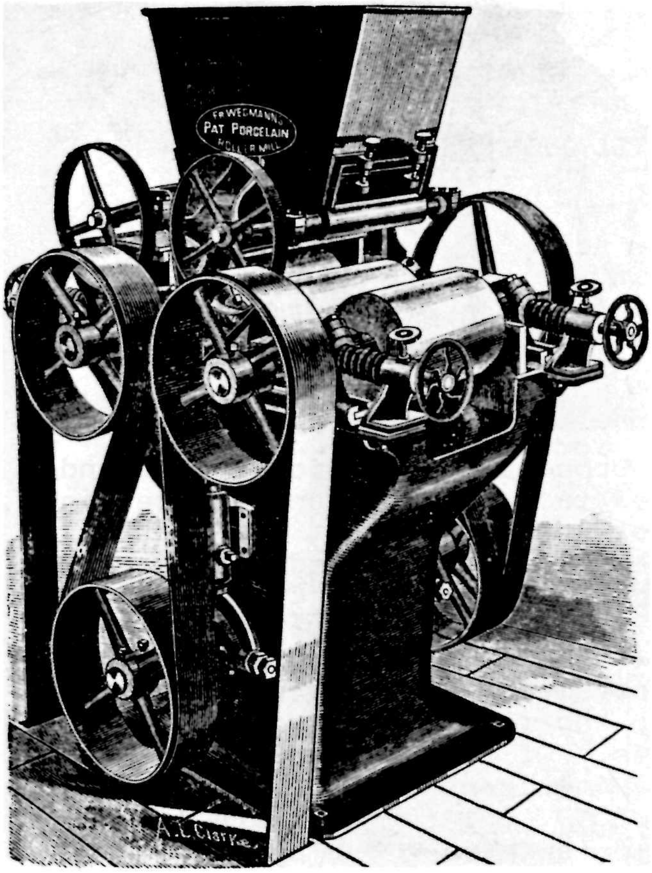


Figure 46. Model of F. Wegmann's porcelain roller mill manufactured in the United States with an improved stand in 1880. (R.J. Abernathy, op. cit., p. xi).

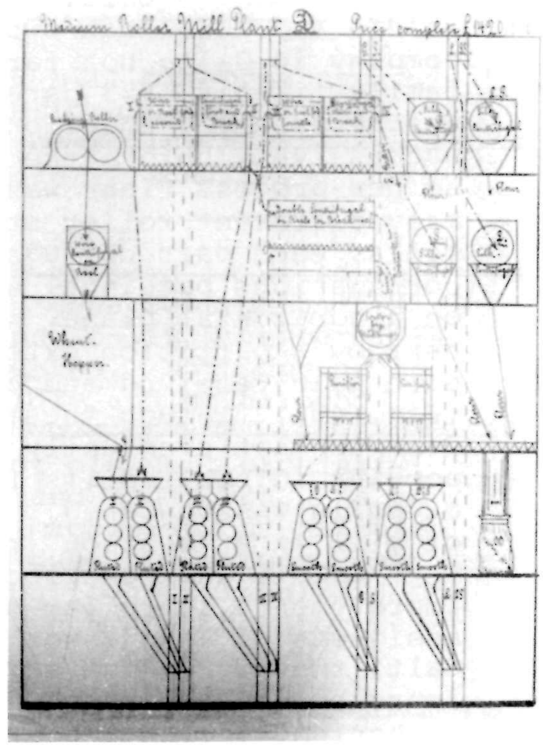


Figure 47. Plan for an automated medium-sized roller mill ca. 1880. Dot-and-dash line indicates flow of stock from machine to machine and the broken line represents elevators. Flow of grain at the beginning and flour at the end is shown by unbroken line. (*Archives of Waterloo Historical Society, Snider Family Papers.*)

ROLLER-MILL PATENTS

> *The great revolution in the milling industry in Canada and the United States came between 1875 and 1885 when the roller or Hungarian system of milling was introduced.*[1]

Imported rollers were brought to Ontario in 1875 and though rollers were reported to have been manufactured in Waterloo in 1876, it was not until 1878 that the first Canadian patent for a roller mill was granted - this to Darius C. Newell, an American from New York City, about whom nothing is known. From 1878 on the number of patents increased so that by 1886 46 had been granted, not only for roller mills and their improvements but also for disc mills and disintegrators, another short-lived type of machine used in gradual reduction systems. Of the 46 patents, 10 were granted to Canadians, 35 to Americans and one to a Scot (see Append. B, Manuscript Report No. 201 for complete list).

The first roller-mill patent taken out by Canadians was granted to John Goldie and Hugh McCulloch on 21 June 1883. Goldie and McCulloch owned a large foundry and millwrighting company in Galt, not far from the roller mills of the Snider family. Their 1883 patent rollers "combined in one machine the necessary graduations through which grain has to pass successively before the desired fineness is attained"[2] so new process flour was completed in one machine instead of many different roller stands. Four pairs of chilled iron rolls, each pair corrugated with a diminishing number of corrugations per inch, were contained in one stand and lay on a horizontal plane. Each pair was separated from the next by a partition extending from hopper to receiver so each pair received and discharged a separate stream of stock (Fig. 48). Though these rollers were different from roller designs that eventually became standard, they were probably popular in small mills for which their compact arrangement of rolls was designed. Dedrick (1924) referred to this type of mill as a "section" roller mill.

Goldie and McCulloch took out a second patent for improvements to roller mills in the summer of 1883. As assignees of John Esson Wilson, a mechanical engineer of Galt, they were granted a single patent for two of Wilson's improvements, an "automatic roll feed" and a "set back mechanism."[3] The feeder was designed to solve the problem of feeding grain evenly along the rollers' length. The set-back mechanism allowed rolls to separate evenly and

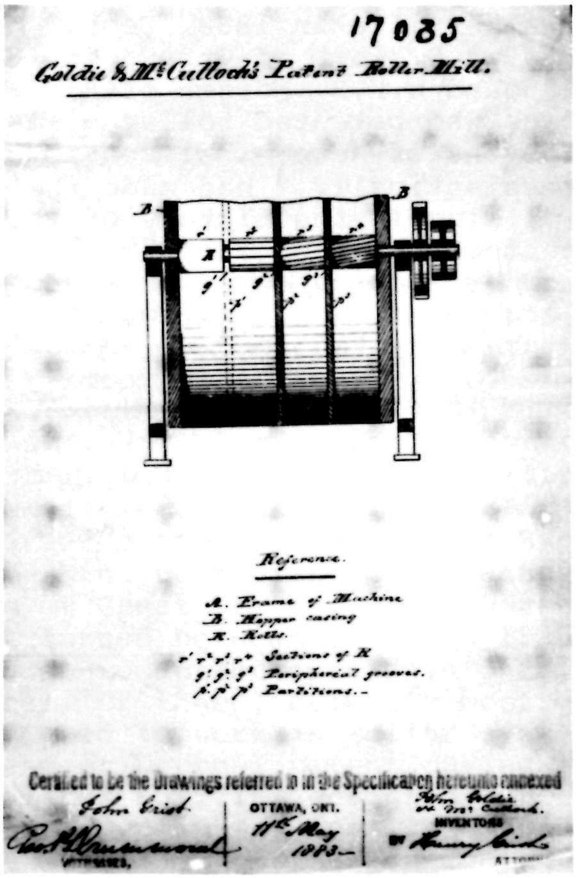


Figure 48. Section type of roller mill patented by Goldie and McCulloch of Galt, Ontario, in 1883. This view shows only half of each pair of rolls. (*Canada. Department of Consumer and Corporate Affairs.*)

rapidly. Two additional patents were granted to Wilson a year later similar to his first two. On 6 September 1884 his feed spreader for roller mills, and on 29 November 1884 his adjustable roller mill, were patented. Both appear to have been designed to work on the Goldie and McCulloch rollers.

J.E. Wilson became well known for his mill machinery and position with the firm of Goldie and McCulloch. As a mechanical engineer, draughtsman and machinist, he patented mill furnishings from flour bolts to dust collectors. By 1886 he was foreman of Goldie and McCulloch's planning department arranging mills with furnishings - the Stockwell Roller Mills were set up by him with many of his own patents. Known as a milling expert in his day, he was responsible for arranging many of the roller systems in Ontario.

Other Canadians were granted roller mill patents: Thomas Reid of Walkerville in 1883, George Malcolm of Tavistock in 1884, J.H. Lamb of Ottawa in 1884, W. Hutchison of Ottawa in 1885 and W.H.B. Morgan of Ridgetown in 1885.

The Americans who patented roller mills in Canada included John Stevens of Neenah, Wisconsin. He, it was claimed overenthusiastically,[4] had made the greatest improvement in milling in the history of the world with his inventions, patented in Canada in 1880, 1881 and 1884. Other better known roller patents used in Canadian mills included three granted to W.D. Gray of Milwaukee between 1881 and 1883, three granted to D.W. Marmon of Indianapolis in 1884, and five to the Case Manufacturing Company of Columbus, Ohio, in 1884. Inglis and Hunter, a mill outfitting company in Toronto and Hamilton, secured rights to the Case manufactures and installed them in many Ontario mills in the 1880s.

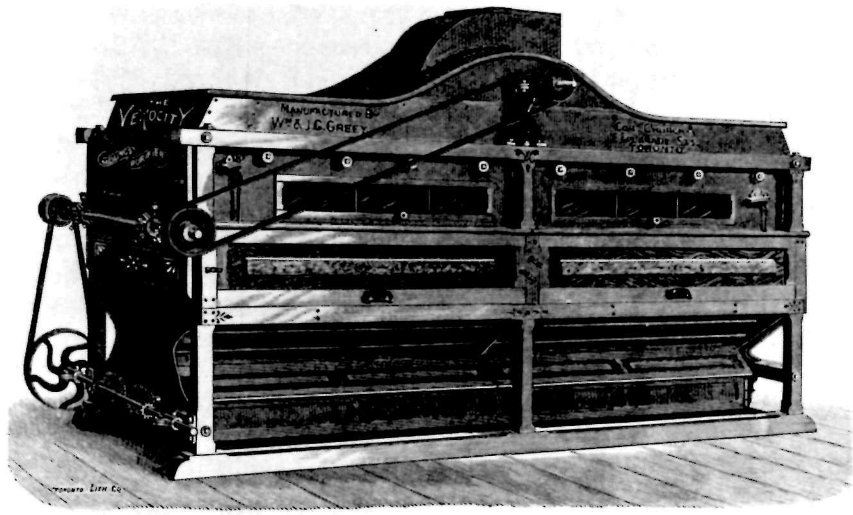
PURIFIERS

By 1887 purifiers were "so universally used, and the necessity for their use so well understood and appreciated by all intelligent and progressive millers"[1] that purifier manufacturers no longer had to promote them. Purifiers were an established fact for gradual reduction milling.

In Canada 31 patents for purifiers and their appliances were granted between 1878 and 1886, a few of these extensions of former patents (see Append. B, Manuscript Report No. 201). Nine were granted to Canadian residents, two to residents of Great Britain and the rest to Americans. Almost half were issued between 1883 and 1886, the period when roller gradual reduction spread in Ontario and North America in general. Of these, probably most were specifically designed to work in roller systems.

Perhaps the most unusual patent during the period was an electric middlings purifier designed to be used in millstone gradual reduction systems. In Canada this patent was granted on 4 May 1880 to Kingsland Smith of New York and T.B. Osborne of New Haven, Connecticut. In 1881, an article in *The Scientific Canadian*[2] gave details about its development and operation. A series of hard rubber rolls were electrified by the friction of hair, silk, wool or any suitable material so the rolls attracted bran whch was then brushed into a bran receiver. Floury particles were prevented from being attracted with the bran. It was claimed the machine produced a greater yield of flour than other machines of the day. Not only flour was saved, but also power and space were conserved because this purifier excited less dust about the mill. The hazards of dust explosions were overcome and the need for air purifiers diminished. (Air purifiers and dust collectors were recent innovations in mills following the disastrous mill exploston in Minneapolis in 1878, and were necessary to disperse flour dust especially in large gradual reduction mills.)

The "Velocity" middlings purifier manufactured by William and J.G. Greey of Toronto in the 1880s was popular in millstone and roller gradual reduction mills in Ontario. In 1883, one model was reportedly installed in a small 50-barrel millstone mill on Manitoulin Island,[3] and in 1887 possibly an improved version of the 1883 model was featured in an article. It was described as Greey's "new" Velocity purifier (Fig. 49) and was probably adapted to roller mills.



GREEY'S NEW "VELOCITY" MIDDLINGS PURIFIER.

Figure 49. The Velocity Middlings Purifier manufactured and sold by the Toronto firm of Wm. and J.G. Greey in 1887. (*Dominion Mechanical and Milling News [May 1887], p. 1.*)

BOLT MACHINES

> *The manufacture of flour may be divided into two great classes, viz: the reduction and separation; one of which is not possible without the other, and both necessary in the manufacture of flour. Bolting therefore may be classed as the index to reduction, showing how to proceed and when done.*[1]

After every break and reduction it became practice to bolt the ground stock so its constituents could be channelled separately to the next stage of the process. A variety of bolts, either round or polygonal, covered with suitable cloths, was employed, each to do a specific job within the system. Since systems varied, arrangements varied, and each arrangement depended on the work done by the rollers. So many improved bolts were offered by inventive minds during the roller revolution that it was said the roller-milling era brought with it a greater variety of bolting machinery than ever before.

This multiplicity is best illustrated by comparing the arrangements of two mills producing 100-200 barrels daily, one using the old process of 1853[2] and the other an all-roller process of 1888.[3] The former mill fitted with three runs of millstones required six polygonal reels 20 feet long; the two upper reels were for superfine flour, the two lower were return reels and the lowest included a middlings bolt and a bran duster. The roller mill with 14 pairs of rolls required eight flour-dressing machines, two centrifugal reels, six scalpers, one bran duster and one shorts duster. Such an assembly of bolting machines combined with purifiers required dust collectors and dust rooms to deal with the large amount of flour dust.

One of the more important types of bolt used in roller milling was the centrifugal bolt. Invented in Europe, it was designed with fast-moving wings inside the reel to break up flaky flour formed by rollers so flour could be bolted effectively. Clothed with various silks and coarser cloths, the centrifugal reel was used instead of or in addition to flour dressers. It was an efficient machine and had a large capacity compared to ordinary flour bolts. It came to be criticized especially by millers of hard wheat, however, for its fast and harsh action which left flour specky, wore out silks and deteriorated stock. Since the degree of flaking depended on the condition and variety of wheat and the pressure of rollers and other factors, mills could be arranged with gentler machines. Differential reels were a gentler type of bolt, and throughout the 1880s a variety of other improved flour bolts and dressers were devised, some with buckets and elevators inside to distribute stock evenly. Mill-furnishing firms' catalogues and patents of the period show the variety of bolts conceived, some used with centrifugals and some in their place.

Scalpers or preparatory bolts were another type of bolt that became especially needed in roller and millstone gradual reduction systems. Used in the break section of the mill primarily, scalpers separated stock so only the coarse was sent to the next break while the fine was channelled elsewhere, perhaps to a grader. Graders were reels that separated various grades of middlings (before their purification) from fine flour, which was sent to flour reels or dressers, or for packing. Flour dressers were clothed with finest silks to separate better qualities of flour channelled from reduction rollers. Dusters were reels specially clothed for cleaning the fine dust clinging to bran and middlings.

This cumbrous accumulation of bolting equipment changed with the invention of the plansifter of Carl Haggenmacher of Budapest about 1887 (Fig. 50). His device scalped, graded

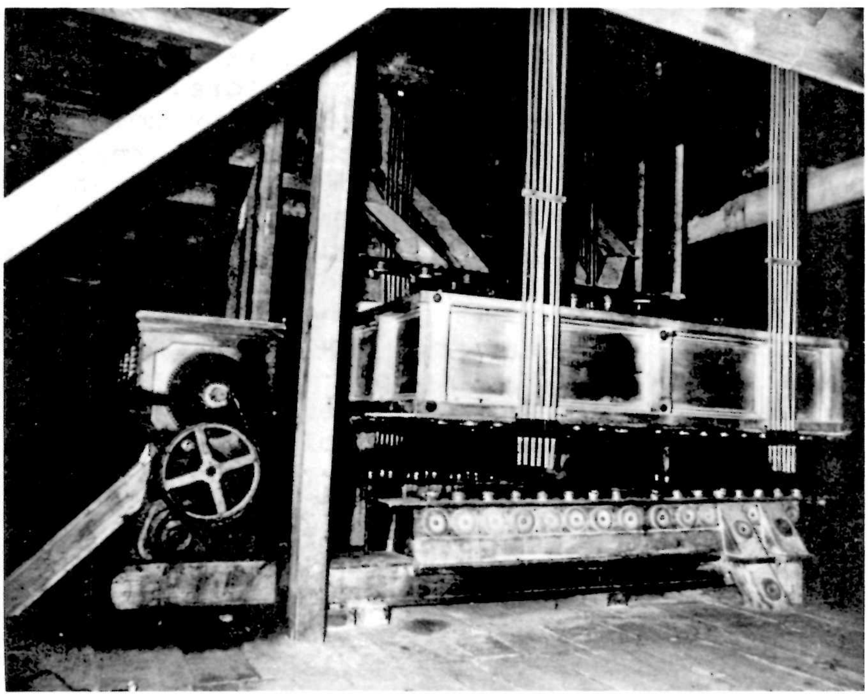


Figure 50. Plansifter of Carl Haggenmacher furnished by Wm. and J.G. Greey, Toronto, Ontario, in 1894. This invention revolutionized bolting methods in flour mills.

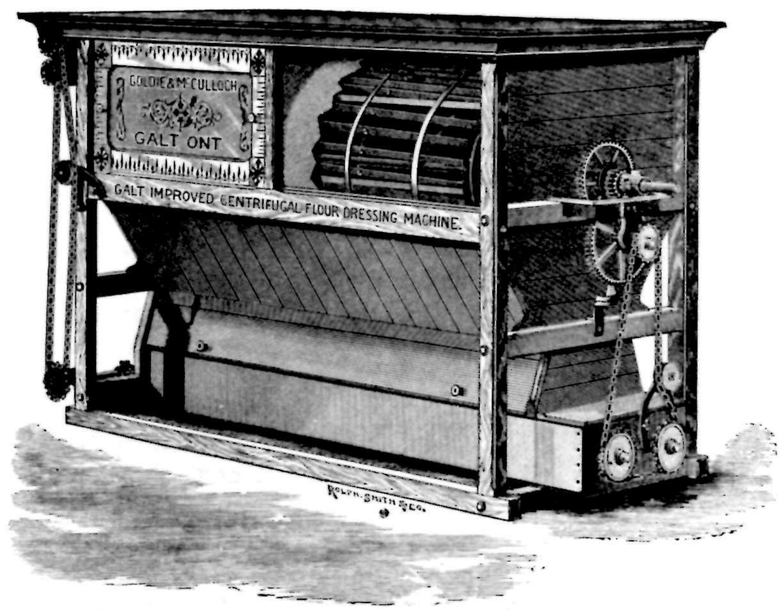
and dressed flour, taking up less room and requiring less power than the other machines. For example, when 90 plansifters furnished the huger Pillsbury A mill in Minneapolis in 1894, they eliminated 300 reels, 900 pairs of gears, shafts driving 600 short conveyors, 50 scalpers and graders and 20 centrifugal reels so the mill required 200 horsepower less than before. The invention of the plansifter began a trend of invention away from the revolving reel toward bolt machines with flat sieves moving with a rotary motion.

European manufacturers of bolting cloth kept up with roller milling, weaving reinforced cloths stronger, more regular and with greater capacity than before. One French manufacturer used silk threads made "absolutely" cylindrical by the twist, an operation that at the same time increased their elasticity and tenacity.[4] Grit gauzes for middlings and grits were manufactured by Viennese weavers heavier and stronger than silks. Various grades of grit gauze were given numbers which corresponded to the number of threads to the Viennese inch. Except for fine wire cloths used on dusters, scalpers and country bolts, as well as some non-silk bolt cloths manufacturable in Canada, most cloths (particularly silk cloths) were imported from Europe. A silk numbered as high as 16 was used by Baldwin in 1887 in his Aurora mill to separate patent roller flour.[5]

Canadian patents granted for bolting machinery in the 10 years from 1875 to 1886 were six times the number granted since the beginning of the patent office in 1824. Of the 37 new machines listed, 20 were designated as either a "bolting apparatus" or a "flour bolt," 8 were flour dressers, 4 were centrifugal flour bolts or reels, one was a combined bolter and duster, one a bran cleaning machine, one a scalping reel, one a combined bolt and purifier and one a flour box and sifter. Detailed study of the specifications may show that those referred to in general terms as flour bolts were specific types of bolts, perhaps centrifugals or scalpers. Other bolting patents were granted for a flour bolt conveyor, a means of manufacturing bolt material, and devices for tightening and stretching bolt material, bringing the total number of bolting apparatus patents to 41.

The most active patentee was George Thomas Smith of Jackson, Michigan, in 1871 co-inventor in Minneapolis with Edmund Lacroix of the middlings purifier (see Part IV). In 1884 Smith founded the G.T. Smith Middlings Purifier Company in Stratford, Ontario, a company that became famous for outfitting flour mills across Canada. Between 1883 and 1886 Smith and his various assignees were granted nine patents for a range of bolting apparatuses. Other patentees from Ontario included L. Baxter of Brantford (associated with the Waterous Engine Works), M. Crawford of Wiarton, J. and J.

Riddel of Packenham, A.L. Battson of Morrisburg, James Huxtable of Hornings Mills and Isaac W.W. Plewes of Toronto. James Esson Wilson, the engineer employed by Goldie and McCulloch of Galt, was granted two patents for flour dressers in 1884 and 1886, the latter a centrifugal flour dresser (Fig. 51). In 1886 one of these bolts was installed



CENTRIFUGAL FLOUR DRESSING MACHINE

Figure 51. Centrifugal flour dresser manufactured by Goldie and McCulloch of Galt in 1886. (*Dominion Mechanical and Milling News [Nov. 1886], p. 15.*)

at the Stockwell Steam Mills with a specially devised conveyor ingeniously buit to prevent choking and fire caused by friction in the conveyor box. A. Dobson of Beaverton, Ontario, was another who patented a flour dresser (Fig. 52), which was installed in Dobson and Campbell's Beaverton Mill. There, in 1887, it worked with Goldie and McCulloch rollers in what was claimed to be "the only mill in Canada using an entire flour dressing system"[6] - a contrast to centrifugal systems of the day.

Of the total of 41 Canadian patents granted for bolting machinery between 1876 and 1886, 31 were assigned to American-based inventors. Johnathan Mills, who contrived his own system of flour making, was one of these and to him was granted the first Canadian patent for an improved centrifugal bolt in 1882. Holcomb and Heine of Silver Creek, New York, makers of Excelsior mill machinery under the firm known as Huntley, Holcomb and Heine, patented improvements to centrifugal reels in 1883, and Heine patented a flour bolt in 1886. W.D. Gray of Milwaukee, Wisconsin, was granted a patent for his improved scalping reel in 1886, to be used in all probability with his patented roller mills. The Knickerbocker Company of Jackson, Michigan, patented two bolting apparatuses in 1884 (see Append. B, Manuscript Report No. 201 for complete list).

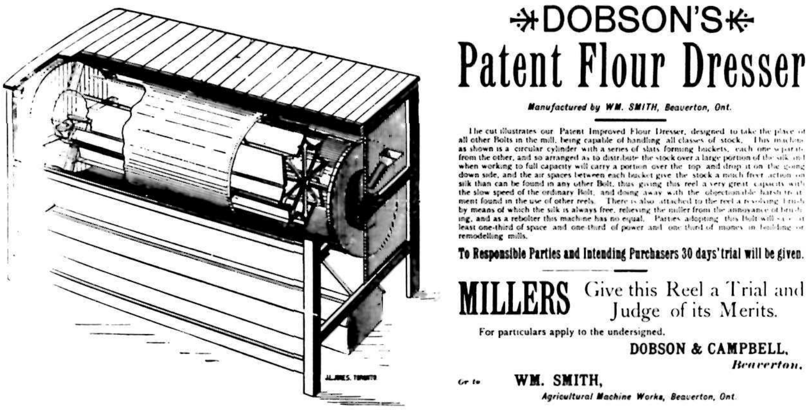


Figure 52. Flour dresser patented by A. Dobson in 1886 and manufactured at the Agricultural Machine Works, Beaverton, Ontario. (*Dominion Mechanical and Milling News [August 1887], p. 31.*)

GRAIN

The quality of spring wheat in Ontario had deteriorated by the 1870s partly due to poor soil management and weakened seed. Its strength was poor and its yield per acre was low, but the demand for hard wheat was great owing to the new process of gradual reduction which made a strong flour much in demand by bakers. Ontario farmers strove to grow what millers wanted but could not compete with the plump spring wheat sown on the rich new soil of the American western states of Minnesota and Dakota. Some turned to other varieties of hard wheat. Wild Goose wheat, sometimes called Arnecta, was a coarse, hard, flinty spring variety difficult to mill especially on millstones. It made a strong darkish flour that millers mixed with winter wheat flour to upgrade it. A favorite substitute for spring wheat among farmers west of Hamilton was red winter wheat. According to some millers this made excellent strong bakers' bag flour, especially when strengthened with a little spring wheat flour.[1] Fife wheat was still the favorite of farmers and millers, however, and though new seed from Manitoba was brought to Ontario farmers in 1876, its harvests were not up to expectation except in areas where extra effort had been made to replenish the soil.

In 1879 to protect the farmer (whose worn out crops of spring wheat could not compete with the beautiful harvests of the western states), and to establish a degree of reciprocity, a tariff of 15 cents per bushel was levied on foreign wheat, previously allowed in free. This measure discriminated against Ontario millers who had been dependent on duty-free American wheat and recently had invested in the latest machinery for gradual reduction to mill grades of flour which could compete on the international market. Consequently, an order in council was passed in 1880 that allowed millers to grind and pack in bond wheat and other imported grains free of duty so long as the product was exported. Smaller inland millers and farmers were left out of this arrangement, however. One dissatisfied farmer believed it to be "one of the worst orders-in-council that could be adopted"[2] since it allowed the grinding of virtually duty-free grain at mills advantageously situated along railways, canals and ports.

By 1882 the 15-cent tariff on United States wheat was seen by many Ontario farmers as the measure that had raised the price of their wheat, in particular spring wheat so that by the 1880s it sold for more than winter wheat. Only a few realized that the new technique of gradual reduction by millstones and rollers (which had increased the demand for spring wheat in Ontario at a time when spring wheat was scarce), very likely played a part in raising the price of spring wheat. The strong bakers' flour thus made produced a bread "not only whiter and more nutritious, but given a number of pounds [would] yield more loaves."[3]

The reports of the Ontario Agricultural Commission in 1881[4] and the Select Committee of Enquiry regarding the Tariff in 1883 reveal how the farmer's choice of wheat crop - dependent on the local miller's technique of milling - varied during the early 1880s when milling methods were in transition. Wild Goose wheat, hard and flinty, was difficult to mill especially on millstones, but on rollers of Toronto mills it was made into a reasonable flour for bakers; hence farmers selling to progressive millers using rollers could grow it profitably. Softer or medium hard winter wheats such as "red winter" were more easily milled into a profitable flour on millstones than hard spring varieties; hence smaller, less progressive mills still using millstones could exist in winter wheat lands longer than those surrounded by spring wheat crops. Though it was generally agreed that Fife was the best of all spring wheat (the same as Minnesota wheat), yet it still required the gradual reduction process to mill it into a lively flour able to compete with the whiteness of winter wheat flour.

This difference in methods of milling different grain during the transition from millstone to roller (even old process millstone to new process millstone) explains the broad, seemingly erroneous statements made by farmers and millers queried by the select committee of the House of Commons on the tariff in 1882.[5] It was stated by Mr. Wheler, M.P., that millers did not want Canadian spring wheat. True, they and especially he did not want the worn out Fife or the hard flinty goose wheat then available. But what Wheler most likely meant was that millers like himself, owners of millstone mills using the old process, did not want spring wheat, the reason being they could not mill it into flour able to compete with roller flour being milled from northwestern wheat in roller-equipped progressive mills. His hope that red winter wheat be adopted by Ontario as well as Manitoba farmers in place of spring wheat was a hope typical of many millstone millers of the day. It was a hopeless hope and by 1886 he knew it. His mill at Meadowvale was sold to a new owner who immediately installed the latest roller equipment, and this to mill winter wheat.

The 857 bushels of Manitoba seed wheat brought east to Ontario farmers on 26 October 1876 was among the first of many grain shipments from the Canadian northwest. More for milling and trade were to follow. After 1879 when CPR lines extended from the east to Winnipeg, this western Canadian trade improved. By 1881 the Ogilvie Company with mills in Montreal, Goderich and Seaforth, Ontario, alone transhipped 200,000 bushels to eastern Canada, 10 times the amount it had brought east in 1878. In 1881 Shirk and Snider visited the west and made arrangements for constructing a grain elevator at Emerson. Throughout the 1880s these and other eastern mill owners went west building grain elevators and roller mills to profit from the golden stores of new wheat waving on the western plains, thus spelling the end of Ontario's spring wheat era.

The superior red Fife grain of the Canadian West called for changes in the inspection laws, changes that began in 1883 with a small amendment to the 1874 grain standard. Now flinty Fife wheat, if raised in Manitoba or the Northwest Territories, could qualify for grades higher than No. 2 spring wheat, whereas the old law had relegated it to a grade no higher than No. 2 spring wheat.

By 1885 all the standards that had been set in 1874 and 1883 were repealed and entirely new standards substituted which continued in effect until 1895. For the first time since standards had been set for grain in 1863, spring wheat was listed ahead of winter wheat, a sign perhaps of its new importance. "Extra Manitoba hard wheat" composed of red Fife wheat weighing 62 pounds per bushel was the choicest grade of spring wheat. Next in order were No. 1 and No. 2 Manitoba hard wheat composed of 85 per cent red Fife grown in Manitoba or the Northwest Territories. Three grades of "Spring wheat" of no specific variety were also listed, and after "rejected spring wheat," three grades of goose wheat were given. Winter wheats were divided into "Extra white winter wheat...pure, choice in colour, sound, plump and well cleaned" weighing not less that 60 pounds per bushel; "white winter wheat" in two grades; "red winter wheat" in two grades; and two grades of "mixed winter wheats." No. 3 winter wheat, 57 pounds to the bushel, was wheat not clean enough to be graded No. 2. Damp wheat of winter or spring varieties was to be reported by inspectors as "no grade," and sweating, bin-burned or wheat badly mixed with extraneous grains and seeds were "condemned." Mixtures of rice wheat (the same as goose or California wheat) or red chaff wheat with other wheats were excluded from inspection.

Thus it can be seen that by 1885 spring wheat of the choicest grades belonged to the western provinces. Winter wheat became the mainstay of Ontario wheat growers and was mixed with western wheat for strong flour or milled into pastry flour. Much Ontario spring wheat land was converted to other crops or to livestock, and more than ever mixed farming took the place of wheat farming in Ontario.

GRAIN CLEANING

In a prize-winning essay published in 1887 in the *Dominion Mechanical and Milling News*, W.J. Baldwin outlined eight fundamental steps of milling which he followed in his 150-barrel roller mill at Aurora, Ontario.[1] The separation, scouring and brushing of impurities and admixtures from his winter wheat was the first fundamental in milling. First a rolling screen separated seeds and impurities from grain, then an ordinary separator did a closer job; third, a gentle scourer with a rubbing action removed the strawlike dust and hairy ends, and a good brush machine removed any of the remaining loose scourings. The fifth step in cleaning was to split the grain down the crease using either a disc reduction machine or a set of rollers so the germ could be easily removed during the early stages of milling.

With the change to roller milling and its corresponding new approach to grain cleaning, progressive millers were offered improved types of cleaners. Millers continued to agree that cleaning was important, that gentler machines were better than harsh ones, but controversies were waged over "degerminators" used to split and remove the germ during the early stages of milling, and "decorticators" used to remove the outer bran covering. Some of these differing opinions of machinery stemmed from the varied characteristics of wheat and the fact that some machines were not suited to particular varieties. Other machines worked better with rollers than with millstones, and some did a bad job no matter where or how they were used.

Abernathey, writing in 1880 when rollers were just coming in and the majority of millers used millstones run high or low, defined basic rules for wheat cleaning. The separation of good from bad was very important; mills should be arranged with cleaning departments equipped for the worst crops so in good seasons some machines could stand idle. When wheat was very bad a second separator after the receiving separator was necessary to do a closer job removing oats, small weeds and cockle. A grader then separated the good from bad and broken wheat. A gentle smutter, then a polishing machine with brushes that did not break the grain's outer bran, finished the job. Whatever the method or machine, it was important that grain's coating be preserved and no attempt be made to remove or decorticate it, and that the grain never be broken since this exposed the white endosperm which then became prey to dust and scourings so the flour was affected. No attempt should be made to remove the germ either, since this was separable after milling.

Abernathey's prejudice against removing the germ was not held by all roller millers of the 1880s, many of whom like Baldwin split the grain to remove the germ in the first break using rollers (or as the last step in grain cleaning, however one wanted to differentiate). Once split from the grain, the germ was rolled flat so it was easily bolted from the finer grind. Those speaking against germ removal were millstone millers who had been persuaded, or misguided, to use degerminators, a harsh-action machine, on the mistaken theory that the darkness of stone flour was due to crease dirt in grain. By splitting grain open and scouring off the dirt and germ before milling, they expected to obtain a white flour better able to compete with roller flour, and in this they were sadly disappointed. Degerminators sometimes were so badly designed that they broke grain rather than split it and their scouring action created more dust and injured bran than was good for grain so the resulting flour was darker than ever. Admit it or not, some of the colour of millstone flour was due to the stones' action in pulverizing bran and to the heat of the stones as well as to crease dirt.

Decorticating or removing the outer bran was also a subject for discussion among millers of the period. Some claimed that no machine did a complete job, that harsh scourers and emery wheels only partly removed the bran so what was left came off in smaller particles than ever, and these were pulverized into dust impossible to remove from flour so flour was darkened. Chemical processes for decorticating were recommended according to one view recorded in the *Scientific Canadian* in 1880. Proven successful in Austria-Hungary, the process required soaking wheat for about 20 minutes in 15 pounds of English sulphuric acid, then thoroughly washing it in pure water first, followed by a second bath in water and soda before it was carefully spread to dry on linen cloths. Used on limited quantities of wheat, the method removed the outer bran (excepting that in the crease), but because it was slow, expensive and required large drying rooms, it could "hardly be called practicable."[2]

Murray Case, reviewing grain-cleaning methods in 1890, believed in washing all varieties of hard spring wheat, quickly, for one or two seconds only, so just enough water remained with the bran to toughen it but not affect the inner kernel. His technique after wetting was to elevate the wheat by suction to the top of the mill where it arrived dry and ready for tempering in the wheat bin. Case condemned the old method of "damping," that is, using warm water until the bran was moist and then rubbing it off in large flakes "with any kind of severe rubbing device" on the grounds that the kernel was left in a "half peeled condition" and not in the "splendid milling condition" claimed by the proponents of the method.[3] Even he himself had espoused the process earlier, but now he criticized it, writing that the remaining bran was so weakened it was pulverized into dust that coloured flour and was unsaleable. Case's new "instantaneous" method of washing was better than damping because the inner berry was unaffected and every berry was uniformly dampened. The scraping action of break rolls, rather than a decorticator or emery wheel, ensured a broader bran and white flour. He predicted that time and experience would demonstrate the superiority of his washing method so all wheats, soft and hard, except wheat damp and fresh from the thresher, would be so washed before milling. Interestingly, Case in 1890 agreed with Abernathey in 1880 that the wheat berry should be cleaned and polished without destroying the outer coating of bran. Harsh and severe sandstone cylinders used to decorticate, as well as fast-running emery wheels, had cost millers much before they had thrown out the deleterious machines.

Magnetic separators to extract pieces of metal accidentally mixed with grain began to be used in the United States once the wire binder became popular on western farms. According to Storck and Teague, Charles Espenshied devised the first in 1878 consisting of a simple set of magnets in a box that was placed where grain was in motion.[4] Later magnetic separators were more complex.[5]

ROLLER FLOUR

At present most of the flour manufactured in the country is manufactured by what is known as the roller process.[1]

Speaking in the House of Commons in July 1887, Mr. Costigan, M.P., explained the reason for the amendment to the flour inspection law before the house, and the need to give immediate recognition to the superior grades of flour being produced by rollers. What he did not include was that rollers had been introduced to Ontario mills as early as 1875 and since then had been producing much merchantable flour. The 1874 flour inspection Act, which recognized some of the new grades of flour made by millstones using the new process of gradual reduction, was outdated in the view of roller flour manufacturers. The lack of legal recognition for roller flour from 1877 to 1887 meant that it was selling below its value, especially in 1887, since it could only be branded "extra superior," the top quality that applied to stone-ground flour, less fine and darker than the top grade of roller flour.[2]

The slowness of the government in legally recognizing roller flour must have been discouraging to roller-mill owners. In 1885 the Dominion Board of Flour and Meal Examiners (chosen by boards of trade across the Dominion) met in Ottawa on 18 November and decided that a change was needed "in view of the revolution in the manufacture of flour during the last decade."[3] But the roller grades agreed upon by the Montreal Corn Exchange in February 1886 were too few, in the view of the Toronto flour examiners. Montreal's choice of one grade for winter and one for spring wheat was insufficient, and therefore the Toronto meeting, held in February 1886 shortly after the Montreal meeting, resolved to take action to have "patent process flours" recognized in the new act. They proposed that the fullest information possible be given to the Dominion Board of Examiners to guide them, and that the government be asked to pay the expenses of a commission of merchants or flour experts who would visit the principle flour centres in the United States and examine their rules and regulations before deciding on amendments. Whether this proposal was acted on is not known, but by the fall of 1886, an amendment to the old law of 1874 had been drawn up and approved by the Dominion flour examiners, and this was presented to the House of Commons as Bill 152. When mill owners learned, however, that the house was planning to break early in the summer of 1887 before considering Bill 152, an important delegation came to Ottawa from the Montreal Board of Trade to convince the government that the measure should be passed before the session ended.

The amendment thus pushed through the House of Commons repealed the previous definitions of all eight stone-ground qualities and substituted new ones. Now the very superior quality of flour made by the roller process was to be branded "patent (winter wheat)" or "patent (spring wheat)," and the second quality of roller flour was to be branded "straight roller." Third quality "extra," fourth "superfine" and another quality known as "strong bakers" could be manufactured by either roller or stones. By 1889 a fifth quality "fine" was added by amendment.

In a lecture delivered to the Natural History Society of Montreal in 1890, J.T. Donald defined roller-flour grades known as patent, strong baker's, graham and baker's graham.[4] Strong baker's, he said, made up about 54 per cent of flour and was from the exterior part of the grain containing a large proportion of gluten. It was somewhat dark because of bran and a high percentage of oil, but it was popular among bakers who could bake it into large loaves without the use of pans. "Patent flour" was milled from the inner portion of grain and though less glutinous, was whiter and used for family baking and finer qualities of bread; 40 per cent of flour made by rollers was patent. Graham flour he defined as whole wheat, and baker's graham as "partly graham" - perhaps with a little extra baker's added. Low-grade flour made up 6 per cent of roller flour and was branny, germy, had little gluten and was useful mainly for cattle food. Interestingly, Donald left out "straight" flour, a mixture of patent with strong baker's.

The names "patent," and "straight" flour appear to have originated in the 1870s when gradual reduction using millstones was introduced. Because the new millstone process using patented purifiers produced flour of superior strength, colour and baking qualities, new names were needed to distinguish it from old process flour. The top quality of flour made by patented machinery and process was therefore dubbed "patent" flour, and this referred to flour made from the reground middlings only. Flour made from the first grinding of wheat was "baker's" since it was strongest, baked more bread than others, and was a favorite of bakers. "Straight" was a mixture of baker's with patent. The same terms were applied to products from roller gradual reduction systems. Break flour was baker's, reduction flour was patent, and straight was a mixture of the two.

The Canadian flour inspection law of 1873 and its 1874 amendment did not name "patent" or "straight" but only "strong baker's," so Canadian new process millstone millers of the 1860s and 1870s as well as roller millers found other names for their new flour. Some exported it to the United States where a consumer market existed.

Many Canadian flours were known by brand names chosen by the mill owner, and sometimes these brands were registered trademarks. In 1879 the Stockwell Steam Mills in Galt owned by Archibald Gilchrist produced flour marked "Princess Louise patent."[5] Soon afterward "patent" flours were described by the Montreal Corn Exchange as very much in demand, scarce and highly priced. Unfortunately for researchers the Gilchrist's trademark did not reveal whether the flour was gradually reduced on millstones or rollers. Later trademarks of the 1880s sometimes included "roller" indicating that the flour was made by the latest improved process.

There was criticism of the new patent flour made by rollers, especially in the United States. Some claimed that the popular craze for white flour had resulted in the ruination of hard, sweet, northwestern wheat, now that it was rolled into the lightest starchy flour comparable to white winter or soft wheat flour. Others called the high grades of patent flour undemocratic and evil, "suitable for countries where people are graded all the way from No. 000 up to No. 18"[6] (a reference to bolt cloth numbers). Though fit for European aristocracy the new grades were too fine for North Americans, the majority of whom baked their own bread and needed a strong flour that would rise well. Millers were challenged to produce a good graham flour or a straight mixture that would be as highly regarded in America as patents were in Europe.

In Canada there was a complaint in 1886 that the roller process had produced a plethora of unsaleable low-grade flour. Due to the more thorough job of roller systems in separating the branny, germy part from the flour as well as to the reasonable price of good flour, the class of people who previously had bought stone-ground low grades - then more floury than roller low grades - now bought good white roller flours. Though there was every reason to rejoice for the poorer Canadians, a market was needed for low grades and millers were encouraged to improve their milling to make a minimum of low grade flour.

In general, then, rollers produced too high and too low grades for the major needs of North Americans. But European markets were found for these extreme grades and various roller processes evolved better suited to local needs. Tastes changed too, and by the 20th century, roller grades had become the expected standard of the majority of Canadians. The public had been "educated" to demand the higher grades produced by rollers.

DOMINION MILLERS' ASSOCIATION

In 1875 Canadian mill owners and those involved in the milling industry organized themselves into the Dominion Millers' Association which was incorporated by an Act of Parliament on 9 July 1892. The objects of the association stated in the law were "to extend and improve the manufacture of flour and meal, the business...shipping and sale...of grain, flour and meal, and to assist the members...to arbitrate, adjust, settle and determine controversies and misunderstandings between persons engaged in the said trade."[1] Born out of the depression of the 1870s, the association sought to pressure government into solving some of the problems facing the flour-milling industry caused by changing techniques in milling, unequal terms of trade between the United States and Canada and high rail freight costs.

The new process of millstone gradual reduction initiated in Mineapolis in 1871 by use of Lacroix and Smith's purifier was realizing large profits for American millers milling, up to then, cheap hard spring wheat of Minnesota and the new northwestern states. American consumers willingly paid fancy prices for the superior grades and mill owners made handsome profits, profits that allowed them to export their lower grades to Canada, especially the Maritimes, and sell them for less than Ontario manufacturers could sell theirs. Ontario millers were unable to compete in the Maritime trade with American millers whose profits from high grades, often cheaper rail freight expenses and duty-free produce permitted them to lower their price in favour of the consumers.

By 1876 mill owner James Goldie reported that a "good many" mills in Canada were producing new process flour from spring wheats without realizing any of the handsome profits obtained by their American competitors because the Canadian people would not pay the higher price in proportion to that charged for the inferior grade.[2] It was stated that Canadians had not been educated to buying superior grades as the Americans had, that Canadians would not pay "two dollars per barrel for a superior article" and that Canadian millers were having to mix the superior grades with lower ones in order to sell it in Canada.[3] Those who sought profits by exporting to the United States had to pay a tariff of 20 per cent (*ad valorem*) per barrel of flour. Canadian grain entering the United States was taxed 20 cents per bushel, while American grain and flour entering Canada was duty free. These disadvantages plus the high rail freight rates, higher often than those in the United States, and the trouble and delays in bonding grain and flour to the seaboard from inland mills seriously affected the Canadian flour-milling industry.

It was to find a remedy for these ills that the Dominion Millers' Association was formed. Their petitions, presented to the select committee inquiring into the cause of the depression in 1876, were influential in bringing about a change in tariff law passed in 1879. In accordance with Sir John A. MacDonald's protective policy, a duty of 15 cents per bushel of wheat and 50 cents per barrel of flour was laid on United States produce entering Canada. In 1880 to benefit millers dependent on United States wheat, an order in council was passed allowing the grinding and packing in bond of wheat, maize and other grain.

The official organ of the Dominion Millers' Association (this was denied by its editor) was an important monthly journal known as the *Dominion Mechanical and Milling News*. First published in 1883 by the Beaver Publishing Company in Toronto when A.J. Wenbourne was manager, it changed its name in 1889 to *Electrical Mechanical and Milling News*. Soon afterward, in December 1890, the publishers' interest was sold to A.G. Mortimer, already publisher of the *Canadian Lumberman*, and he continued it under the title *Canadian Miller and Grain Trade Review*. Mortimer had been with the journal since 1883 as a travelling correspondent visiting mills across the Dominion. Begun in the roller-milling era, the flour-milling portion of the journal was predominantly concerned with roller milling and described in detail new installations of roller systems in mills across the Dominion as well as topical developments in mechanics outside of milling. Letters and advertisements provided readers with practical information.

In the late 1880s local associations of the Dominion Millers' Association were formed to deal with local problems and to assist in finding objectives and work in conjunction with the central organization. In 1889 millers representing the counties of Middlesex, Elgin, Essex, Kent and Lambton joined together, followed by another representing the counties of Brant, Haldimand, Norfolk, Waterloo and Oxford, and a third northern group representing York, Cardwell, Grey, Simcoe and Muskoka. There were many advantages for such associations according to J.C. Hay, president of the Dominion Millers' Association in 1889, who urged small grist and flour millers particularly to join lest they be driven out of business by the "disastrous course" the milling industry was taking.[4] The great grievance was the inadequate tariff on American flour - 50 cents per barrel - which millers argued was actually a bonus of 20 cents per barrel to the American miller. This was calculated on the basis that 4 3/4 bushels of grain produced one barrel of flour (according to government standard) and the duty on United States wheat was 15 cents per bushel, "hence, the duty on wheat to make a barrel of flour is 71 1/4 cents or a duty on the raw material of 21 1/4 cents per barrel above that on the manufactured article"[5] (Fig. 53). Though Canadian millers had a real and serious cause to grieve, even Sir John A. MacDonald doubted justice would be done since Ontario and Manitoba members of Parliament stood alone against those of the Maritimes and British Columbia. Relatively powerless when faced with political realities of the day, the Dominion Millers' Association did much for the flour-milling industry and further study of its activities will reveal important information about the history of milling in Canada during the last quarter of the 19th century and the 20th century.

PRETTY PROTECTION!

(Duty on flour sent in by Yankee millers, 50c. per barrel; duty on corresponding amount of wheat imported by Canadian millers, 71¼c.)

SIR JOHN.—"My dear milling friend, don't judge by appearances. I DO love you (and your vote;) and I DO hate the unspeakable Yankee. But there are political exigencies, you know—and besides, you can't deny that I am 'protecting' you from the necessity of working your mills, don't you see!"

—*Grip.*

Figure 53. Cartoonist's version of the "great grievance" that mill owners experienced due to unequal tariffs in the 1880s. (*Electrical, Mechanical and Milling News, [June 1889], p. 8.*)

EPILOGUE

> *In the course of a very few years, the great majority of flour mills throughout the Dominion scrapheaped the obsolete stone system and replaced it by the modern Hungarian roller machines.*[1]

Writing with some poetic license since most rollers installed throughout the 1880s were manufactured in North America, Oliver Master emphasized the main reason for the decline of millstone systems. During the last quarter of the 19th century, rollers were housed in new and old mills. Sometimes alternative structures such as woollen mills were converted to roller flour mills in a relatively simple modification since the special "husk" construction necessary to support millstones was not needed. Defunct mills, razed by fire or swamped by floods, if rebuilt were usually installed with rollers. But millstones continued to be used and often those thrown out by roller millers were relocated economically in stone systems. Combined roller systems already described, grist and feed mills, and mill owners who could survive without rollers or who believed rollers were a fad used millstones.

Accounts of mills newly installed with rollers in the 1880s recorded that chop stones, on the same floor as the rollers and runnable with or without the roller system, were used in mills for making feed for farmers.[2] Such "grist and flour mills" operated in close relationship with local farmers and were a constrast to the increasing numbers of large commercial roller mills having little contact with farmers who milled vast quantities of grain shipped from far and near. As Ontario farmers switched to mixed farming, their need for a grist mill to make feed and chop for livestock increased, and it was the rural mill or one on the edge of an urban community that used millstones for feed (at least until the stones were replaced with modern metal grinders for chop). Often old French buhr stones were redressed with suitable patterns for cracking and chopping various grains brought by the farmers, and sometimes a separate run was used to make custom flour for the farmer's wife.

Some millers, especially of soft wheat, clung to millstone systems believing that millstone flour would always be better than roller flour. Some retained stone systems because they could not afford new roller machinery.

As long as a market for stone-ground (often whole wheat) flour remained, these millers survived, especially if they had other sources of income. As time progressed however, they faced the fact that their flour would never be as profitable as roller flour. The cost in time and money of employing a dresser was expensive. Skilful stone dressers were increasingly difficult to find, many of the best being employed in roller mills. Never an attractive calling, stone dressing took years of experience to learn and few young men were interested in learning a dying art. Late 19th-century milling journals frequently published helpful articles describing the principles of stone dressing, but these could not take the place of experience. In 1891 Abernathey described the conditions of some buhr mills he had seen in the United States, one of which produced the "dingiest, darkest soggiest bread"[3] he had eaten for a long time. As a remedy he insisted that millers take more care in stone dressing, as well as at the various stages of grain cleaning, purifying and flour bolting so that "sweet healthy flour" was manufactured.

Sweet, healthy flour from millstones continued to be manufactured in mills in the 20th century for a variety of reasons, the chief one being the existence of a market for natural whole wheat flour free from the adverse effects of bleaching, additives and overpurification which began to afflict modern mass-produced flour. The mill at Ancaster near Hamilton, Ontario, which produced whole wheat flour in the 1970s for local bakeries and tourists, is one lasting example. Built in 1863 on a water privilege occupied by mills since the 18th century, the Ancaster Grist and Flouring Mill was a modest structure, 40 feet by 70 feet, soundly constructed of stone to mill merchant and custom flour on its three runs of millstones. Well situated on the edge of a large urban and rural community, powered by an unfailing though waning fall of some 50 feet afforded by the Niagara escarpment, the enterprise, soon out of date with the new process of 1870s, could be economically run in the 19th and 20th centuries to mill roller flour, whole wheat flour, feed and chop, or to store and sell veterinary supplies, fencing and nails. The mill's convenient location near markets on a cheap waterpower which could be augmented economically, its modest size, sound construction and versatility plus the determination of its owners to realize a worthwhile investment were important factors resulting in the mill's survival into the 1970s.

The processes employed in 20th-century millstone mills differed from those in the 19th-century mills though it is sometimes implied that such mills are little changed from a century ago. New wheat varieties and methods of preparing wheat for grinding, new stone dresses to suit the wheat or other grain ground, new sources of power, new mill accessories plus a changed economic, social and agricultural milieu account for some of the differences.

The general trend of improvements made in manufacturing flour in Ontario mills from the 1780s to the 1880s was toward processes that made more flour from a bushel of wheat, whiter, finer and of better quality than before. While the automatic fast reduction method of the first half of the 19th century made more flour faster than before, the new process of the 1860s made more, not as fast but of better, more "lively" quality than the old process had. Rollers of the 1880s made an even whiter, better quality flour in machines that were economically run on a large scale.

Despite the change to mixed farming in Ontario and the development of western wheat lands, the flour-milling industry in Ontario continued to increase its output. In 1871, 951 grist and flour mills were recorded in Ontario by the census. In 1881, 1,034 mills manufactured products valued at $29,859,118.00. An increase of 44 mills by 1891 and a provincial output of products valued at $36,558,320.00 reflected the increased productivity of Ontario roller mills milling western as well as local wheat. The lead Ontario mills established in the production of Canadian flour in the mid-19th century was held in the 20th century largely as a result of the early development of the flour-milling industry in a region blessed with fertile soil, good waterpowers, transportation routes, an expanding market and most important, energetic people who found ways of improving Ontario's resources for the benefit of themselves and others (Fig. 54).

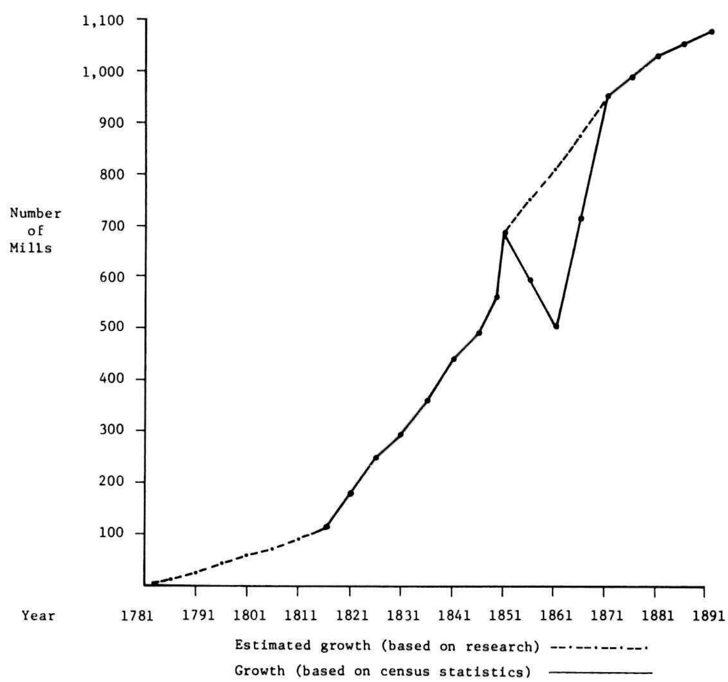


Figure 54. Graph showing growth of the flour-milling industry in Ontario from the 1780s to the 1880s.

GLOSSARY

APRON. A reinforced fronting on a dam in the form of a slide or shelf designed to protect the foundation of the dam from being undermined by falling logs and ice

ASPIRATOR. A machine to remove lightly chaffy material from grain as it was broken on the break rolls. The resulting flour or meal was less red in colour due to the chaff husks being saved from decimation by rollers.

AUTOMATIC MILL. A mill that operated with Oliver Evans's labour-saving devices (the bucket elevator, conveyor, hopper boy, drill, descender)

BAIL (bale, millstone bridge, balance-rynd). The iron bar embedded and bridging the eye of the runner stone. In the centre of the bale was an indentation or cock-eye into which the upper end or cock-head of the spindle fitted so the runner millstone was balanced on the spindle.

BAIL (bale). The iron arm of a millstone hoisting crane. The lower end of a bail was hooked to one side of the iron hoop circling the millstone. The upper end of the bail was attached to the hoisting screw of the crane. Two bails, one on each side of the stone, held the stone as it was raised for dressing or repairs.

BAKER'S FLOUR. A flour favoured by bakers. "Strong baker's flour" was first manufactured in the 1860s by extra high grinding and gradual reduction. Defined as flour from the first grinding of gradually reduced wheat, it was darkish in colour containing a high percentage of gluten and colour found in the outer layers of the endosperm.

BALANCE-RYND (balance-rind, -rhynd, -rine). See BAIL. The balance-rynd balanced the runner stone whereas the stiff-rynd or CROSS held it securely.

BANAL MILL. A seigneurial mill at which habitants within the seigneurial domaine were bound to have their grain ground for a toll of 1/14 of the grain brought to be milled

BARM. Specifically a yeast derived from the froth formed on malt or other alcoholic liquors during fermentation and used for raising bread. Derived from old German, "barm," the word generally meant a ferment or leaven.

BEDSTONE. The stationary stone of a pair of millstones, usually the bottom

BOLT (boult, reel). A machine in which flour was separated through cloths of different mesh into qualities such as superfine, fine, middlings et al. The lower part of the bolt machine was the chest where flour qualities were collected and conveyed to the next stage of processing. Most bolts were revolving reels, cylindrical or polygonal in form, until the invention of the plansifter in 1887 which used horizontal screens that shook.

TO BOLT (boult). To sift, grade, dress or separate flour meal into different qualities

BOLTING CLOTH. The mesh cloth covering the frame of the bolt machine and purifier, and through which flour was graded. Cloths were woven of wire, horse hair, wool, cotton, silk et al., and each weave was numbered by the manufacturer according to the number of the threads or the number of spaces per inch.

BOSOM (breast, swallow). The hollowed area around the eye of the runner millstone, variously shaped, to better admit grain through the stones

BOX. A bearing in the form of a box

BRAN. The transparent outer skin of wheat separable in large light flakes, and the inner coloured true bran, tough and incorporated with the hard sweet aleurone layer of the seed

TO BREAK (chop, granulate). To grind grain into middlings (or broken grain) as opposed to reducing middlings into flour. To break and to reduce were steps in milling which became distinct operations in gradual reduction mills.

BRIDGE-POT. See COCK-EYE

BRIDGE-TREE. The crossbeam supporting the foot of the millstone spindle. Directly below the bedstone, the bridge-tree was fitted with a step and bearing in which the toe of the spindle revolved. The bridge-tree could be raised or lowered before or during milling by a lightering screw, and this in turn raised or lowered the runner stone to mill high or low.

BURR (buhr, bur). A general term for a millstone or rock from which millstones were hewn. The burr referred to the rough surface necessary for grinding grain. French burrs were from quarries in France and were the best qualith for milling wheat.

CANAILLE (carnelle, cornel, carnal). See CARNEL

CARNEL. A general term for the coarse part of the bolted flour. Derived from the French *canaille* meaning coarse, it might include grades also known as sharps, middlings, shorts.

CENTRIFUGAL REEL. A specific type of force bolt either round or polygonal with a large capacity in which fast rotating beaters forced out the flour

CHEAT. Chess, a weed seed harvested with wheat

CHESS (*Bromus secalinus*). A weed growing among wheat, the seeds of which mixed with wheat and had to be separated, often through a chess screen

CHIME (chine). The projecting rim at the head of a barrel formed by the ends of the staves

CHIT. The germ of wheat

CHOP. 1. A term used in gradual reduction milling to designate the meal or stock produced from the first millstone grinding or the break rollers. 2. A term used in feed milling to refer to the broken grains of cereals making feed for livestock.
COCK-EYE (pivot hole, bridge pot). The supporting bearing, socket or pot for the cock-head of the spindle which was cast into the balance-rynd bridging the eye of the runner stone
COCK-HEAD. The upper end or tip of the spindle which was borne by the cock-eye
COG-PIT (cog-hole). The area where the main gearing of a mill was located
COMBINATION MILL (mixed mill). A mill using both rollers an millstones to manufacture flour by gradual reduction
COMPOSITION BOX. A bearing made up of two or more brasses
CONDITIONING. The process of forcing grain into the best condition for milling by tempering and/or drying.
CONE WHEEL. A bevel gear transmitting motion by using two cones rolling together
CONVEYOR. A late 18th-century automatic device of Oliver Evans employing an endless screw to convey flour or grain horizontally from place to place in a mill
COUPLING. A device to connect ends of shafting. A coupling box was a metal box in which the ends of two shafts were fastened to couple them in line.
TO CRACK. To put cracks in the land of the millstone, part of the process of millstone dressing. With special cracking picks, small cracks were cut into the stone to provide more cutting surface.
CRACKING ROLLS. Roller mill machines designed to split grain along the crease and separate the germ
CREAM OF TARTAR. Potassium acid tartrate or potassium bitartrate, a white crystalline salt with pleasant acid taste found in grapes and in tartars for winemaking. Cream of tartar was the choicest and most essential ingredient in tartar.
CROE. An incorrect form of CROZE
CROSS (stiff-rynd, ink). A cross-shaped cast iron bridge imbedded in the eye of the runner stone so that the runner stone was poised rigidly on the spindle
CROWN-WHEEL. 1. A face gear in which the cogs were perpendicular to the plane of the motion of the wheel, like a crown in appearance. 2. The large cog wheel at the head of the mainshaft in the cog pit, i.e. in the position of a crown. 3. The bevel gear at the top of the mainshaft in a mill.
CROZE. The horizontal groove along the staves of a barrel, circling the inside top and bottom of the barrel into which the heads fitted
CURB (tun, vat). The wood or metal casing covering millstones
CUSTOM MILL (grist mill). A mill to which customers or farmers brought their grain to be milled for a toll into flour and feed for family and livestock

CYLINDRICAL REEL. See BOLT

DAMPING (dampening, tempering). The process of wetting (and then drying) clean wheat so that the husk was toughened and less likely to decimate during milling

DAMSEL (dansil, dandelion). A device to regulate the feed of grain into the millstone. Placed on the revolving spindle or stone, the revolving damsel intermittently struck the shoe of the hopper so that grain was jiggled out. The term "damsel" is derived from the chattering sound it made.

DECIMATE. A term used in milling meaning to crush or divide into particles

DECORTICATOR (debranning machine). A grain cleaner for removing the husk of grain

DESCENDER. An automatic device of Oliver Evans to move grain or meal horizontally on a belt across an area with a small descent. The descender operated on the principle of an overshot water wheel.

DIFFERENTIAL REEL. A type of force flour bolt, round or polygonal, popular during the new process similar to the centrifugal reel but with smaller capacity and more gentle action

DISC MILL. See DECORTICATOR

DISINTEGRATOR. A grain cleaner popular after the late 1870s which split grain across the crease exposing the germ and crease dirt so that they could be scoured off and separated before milling

DRAFT (draught, drift). The eccentricity of furrows in a millstone dress and their direction reckoned by the distance of the master furrow's fore edge before the centre of the stone, to regulate the sweeping action of the stone

DRESS. The pattern picked into the face of millstones

TO DRESS. 1. To pick and make true a pattern on millstones. 2. To bolt, usually the finer qualities of flour.

DRILL. A late 18th-century automatic device of Oliver Evans to move flour or grain from place to place nearly horizontally. Its function was the same as a conveyor but used a rake rather than a screw and was cheaper.

DRIVER (mace). The iron bar that fitted tightly to the spindle neck and drove the runner stone

DROIT DE BANNALITE. Right of the seigneur obligating all those residing in his domaine to have their grain ground in his mill and in no other

DUSTER. A bolt devised about the 1840s to separate flour dust from coarse matrials, thus saving fine flour normally lost with feed, bran, shorts et al.

ELEVATOR. A late 18th-century device of Oliver Evans to hoist grain and flour up to the various storeys of a mill by use of a string of buckets revolving around a belt. A ship's elevator elevated grain from ship to mill and was adapted for raising grain from wagon to mill.

ENDING STONES (sheeling mill). Millstones set high enough to hull and scour grain, part of the grain cleaning process practised in some early 19th-century mills
EYE. The hole in the centre of millstones or gears
FACE. The surface of millstones that was dressed
TO FACE. To make the face of millstones perfectly true (or perpendicular to the spindle), a part of stone dressing
FACE WHEEL. A gear with cogs on the side or face
FANCY FLOURS. Those brands that ran above the inspection standard of the day
FANNING MILL (fanner, separator). A grain cleaner employing a fan and usually screens to blow off and separate light chaffy matter from clean grain in a mill; also used in threshing
FARINA. Starchy granules of wheat (or other cereal, nut or root)
FLOUR COOLER. A device to cool flour (a chamber, tub, hopper-boy, millstone exhaust) before being bolted
FLOW SHEET (flow chart). A plan of the layout of machinery indicating the flow of grain from the beginning to the end of its manufacture into flour
FLUME (fleume, floom). The part of the race before the water wheel in the form of a trough or channel
FURROWS. The larger grooves (for cutting, distributing and ventilating picked into the face of a millstone). The leading or master furrow extended from the eye or bosom to the skirt, and from it branched auxiliary furrows (sometimes referred to as second and skirt furrows). The master and auxiliary furrows made up a "quarter" of the millstone dress.
GEAR (wheel). See CONE WHEEL, CROWN WHEEL, FACE WHEEL, MITRE WHEEL, PINION, PIT WHEEL, SEGMENTAL GEAR, SPUR WHEEL
GRADER. A flour bolt used in roller milling to grade *middlings into uniform sizes (previously done by* purifiers) so they could be reduced on appropriate rollers
GRADUAL REDUCTION. Method of milling practised on the continent and adopted in Ontario in the 1860s by which wheat was gradually milled to flour in a series of grindings. Special mllstones (replaced later by rollers), and special bolts or purifiers distinguished this "new process" from the "old process" of fast reduction.
GRIST. Grain to be ground, or the ground meal
GRIST MILL (custom mill). A mill that ground grains for the farmer for a toll in grain, as distinct from a merchant mill which ground grain for commerce. In the 1880s grist mills ground grains for the farmer for either cash or toll.
GRITS. Large middlings made by gradual reduction
GROATS. Hulled and/or crushed grain of various kinds, chiefly oats but also wheat, barley and corn

GUDGEON. A metal pivot fixed or let into the end of a wooden beam, shaft or axle on which a wheel turned

HEAD. The distance water fell from the penstock to the water wheel as opposed to the "fall" or distance from the water wheel to the stream below the wheel

HESSIAN FLY (*Cecidomyia destructor*). A wheat pest, probably indigenous to North America but believed to have been introduced from Europe in the straw of Hessian mercenaries' baggage. The larva of the fly sucked juices from wheat stalks which then yellowed and drooped. This may have been the same as the "Independent fly" noted in the 1790s in the Kingston area and presumably from the United States.

HIGH GRINDING. A method of grinding with millstones set wide enough apart to break grain into particles rather than grind it into flour

HOP. The ripened cones of the female hop-plant (*Humulus Lupulus*) used to give a bitter flavour to malt liquors, and as a tonic and soporific. Hops were boiled in water and the resulting bitter liquid was used to flavour leavenings for bread in Upper Canadian homes.

HOPPER. A square or circular funnel of wood or metal in which grain or flour was held and fed to various mill machines

HOPPER BOY. A late 18th-century automatic device of Oliver Evans to cool flour before bolting. Radial rakes swept meal in a circular vat and channelled it to an outlet leading to the next stage of processing. The hopper boy did the task previously done by a boy and rake, impelled by the miller's order to "Hop to it, boy!"

HUSK (hurst or hursting). The frame of extra strong timbers to support and keep the millstones level in a mill

INDEPENDENT FLY. Possibly another name for the HESSIAN FLY now believed to have been indigenous to North America

IRONS. Iron materials, as distinct from wooden materials, needed to construct a mill, such as nails, gudgeons, bands for gears, etc. "Millstone irons" included the spindle, ryne, damsel, driver, the band circling stones, etc.

JOURNAL. That part of a shaft or axle that rested on a bearing

JOURNAL BEARING. The support for a shaft, axle or journal

KILLED FLOUR. Meal or flour scalded or overheated by grinding so that it would not hold air when baked due to having its gluten impaired

KILN DRYING. The drying of grain to reduce its moisture content so that the resulting flour would keep and not sour early

KING'S MILL. A government mill owned by the Crown built for the use of settlers, sometimes auctioned off to a private owner

LANDS. The high area on the face of a millstone which was unfurrowed but sometimes cracked by the millstone dresser to provide a grinding surface for wheat

LEAVEN. Specifically, a quantity of fermenting dough (derived from natural yeasts in wheat) which was reserved from a previous batch and used to raise bread. The term was also used in a general sense to mean any rising agent including yeast and baking powder.

LIGHTER SCREW (lightering rod). An iron rod screwed to the front end of the bridge-tree extending up to the stone floor and ending in a screw and hand wheel which, when turned, raised or lowered the runner stone

LONG SYSTEM. A system of breaks and reduction in early roller milling using as many as seven breaks and 14 reductions for a total of 21 grindings, producing numerous grades of flour

LOW GRINDING (low milling, flat grinding). The fast reduction old process of milling which ran the stones close together so that as much flour as possible was milled at the first grinding

MANCHET. A fine English bread of white wheat flour made into small oblong rolls or loaves

MEALMAN. A dealer in meal and flour

MEDIUM SYSTEM. A system of gradual-reduction roller milling which required 3-4 breaks and 5-7 reductions totalling 8-11 grindings, a medium between long and short systems

MIDDLINGS. Coarse particles of wheat kernel comprised of starch and the hard glutinous layer beneath the husk

MIDGE. See WHEAT MIDGE

MILL-RACE (raceway, sluice). The waterway leading to the water wheel of a mill. The section before the wheel was the head-race, and that after the wheel the tail-race or mill-tail.

MILL SEAT (mill site, mill lot, mill privilege, water or hydraulic privilege). A tract of land containing a waterpower capable of driving a mill

MILLSTONE EXHAUST (millstone ventilator). A device, first devised in the 1840s, to cool flour as it was being ground by the millstones and therefore applied to the millstones

MITRE WHEEL. Each of a pair of bevelled cog wheels, the axes of which were at right angles and which had teeth set at an angle of 45 degrees

MUSTY (Mouldy). "Musty flour" in the mid-19th century was described with red or blue fungus growths apparent to the eye. Some musty flour was noted only for its mouldy odour. The growth of mould spores in wheat flour was stimulated by damp warm conditions.

NEW PROCESS. The process of gradual reduction introduced to Ontario millstone millers and modified by them in the 1860s and 70s. Flour was milled in a series of grindings on stones run high and slow. Rollers began to replace stones for gradual reduction in the late 1870s.

OFFAL. A general term referring to the less valuable products of flour milling, i.e. bran, shorts and screenings tailed out of the flour bolts and grain cleaners and fed to livestock

OLD PROCESS. The fast reduction method of milling, traditionally British and best suited to soft wheats, in which stones were run low to mill as much flour as possible in the first grinding; superseded by the "New Process" of gradual reduction in the 1860s

PAINT STAFF. See RED-STAFF

PATENT FLOUR. Flour made by the new patented process of graded reduction or specifically that made from reground middlings

PENSTOCK. A channel, trough, pipe furnished with a gate through which water was conveyed to a water wheel. Sometimes used to mean the sluice or floodgate for regulating the flow from a head of water enclosed in a pen.

PINION. The smaller of two cog wheels in gear

PIT WHEEL. The first driven gear or cog wheel parallel to the water wheel inside the mill

PLANSIFTER. A flour bolt using horizontal flat screens (instead of a reel) devised in 1887 by Carl Haggenmacher of Budapest and improved thereafter, to scalp, grade and dress flour, jobs previously done by separate machines

PLUMPING MILL (hominy block). A mortar and pestle type of handmill, the mortar made of a hardwood hollow stump and the pestle of heavy wood. Sometimes a cannonball and cord worked by use of a labour-saving lever (with a tree branch as fulcrum) served as a pestle, to make cornmeal or wholewheat.

POLLARDS. Floury fine bran sifted from flour but of higher grade than pure bran since it contained more sweet, protein matter

POLYGONAL REEL. A hexagonal or octagonal reel for bolting flour, popular in last half of 19th century

PRESBURGH BISCUIT. A type manfactured in Presburgh, Hungary (now Bratislava, Czechoslovakia)

PROOF STAFF. A metallic straight edge to prove the correctness on the red-staff and the trueness of the millstone face

PURIFIER. A special bolt using air currents and bolt cloths designed for the new process to clean and (usually) grade middlings before their remilling on middlings stones or rollers

QUARTER (harp). The section in a millstone dress comprising the main furrow and its auxiliary furrows. Names to designate millstone dress sometimes referred to the number of quarters in the millstone - "twelve quarter dress" - or to the number of furrows in each quarter - "three-quarter dress".

REDUCTION (milling, grinding). The reducing of grain to flour, or specifically, the remilling of middlings into flour (as roller mills became organized into break and reduction area)

REEL. A flour bolt in the form of a cylindrical or polygonal reel that revolved (See CENTRIFUGAL, DIFFERENTIAL, POLYGONAL reels)

ROLLING SCREEN (grain cylinder). A grain cleaner in the form of a cylindrical frame covered with wire screen of various layers and mesh that revolved and separated grain from some of its impurities, often with the help of a fan - hence a "fanning mill"

RUN. A pair of stones

RUNNER. The stone in a run that revolved, usually the upper stone

SALERATUS. An aerated salt such as pearlash or soda used to raise bread or sweeten sour dough or flour

SCALPER. A flour bolt or grain screen that separated the coarse from finer particles. In gradual reduction with rollers, flour scalpers were one of the various bolts required, especially in the break section of the mill.

TO SCALP. To bolt or screen the coarse from the fine

SCRATCH ROLLS. Finely fluted rollers designed to clean flour from bran

SCREENINGS. Broken grain, seeds, chaff and foreign matter screened during grain cleaning, sometimes sold as feed or for distilling

SEGMENTAL GEAR (Segment gear). A gear wheel composed of a number of pieces that were segments of a circle, bolted, for example, to the spokes or housing of a water wheel (such as overshot) to transmit power to a pinion

SEMOLINA. Large hard wheat middlings, especially from durum wheat but used in early days to denote large hard grits (derived from Italian *semola* meaning bran)

SEPARATOR. A grain cleaner that separated good and bad by blowing and screening rather than scouring

SHARPS (middlings). Coarse granular grind with sharp edges useful in the early days for keeping the flour mesh of the bolt cloth open on hot damp days

SHIP'S STUFF. Low-grade branny flour equal in quality to pollards or carnel used to make ship's biscuit

SHORTS. Germy and branny portion bolted from flour

SHORT SYSTEM. A system of gradual-reduction roller milling in which as few as five grindings (two breaks and three reductions) reduced grain to flour

SIMNEL (symnel). Bread or biscuit made of fine wheat flour, derived from the Latin *simila* meaning fine wheat flour. A rich currant cake eaten on the middle Sunday in Lent was also known as simnel in England.

SIZING ROLLS. Special rollers designed to break down large middlings to the proper size suiting the milling system

SMUTTER (smut mill or smut machine). A specific type of grain cleaner that scoured and separated good wheat from smut-diseased wheat. The term was also used in a general sense to mean any grain cleaner.

SOCCAGE (socage). Land tenure derived from the manorial system of Great Britain

SOUR FLOUR. Flour with a sour taste caused by the formation of acids under excessively warm and moist conditions

SPECKY. A term used by flour millers in the late 19th century to describe flour specked with bran

SPINDLE. The shaft that spun the runner millstone. It was divided into sections known technically as the toe, foot, body, head and cock-head.
SPUR WHEEL. A gear wheel with cogs or teeth on the periphery projecting radially from the centre to which others were connected
TO STAFF. To measure the trueness of the face of the millstone to guide the stone dresser
STEP. A fitting or a lower bearing or block on which a vertical pivot or shaft rotated; e.g., spindle step
STOCK. General term for any grain product undergoing manufacture into flour
STRAIGHT FLOUR. A flour made by mixing patent and baker's flour
SUPERFINE. A quality of flour produced from the major portion of the wheat kernel. Until 1841 superfine was first quality and by the 1880s it was the middle quality according to federal statute.
SWALLOW. See BOSOM
SWEEP (sweepstick). A tool that ensured the accurate installation of the bail in the runner stone so that the stone balanced on the spindle
SWEEPINGS. Grain and flour that spilled or wafted to the mill floor and was swept away or sold as low grade feed
TAILINGS. Stock that poured out the tail of the flour bolt or screen, as opposed to the "throughs"
TARE. The deduction from the gross weight of a barrel of flour equal to the weight of the barrel itself. Also meant weed seeds.
THROUGHS. Stock that bolted through the bolt cloth or screen
TO TRAM. To make the spindle perpendicular to the true face of the millstone
TRAMPOT (ink and step, bridging box, step brass). The box bearing for the toe of the spindle situated on the bridge-tree
TRAM-STAFF. An instrument that tested the squareness of the millstone spindle
TUB WHEEL. A water wheel with a vertical axis and radial floats
WATER GATE (penstock, sluice gate). A portal to control the flow of water in the penstock or race; the *head gate* opened or closed at the dam; a *sluice gate*, *penstock* or *pentrough* opened at the wheel, and the *tail gate* opened and closed at the tail race
WHEAT MIDGE. A pest that attacked Ontario wheat crops in 1-12 July and was a factor in causing farmers to change from fall wheat to spring wheat crops which were less affected, or to mixed farming
YEAST. Specifically a minute fungus of the genus *Saccharomyces*, which produced fermentation in saccharine fluids reproducing by budding. Yeasts taken from froths on fermenting alcoholic drinks were used because of their flavour and because they supplemented the natural yeasts in wheat flour.

ENDNOTES

Introduction

1 PAC, MG23, GIII, 1, Letterbook, George Allsopp, mill owner of Jacques Cartier, Quebec, to his son, 12 May 1793.

Government Mills

1 Ernest A. Cruikshank, ed., The Settlement of the United Empire Loyalists on the Upper St. Lawrence and the Bay of Quinte in 1784 (Toronto: Ontario Historical Society, 1966) (hereafter cited as Settlement), p. 145. General Haldimand was writing of the needs of the Loyalists in the summer of 1784 when provisions, especially flour, supplied by the government were low. Before water- or wind-powered mills were established in the area known now as Ontario, or when mills were too far away, Loyalists used various hand mills. Coffee mills and plumping mills, an Indian invention for corn, were used to make meal from wheat.

2 William B. Munro, The Seigniorial System in Canada (Cambridge: Harvard Univ. Press, 1907), pp. 101-26.

3 Ernest A. Cruikshank, ed., Records of Niagara, A Collection of Documents Relating to the First Settlement, 1778-1783 (Niagara-on-the-Lake: Niagara Historical Society, 1927), p. 39.

4 Ibid., p. 45. The nails, irons, stones, bolting cloths and saws were probably "excepted" since the government provided these free.

5 Ibid., p. 47. The iron works were possibly made at the Saint-Maurice forges.

6 Thomas W. Casey, "Napanee's First Mill and Their Builder," Ontario Historical Society Papers and Reports, Vol. 6 (Toronto, 1905), pp. 50-54.

7 Canada, Public Archives (hereafter cited as PAC), MG19, E1, The Selkirk Papers (hereafter cited as Selkirk), Vol. 52, pp. 19,688-89. Selkirk's Diary of 1803-4 is found in Vol. 51, pp. 19,384-19,655, and Vol. 52, pp. 19,656-20,189.

The Move for Private Ownership of Mill Sites

1 Ernest A. Cruikshank, ed., Settlement, p. 45.

2 Ernest A. Cruikshank, ed., Records of Niagara, 1784-87 (Niagara-on-the-Lake: Niagara Historical Society, 1928), pp. 81-84.

3 Ibid.
4 Ibid.
5 PAC, RG1, E3, Vol. 47, pp. 12-14, State Papers of Upper Canada, 1792.
6 Ibid.
7 Ontario. Bureau of Archives, Third Report of the Ontario Bureau of Archives, 1905 (Toronto: 1906) (hereafter cited as Report), p. lxx.

Governor Simcoe's Influence on the Flour-Milling Industry

1 John Graves Simcoe, The Correspondence of Lieut. Governor John Graves Simcoe, with Allied Documents Relating to his Administration of the Government of Upper Canada, ed. E.A. Cruikshank (Toronto: Ontario Historical Society, 1923) (hereafter cited as Simcoe), Vol. 1, p. 20.
2 PAC, MG23, HI1, Wolford Simcoe Papers, Series 3, Book 2, pp. 238-40.
3 Ontario. Bureau of Archives, Report, p. 333.
4 James Croil, Dundas; or a Sketch of Canadian History (Montreal: Dawson & Son, 1861), p. 133.
5 N.A. Innis and A.R.M. Lower, Select Documents in Canadian Economic History, 1783-1885 (Toronto: Univ. of Toronto Press, 1933), pp. 219-23. In his letter to the Board of Trade on 1 September 1794, Simcoe proposed establishing wheat as the universal staple of Upper Canada; its flour would be bought by the government to supply the troops and the British possessions in the West Indies. In exchange the supplier would receive notes payable in gold or silver on demand at stated periods. To do this the home government was to provide a sum of money vested in certain trustees to finance and form regulations for the improvement of the manufacture of flour, and only that flour meeting the requirements set by the "company" would be purchased.
6 Ibid. Simcoe's desire to produce a high standard of flour may have been part of the reason why he began by making contracts with mill owners such as Cartwright and Hamilton, who had capital to invest in well-equipped mills.
7 Ibid. Montreal as the seat of the Upper Canadian export flour commerce came under stricter flour inspection laws than Upper Canada. In 1806 an Act of Lower Canada repealed the Quebec ordinance of 1785 and set rules for merchantable flour which were more stringent than those enacted in Upper Canada until 1841. The Act of Union in 1841 and a new flour inspection law applicable to both provinces meant that Upper and Lower Canadian flour inspection was the same.
8 PAC, MG23, HI1, Wolford Simcoe Papers, Series 3, Book 4, p. 38. McGill probably reasoned that the smaller the

barrel, the less waste in the event of its contents souring, while Simcoe and the trade may have wished for larger 200- or 224-pound barrels for the sake of economy.

Some Problems Establishing Early Mills

1 Ernest A. Cruikshank, ed., Settlement, p. 152.
2 PAC, RG1, L4, Vol. 2, p. 182.
3 Due to the ambiguous use of the term "miller" in documentary evidence, it is not certain whether the "miller" who leased a king's mill actually operated the mill or whether he then hired a miller. Small mills were probably operated by the lessee because this was a more profitable arrangement.
4 James J. Talman, ed., Loyalist Narratives from Upper Canada (Toronto: The Champlain Society, 1946), p. 133.
5 Ibid.

Method and Technology of Grist and Flour Mills

1 Oliver Evans, The Young Millwright and Miller's Guide (Philadelphia: Carey and Lea, 1832) (hereafter cited as Guide [1832]), pp. 260-61.
2 Harry B. Weiss and R.J. Simm, The Early Grist and Flouring Mills of New Jersey (Trenton: N.J. Agricultural Society, 1956), pp. 72-75.
3 B.W. Dedrick, Practical Milling (Chicago: National Miller, 1924), Chap. 2.
4 Harry B. Weiss and R.J. Simm, op. cit., p. 69.
5 William B. Munro, op. cit., p. 116.
6 Oliver Evans, Guide (1832), p. 317.
7 PAC, MG23, GIII, 1, Allsopp Papers, Letterbook, p. 14.
8 Andrew Gray, The Experienced Millwright (Edinburgh: Archibald Constable, 1806).
9 William C. Hughes, The American Miller and Millwright's Assistant (Philadelphia: H.C. Baird, 1855), pp. 234-44, "Extract from the Report of the National Academy of Paris, April 21, 1852, on the Quarries and Millstone Yards of M. Roger-fils at Ferté-sous-Jouarre."
10 Millnotes, ed. S. Buckland, D.H. Jones, J.K. Major (2 Eldon Road, Reading, England), No. 1 (Oct. 1970), p. 11.
11 Harry B. Weiss and Robert J. Simm, op. cit., p. 53.
12 David Craik, The Practical American Millwright and Miller (Philadelphia: H.C. Baird, 1882), p. 293.
13 Selkirk, p. 19,896.
14 Oliver Evans, op. cit., p. 310.
15 David Craik, op. cit., pp. 306-7.
16 John Russell, "Millstones in Wind and Water Mills," Newcomen Society Transactions, Vol. 24 (1943-45), p. 61.
17 Queen's University Archives, The Hon. Richard Cartwright Papers, Business Correspondence, 1799-1802, p. 71. John

Storck and Walter D. Teague, Flour for Man's Bread (St. Paul: North Central Publishing, 1952), p. 169.
18 "A Brief History of the Manufacture of Silk Bolting Cloths," Canadian Miller and Cerealist, Vol. 5 (July 1913), p. 158.
19 PAC, MG23, GIII, 17, Robert Hunter.
20 Thomas W. Casey, op. cit., p. 54.
21 PAC, MG23, HI1, Wolford Simcoe Papers, Series 3, Book 2, pp. 238-40.
22 Oliver Evans, op. cit., p. 159.
23 PAC, MG23, GIII, Allsopp Papers, Vol. 1, p. 14. The large merchant and custom mill of Allsopp was completed in 1785 at the present site of Donnaconna, Quebec, and was constantly updated. Allsopp's letterbook records valuable information about the late 18th-century grain and flour trade in North America.
24 David Craik, op. cit., pp. 99-100.
25 Verschoyle B. Blake, "Remarks on the Construction etc. of Early Dams," memo to Jacob Spelt (private records), n.d.
26 PAC, MG23, HI1, Wolford Simcoe Papers, Series 3, Book 5, p. 203.
27 Selkirk, p. 19,674.
28 PAC, RG1, E3, Vol. 34, Pt. 2, p. 102.

The Genius of Oliver Evans
1 Isaac Weld, Jr., Travels through the States of North America and the Province of Upper and Lower Canada during the Years 1795, 1796 and 1797 (London: J. Stockdale, 1807), Vol. 1, p. 34.
2 The Repertory of Arts and Manufactures: Consisting of Original Communications, Specifications of Patent Inventions, and Selections of Useful Practical Papers from the Transactions of the Philosophical Societies of all Nations etc., etc. (London: Printed for G. and T. Wilkie, 1794-1825), Vol. 4, pp. 319-28.
3 The improvements include those made in hulling rice, heating rooms, chimneys, distilling, threshing machine (using an elastic flail) and canning.
4 Oliver Evans, Guide (1832), pp. 370-88, "Extracts from Buchanan on Millwork."
5 Oliver Evans, The Young Mill-Wright and Miller's Guide (New York: Arno Press, 1972) (hereafter cited as Guide [1850]).
6 Ibid., p. 281.
7 Ibid.
8 Ibid.
9 Oliver Evans, Guide (1832), p. 271. The 1850 edition shows the latter part of this quotation as "reading, or otherwise."
10 Oliver Evans, Guide (1850), p. 223.
11 Ibid., p. 246.
12 Ibid.

The Introduction of Automatic Milling to Upper Canada

1 Selkirk, p. 19,688-9. Selkirk illustrated his account with a sketch of Evans's hopper boy.
2 Ibid., pp. 19,884-85 (entry for 20 November 1804).
3 Ibid., probably a screen-fanning rolling mill.
4 Charles Aiken, "Journal of a Journey from Sandwich to York in the Summer of 1806," Ontario Historical Society Papers and Report, Vol. 6, p. 15.
5 This remark that mills for Cartwright and Hamilton were built later by the same millwright establishes perhaps that Hatt's Dundas mill was equipped with Evans's devices before Cartwright's mill at Napanee, and both were initially installed sometime before 1803.

The Growth of the Flour-Milling Industry

1 William Cattermole, Emigration. The Advantages of Emigration to Canada (Toronto: Coles, 1970), p. 89.
2 Amelia Harris, "Historical Memoranda by Mrs. Amelia Harris," in James J. Talman, ed., Loyalist Narratives from Upper Canada (Toronto: The Champlain Society, 1946), p. 135.
3 Ontario. Department of Lands and Forests. Conservation Authorities Branch, Spencer Creek Conservation Report: History (Toronto: 1962), p. 93.
4 A. Lillie, Canada; Physical, Economic and Social (Toronto: Maclear, 1855), p. 171.
5 Ibid., p. 175.
6 W.W. Smith, Gazetteer and Directory of the County of Grey for 1865-66 (Toronto: Globe Steam Press, 1865).

Government Encouragement

1 PAC, MG23, HI1, B9, Wolford Simcoe Papers, p. 101.
2 PAC, RG1, L3, Vol. 184, Upper Canada Land Petitions, E Bundle, Ernestown Mills.
3 PAC, RG1, E3, Vol. 15, pp. 187-92; see also Vol. 16, pp. 162-67; see Petitions, in Upper Canadian House of Assembly Journals 1792-1840 and Legislative Assembly Journals from 1841-1867 for the Province of Canada.
4 PAC, RG1, E3, Vol. 66, Pt. 1, pp. 76-81.

Mill Architecture

1 Mary Gapper O'Brien, The Journals of Mary O'Brien, 1828-1838 (Toronto: McMillan, 1968), pp. 87-8.
2 PAC, MG24, I130, 6 September 1847.
3 Patricia W. Hart, Pioneering in North York, a History of the Borough (Toronto: General Publishing, 1968), p. 71.
4 David Craik was a miller, millwright and author of The Practical American Millwright and Miller first published in 1870 by Henry Carey Baird of Philadelphia. The guide gives practical technical information based on the author's experience in mills in the northern United

States and Canada from about the 1830s to the 1860s, when automatic low grinding was practised. In 1870 Craik lived at Church Mills, Chateauguay, Franklin County, New York, close to the Quebec border. The portion of his work on architecture was taken from The Practical American Millwright and Miller (Philadelphia: Henry Carey Baird, 1882), p. 250.

5 Ibid., p. 265.

6 William C. Hughes, op. cit., pp. 110-11.

7 Henry Pallett, The Miller's Guide (Chester: Hanna and Phillips, 1853), p. 75.

8 David Craik, op. cit., p. 265. Craik's Guide gives numerous examples of gearing.

9 Ibid., p. 258.

10 Robert Gourlay, A Statistical Account of Upper Canada, 1817, Compiled with a View to a Grand System of Emigration (New York: Johnson Reprint, 1966), Vol. 1, p. 518. The Delta Mill is a national historic site.

11 Mabel Burkholder, "Palatine Settlements in York County," Ontario Historical Society Papers and Reports, Vol. 36 (1945), p. 92.

12 David Craik, op. cit., p. 262.

13 Judith C.M. Roberts, Report on Herron Mills, Lanark County (Ottawa: Canadian Engineering Heritage Record, 1973), pp. 2-3.

Waterpower Plants

1 Selkirk, p. 19426.

2 William Carter Hughes, owner of a grist and flour mill at Milford, Michigan, just west of Detroit, was an experienced millwright, miller and the author of two editions of The American Miller and Millwrights' Assistant. The first was published in 1850 by Harsha and Hart of Detroit, and a revised and updated edition of 1855 was first published in Philadelphia by Henry Carey Baird and in London, England, by Trubner & Co. Hughes' guide gives up-to-date practical details required by millers and millwrights and mill owners and reflects the growth of numerous manufactories making mill furnishings in the United States during the first half of the 19th century. He promoted a variety of newly patented machinery as well as a few of his own inventions. His method of dam construction is found in The American Miller and Millwrights' Assistant (Philadelphia: Henry Carey Baird, 1855), pp. 118-20.

3 David Craik, op. cit., pp. 156-76.

4 Selkirk, p. 19,674.

5 Ibid., p. 19,563.

6 Ibid., p. 19,426.

7 Jacob Keefer, born in Thorold township on 8 November 1800 and deceased 12 June 1874, was in 1828 the owner of a sawmill at Thorold, and from 1845 to 1850 the owner of "Welland Mills" a large five-storey stone merchant

flour mill with four runs of stones at Thorold. Keefer's journal was written between 1846 and 1853 to record the progress of his flour-mill venture and provides among other things useful data regarding milling, millwrighting and the grain and flour trade in the Niagara area. Keefer referred in his journal to three letters he received in 1846 (when his mill was under construction) from "Oswego people...on the subject of the Central Discharge Wheel." See PAC, MG24, I33, entry for Monday, 10 December 1849.

8 David Craik, op. cit., pp. 94-155.

9 Citizen (Ottawa), 14 February 1860.

10 "Ancaster, Grist and Flour Mill," True Banner and Wentworth Chronicle, 17 December 1863.

11 Great Britain. Army. Corps of Royal Engineers, Aide Mémoire to the Military Sciences (London: John Weale, 1852), Vol. 3, p. 752.

12 Ibid., pp. 756-57.

13 Fitz Water Wheel Company, Catalogue of the Fitz Water Wheel Company (Hanover: 1928), p. 35.

14 John Rennie, "Experiments on the Power of Waterwheels," Quarterly Papers in Engineering (Dublin: George Rennie, 1845).

15 Canada. Department of Agriculture and Statistics, Patents of Canada, 1824-1849 (Ottawa: 1860), Vol. 1, patent number 179.

16 Ibid., patent number 167.

17 Ibid., patent number 168.

18 Ibid., patent numbers 180 and 63.

19 Ibid., patent number 75.

20 Ibid., patent number 219.

21 Ibid., patent number 121.

22 Ibid., patent numbers 250 and 133.

23 Canada. Department of Agriculture and Statistics, Patents of Canada 1849-1854 (Ottawa: 1865), Vol. 2, patent numbers 337 and 479.

24 Canada. Department of Agriculture and Statistics, List of Canadian Patents from the Beginning of the Patent Office, 1824 - 1872 (Ottawa: Maclean, Roger and Co., 1882) (hereafter cited as Canadian Patents), patent number 520. Nicholas Lacroix and his brother Edmund N. were millwrights born and educated in France and are credited with creating a revolution in milling methods in Minnesota in the 1870s. See Part IV.

25 Ibid., patent number 1560.

26 William C. Hughes, op. cit., pp. 57-66, 246-49, 260-75.

27 G.P. de T. Glazebrook, Life in Ontario, A Social History (Toronto: Univ. of Toronto Press, 1968), p. 42.

28 Colonial Advocate, 3 June 1824.

29 Joseph Pickering, Inquiries of an Immigrant: Being the Narrative of an English Farmer from the Year 1824 to 1830 (London: Effingham Wilson, 1832), entry for 23 July 1827.

30 Ernest Green, "The Niagara Portage Road," Ontario Historical Society Papers and Reports, Vol. 23, p. 36.
31 PAC, RG1, E3, Vol. 8, pp. 10-11.
32 PAC, MG24, D19, Ward Papers, p. 53.
33 "Journal of the Legislative Assembly of Upper Canada for 1811" in Ontario. Bureau of Archives, Eighth Report of the Bureau of Archives for Province of Ontario (Toronto: L.K. Cameron, 1912), p. 441.
34 William Cattermole, op. cit., p. 184.
35 Canada. Department of Agriculture and Statistics Patents of Canada 1824-1849 (Ottawa: 1860), patent numbers 12, 81, 25.
36 William H. Smith, Smith's Canadian Gazetter (Toronto: H. & W. Rowsell, 1846). Steam mills were reported at Amherstberg, Chatham, Chippawa, Cobourg, The Junction, Kingston, Maitland, Oakville, Port Colborne, Port Sarnia, Prescott, Preston, Sandwich, St. Davids, Sydenham, Toronto, Vankleek Hill and Wellington Square.
37 A. Lillie, op. cit., p. 171.
38 David Craik, op. cit., p. 419. Craik lived at Chateauguay, N.Y., near the Quebec border.
39 E.B. Shuttleworth, The Windmill and Its Times (Toronto: W.C. Gooderham, 1924), p. 42.
40 William C. Hughes, op. cit., p. 189.
41 Ibid.
42 David Craik, op. cit., pp. 417-21.
43 University of Western Ontario Archives, Regional Collection, Weldon Library, James Hamilton Papers, "Estimate for Messrs Hamilton and Warren, Kettle Creek, U.C., Mill Castings," 24 May 1830. The total cost of brass and iron castings amounted to $851.20 subject to duties.
44 The Canadian Correspondent, 10 May 1834.
45 David Craik, op. cit., p. 262.
46 Ibid., p. 256.
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48 Ibid., p. 7.

Millwrights

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3 Ibid., pp. 89-90.
4 Selkirk, pp. 19,930-1.
5 Ibid., p. 19,812.
6 PAC, MG24, I26, Vol. 7, letter of 31 May 1817.
7 Ibid.
8 David Gibson, "Conditions in York a Century Ago," Ontario Historical Society Papers and Reports, Vol. 24 (1927), p. 361.
9 William Cattermole, op. cit., p. 94.

10 Ibid., p. 183.
11 James B. Brown, <u>Views of Canada and the Colonists</u> (Edinburgh: Adam and Charles Black, 1851), p. 367.
12 William Cattermole, op. cit., p. 172.
13 PAC, MG24, I33, Keefer Journal.
14 Ibid., entry for Monday, 23 November 1846.
15 Ibid., entry for Wednesday, 28 April 1847.
16 Ibid., entry for Thursday, 10 June 1847.
17 Ibid., entry for Saturday, 24 April 1847.

Millers and Mill Owners
1 William C. Hughes, op. cit., p. 101.
2 Henry Pallett, op. cit., p. 43.
3 PAC, MG23, HII, 13, Elias Smith Papers, letter of 28 January 1800.
4 Henry Pallett, op. cit., p. 43.
5 Ibid.
6 PAC, MG24, I131, Nelles Papers, p. 236.
7 PAC, MG24, I33, Keefer Journal, entry for 10 August 1847.
8 PAC, MG24, I130, Wadsworth Papers, letter of 6 September 1847.
9 James B. Brown, op. cit., p. 367.
10 James J. Talman, ed., op. cit., "Historical Memoranda by Mrs. Amelia Harris," p. 135.

Automatic Fast Reduction Process of Milling
1 Oliver Evans, <u>Guide</u> (1832), pp. 201-41.
2 Ibid., pp. 262-64.
3 William C. Hughes, op. cit., pp. 202-3.
4 Canada. Department of Agriculture and Statistics, <u>Patents of Canada 1849-1854</u> (Ottawa: 1865), Vol. 2, patent number 279.
5 Ibid.
6 PAC, MG24, I33, Keefer Journal. This may have referred to David Bonnell or Enos Bunnell, a Brantford mill owner, or some other Bunnell concerned with milling.
7 Ibid., entry for Monday, 25 June 1849.
8 Henry Pallett, op. cit., p. 38.
9 David Craik, op. cit., p. 351. Since Craik's method made no use of a middlings purifier, this method of regrinding middlings was not the same as the new process of the 1860s and therefore is included here.
10 Craik was writing about superfine grades of flour which, when cheap, resulted in little demand for grades lower than superfine or what he termed "inferior" flour.
11 Metropolitan Toronto Library, Baldwin Room, The Goldie Papers, letter of 20 November 1850.
12 Ibid. Different letters in 1850 refer to different kinds of stones. In March 1850 the stones were described as "one run of gristing stones and one for chopping." The gristing pair probably were removed in

view of the fact that Goldie considered grist or country work unprofitable compared to merchant work. Four months later Goldie wrote that two runs of stones included a "flouring run being £40 and the other for chopping £10." The latter were used for making feed for livestock.

13 PAC, MG28, III56, Toronto Board of Trade, Council Minute Book, 30 April 1850 to 24 January 1871, p. 116, being a newspaper clipping originally published in The Montreal Witness of 6 December 1856, "Commercial Review" by John Dougall.

14 Ibid.

15 Ibid.

16 Ibid.

17 Henry Pallett, op. cit., p. 35.

18 William C. Hughes, op. cit., p. 203.

19 E.A. Cruikshank, ed., Records of Niagara, 1805-1811 (Niagara-on-the-Lake: Niagara Historical Society, 1931).

20 E.B. Shuttleworth, op. cit.

21 John Squair, The Townships of Darlington and Clarke including Bowmanville and Newcastle, Province of Ontario Canada (Toronto: University of Toronto Press, 1927), p. 458.

22 Ibid.

23 M. McLaughlin, "The Milling of Fifty Years Ago, With Notes of Its Subsequent Development," Dominion Mechanical and Milling News (August 1887), p. 6.

24 William C. Hughes, op. cit., p. 165.

Grain Varieties

1 Robert L. Jones, History of Agriculture in Ontario, 1613-1880 (Toronto: University of Toronto, 1946), p. 100.

2 James B. Brown, op. cit., p. 402. Yields of wheat per acre varied above and below this "average" according to the condition of the soil and seed, pests, etc.

3 Ibid.

4 Robert L. Jones, op. cit., pp. 102-5.

Grain Cleaning and Drying

1 Selkirk, p. 19,885.

2 PAC, MG24, I26, Hamilton Papers, Vol. 9.

3 PAC, MG24, I131, Nelles Papers, p. 29.

4 Henry Pallett, op. cit., pp. 31-32.

5 Canada. Department of Agriculture and Statistics, Patents of Canada 1849 to 1854 (Ottawa: 1865), patent numbers 404, 276, 284, 290 and Canadian Patents, patent numbers 495, 947 and 984.

6 Canada. Department of Agriculture and Statistics, Patents of Canada 1849 to 1854 (Ottawa: 1865), Vol. 2, patent number 454.

7 John Storck and Walter D. Teague, op. cit., p. 190.
8 Ibid., p. 191.
9 <u>Canadian Patents</u>, patent number 1326.
10 Ibid., patent number 1056.
11 Samuel Deane, <u>The New England Farmer; or Georgical Dictionary</u> (New York: Arno Press, 1972), p. 392. Present research reveals that smut is caused by various parasitic fungi some of which affect the seed of wheat (common bunt), others the flower of wheat (loose smut of wheat). When seed is infected the flower produces smut balls in the place of normal kernels. When the flower is infected the seed appears normal but produces a generation of wheat stalks in which the entire head is infected and blown bare by harvest time.
12 Great Britain. Patent Office, <u>Subject Matter Index (Made from Titles only) of Patents of Inventions from March 2, 1617, to October 1, 1852</u> (London: 1854). Pt. I, p. 32, patent number 2721.
13 United States. Patent Office, <u>Subject Matter Index of Patents for Inventions issued by the U.S. Patent Office from 1790 to 1873 inclus</u>. (Washington, U.S. Government Printing Office, 1874), Vol. III, p. 1371.
14 PAC, MG24, I26, Vol. 9, Hamilton Papers, letter of 28 April 1812.
15 Ibid.
16 William C. Hughes, op. cit., pp. 219-23.
17 Ibid., pp. 121-23.
18 Canada. Department of Agriculture and Statistics, <u>Patents of Canada, 1824 to 1849</u> (Ottawa: 1860), Vol. 1, patent no. 159.
19 Ibid., patent number 58.
20 Ibid., patent numbers 125 and 238.
21 <u>Canadian Patents</u>, patent number 698.
22 Ibid., patent number 848.
23 Ibid., patent number 581.
24 Ibid., patent number 1397.
25 William C. Hughes, op. cit., pp. 157-8.
26 Ibid., p. 128.
27 Ibid.
28 <u>Canadian Patents</u>, patent numbers 68 and 188.
29 Ibid., p. 16, patent number 298.
30 Ibid., p. 33, patent number 669.

Millstones

1 Abraham Rees, <u>The Cyclopaedia; or Universal Dictionary of Arts, Sciences and Literature</u> (London: Longman, Hurst, Rees, Orme & Brown, 1819), s.v. "Millstone."
2 J. Leander Bishop, <u>A History of American Manufacturers from 1608 to 1860</u> (New York: Augustus M. Kelley, 1966), Vol. 1, p. 149.
3 J.E. Mitchell, "Millstones and Burr-Blocks of La Ferté-sous-Jouarre," in William C. Hughes, op. cit., pp. 234-44.

4 Ibid.
5 J.-C. Taché, Sketch of Canada, Its Industrial Condition and Resources (Paris: Hector Bossange & Sons, 1855), p. 93.
6 Selkirk, p. 19,893.
7 James B. Brown, op. cit., App. 1.
8 Ibid.
9 The Bathurst Independent Examiner (Perth), October 1829.
10 William H. Smith, Smith's Canadian Gazetter (Toronto: H.&W. Rowsell, 1846), pp. 37, 49.
11 PAC, MG23, HII, 13, Elias Smith Papers, letter of 28 January 1800.
12 William Cattermole, op. cit., p. 24.
13 Rochester Telegraph, 24 December 1822.
14 J. Leander Bishop, op. cit., Vol. 3, p. 261.
15 William C. Hughes, op. cit., p. 73.
16 J. Leander Bishop, op. cit., Vol. 2, p. 185.
17 John Russell, op. cit., pp. 55-64.
18 William C. Hughes, op. cit., p. 89-90.
19 Ibid., p. 89.
20 Abraham Rees, loc. cit.
21 William C. Hughes, op. cit., p. 85.
22 David Craik, op. cit., p. 306.
23 Canada. Department of Agriculture and Statistics, Patents of Canada 1849 to 1854 (Ottawa: 1865), Vol. 2, patent number 366.
24 Canadian Patents, patent number 974.
25 Ibid., patent number 1133.
26 William C. Hughes, op. cit., p. 26.
27 Sir William Fairbairn, op. cit., p. 450.
28 Canada. Department of Agriculture and Statistics, Patents of Canada, 1824 to 1849 (Ottawa: 1860), Vol. 1, patent number 211.
29 William C. Hughes, op. cit., pp. 196-98, see engraving on frontispiece.
30 J. Leander Bishop, op. cit., vol. 3, p. 262.
31 William C. Hughes, op. cit., p. 227.
32 Ibid., pp. 230-34, includes a descriptive diagram.
33 Ibid., pp. 244-45, includes a descriptive diagram.
34 Henry Pallett, op. cit., p. 21.

Flour Bolts
1 Upper Canada Gazette, 13 December 1803.
2 PAC, MG24, I55, Gideon Olmstead, Examination of Caleb Edwards, 27 August 1838.
3 John Storck and Walter D. Teague, op. cit., p. 169.
4 PAC, MG24, I26, Vol. 9, Hamilton Papers, letter of 12 May 1812.
5 M. & W. Livingston at 70 Broad Street mailed out cards displaying 12 small samples of anchor bolting cloths ranging from number 00 to 10. One such display card was found glued to the inner cover of a third edition (ca.

1817) of Oliver Evans's *Millwright's Guide*, seen in Fig. 29.

6 Thomas W. Poole, *A Sketch of the Early Settlement and Subsequent Progress of the Town of Peterborough and of each Township in the County of Peterborough* (Peterborough: Peterborough Review, 1867), p. 158.

7 David Craik, op. cit., pp. 324-25, 341.

8 "A Brief History of the Manufacture of Silk Bolting Cloth," *Canadian Miller and Cerealist*, Vol. 5 (July 1913), pp. 158-59.

9 "A Century of Progress in Bolting Cloth Manufacture," *Canadian Milling and Feed Journal*, Vol. 17, No. 6 (June 1936), p. 19.

10 Ibid.

11 William C. Hughes, op. cit., p. 97.

12 Ibid., p. 259.

13 Ibid., p. 255.

14 Ibid., p. 215.

15 David Craik, op. cit., p. 322.

16 Ibid., pp. 322-24.

17 William C. Hughes, op. cit., pp. 200-1.

18 Canada. Department of Agriculture and Statistics, *Patents of Canada, 1824-1849* (Ottawa: 1860), patent number 116.

19 *Canadian Patents*, patent number 1097.

20 David Craik, op. cit., pp. 328-41.

21 Ibid., pp. 423-28.

22 William C. Hughes, op. cit., pp. 94-95.

23 Ibid., pp. 95-97.

24 Henry Pallett, op. cit., p. 29.

25 R.C. Brown, *The New Process Milling or Practical Suggestions on the Reconstruction of Mills* (Elgin: S.L. Taylor, 1877), p. 33.

Legislation Related to Flour Milling

1 Upper Canada. Laws, Statutes, etc., *The Statutes of Upper Canada to the Time of the Union, Revised and Published by Authority* (Toronto: Robert Stanton, 1843), Vol. 1, Public Acts, 41st Geo. III, Chap. 7. From the account the instrument was a bore about half an inch in diameter which cut through the head of the barrel allowing the extraction of a sample of flour for inspection. This clause in the inspection act was more detailed in later laws which required that the hole be plugged and the flour returned to the owner.

2 Ibid., 1st Geo. IV, Chap. 5.

3 Ibid.

4 Ibid.

5 Canada (Province). Laws, Statutes, etc., *The Provincial Statutes of Canada, 1841* (Kingston: 1842), Vol. 1, Reserved Acts, 4th & 5th Victoria, Caption 89, Sect. 10. Inspection was carried out in the store, shop or

warehouse of the inspector, or in a store in the district of the inspector.

6 Ibid., Sect. 22.

7 Canada (Province). Laws, Statutes, etc., Statutes of the Province of Canada (Toronto: 1856), 19th & 20th Victoria, Caption 87.

8 Ibid., Sect. 26.

9 Upper Canada. Laws, Statutes, etc., op. cit., 1843, Vol. 1, Public Acts, 9th Geo. IV, Chap. 4, Sect. 2.

10 Ibid., Vol. 2, Local and Private Acts, 3rd Wm. IV (1833), 4th Wm. IV (1834), 6th Wm. IV (1836), and 3rd Victoria (1840).

11 Canada (Province). Laws, Statutes, etc., Provincial Statutes of Canada, 1846 (Montreal: Queen's Printer, 1846), Vol. 2, 9th Victoria, Caption 52.

12 Ibid., The Provincial Statutes of Canada, 1848 (Montreal: Queen's Printer, 1848), 11th Victoria Caption 10, Sect. 2.

13 Ibid., The Provincial Statutes of Canada, 1849 (Montreal: Queen's Printer, 1849), 12th Victoria Caption 87, Sect. 5.

Introduction of Gradual Reduction to Ontario

1 John Storck and Walter D. Teague, op. cit., p. 202. Augustin Rollet wrote Memoire sur la meunerie, la boulangerie et la conservation des grains, which was published in 1847.

2 John Storck and Walter D. Teague, op. cit., p. 201.

3 R.C. Brown, op. cit.

4 Ibid., p. 25.

5 Oliver Master, "The Canadian Flour Milling Industry," Canadian Miller and Cerealist, Vol. 7 (May 1915), p. 107.

6 Elliot Richmond, "E.W.B. Snider," Ninth Report of the Waterloo Historical Society (1921), p. 184.

The Improvements of John Brown, Waterloo County, 1863

1 Waterloo Historical Society, "Parkway (German Mills) Closed," Forty-Ninth Annual Volume of the Waterloo Historical Society (1962), p. 60.

2 Ibid., pp. 59-60.

3 Ibid., p. 60.

4 E.W.B. Snider, "Waterloo County Forests and Primitive Economics," Sixth Annual Volume of the Waterloo Historical Society (1918), pp. 21, 24.

5 Oliver Master, op. cit., p. 107.

6 Canada. Department of Consumer and Corporate Affairs. Patent Office Search Library, Canadian Patent File, No. 1495, 11 March 1863, John Brown (hereafter cited as John Brown). See letter of 14 October 1862 from D.S. Shoemaker, Berlin, to the Minister of Agriculture, Quebec, included with the original application and patent.

7 Ibid.
8 Ibid., specification and description, p. 2. See also plan of millstones in Figs. 5, 6 and 7 of specification.
9 Ibid., specification and description, pp. 1-6. See also plan of bolt, Figs. 1, 3, 3, 4, 8.
10 Ibid., p. 5.
11 Ibid.
12 Ibid., letter of 14 October 1862 from D.S. Shoemaker, Berlin, to the Minister of Agriculture, Quebec.
13 Elliot Richmond, op. cit., p. 184.
14 John Brown. See "Specification and Description," p. 4.
15 Oliver Master, op. cit., p. 108.
16 James Sutherland, County of Waterloo Gazeteer and General Business Directory for 1864 (Toronto: Mitchell & Co., 1864), p. 187. The spelling of Haxall varied, Hoxall and Haxal noted before 1877, and Hexel in 1884.
17 Armstrong & Co., County of Waterloo Directory, 1887-78 (Toronto, 1878) as reprinted by Ross Cumming in Historical Atlas of Waterloo and Wellington Counties, Ontario, Illustrated 1877-1881 (Owen Sound; Richardson, Bond and Wright, 1972), p. 45.
18 Ibid.
19 Ibid., p. 41.
20 Oliver Master, op. cit., p. 108. Some of this shipped via Montreal may have been the favorite brands recorded in the lists of the Montreal Corn Exchange in the 1860s.
21 United States. Patent Office, Specifications and Drawings of Patents Issued from the U.S.P.O. (Washington: Government Printing Office, 1866) (hereafter cited as Specifications and Drawings) see No. 51,549, 19 December 1865, John Brown of Utica, New York.
22 Ibid., Specification of Letters Patent No. 51,548, 19 December 1865.
23 John Storck and Walter D. Teague, op. cit., p. 207.
24 M.D. Leggett, "Index of Trademarks Registered in the United States Patent Office from 1790 to 1873 Incl," in the United States Patent Office, Subject Matter Index of Patents for Inventions issued by the United States Patent Office (Washington: Government Printing Office, 1874), Vol. 3, p. 1934.
25 Oliver Master, op. cit., p. 108.
26 Canada. Department of Consumer and Corporate Affairs. Trademark Office, Register Number 6, Folio 1162, application dated 12 September 1877.
27 William W. Evans, comp., Waterloo County Gazeteer and Directory for 1884-85 (Toronto: Hill and Weir, 1884), p. 28. This may have been produced from rollers and therefore was different from the earlier product branded Haxall gradually reduced on millstones. There is no evidence "German Hexel" was a registered trademark.

The New Process of Edmund and Nicholas Lacroix in Minnesota, 1870

1 John Storck and Walter D. Teague, op. cit., p. 205.
2 George D. Rogers, "History of Flour Manufacture in Minnesota," Collections of the Minnesota Historical Society, Vol. 10, Pt. 1 (1905), p. 47. The date given here for the Lacroix's invitation to come to Faribault is 1861, whereas Storck and Teague write they were "induced" to come in 1865.
3 Canadian Patents, patent number 520.
4 George D. Rogers, op. cit., p. 48.
5 Canada. Department of Consumer and Corporate Affairs, Canadian Patent Office Record (hereafter cited as CPOR) (Ottawa: 1873), Vol. I, Patent Number 1739, 7 November 1872.
6 Ibid., Patent Number 2762, 25 September 1873.
7 United States. Patent Office, Specifications and Drawings Patent Number 127,719, 12 May 1872.
8 Charles B. Kuhlman, The Development of the Flour Milling Industry in the United States (Boston: Houghton Mifflin, 1929), p. 119. These handsome profits allowed U.S. millers to dump their lower grades duty free on the Canadian market for cheaper than Ontario millers could produce, thereby contributing to Canadian depression.
9 George D. Rogers, op. cit., pp. 48-49.
10 Canada. Department of Consumer and Corporate Affairs. Patent Office Search Library, Canadian Patent File Number 2409, 4 June 1873, G.T. Smith; see Specification.
11 Ibid.
12 CPOR (Ottawa, 1873), Vol. I, patent number 2257.
13 Ibid., patent number 2258.
14 John Storck and Walter D. Teague, op. cit., p. 212, Fig. 90.
15 Canada. Laws, Statutes, etc., Statutes of Canada, 1884, Fifth Parliament, 47th Victoria (Ottawa: Brown Chamberlin, 1884), Vol. I & II, p. 118.
16 Charles B. Kuhlman, op. cit., p. 120.
17 R.C. Brown, op. cit.
18 Robert L. Jones, op. cit., p. 245.
19 Canada. Parliament. House of Commons, "Report of the Select Committee on the Causes of the Present Depression of the Manufacturing, Mining, Commercial, Shipping, Lumber and Fishing Interest," Journals of the House of Commons of the Dominion of Canada, Vol. X from 10 Feb. to 12 April, 1876 inclus. 39th Victoria, 3rd Parliament, Session 1876 (Ottawa: McLean, Roger, 1876), App. 3, p. 66.
20 Ibid., p. 75.
21 Ibid., p. 76.

Grain and Methods of Preparing it for Milling

1 Henry Youle Hind, ed., Journal of the Arts and Manufactures for Upper Canada, Vol. 2 (September 1862), p. 257.

2 Robert L. Jones, op. cit., p. 246.
3 Ibid.
4 Ibid., p. 247.
5 Ibid.
6 Canada (Province). Laws, Statutes, etc., *Statutes of Canada, 1863*, 26 Victoria, Caption 3.
7 Robert L. Jones, op. cit., p. 237.
8 Canada (Province). Laws, Statutes, etc., *Statutes of Canada, 1863*, 26 Victoria, Caption 3.
9 *Ibid., 1874.*
10 Toronto. Board of Trade, *Annual Report of the Board of Trade with a Review of the Commerce of Toronto for 1863* (Toronto: Globe Printing, 1864), p. 8.
11 Toronto. Board of Trade, *Annual Review of the Commerce of Toronto for 1867*, ed. William Sutherland Taylor (Toronto: Globe Printing, 1868), p. 9.
12 Ibid., *The Commerce of Canada Considered, etc., etc., etc.* (Toronto: Globe Printing, 1867).
13 Ibid., p. 9.
14 Ibid., p. 16.
15 R.C. Brown, op. cit., p. 11.
16 *Canadian Patents*, patent numbers 1490 and 1514.
17 Ibid., patent number 1529.
18 Ibid., patent number 1509.
19 Ibid., patent number 2141.
20 Ibid., patent number 2241.
21 Ibid., patent number 3270.
22 *CPOR* (Ottawa: 1875), Vol. 3, patent number 5081, 24 August 1875.

Grain Cleaning

1 Canada. Department of Consumer and Corporate Affairs, "Cleaning and Preparing Wheat for Grinding," *The Scientific Canadian Mechanic's Magazine and Canadian Patent Office Record* (February 1880), p. 38.
2 R.C. Brown, op. cit., pp. 9-10.
3 B.W. Dedrick, op. cit., p. 33.
4 John Storck and Walter D. Teague, op. cit., p. 215.
5 *Canadian Patents*, patent number 1937.
6 Ibid., p. 113, patent number 2375.
7 Ibid., patent numbers 1842, 1900, 2019, 2295, 2406, 2409, 2747, 3234, 3238, 253, 269, 338, 559, 1002, 1070, 1334, 1872, 1641; *CPOR* (Ottawa: 1873), Vol. 1, patent numbers 2524, 2554; *CPOR* (Ottawa: 1874), Vol. 2, patent numbers 3484, 3627, 3912; *CPOR* (Ottawa: 1875), patent numbers 5182, 4609, 5204.
8 *Canadian Patents*, patent number 1056 and *CPOR* (Ottawa: 1874), Vol. 2, patent numbers 3807, 3860.
9 *CPOR* (Ottawa: 1874), Vol. 2, patent number 3783, 24 August 1874.
10 *CPOR* (Ottawa: 1875), Vol. 3, patent number 5364, 11 November 1875.
11 Ibid., patent number 4226, 7 January 1875.

12 "Cleaning and Preparing Wheat for Grinding," The Canadian Patent Office Record and Scientific Canadian (Ottawa: 1880), p. 38.
13 Great Britain. Patent Office, Index, Patent number 827, 10 May 1765; patent number 968, 13 October 1770.
14 CPOR (Ottawa: 1881), Vol. 14, patent number 12,859, 21 June 1881 of L. Gathmann, Chicago, Ill.
15 CPOR (Ottawa: 1872), Vol. 1, patent number 1781; and CPOR (Ottawa: 1875), Vol. 3, patent number 4482.

Millstones of the New Process
1 John Brown, pp. 3, 6.
2 United States. Patent Office, Specifications and Drawings (Washington: Government Printing Office, 1866), patent number 51,549, 19 December 1865, John Brown of Utica.
3 R.C. Brown, op. cit., pp. 14-24.
4 John Brown, patent number 1495, 11 March 1863, and John Brown's United States Patent, number 51,549, 19 December 1865.
5 R.C. Brown, op. cit., pp. 14-24.
6 B.W. Dedrick, op. cit., p. 33.
7 R. James Abernathey, Practical Hints on Mill Building (Moline: 1880), p. 180.
8 Canadian Patents, patent numbers 1741 and 1786.
9 Ibid., patent numbers 2645, 276, and 1575; CPOR (Ottawa: 1873), Vol. 1, patent numbers 2056, 2206; CPOR (Ottawa: 1874), Vol. 2, patent number 3275; CPOR (Ottawa: 1875), Vol. 3, patent number 4620.
10 Canadian Patents, patent numbers 1755 and 2704; CPOR (Ottawa: 1875), Vol. 3, patent number 4687.
11 CPOR (Ottawa: 1875), Vol. 3, patent number 5186.
Canadian Patents, patent numbers 1907, 2851, 584, 855.
13 Ibid., patent number 3183.
14 Ibid., patent number 1544.
15 CPOR (Ottawa: 1874), Vol. 2, patent numbers 3402 and 3984.
16 Ibid., patent number 3363.
17 CPOR and Scientific Canadian Mechanic's Magazine (July 1873), pp. 119-20, "Henry's Improved Spindle Step."
18 CPOR (Ottawa: 1875), Vol. 3, patent number 4445.
19 Henry Youle Hind, ed., op. cit., Vol. 6, No. 10 (October 1866), p. 277.

Purifiers
1 R.C. Brown, op. cit., p. 5.
2 CPOR (Ottawa: 1876), Vol. 4, patent number 6062. Louis Gathmann was also the patentee in 1881 of a brush grain cleaner.
3 CPOR (Ottawa: 1873), Vol. 1, patent number 1793.
4 CPOR (Ottawa: 1877), Vol. 5, patent number 8094.
5 CPOR (Ottawa: 1873), Vol. 1, patent number 2829.

6 "Exhibition Supplement," The Canadian Monthly and National Review, Vol. 6, (July-December 1874), p. 5.
7 J.H. Beers and Company, Illustrated Historical Atlas of the County of Ontario, 1877 (Port Elgin: Ross Cumming, 1973), p. 13.
8 CPOR (Ottawa: 1874), Vol. 2, patent number 3220.
9 Ibid., patent number 4031.
10 CPOR (Ottawa: 1875), Vol. 3, patent number 4644.
11 J.H. Beers, and Company, op. cit., p. 13.
12 Canada. Department of Consumer and Corporate Affairs. Trademark Office, Register Number 3, folio 484, 11 April 1874.
13 Ibid., 11 April 1874, fols. 478-84.
14 CPOR (Ottawa: 1876), Vol. 4, patent numbers 5942, 6325.
15 CPOR (Ottawa: 1874), Vol. 2, patent number 3014.
16 Ibid., patent numbers 3895, 3894 and 3918.
17 CPOR (Ottawa: 1873), Vol. 1, patent number 2778, 6 October 1873, P.T. Trimmer.
18 Ibid., patent number 2065 of Huntly, Holcomb and Heine, manufacturers.
19 CPOR (Ottawa: 1874), Vol. 2, patent number 3214.
20 CPOR (Ottawa: 1875), Vol. 3, patent numbers 5225.
21 Ibid., patent number 4869.

Flour Bolting for the New Process
1 John Brown, see specification, pp. 1-6.
2 R.C. Brown, op. cit., Ch. 7, pp. 32-38.
3 Ibid., pp. 39-46.
4 Ibid., p. 32.
5 Canadian Patents, patent number 199.

Flour During the Period of the New Process
1 Canada. Department of Corporate and Consumer Affairs. Trademark Office, Trademark Register (hereafter cited as Trademark Register), Vol. A, Pt. 1, p. 3.
2 Ibid., p. 5.
3 Brown's Toronto General Directory (Toronto: Maclear and Co., 1856), p. xiv. In 1856, F.A. Whitney & Co. was the sole manufacturer of Jones's patent preparation.
4 Trademark Register, Vol. 1, p. 40.
5 Montreal Corn Exchange, "Weekly Prices Current in Montreal," Nos. 1-927 (8 May 1863-30 December 1880), Friday, 29 July 1864.
6 Ibid., Friday, 5 August 1864.
7 Ibid., Friday, 13 September 1867.
8 Ibid., Friday, 29 October 1869.
9 PAC, MG28, III, 44, Montreal Board of Trade, Vol. M2785, 31 May 1869, pp. 123-4.
10 Great Britain. Parliament, Acts of the Parliament of the United Kingdom of Great Britain and Ireland (35th and 36th Vict.) (Ottawa: Queen's Printer, 1873), C24, p. 167.

11 PAC, MG28, III, 56, Toronto Board of Trade, "Circular" from James Rough, Flour Inspector, Toronto, 1 August 1873.
12 Great Britain. Parliament, Acts of the Parliament of the United Kingdom of Great Britain and Ireland (37th Vict.) (Ottawa: Queen's Printer, 1874), C. 24, p. 201.
13 Trademark Register, Vol 3, pp. 478-84.

Diversity of Roller-Milling Systems

1 "Prof. Kick on Modern Milling," The American Miller (Sept. 1891), p. 607.
2 Richard Bennett and John Elton, The History of Corn Milling (New York: Burt Franklin, 1964), Vol. 3, p. 304.
3 L. McKinnon, op. cit., p. 3.
4 B.W. Dedrick, op. cit., pp. 97-141.

Snider Pioneer Roller Mills

1 Elliot Richmond, op. cit., p. 184.
2 Ibid., p. 187.
3 Kitchener Public Library, Snider Family Papers, Hoerde and Company to E.W.B. Snider, 26 February 1875.
4 Ibid.
5 Ibid., 20 May 1875.
6 Ibid.
7 Ibid., 26 February 1875.
8 Ibid.
9 Ibid., 4 September 1875.
10 Ibid., Hoerde and Company Catalogue No. 22.
11 Kitchener Public Library, Snider Family Papers, Hoerde and Company to E.W.B. Snider, 13 January 1876. Iron rollers were criticized by millers using early designs because they exerted too much pressure and produced caked flour.
12 Ibid., Hoerde and Company Catalogue No. 37.
13 John Storck and Walter D. Teague, op. cit., p. 260.
14 Elliot Richmond, op. cit., p. 184.
15 Oliver Master, op. cit., p. 109.
16 E.W.B. Snider, "Waterloo County Forests and Primitive Economics," Sixth Annual Volume of the Waterloo Historical Society (1819), n. 23, p. 24.
17 Elliot Richmond, op. cit., p. 187.
18 Armstrong and Company, County of Waterloo Directory, 1877-78 (Toronto: 1878) included in the reprint edition of Ross Cumming, ed., Historical Atlas of Waterloo and Wellington Counties, Ontario, Illustrated, 1877-1881 (Owen Sound: Richardson, Bond & Wright, 1972), p. 45.
19 Ibid., p. 43.
20 Illustrated Atlas of the County of Waterloo, 1881 (Toronto: H. Parsell & Co. 1881) included in the reprint edition of Ross Cumming, ed., op. cit., p. 12.
21 Ibid., p. 18.

22 Kitchener Public Library, Snider Family Papers, engraving of Lancaster Roller Mills.
23 Canada. Department of Consumer and Corporate Affairs. Trademark Office, Register 6, fol. 1205.
24 "The Old Shoemaker Mill," Bridgeport, Ontario. Canadian Milling and Feed Journal, Vol. 13, No. 10 (October 1932) p. 7. The article states the award was won "at the Philadelphia Centennial Exhibition in 1878." Though the centennial was held in 1876, the exhibition facilities were probably used again in 1878.
25 Illustrated Atlas of the County of Waterloo, 1881, p. 12.
26 Ibid., p. 10.

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2 Chronicle-Telegraph, One-Hundred Years in Waterloo County, Canada, Semi-Centennial Souvenir, 1856-1906 (Waterloo: 1906), p. 84.
3 Miriam Hilborn, "The New Dundee Flour Mills," 49th Annual Volume of the Waterloo Historical Society (1962), p. 78.
4 Kitchener Public Library, Snider Family Papers, "New Process of Milling," E.P. Allis and Company, Milwaukee, Wisc.
5 Ibid., "Verbesserter Patent - Porzellan - Walzenstuhl," Weber & Bunzli, Uster, Switzerland. The text of this German brochure translates into an account almost identical to the text of the E.P. Allis brochure describing Wegmann's porcelain rollers.
6 Ibid., Wilhelm Braun, Carlsbad, to E.W.B. Snider, 23 March 1881. It is not known whether Wilhelm Braun was related to John Braun, the patentee of 1863 machinery improvements used in the new process.
7 Miriam Hilborn, op. cit., p. 78.
8 Elliot Richmond, op. cit., p. 185.
9 Miriam Hilborn, op. cit., p. 78.
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