Delta Mill Conservation Report

(Abridged Version)

This document was prepared for the Delta Mill Society in 1996 by André Scheinman, Heritage Preservation Consultant in advance of the 1999-2003 restoration of the Old Stone Mill National Historic Site. This is an OCR scan done in 2017.

This is an abridged version of the original document, it has been placed online for the history and Old Stone Mill observation elements that it documents. The restoration recommendations and costs have been removed since they aren't relevant for this purpose (and were superseded by the actual 1999-2003 restoration).

This document remains the best description of the interior architecture of the mill and the condition of the building prior to restoration. Through continued research, a more accurate history of the mill than is presented in this document is now known. Those interested in the history of the mill are encouraged to read:

Fritz, Paul S., ***A History of the Old Stone Mill, Delta, Ontario***, The Delta Mill Society, 2000

Ranford, Wade, ***A History of Grist Milling in Delta***, The Delta Mill Society, 2006.

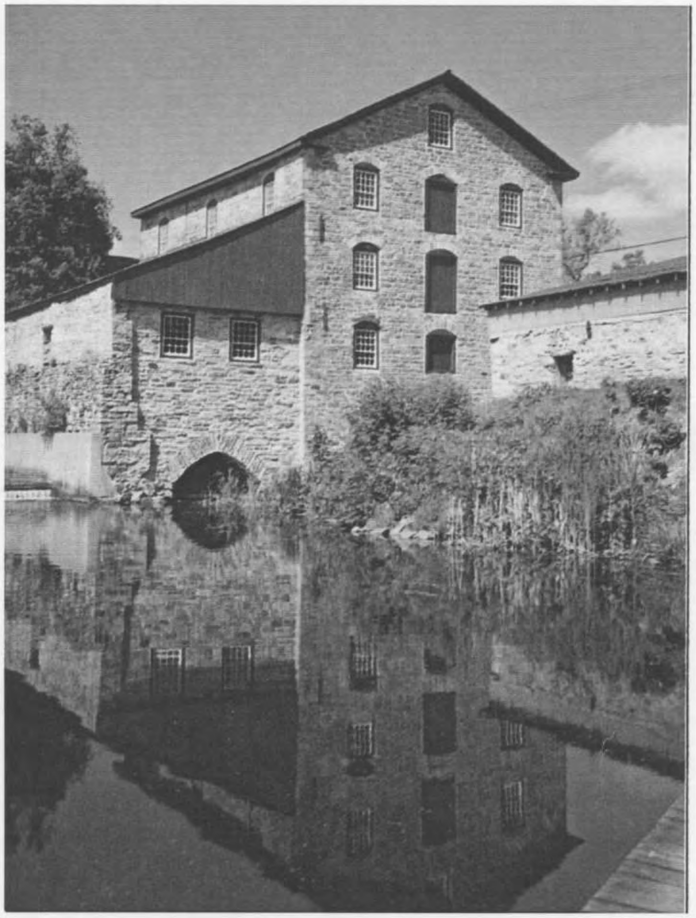
Watson, Ken W., ***Tour Guide Manual and History of the Old Stone Mill NHS***, v.1.5, The Delta Mill Society, 2018 (PDF available on DMS website).

Watson, Ken W., ***Building the 1810 Old Stone Mill in Delta, Ontario***, The Delta Mill Society, 2018 (PDF available on DMS website).

Questions can be directed to the Delta Mill Society at: info@deltamill.org

Ken W. Watson
The Delta Mill Society
May 2018

DELTA MILL CONSERVATION REPORT



Prepared by:
Andre Scheinman Heritage Preservation Consultant
William Trick, Mechanical Engineer
McNeely Engineering Consultants
M.D. Smith

For: ***The Delta Mill Society*** *(6/05/96)*

DELTA MILL CONSERVATION STUDY

TABLE OF CONTENTS

I.	INTRODUCTION	4-6
II.	REGIONAL/PROVINCIAL CONTEXT	7-8
III.	CONCEPT STATEMENT	9
IV.	GOVERNMENT DESIGNATION STATUS	10-12
V.	HISTORICAL BACKGROUND/ ARCHITECTURAL EVOLUTION	13-54
VI	BUILDING CONDITION SURVEY AND ANALYSIS	55-71
VII	CONSERVATION/RESTORATION PLANNING	72-84
VIII.	IMPLEMENTATION	85-88
IX.	OPERATION	89-91
	APPENDICES	92

Inspec-Sol Reporting Letter (15/13/95)
William Trick Reporting Letter (15/01/96)
William Trick Reporting Letter (21/02/96)
Designation By-Law No.477

ACKNOWLEDGMENTS

The Study Team gratefully acknowledges the assistance and cooperation of the Restoration Committee of The Delta Mill Society i.e. Peggy Fry, David Mess and Art Shaw whose knowledge of, and concern for, the Mill, certainly set the tone for the Study. Also thanks to Anna Greenhorn and Evelyn Saunders of The Delta Mill Society who considerately ensured the timely processing of invoices. Manuel Stevens, of Parks Canada, Cornwall consistently provided insight into the Federal perspective.

As others before me I have drawn extensively on the research compiled by Susan Warren for the Delta Mill (Delta Mill files) pursuing 'leads' first encountered in that material. (Items, within the Historical Background section of the Report, not otherwise footnoted, may be assumed to derive from this material.) Likewise the published Bicentennial Lecture of Paul S. Fritz, "Land Surveyors, and Settlers: The Origins of Bastard and South Burgess Townships, Leeds County, Ontario" opened up a wide range of important sources.

Photos and sketches not otherwise attributed are by André Scheinman.

DELTA MILL CONSERVATION STUDY

I. INTRODUCTION

This report explores the origin, evolution, present condition, and significance of the 'Stone Mill' at Delta and the optimum practical means for its conservation and enhancement. The structure is a landmark not only for the quality of its architecture and construction, but also because it represents the birthplace of settlement for this region, the rationale for the village which has grown up around it and is emblematic of early industry in the then young Province. It is the province's earliest surviving purpose-designed manifestation of 'the automatic mill', following the great revolution in milling technology developed by the American inventor Oliver Evans at the end of the 18th century. The early history of the Mill is intertwined with some of the region's most important families.

Fig.1 The Delta Mill - South Elevation

*Footnotes are included in the Historical Background Section of the Report.

The Delta Mill occupies a picturesque site at the heart of the village of Delta, on Highway 42, at the 'millstream' connection between Upper and Lower Beverley Lakes (Fig.2). The first mill at the site was built by or for area pioneer Abel Stevens c.1796 on the natural water course of Plum Hollow Creek, slightly to the east of the current millstream. Stevens' dams and subsequent millponds began the dramatic change in area hydrography which resulted in the creation of Upper Beverley Lake. His timber frame mill was operated from about the turn of the 18th century until 1808 by Nicholas Mattice, U.E.L. In 1808 Stevens sold the mill property to William Jones who with his business partner Ira Schofield had, by 1812, constructed in local stone, the handsome structure which largely remains extant today. Jones' new, higher dam on the blasted out millstream channel completed the lake creation process begun by Stevens. The stone mill appears to have been powered by a breast wheel and the scale and detail of the building strongly suggest the influence of Oliver Evans' first prototypes and thus the early utilization of the Evans' automatic process. The waterwheel remained the powering technology for the mill through the ownership of Jones' widow Amelia and her husband James Macdonnell. It was the subsequent owner, Walter Denaut who replaced the waterwheel with turbine power c.1860, constructing the turbine shed in the area of the original sawmill, to house the turbines. His technical improvements brought the mill back to prosperity and for that period it probably had a modest 'merchant' function as well as providing for the local clientele. In the 1890's George Haskins converted the mill to roller processing and was running the sawmill with a steam engine which also eventually provided electricity via a Dynamo. By 1922 however flour milling at the Stone Mills had ceased when the building was converted to a feed mill by Hastings Steele. This included 'dropping the husk' to its current location.

The mill ceased production after 1949 though the owner still controlled the water level at Upper Beverley Lake through the mill dam until 1962 when a new concrete dam was built upstream. Steele, though clearly attached to the old mill, could not really maintain the large structure and it fell into disrepair. In the early 1960's the fate of the building was in question but Steele facilitated its being turned over (for $1.00) to a group dedicated to its preservation, the nascent Delta Mill Society on condition that it become a museum. Largely through their efforts threats to the building were staved off, the building was declared a national historic site (1970, plaqued 1973) and in 1973-4 the building was stabilized and restored, opening to the public as a museum.

While much of the Society membership has changed the dedication has remained and thus an ongoing commitment to building maintenance, research, relevant artifact collection, improved display, fund-raising and the acquisition of the adjacent Denaut carriage shed and the old Town Hall. A desire to comprehensively plan for the building's future (as well as better understand its past) was further catalyzed by the recognition of potentially serious (in the long term) structural problems at the Mill leading to the initiation of this current Study by The Delta Mill Society.

As a building which is both a national and provincial landmark it was accepted into the federal government's cost-sharing program for national historic sites in 1993 with both levels of government as its potential partners. This Conservation Study, which serves to underpin the nature and extent of the site's significance and delineates the program required to preserve its structural and architectural integrity, is a necessary pre-requisite for receiving funds through that program should such become available.

Fig.2 Air-photo of Delta Area c.1952
(Air-photo Library, Queen's University)

II. REGIONAL/PROVINCIAL CONTEXT OF THE MILL

The Delta Mill is unique in the Province of Ontario. It is the only remaining stone grist mill predating 1812; one of only three mills surviving from that early formative period and the most architecturally significant. The John Backhouse Mill, Port Rowan (Fig.3) and the Balls Falls Mill, the other, pre-1812 buildings are relatively modest wood frame structures. The Delta Mill is the earliest surviving mill which exhibits the built-form characteristics of having been designed for Oliver Evans' 'automatic process'. It is a particularly fine example of the synthesis of British Palladian stylistic sensibility with industrial function. There are a number of other stone mills e.g. McDougall Mills, Renfrew(Fig.4) which are generally similar in appearance but these are virtually all post 1830.

As indicated in the introduction the millsite can be considered the birthplace of Bastard Township and is the key remaining settlement site on the Gananoque waterway north of the town of Gananoque itself. It is thus appropriate that it is here that past local industries and settlement lore is collected and commemorated. The Mill's continued presence keeps alive the sense of other seminal developments such as the Lyndhurst ironworks; the Hicock foundry; local marble quarrying and cutting; area lime kilns and the Brockville and Westport Railway. With sites such as St. Paul's Church and the Lyndhurst Bridge it assists in preserving a sense of that first period of significant development in the area.

The Stone Mill is important in the context of the Rideau Canal System specifically because it pre-dates the Canal. A mill of its scale and pretension would never have been built at that location once the optimum transportation corridor to the St. Lawrence had been clearly established elsewhere. Indeed the owners of the Mill in the 1830's lived in hope that a link with the Canal would be established. When Stevens and then Jones were building it was possible for them to envision a main transportation route which might come down the Gananoque system as opposed to, or along with, the Cataraqui. The stonework of the mill provides an interesting comparison with that of the Canal related structures, evincing a high level of skill from a time before the influx of Scottish masons, associated with the canal building process, established their legacy of fine stonework throughout Eastern Ontario.

In general the Delta Mill forms an important component of the network of historic sites which allows the Kingston/Brockville area to still provide a relatively comprehensive picture of the Province's past involving the full range of domestic, ecclesiastical, institutional, military and industrial aspects.

Fig.3 Backhouse Mill, Port Rowan c.1798
(from Watermills of Ontario, Quebec, & Maritime Canada)

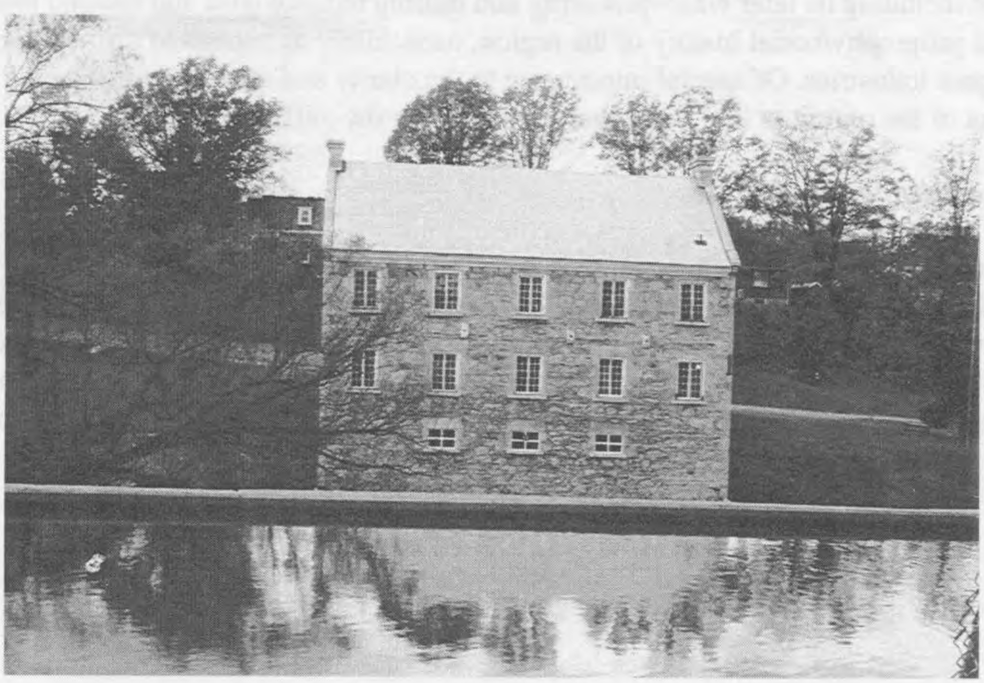


Fig.4 McDougall Mill, Renfrew County c.1850

III. CONCEPT STATEMENT

The Delta Mill Society's Mission

As is made clear both directly and indirectly throughout this Study the Delta Mill Museum's most significant artifact is the Mill building itself. It is the many attributes manifested in that structure, discussed to a large extent above, that will always make the museum unique. Furthermore recent research has served to clarify how close the Delta Mill is to the Oliver Evans' prototype, giving further justification to the Mill Society's stated aim "to preserve the Delta Mill and at some time to restore it to working order. We will show its changing technology and purpose up to the present time."

The Mill Society is also dedicated to "show, through exhibits and artifacts, how the grist mill was one of the most important elements when Delta was first settled, and to research the evolution of the communities served by the mill. There will be emphasis on the establishment of the industries of the area, and the changing patterns of economic activity in response to various influences, especially technology, up to 1900."

Thus there are clear foci to the museum's objectives: the mill itself, particularly as built, but also including its later water-powering and milling technologies and beyond that the cultural geography/social history of the region, particularly as expressed through the area's past industries. Of special importance to the clarity and relevance of focus is the defining of the region as the "communities served by the mill".

The Conservation Study

This Conservation Study will examine in detail the historical background and architectural evolution of the building as the basis for understanding its significance and responsibly planning for its future. Furthermore the present condition of the Delta Mill will be comprehensively reviewed in order to develope a program for the careful, long term conservation of the building consistent with its status as a national historic site.

IV. GOVERNMENT DESIGNATION STATUS

The Delta Mill has long been recognized by all three levels of government as being of special importance.

Federal

In 1970, following a background study (agenda paper) the Delta Mill was recommended for designation as a historic site by the Historic Sites and Monuments Board of Canada (HSMBC). The Board minute recommending designation reads:

> "that this mill is of national historical and architectural importance and should be commemorated by a plaque; and, in view of its physical condition, should be drawn to the attention of the appropriate authorities of the Province of Ontario."

The site was duly plaqued in 1973. The plaque reads:

> OLD STONE MILL
>
> The first mill on this site was built about 1796 by Abel Stevens, a loyalist and early industrialist from Vermont. After 1800 the property passed to a member of a prominent local family, William Jones who by 1810 had constructed the present stone mill. One of the oldest surviving mills in Ontario, it is a fine example of Canadian architecture and a reminder of the pioneer industrial development of Eastern Ontario.

In 1993 the Mill Society requested funding assistance through the National Cost-Sharing Program and a second agenda paper was undertaken to consider the status of the Mill relative to other historic sites applying to that program. A cost sharing partnership was developed which included the federal and provincial governments along with The Delta Mill Society and though funds are not currently available this relationship is still in place. In acknowledging the acceptance of the Mill into the program (January 23, 1993) it was recommended that "any Program funds which might be provided in that regard be directed towards mitigating the Mill's potential for structural failure in the long term."

Provincial

The Mill was one of the first projects funded by the newly formed Ontario Heritage Foundation (OHF) in 1973-4. The Ontario Ministry of Natural Resources was also involved with stabilization work to the Turbine Shed associated with improvements to the stream channel at that time. The Province has maintained its interest in the building and annually provided the Society with the Heritage Organization Development Grant through the Ontario Ministry of Culture. This grant has been reduced in the last two years due to general 'cutbacks' in the Ministry programs. The Province is a partner in the cost sharing partnership described above.

Municipal

The Township of Bastard and South Burgess has designated the building as being of architectural and historical significance under the Ontario Heritage Act, January 16, 1978 (By-Law no.477 appended).

Public Benefit /Economic Benefit

The ongoing preservation of the Delta Mill provides the public with an opportunity to appreciate one of the best and earliest examples of the industrial architecture of Upper Canada and assists them in understanding the nature of early water-powered grist milling and the ensuing changes in grist milling technology. Displays within the museum broaden this understanding to include other historic industries of the region. The quality of the architecture and the siting of the building make it both an aesthetic and educational experience. As a result of the findings of the recent archaeological study and this Conservation Study there is the potential to make the public more aware of the genius inventor Oliver Evans and the impact of his innovations on milling practice particularly as reflected at the old Stone Mill.

The Delta Mill acts as a repository for area artifacts, photos and documents related to local industry which might otherwise be lost but are critical to the identity of the area as well as being an important resource for scholars.

The Mill makes the Village of Delta a tourist destination. Delta becomes a stop on the Highway 42 tourists' path which translates into spending on Main Street. Visitors end up eating at the local restaurant and buying pop, ice-cream and film at the general store etc. Summer cottagers on the adjacent lakes likewise make a trip to the Mill as a change and/or rainy day diversion. Special events such as the Maple Syrup Festival in which the Mill plays an important role bring in large numbers of people into the region.

The proposed stabilization and restoration program will ensure (along with continued maintenance) the long-term preservation of the structure and the heritage attributes which characterize it as a national historic site.

The restoration of the building will serve to increase public enjoyment and safety and expand educational opportunities at the site resulting in increased visitation with an economic spin-off for the area. As well the actual work on the building will provide employment to local trades and artisans and give a boost to materials suppliers.

Public Support

Public support for the Mill and its current building conservation objectives is perhaps best indicated by the excellent response to a request for letters of support solicited by The Mill Society in association with its jobsOntario application in 1994. The percentage of response to the over 160 solicitations was 49%, an unusually high return. The respondents included Councillors, representatives of the area's business community, the region's newspapers, and managers of other important historic and natural sites within Eastern Ontario. The sentiments expressed in response make clear that the Delta Mill is appreciated as an important historic landmark and educational facility; is considered a key component in tourist visitation to the area and that its conservation and enhancement is thought of as critical to the region's economic future.

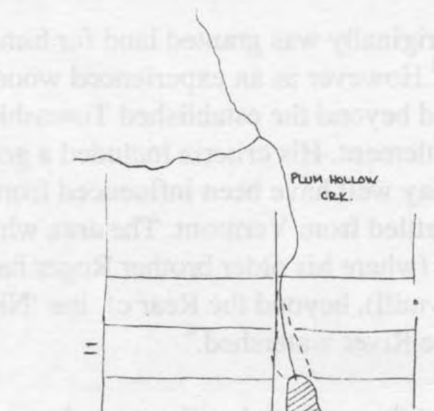


Fig.5 Hydrography sketch due to Stevens' dams c.1799

V. HISTORICAL BACKGROUND / ARCHITECTURAL EVOLUTION

Abel Stevens and the First Mills (c.1796-1808)

The story of the development of the Delta Mill site extends back to the state of Vermont at the time of the American Revolution. It is from here that Abel Stevens, frontiersman and devout Baptist, emigrated, in 1793 having served the British in an undercover capacity during that conflict. The timing of his move suggests that he was particularly motivated by Simcoe's proclamation of February 7, 1792 inviting Loyalists still residing within the former colonies to apply for land grants in the new settlements to the north.[1]

Stevens petitioned and originally was granted land for himself and each of his children in Scarborough Township.[2] However as an experienced woodsman[3] he continued to explore the unsurveyed hinterland beyond the established Townships for what he considered an optimum location for settlement. His criteria included a good potential millseat and his general considerations may well have been influenced from the start by a desire to create a Baptist community resettled from Vermont. The area which most met his liking was east of the Rideau Lakes (where his older brother Roger had settled and by 1793 had already established a sawmill), beyond the Rear of the 'Ninth Township', in the upper reaches of the Gananoque River watershed.[4]

This area included at least two potential millseats and was surveyed by William Fortune in 1794 not long after the arrival of Stevens' Vermonters. Stevens began earnestly petitioning for confirmation of title to this tract for himself, his family and for the five other Baptist families from Vermont for whom he acted as spokesperson. His petitions of 1794 describe how the Vermont Baptists had brought 'Mill Irons' with them and 'Mechanics to erect the necessary buildings' possibly including a millwright along with more general timber framers. This confirmation was slow in coming and indeed the right to the prime mill sites was contested by the powerful Sherwood clan leaving Abel to complain that the 'Iron work for Mills are laying by & Damaging by Rust' in his petition of May 1795 which restated his case for ownership. However, in the end his value as a catalyst for settlement seems to have been recognized by the government and rewarded though perhaps not to the full extent which Abel Stevens would have wished. The Surveyor General was first directed to "endeavour to accommodate each (Sherwood and Stevens) with a separate fall on the Gananoqui water" (June 19) and later "that Abel Stephens and his Associates should be confirmed in their present Improvements.[5]

---

1 E.A. Cruickshank, "The Activity of Abel Stevens as a Pioneer", Ontario Historical Society Papers and Records, Vol. XXXI, 1936. p.56

2 Ibid.

3 A.M. Caverley M.D., History of the Town of Pittsford Vt., with Biographical Sketches and Family Records , Rutland: Tuttle and Co. Printers, 1872.

4 Petition of Abel Stevens to the Land Board May 17, 1794 exerpted in Cruickshank "...Abel ...as a Pioneer", p.57

5 Petition references 1794-1795 from Cruickshank, pp.57-63

Although the exact date of the erection of Stevens' mills is unknown his mill, mill dam and the mill creek are all noted by the surveyor Lewis Grant in 1797[6] as he checked and refined Fortune's and Sherwood's earlier work. Interpreting the exact location of the original Mill is somewhat problematic partly because first Stevens' and later Jones' mill ponds (which between them created Upper Beverley Lake) have so changed the original hydrography and partly because Grant's notes refer to the mill, mill dam, and creek either as being in Concession X (the upper reaches of the lake are still within that concession) or possibly is simply using these features as descriptive reference points for placement of the Tenth line. In any case Grant begins to refer to the mill creek at Lot 7 (as well as 'improvements by one of the Stevens') to Lot 11 where he notes 'corner mill pond rise'. Above his entry to Lot 17 he notes 'Mr. Stevens' Mill dam'. At Lot 20 he indicates 'small creek/mill run 3 ch(ains) to left.' Then at Lot 23 he records 'Mill creek then run S 36 degrees 14 chains across creek then continued line 54 degrees to W. Mr. Stevens' Mill 4 chains to the right then run S.' The configuration which this arrangement would seem to produce is presented in Fig.5 . From Lewis Grant's remarks quoted earlier it would appear that Steven's original Dam (Lot 17) was located a long way from his mill (Lot 23) and the millpond is noted as commencing at Lot 11. However in his sale of adjacent property to his son in 1799 the 'millpond' indicated as being (in part at least) on Lot 21 and 22 is used as part of the boundary designation (see page following). This may indicate Stevens' use of two dams to create two storage ponds (a not unusual practise to ensure consistent flow), that the dam on Lot 17 was created to feed a natural pond below which the millrun and mill were located or the abandonment and flooding of the Lot 17 dam with the creation of a higher dam downstream. In any case Stevens' dams and resulting ponds began to define the shape of the future Upper Beverley Lake. The narrows on the lake remain adjacent to Lot 17, the site of the original dam. (Fig.5)

To step back even further and attempt to consider the site before any manipulation of the waterway it would appear that Plum Hollow Creek, one of the sources of lower Beverley Lake and hence feeding the Gananoque system, continued in creek form to Lower Beverley its main natural channel to the east of its current location though the lower part of the existing stream (below the Mill) was part of that natural waterway. (This 'lost' channel included part of the village main street and returned as the flood channel in high Spring freshets until the building of the new dam.)[7] There may also have been a smaller creek branch more or less at the current location as Grant notes in his 'remarks' for Lots 21, 22 and 23, Concession IX a "Beaver Dam'; a "Creek runs to the Left' and a Cedar Swamp respectively leading to Gananoque Lake. Also in his contest with the Sherwoods over the property Abel Stevens states that the Sherwoods believe themselves to "have a pitch of eight hundred acres for themselves on each side of the <u>two places</u> where mills can be erected with propriety." Stevens property would have encompassed both creeks. It appears that the first mills may have been on the original main channel while the later Jones' mills were on a diversion created by widening of the channel by 'black powder'. It

---

6 Lewis Grant, Survey of Bastard, 1797. Land Surveyor's Records, Field Notebooks 233, microfilm in Stauffer Library, Documents Section, Queen's University, Kingston.

7 Discussions with Stu Wright, January 1996.

is possible too that the existing channel was first developed by Stevens' as the mill run while the natural course remained open to the east of the Mill.

The primeval forest of the area was a diverse mixed forest including beech, maple, elm, hemlock, cedar and pine and it would seem that Stevens' first mill was a sawmill particularly required in the construction of the settlement. The mill itself was undoubtedly a timber frame structure.

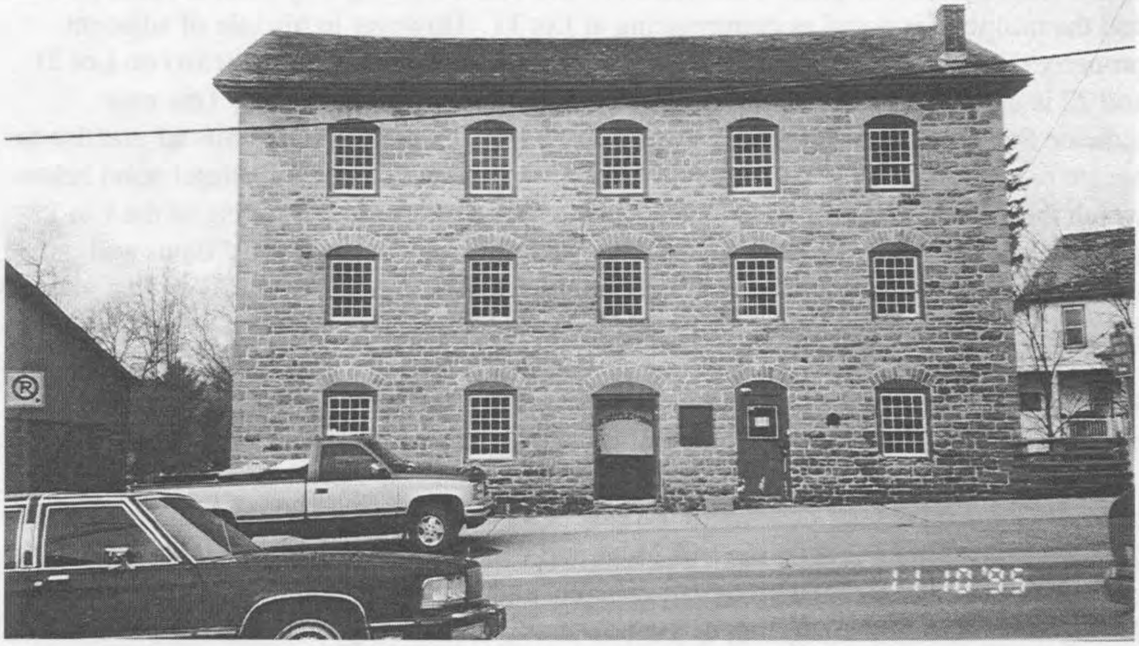


Fig. 6 Front Elevation

Stevens and Mattice

By 1799 the mills on Stevens' property (which by this time included a grist mill) were being operated by Nicholas Mattice. In that year Abel Stevens Sr. sold his son part of Lots 22 and 23 Concession IX and the boundary of this property was described as follows:

> "commencing at the north corner of the Bridge near Abel Stevens' and Nicholas Mattices' mills in Bastard from thence Bounding on the (west?) eight chains thence west to the Brook then bounding on the Brook upwards to the corner posts between Lots 21 and 22 then on the side in between Lots 21 and 22 S36 deg.E. to the mill pond then bounding by the said mill pond down to the place of Beginning. [8]

In 1803 it is Mattice and not Stevens' who is assessed for a sawmill and a gristmill with an additional set of stones, the only mills in Bastard to be assessed in that year.[9] Nicholas came from a milling family of Palatine German descent who had originally, like many of their countrymen, settled in the Schoharrie area of New York state.[10] Loyal to the British he served with King's Royal Regiment of New York[11] and was originally granted land in Elizabethtown (400 acres) in 1798. He was 49 in 1803[12], one year older than Abel Stevens[13], like Abel a devout Baptist, and his daughter Lanah married Abel's nephew William Stevens, one of the original settlers in Bastard[14]. Whether Mattice came to Bastard specifically to run the mills, be part of a Baptist community, be with his daughter, or all of the above is not known but certainly he became so identified with the Mills that in most subsequent documents (deeds etc.) referring to the property the mill creek is identified as Mattice's Mill Creek.

It is likely that Stevens' other preoccupations at the turn of the century, such as the construction of the road to Kingston Mills and the effort to obtain the right to establish an ironworks at Lyndhurst [15], necessitated his turning over the milling operations to others. Also grist milling required particular expertise and ideally a professional miller. There is also the possibility that the original Stevens' mill had burned down[16] and that Mattice

---

8 Leeds Land Copy Books, Memorial #286, Deed of Sale:Abel Stevens Sr. to Abel Stevens Jr.(1799), Registered March 19, 1812. Queen's University Archives.

9 Assessments for Bastard Township, Reel Designation MB 2546-2547, Archives of Ontario(AO).

10 'The History of the Elisha Mattice Family', Kingston Public Library.

11 Ibid.

12 Census for Bastard Township, Reel Designation MB 2546-2547, AO.

13 Ibid.

14 Elizabeth Stevens Stuart, Our Stevens' Story (Privately Printed), ISBN 1-895638-00-3, p.99

15 Cruickshank, pp.65-67.

16 Jehiel Sliter, "Pioneer Privations", Memoir of original area settler as published in the Weekly British Whig in Kingston, November 8, 1894.

was also the millwright for his mills or drew on the expertise of his brilliant millwright brother-in-law David Brass[17].

In any case between 1803 and 1807 Mattice continued to be assessed for a sawmill, and a gristmill with two run of stones which remained the only grist mill assessed in Bastard in that period. Mattice's mill was a centre of area life, manufacturing a staple of the settler diet but also providing spiritual sustenance as the premises for the Baptist congregation to hold religious services[18]. In 1808, the year Abel Stevens finally sold him 80 acres of Lot 23 Con. IX,[19] ~~Mattices's assessment is reduced to only a gristmill with one run of stones~~ and Abel Stevens Jr. is also assessed for a grist mill of one run of stones. Perhaps Abel Jr.'s stones were originally from Mattice's mill. The following year Mattice is not assessed for mills but Ira Schofield is listed, as is Abel Jr.

NO, NOT ON ASSESS. FOR 1808 JUST STEVENS

The same day (June 10, 1808) that Abel Stevens sold the 80 acres to Nicholas Mattice he also sold the Mill creek and stream portions of the lot to William Jones[20]. Both transactions were witnessed by Ira Schofield. Stevens was clearly divesting himself of the mill property which he had petitioned so ardently to obtain. Perhaps the transfer of the mill site(s) can be viewed as a generational shift as both Stevens Sr. and Mattice were now in their mid-fifties while Ira Schofield and William Jones were in their mid-twenties. Abel Jr.'s mill appears to have been on what became known as Foundry or Robertson Creek (see Fig.47) , the small stream which enters the Mill Creek, a portion of the land adjacent having been sold to him by his father in the transaction quoted above.

William Jones and Ira Schofield (1808-1831)

Both William Jones and Ira Schofield were scions of extremely well established local families. Jones' father Ephraim was, at his death in 1812, one of the largest landowners in Upper Canada[21] and his brother Charles owned the extensive and lucrative mills at Yonge. [22] Indeed their respective fathers were partners in the Ironworks at Furnace Falls (Lyndhurst). William Jones is assessed for a house in Bastard in 1808 so had probably moved there around that time.

While hard evidence is scarce, the assessment roll information suggests that Schofield, in partnership with Jones, ran the old Mattice mill with its one run of stone in 1809. In 1810, only a sawmill was assessed to Jones and Schofield. The account of early settler S.P. Sliter is that a second fire occurred before the stone mill was constructed. This could have occurred in 1808 and influenced Stevens/Mattice in their departure from milling or after

---

17 Felicity Leung, Grist and Flour Mills in Ontario. Hull: Supply and Services Canada, 1981, p.13.

18 Stuart, Our Stevens' Story

19 Deed of Sale, Abel Stevens to Nicholas Mattis June 10, 1808. D-64

20 Deed of Sale, Abel Stevens to William Jones June 10, 1808. D-65

21 Elva M. Richards, "The Joneses of Brockville and the Family Compact", Ontario History (60) 1968, p.170

22 Robert C. Phillips, *The Flour Milling Industry and Economic Development in Leeds County 1820-1850.* M.A. Thesis, Dept. of Geography. University of Waterloo, 1991.

the initial years of ownership by Jones and Schofield. The stone mill was certainly in place by March 18, 1812 when it is used as a boundary reference in a land transaction between Abel Stevens' Jr. and Smith Curtis, Innkeeper:

> "...on the West Bank of the... stream of Water called Jones' mill stream about 15 rods above the Stone Grist Mill situated on the said stream..."[23]

Given the magnitude of the building it is reasonable then to assume construction began in 1810 with completion sometime in 1811.

Of note too is that in April of 1812 Jones and Schofield purchased 100 acres of Lot 23 Conc. X[24] and Charles Jones another 31 5/8 acres.[25] It appears that the Jones and Schofield families were consolidating property around the mill at that time as part of their industrial base. 1812 is also the year of Jones' marriage to Amelia MacDonell.

By 1814 (no assessment records exist from 1811-1813 presumably due to the War of 1812) Jones and Schofield are assessed together for a stone house, a sawmill, a gristmill with an additional run of stone and a 'merchant shop.'

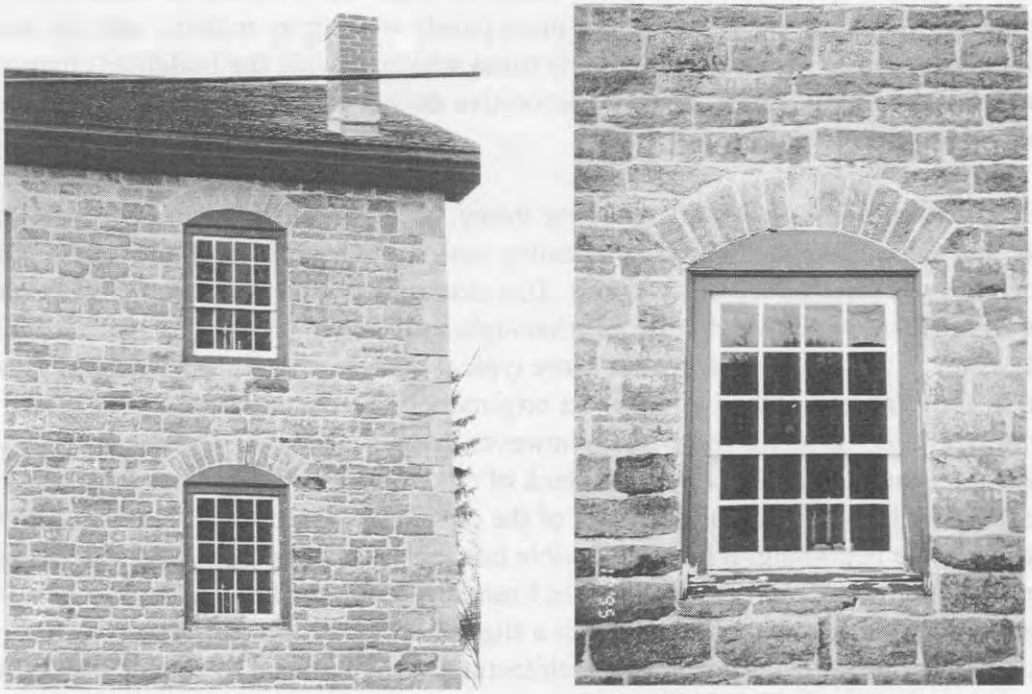


Fig.7-8. Stonework Details

---

23 Deed of Sale, Abel Stevens Jr. to Smith Curtis, March 18, 1812. Memorial #287 Leeds Land Copy Books, Queen's University Archives.

24 Deed, Ira Gilbert to Schofield and Jones, April 30, 1812. M.339 (LLCB) Q.A.

25 Deed, Ira Gilbert to Charles Jones, April 22, 1812. M.335 (LLCB) Q.A.

The Stone Mill

The stone grist mill constructed for Jones and Schofield was an imposing structure rising three and a half stories from the road way to a gabled roof of medium pitch with returned eaves. The scale of the building, together with the quality of the stonework, composition and the restrained yet elegant detailing in the British Palladian manner make it a significant achievement for this period particularly in a hinterland Township. Its little wonder that upon its construction the village became known as Stone Mills[26]. The structure remains impressive even to the jaded modern eye.

Founded on bedrock[27], the mill is constructed of regularly coursed, roughly squared local stone. It is orientated longitudinally to the street with the openings of that facade establishing the classic five bay rhythm of Georgian architecture. The openings are all segmentally arched with stone voussoirs and arranged with the main door, slightly wider than the other openings, in the centre. The building is constructed largely of the sandy crystalline limestone/calcareous sandstone found close to the site. (Both sand and calcite are present in varying degrees.) The provincial geologist noted significant beds of the this material on neighbouring Lot 24, Concession X in 1904, describing it generally as "usually white, but sometimes greenish white, or white with gray bars and stripes. Small scales of graphite are ..disseminated through the rock with serpentine, mica and iron pyrites".[28] It is the combination of the more purely white/gray material and the material with oxidized iron pyrites creating rusty tones which provide the buildings characteristic and handsome mottled hue. The key decorative details of the stonework are the quoins and the vousoirred arches.(Fig.7,8)

The quoins are, from just above the first storey, of larger cut stone units, more regular in size and colour than the typical surrounding masonry. Generally, a more purely white 'marble' was selected for this purpose. This material is also evident in the voussoirs over the third storey windows. At that location eight units make up the arch whereas below it takes eleven (avg.) of the narrower more typical material to arch the opening. This has led to speculation that the building was originally two storeys with the third added sometime later. It seems more likely however given the ideal requirements of Oliver Evans' 'automatic' mills (Fig.9), the lack of evidence for it on the interior of the structure and the substantial resources of the developers that it was intended to be this size from the beginning. It is very possible however that full completion was delayed by the War (both Jones and Schofield were Company Commanders[29]) and may have restarted with a new mason, working in a slightly different manner. Then too the treatment may simply be part of the architectural design, meant to engage the highway traveller's eye from a distance with the more sophisticated detailing of the building. Even

---

26 The village remained Stone Mills until 1826 when it was renamed Beverley after Chief Justice John Beverley Robinson and still later (1856), took its present name of Delta.

27 Inspec-Sol Reporting Letter, November 13, 1995.

28 Willet G. Miller, Limestones of Ontario (Toronto, L.K. Cameron Printers, 1904.) p.72

29 D.H. Akenson, The Irish in Ontario: A Study in Rural History (Montreal: McGill-Queen's University Press, 1984) p.124..

the smaller quoins and voussoirs show evidence of decorative chiselling over the often naturally striated surface.

Plate XXI.

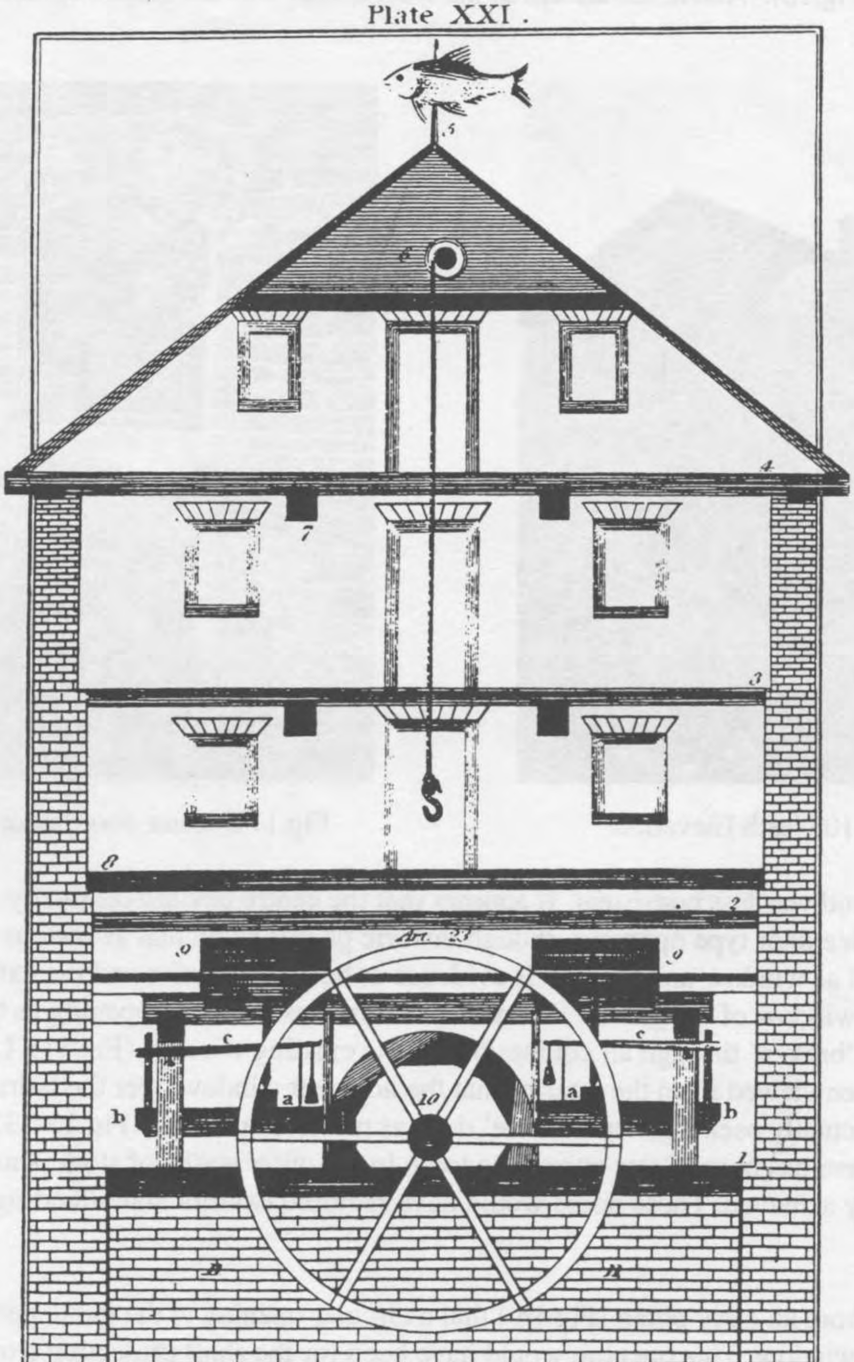


Fig.9 Plate XXI <u>The Young Millwright...</u>

The masonry treatment as described was carried through the rest of the building. The north elevation seems to have always been a symmetrical arrangement of three segmentally arched openings per storey with a single window at the gable to light the attic level (Fig.10). Above the stream at the west corner was the arched opening for the headrace.

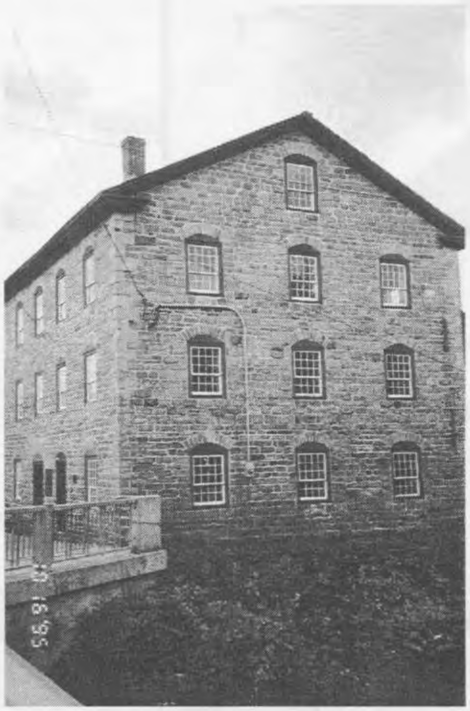


Fig.10 North Elevation

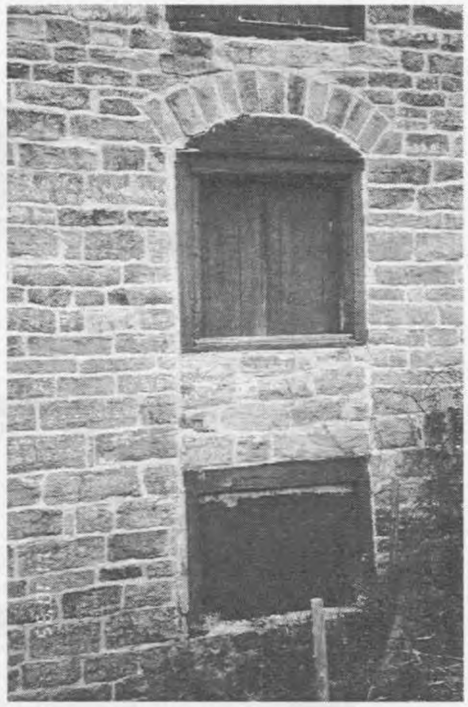


Fig.11 Former door opening

The south end was less consistent. It appears that the centre bay did originally consist of longer service door type openings, though historic photos show that at various times some were glazed as window units. There is evidence at both the interior and the exterior that the middle window of the ground storey was continuous as a door opening as the vertical joint is not 'broken' through all courses below the existing window.(Fig.11). Likewise it appears when viewed from the interior that the adjacent window over the tailrace arch may have actually been the 'waterhouse' door as pictured in Evans (Fig.12-13). Here however there has been a later attempt to tooth in the outer wythe of stone, though not successfully achieved. These doors would have required exterior stairs/landings to allow access.

It appears from an early photo (Fig.14) that a circular opening at the gable peak predated the typical window. This opening would have been for the shaft projection from which a pulley could bring items up from the outside and in the door at the appropriate level (Fig.9). At the west elevation the absence of windows at the first storey (as opposed to the now-infilled windows of the second storey) indicate the mill to have been designed from the outset with an adjacent one storey structure, most likely a sawmill. At the upper two storeys segementally arched window openings divide the elevation into three bays (Fig.15).

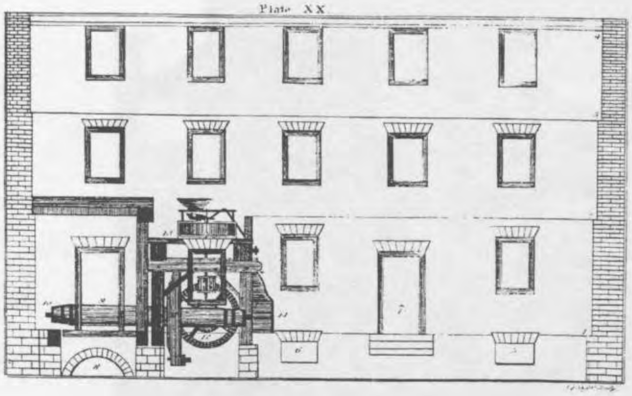


Fig.12 Plate XX The Young Millwright...

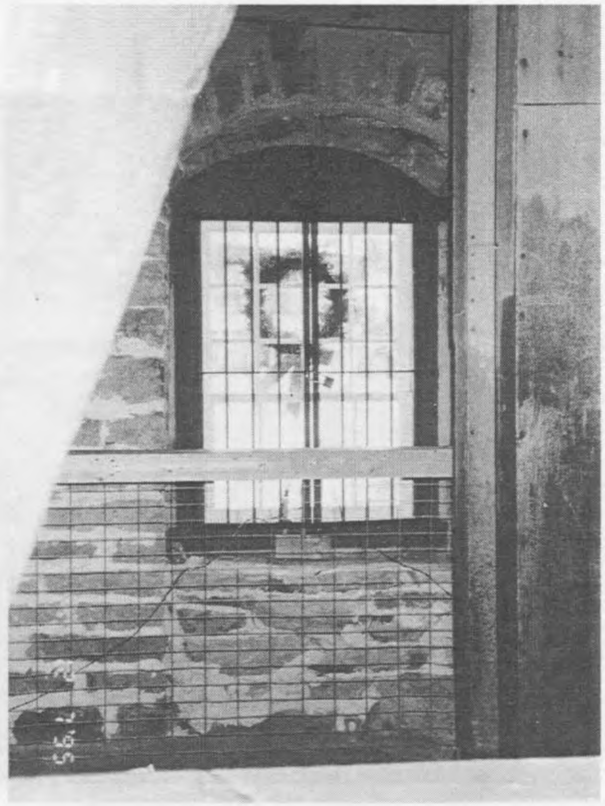


Fig.13 Former 'waterhouse' door

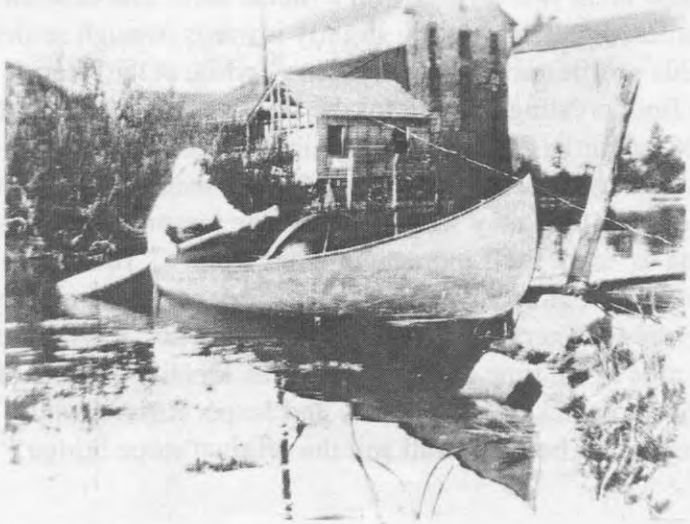


Fig.14 Historic view c.1890
(The Delta Mill Society (D.M.S.)Files)

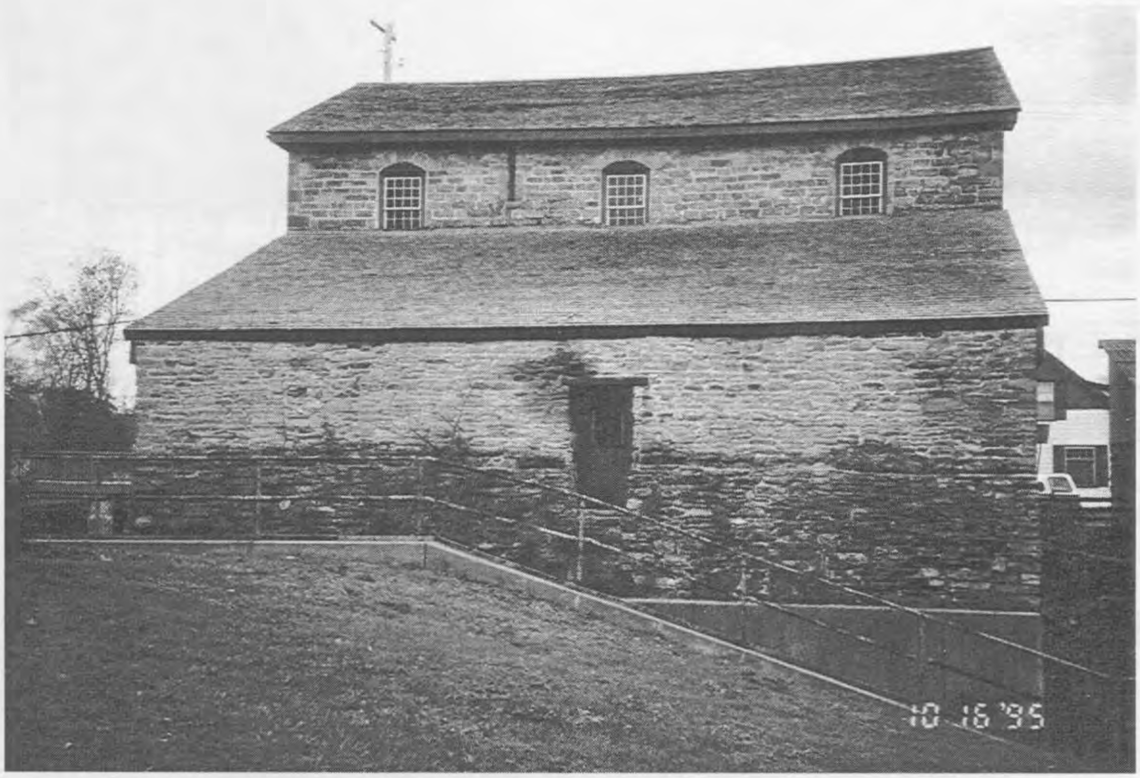


Fig.15 West elevation

It appears that the stone was laid up in two wythes with a rubble core. The exterior wall seems to have been set to a battered profile, angling slightly inwards (though settlements have obscured the clarity of this profile) as advised in Evans[30] while at the interior the stonework steps back at each floor creating bearing for the floor beams and/or joists. Tantalizing is the discovery of the initials 'W.R' and possibly an 'S' or 'J' incised into a 'cornerstone' at the northeast corner of the building (Fig.16). Not seeming to correspond with the names of any of the owners they may well belong to the mason as it was not unusual for masons of the time to 'sign' their more significant work. C. 1811 there would have only been a few masons in the region capable of work of that scale and quality. It is also possible that the builder was an itinerant mason based in Montreal. A further check of the masons working in the area at the time may yet reveal the identity of the builder. The initials might stand for the surnames of Issac Waley and Jasper Russell whom local lore associate with the construction of both the mill and the original stone bridge.[31]

30 Oliver Evans. The Young Millwright and Miller's Guide, 13th Edition , 1850 (Reprint Edition Salem, N.H.: Ayer Company, 1984.) p.209

31 Alice Webster, 'The Old Mill', Athens Reporter, July 14, 1960.

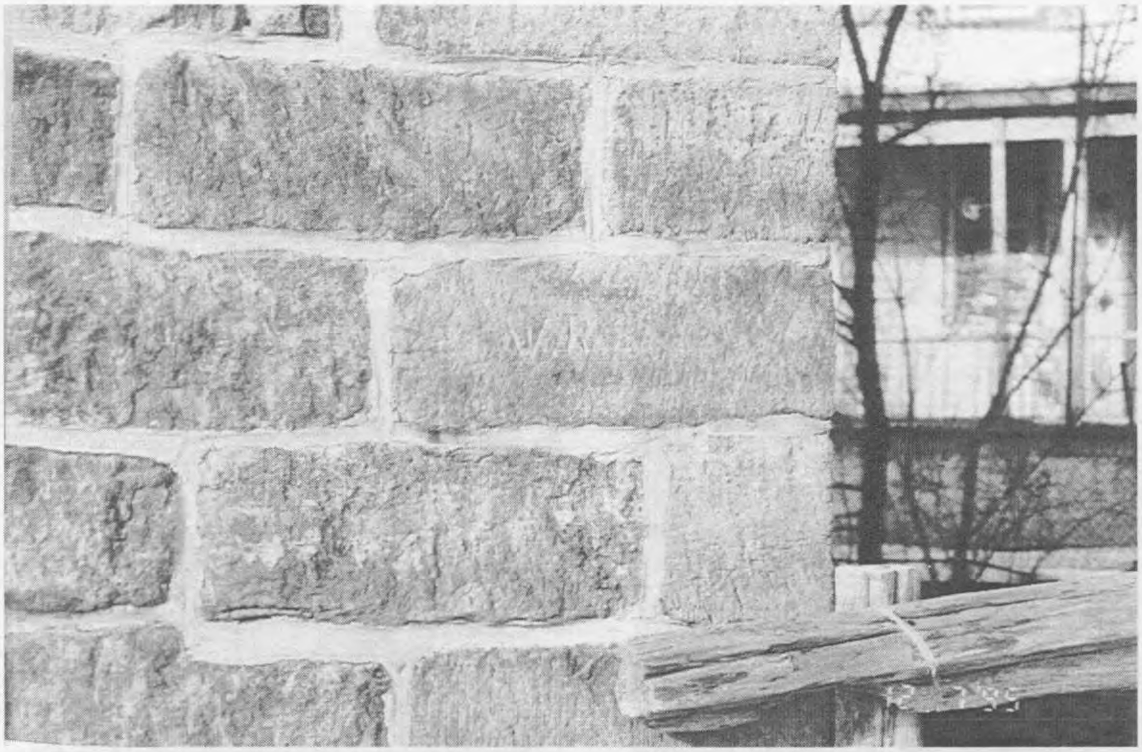


Fig.16 Incised initials

It is probable that in this early period the window sash were themselves arched to fit the original segmental openings opening which would have been a strikingly elegant feature. This extra height may have allowed for a twelve/ twelve light configuration prior to the twelve /eight sash visible in the earliest photos. The original main door, composed of two heavy skins of tongue and groove edge beaded boards made as one by rows of clenched hand-wrought nails, is, remarkably, still in place.(Fig.17,18). This includes the pair of hand-wrought strap hinges with eye and curl terminals and an early latch as well. The position of the massive original rimlock is still readily legible on the interior. The massive jambs, over 24" wide and 3" thick of one plank remain in place. There is much writing of note on the interior face of the door including the name 'William' written in a very similar hand to the signatory of the Deeds involving William Jones and may be he. At the top of the door is written 'William &...' with the name painted/washed out. The entry is very reminiscent of the Jones & Schofield entries in the assessment rolls. It could be that William expunged his partners name when that partnership dissolved, possibly about 1820 from which time only Jones' name appears in the assessment rolls. The mill office door, like the office interior was treated more formally than other areas and would probably have been of six panel configuration originally though four panels are evident on the earliest photos.

Fig.17-18 Mill door details

Another evidence of the 'fine touches' incorporated into this industrial structure is the moulded cornice/soffit which returns at the eaves. The cornice moulding extends up the verge as well. It is possible that the cornice may have originally included a gutter which was later roofed over though no evidence of a rain water leader was noted on site or in the historic photographs.

The chimney appears to have always been in its present location heating the office areas. Wood shingle would be the expected roofing in this early period.

The 'Prime Mover' and Original Husk Placement

The nature and location of the original water power/milling apparatus has been the source of much speculation. After a great deal of investigation and consideration a picture has begun to emerge which differs from many of the earlier theories in certain significant details. This 'new' hypothesis is presented below with the rationale from which the cumulative assumptions arise. The main basis has been the investigation of inconsistencies in earlier theories, careful on site review, detailed review of Evans and

Study Team dialogue drawing on the experience of the mill technology consultant and the recent findings of the prime investigator.

It has been conjectured in the recent archaeology report that the waterwheel breast extended into a depression in the rock bed of the wheel pit. From that assumption a possible diameter of wheel etc. has been conjectured which, despite a number of difficult anomalies, would generally be consistent with the husk in its current position. However this assumption is based on the tailwater level being approx. 5 1/2' lower than its current level. Unfortunately investigation to date has shown this not to be the case. Interestingly enough discussions with MNR have revealed that recent work on the Lyndhurst dam exposed a rock ledge above the dam which they felt probably represented the original water level of Lower Beverley Lake at 90.5 m., compared to its current summer holding level of 91.85m. a promising difference of 1.35m.(4.42'). But dams associated with various industrial operations have been present at that location since the turn of the 19th century typically holding that water at a higher level. MNR's engineer postulated somewhere between its natural and its current elevations. As well recent probing both within the wheelpit and beyond the tailrace arch indicates that bedrock is higher just downstream of the depression[32] indicating that the wheel, if set fully within the depression would not have cleared the tailwater. This would have been unacceptable, as the resulting backwater condition would have negated the wheel's potential pwer. Therefore the axle of the wheel must have been set higher than previously supposed in order to clear the tailwater. If the axle is set higher (a likely location is the area which became the shaft access from the turbine shed) the upper husk timbers impede even the small 9' dia. wheel postulated (in the Archaeological Report). (Fig.19)

The wheelpit itself would comfortably accommodate a 12' dia. wheel, more typical for this type of situation[33]. The husk as currently located does not allow room for the crowngear and is in the path of the horizontal drives. Sufficient space for the elevator boots below the lower husk timbers should be evident but while there is much evidence on the north beam of past elevators there is no room for the boots below the beam. Positioning the husk with a millstone directly over the waterwheel is not typical of Evans design and unless simply running one wheel off a lantern gear and spindle from the wheel itself, quite awkward. It should be noted as well that the husk as it now exists does not rest on adequate foundations, is not set accurately plumb and level as would have been the original condition, and the bottom end of the tentering posts appear to have been cut off.

---

32 Inspec-Sol Reporting Letter, November 13, 1995.

33 Following a general rule of thumb of breast wheel diameter being approx. twice the head.

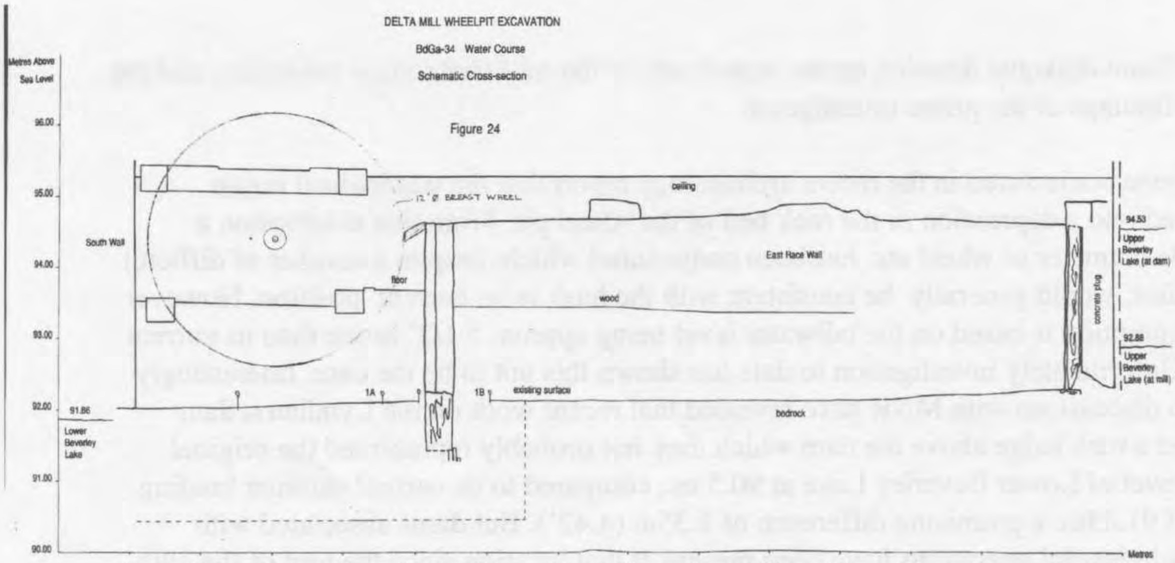


Fig.19 Wheel-pit Cross-section
(Base drawing, Cataraqui Archaeological Foundation)

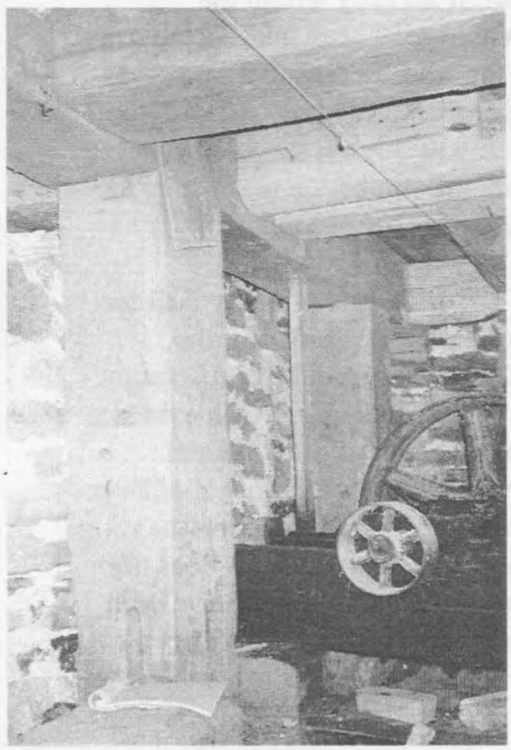


Fig.20 Husk

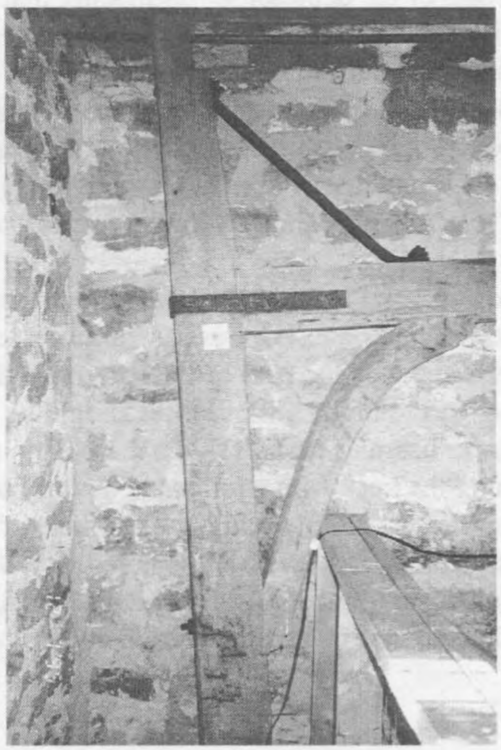


Fig.21 Waterhouse ceiling location

Thus it would appear that the waterwheel was set higher and extended higher than had been previously considered and that the husk was likewise set higher than its current location and to the east of the wheelpit allowing the wheel to extend uninhibited through the first storey within a 'waterhouse' (wheelroom) as shown in Evans (Fig.12). Indeed investigation has shown that the southwest window of the first storey was formerly a door, the door to the waterhouse as in Evans. Also a shoulder at the stone wall below typical second floor level is evident at the southwest (Fig.21), indicating the position of the ceiling/floor over the waterhouse which may have differed in elevation from that of the husk or the rest of the second floor as in the Evans protoype. The millstone and millstone support timbers at the west of the current husk are all relatively recent and would have replaced the original millstone supports. This supposition makes sense of the much older tentering post located in relation to the west millstone. The upper and lower husk beams originally framed into posts adjacent to the waterhouse wall at the west. The two western stones would have been the original set with room on the husk for a third stone which was added sometime later. The original vertical shaft extended up between the two western stones.

The axle of the wheel, assuming a breast wheel[34], would have been set approximately at the height of the headwater (Upper Beverley Lake) assumed as slightly lower than its current elevation (94.53m). The axle gudgeon may have borne somewhere within the area of the current gap in the stonework on the west wall of the wheelpit. The current husk timbers had to have been above the axle and allowed for clearance of half of the diameter of the shaft as well (typ. wooden shaft 18"dia.). Thus a version of the current husk, (though with extended posts) must have been supported by a stone or crib foundation at the basement, continued up through the first storey possibly to finish with the millstones at or close to second floor level much as pictured in Evans (Fig.12). This foundation may have been provided at the south wall by the stone shoulder now utilized for joist support or perhaps was freestanding and the existing knee wall may be a vestige of that wall. The north supports would have been removed when the husk was lowered.

That the husk and grinding operation likely extended through the first and up to the second floor structure can also be seen in the deployment of main floor structure members. A two storey column located just outside the husk (and now just east of its original position) allowed the husk frame to be independent of the floor structure by carrying a third floor beam (Fig.22). The first true floor beam at the second floor level is located 17' from the south wall, an atypically long span for joists to run (as are in position now) and likely indicates an allowance of space for the self-supported husk. The second floor then combined the grinding area, the floor over the waterhouse and conventional floorspace. Given that the length of the original husk can be conjectured from the existing (assuming that the sale ad in 1835[35] refers to 'room' on the husk rather than simply floorspace), the stairs to the basement and to the second floor did not occupy their current

---

34 Breast wheel is best match to available head and presumed flow, also fits available height at 'raceway'.

35 Ad for sale of Mill. Brockville Reporter, September 17, 1835.

positions. The basement stair stinger is inscribed 1922. Likewise the husk timber which carries evidence of a vertical shaft is inscribed 'for vertical shaft' and dated 'April 8, 1922', signed 'Silva Slate' (Fig.23). It is likely that the husk was dropped or reassembled in the basement space at that time. Until then access may have well been simply a ladder type stair within the husk area. Following Ellicott's design in Evans there may well have been a stair to the millstone area of the husk from the main floor and a connecting short stair from there to the rest of the second floor (Fig.24).

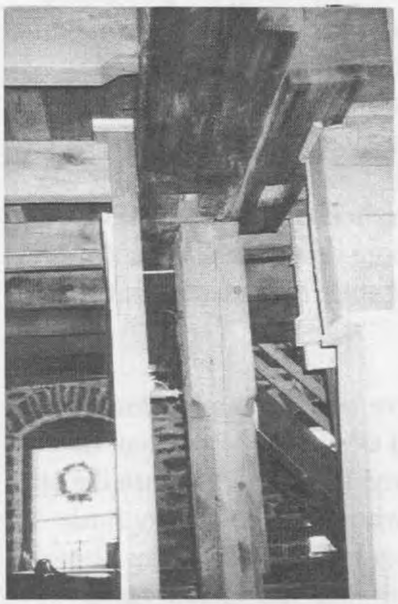


Fig.22 Column

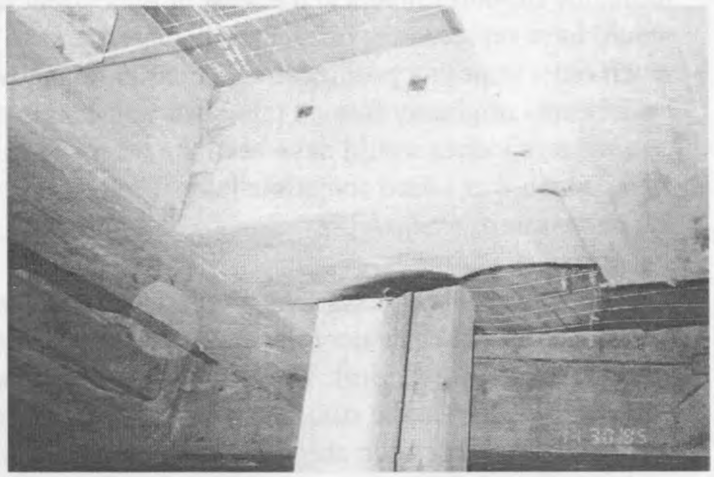


Fig.23 Signed member '1922'

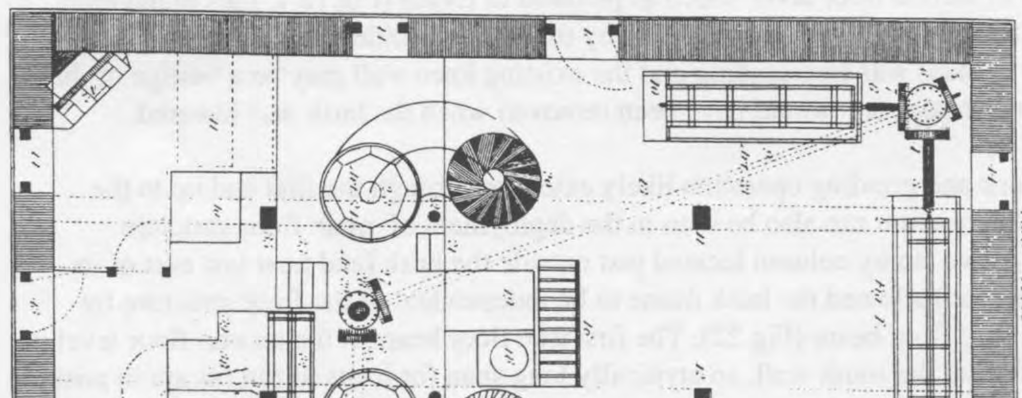


Fig.24 Plate IX Evans (Floor Plan)

From the time that turbine power replaced the vertical waterwheel at the Mill the husk could have been relocated to the west in order to shorten the length of the lay shaft as the waterwheel and waterhouse would have been removed. However, from a technical perspective, the processes would not have allowed the husk to be lowered until the Chop mill period, which coincides with the dating of the lowering of the basement stairs.

As stated above the existing beams which now carry evidence of the vertical shaft are of relatively recent origin. They are machine planed and the pegged jointing of these members actually remained common in mill (and barn) construction up until 1940. The beam at the basement has been inscribed as noted earlier and its equivalent at the second is clearly at least the third generation of member to occupy that space. It follows a much larger original beam (the mortise for which can still be identified in the transverse member in which it was joined) and the simple joist which replaced it and was notched into the original mortise. The current beam occupies part of the original mortice (Fig.25).

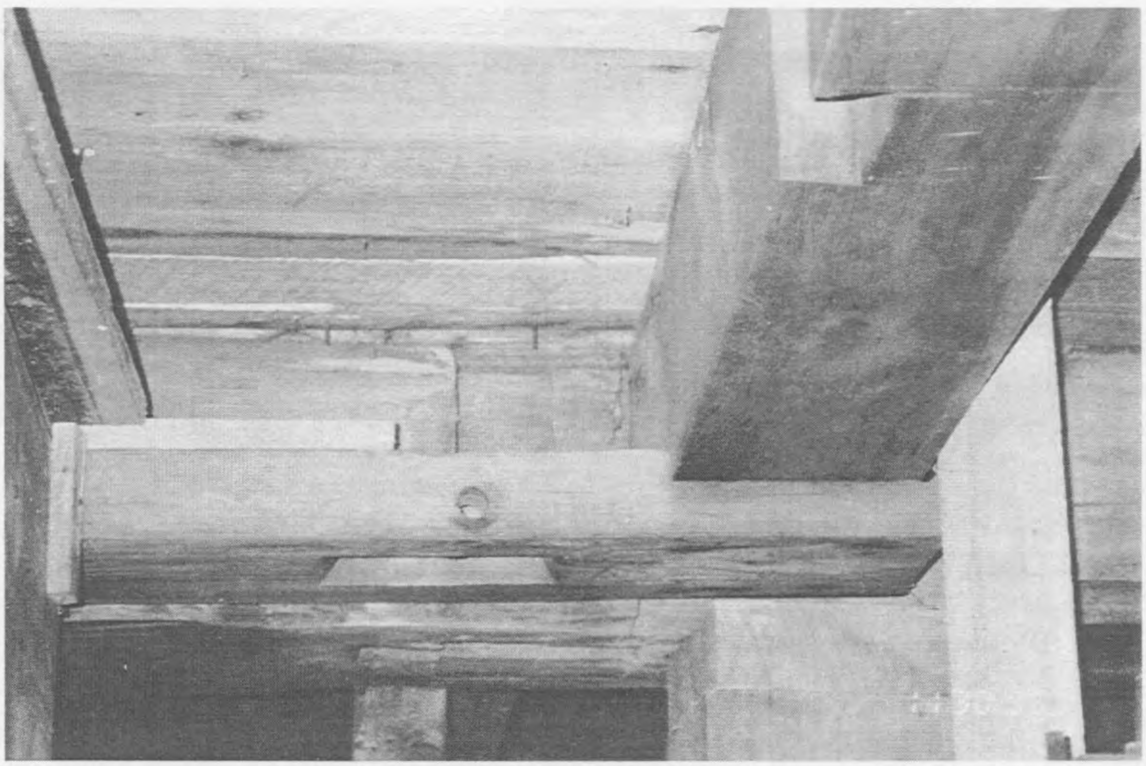
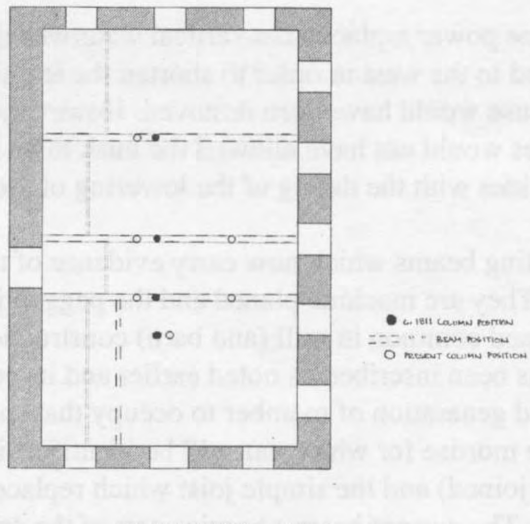
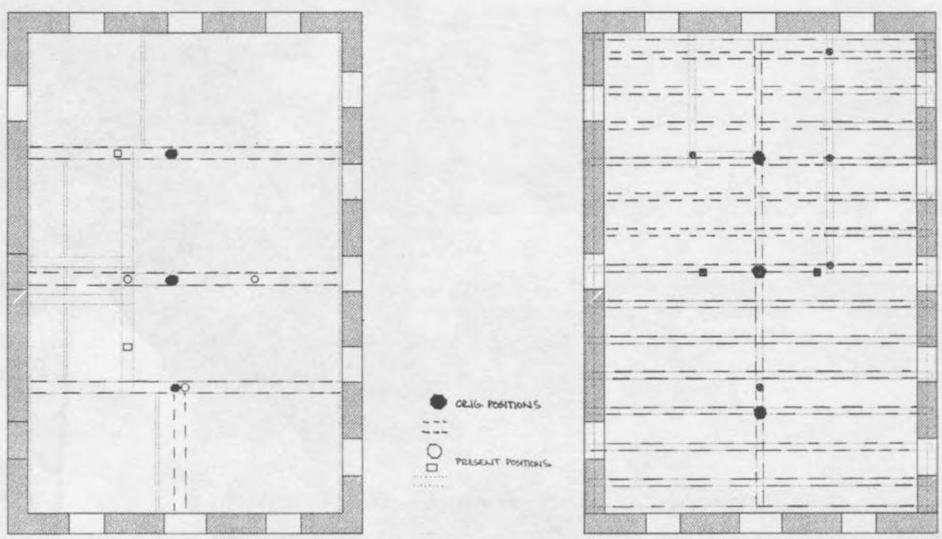


Fig.25 Earlier mortice



FIRST FLOOR PLAN (2ND FLR. FRAMING) c.1811
1:50
FIG. 26



SECOND FLOOR PLAN (3RD FLR. FRAMING) c.1811
1:50
FIG. 27

THIRD FLOOR PLAN (ATTIC FRAMING) c.1811
1:50
FIG. 28

Fig.26-28 Floor Plans

Original Structural Configuration

The original floor framing system is still legible today in the position of beams and the empty mortises related to original column positions. The system was based generally on columns placed at the midspan of three massive timber beams running transversely, between which floor joists running longitudinally were framed. The exception is at the attic storey where a remarkable timber spine beam 14" x 8" runs the length of the building (approx.50 ') with heavy transverse beams @ 9" x 8" o.c. running the full width framed over it and into the timber top plate. The spine beam was again carried by three columns along its length, the northerly two lining up with the column supported beams below. At the south however there was variation from floor to floor based, as discussed, on functional considerations. The columns at the first floor were carried by heavy timbers beams at the crawlspace which were supported by stone piers. At least the centre pier is at its original location.

Of note is the original position of the most southerly column supporting the attic spine beam, approx. 2' south of its current location, which framed into a heavy beam running from the south wall to a mortice at the centre of the southmost third floor beam i.e. just above the original position of the two storey column. Its position (and indeed that of the full length spine beam at the storey level) relate to support of an exterior hoisting mechanism (as at Evans Fig.12,*6)* The original columns are finely chamfered with an ovolo stop creating an octagonal appearance (Fig.29).

The particularly heavy timber framing of the attic floor, (which was originally actually used as a floor area), was due to its function in acting as tie to the longitudinal stone walls, counteracting rafter thrust within the roof truss arrangement. The spine beam shortened the span and stiffened the tying beams particularly important at the members where the roof braces framed in. With heavy floorboards further tying the beams this would have been a extremely strong system.

The roof truss system itself is exceptional and exhibits the skill of a master timber framer. Reciprocally sawn rafters @ 44" o.c. are housed and pegged into the adze finished bevelled ridgebeam at the peak and into the plates at the at the eave (Fig.30). The rafters are supported at midspan by an oblique purlin (7 1/2" x 6") which is braced into the tie beams at every fourth beam (and at the gables) with each brace diagonally strutted in two planes. This creates a form of Queen post truss. An unusual detail is the bracing of the first set of rafters interior to the stone gable back to the ridge beam (Fig.32). All truss members have been hewn and expertly adzed. The original roof sheathing may be the 20" wide material still surviving in a number of locations including the southeast section of the roof.

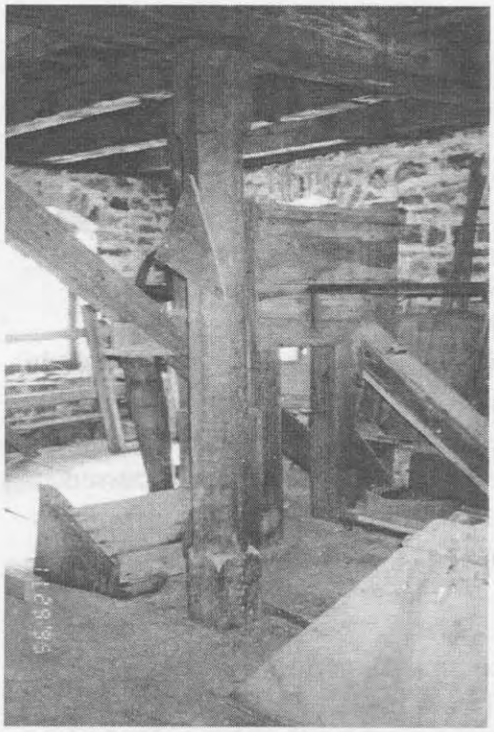


Fig.29 Typ. original column

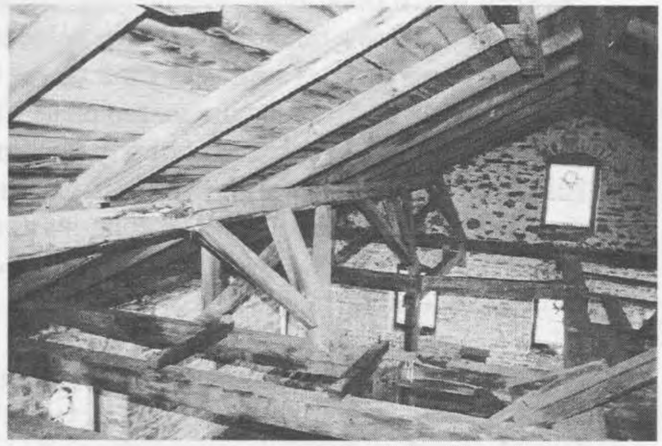


Fig.30 Attic/roof structure

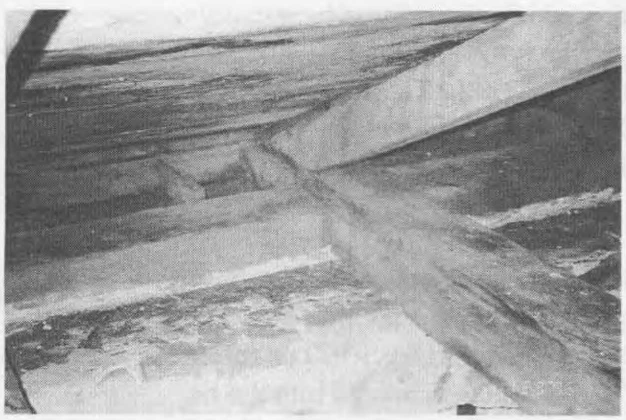


Fig.31 Plate/tie/rafter detail

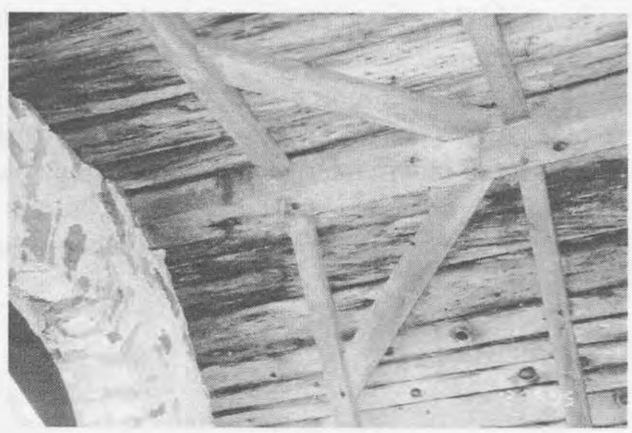


Fig.32 Ridgebeam

As noted earlier the attic had usable floor space of possibly two layers of full 1" planking as reflected in the rows of hand wrought nails which now line and 'stand proud' of the surviving beams (Fig.33). The northeast remnant ceiling is of very early date signified by the split accordion lath and hand wrought lathing nails (newer nails from renailing are also present) (Fig.34). The plaster ceiling may well have extended throughout the northern half of the structure as nailing from lath is evident on the underside of the beam at the north gable and there is a change in the degree of surface rendering still visible at the north which suggests this greater extent of original finish. It is possible that this section of the attic was used as a granary with the plaster acting not only as a 'higher' finish but also to further inhibit vermin. The northeast with its brick chimney built interior to the stone walling appears to have always been the location of the offices. At the Stone Mills this may have included a business office on the ground floor and a private Miller's office/'study' originally on the third floor. The business office seems to have been located in its current location as evidenced by the door opening and by being the only space within the mill where the window surrounds have a finished stool, composed of a single stone, one of which a appears to have initials incised into it.

The stair from the second to the third floor was not in its current position as evidenced by the empty mortise for joist housing on the 3rd floor beam. This stair appears to have been located along the east wall just to the north of the centre window of the second floor and remained there until c.1970. The stairs related to the husk have been discussed earlier. The attic stair appears to occupy its original position and is an early carriage. Otherwise there were likely trap doors between floors accessed via ladders and facilitating further hoisting when required.

Fig.33 Nails

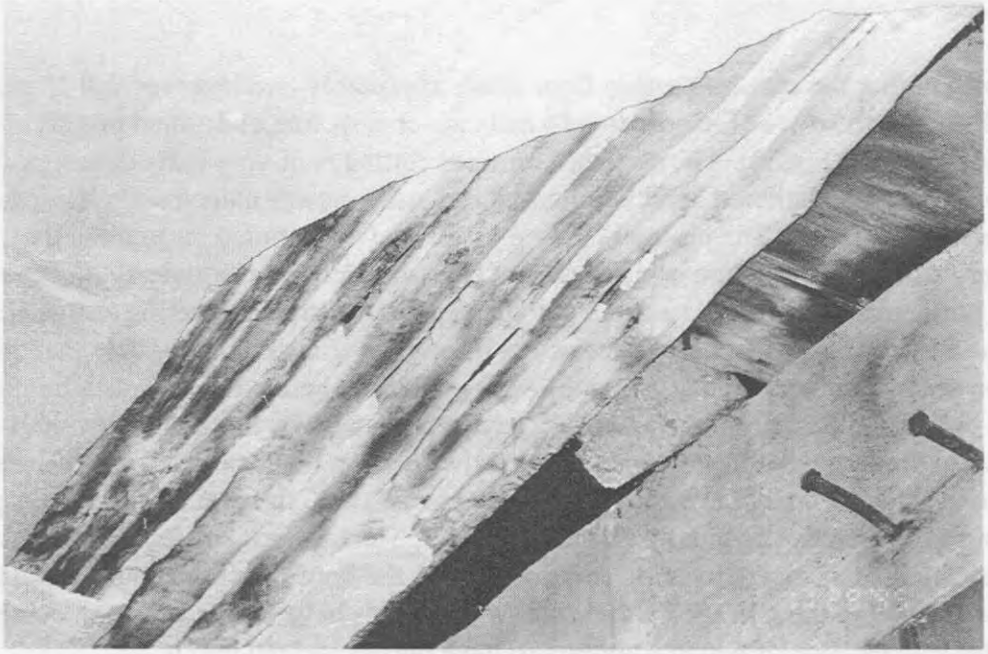


Fig.34 Original plaster

The Dam

Jones apparently created a new primary channel slightly to the west of the natural stream course (possibly widening and deepening a secondary stream, or Stevens' mill run) with, local lore has it, 'black powder' and blocking and filling the original course which includes part of what is now Main Street. He then established a higher dam which flooded out the preceding controlling dams and thus integrated the ponds into a single lake-size body of water over the protests of farmers whose land would be drowned as a consequence. Jones' log and rubble stone dam was built across the stream extending from the northwest corner of the original mill (the mill actually forming part of the dam). The north wall of the original timber frame sawmill would have been built on the dam as was the bridge across the stream. It is possible that the dam was built in two sections with a central stone abutment which may have served as well as a corner pier support for the original sawmill (Fig.35). There was a control gate at the grist mill headrace and stoplogs at the dam as a spill-way to control spring flooding. It is likely that the available net head created by Jones' dam was about 7' as was still the case when estimated by Mr. Herbert Hall of the Charles Barber Company in 1949,[36] there seeming to have been little hydrographic change in the interim.

36 Letter from Herbert Hall, Charles Barber and Sons to Hastings Steele re: replacement of turbines, June 22, 1949.

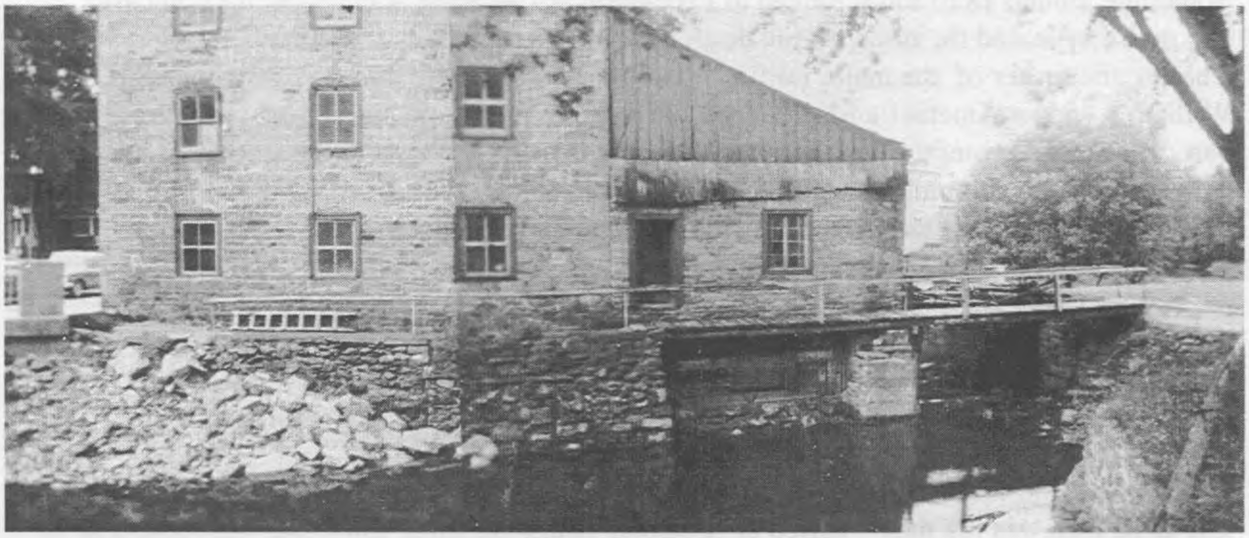


Fig.35 Dam and sawmill abutment 1960. (MNR)

There is a slight possibility that the sawmill had a full stone foundation and may have even been powered by a separate wheel. This would have entailed a complex system involving three potential paths for water travel however and more likely the sawmill was simply founded on piers in the stream. It appears that the sawmill structure was originally quite low given that the original gristmill stonework included second storey windows though none on the first.

The completed mill received high praise from knowledgable traveller's of the time. In 1816 Colonel Cockburn, Deputy Quartermaster at Kingston reported having stayed with " ...a Mr. Jones who lives in the village which consists of about 20 houses, where is an inn, a saw and grist mill(both excellent) and a distillery. The Stream running through the place is the Gananoque River and is sufficiently ample at all seasons for every purpose...Mr. Jones is the proprietor of the mills and a magistrate."

A year later the Presbyterian Minister William Smart described the village, then known as Stone mills thusly for Robert Gourlay's Statistical Account of Upper Canada: " In this township is the village of Stone Mills, the mill here belonging to William Jones Esquire is unquestionably the best of its kind in Upper Canada. Besides the large grist mill there is one carding machine, one saw mill, three stores and one blacksmith shop."

Between 1812 and 1820 the mills were assessed variously to Jones and Schofield (1814-15); James Schofield Jr. (1817-19); and William Jones (1816, 1820) while after 1820 only Jones' name is shown. The shifting responsibility for the mill probably reflects the number of enterprises the principals were engaged in for which prime responsibility had to be shared.

Sometime around 1820 Jones moved to Brockville as Collector of Customs for that City and probably leased the mills. At his death the mills were willed to William's brother Charles, the owner of the major milling operation at Yonge. He in turn passed them to William's widow Amelia (a MacDonnell of the prominent Roman Catholic Glengarry based clan) who promptly sold them to William's cousin Henry, of the successful Brockville based shipping firm of H. & S. Jones. When Henry advertised the mills and associated property for sale in the Brockville Recorder of September 17, 1835 the mills were thus described:

> "-The Mills consist of a Stone Grist Mill, 60 x 40 feet, three stories high, with one run of stone in operation, and sufficient room to place one or two run more;-a large wooden building in which there is a Saw Mill, a Mill for cutting and polishing marble, and a Carding Machine;"

The Grist Mill was not then " leased or occupied" while the other mills had been rented at 50 pounds/annum until March of 1837. As an inducement to the prospective purchaser mention is made of the construction of a lock "at the Whitefish Falls" ..which will make the Mill 'the most valuable of any in the Back country as the navigation will then be completed from the Mill to Montreal or Kingston via the Rideau Canal."

Amelia Jones and James MacDonnell (1836-1847)

In 1836 the Mill was purchased by Amelia (MacDonnell) Jones and her new husband James MacDonnell, a sixth cousin[37]. James had eight young children by his first wife Magdalen Chisolm. Amelia widowed and without children of her own, inherited a relatively young family while moving back to the village in which she had spent much of her life to resume the role of miller's wife. MacDonnell seems to have been a public figure of some consequence in Beverley and environs and was very much involved in the community events of his time. James was an officer in the local militia during the Rebellion of 1837, a local magistrate and was privileged to address the Governor General during the latter's visit to Beverley in 1843 in favour of keeping the seat of the new legislature in Upper Canada.

However despite the lobbying efforts of Macdonnell and local merchant J.K. Hartwell (a friend and former business associate of Jones and Schofield) the link to the Rideau canal system never materialized and it appears that the mill was not profitable in this period. It was heavily mortgaged and it is unlikely in that economic climate that very much in the way of significant improvements were undertaken. It may be that MacDonnell was responsible for the infilling of the window arches in brick to facilitate window replacement and possibly whitewashed the full exterior at that time to gain a relatively uniform appearance between the differing materials.

At James Macdonnell's death August 31, 1847, Amelia, along with James' son Alexander once again inherited the mill. By the end of February 1850 the mill was fully owned by Walter H. Denaut who would bring it back to prominence and the leading edge of milling technology.

Walter Denaut (1849-1889)

Walter Denaut had been closely associated with various members of the Jones family and the village of Beverley for many years prior to his purchase of the Stone Mills. In 1825 he was a clerk for the store then owned by J.K. Hartwell and the Schofields and of which William Jones had previously been part owner. He worked as deputy tax collector for William Jones in Brockville prior to Jones' death and for the shipping company of William's cousins Henry and Sidney Jones among many other jobs. But it was his contracting partnership with James Crawford with contracts to build various locks on the Beauhornois Canal system which made him a financial success. In 1839 he moved back to Beverley, and in 1840 purchased the general store and a large farm prior to his buying the Mill in 1849.

He seems to have been a practical and energetic individual and was responsible for major changes to the mill in keeping with new developments in the milling process and in water-power technology. Given his forty year ownership of the building (1849-1889) it is

37 Dunc MacDonald, 'MacDonells: Soldiers and Millers'; Recorder and Times, June 17, 1987

likely that there was more than one period of renovation. However it is reasonable to view the most dramatic changes as being part of a comprehensive technological upgrading effort in the 1860's. The census of 1861 notes an investment in the mill of $20000.00.(Also indicated is that the mill had 2 employees with Walter Bush as miller and the production of 6000 bushels of flour.) The scale of investment reflects a confidence in the industry based on an increased demand for Canadian wheat in this period.

Turbines and Turbine Shed

The most significant change in the Denaut period was the replacement of the original vertical waterwheel as the power generator with a turbine powered system. Descendants of the horizontal tub wheel, turbines increased steadily in popularity from the 1840's. Turbines were smaller than their waterwheel counterparts, tended to be more efficient than all but the overshot wheel, were less expensive due to greater durability being typically of iron and with less complicated gearing than the many cogged waterwheels[38] (Fig.36).

SWAIN TURBINE.

One of the earlier high class wheels, made with many buckets and small openings, placed in "quarter turn" or "flume curb." Mr. Swain had much to do about starting the testing system. Quite a number of these wheels, ranging in size from 16 to 42 inches in diameter have been tested.

Test of a 21-inch.	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate..............	17.91	300	281	25.65	956.55	.8072
Part Gate,..............	18.25	275	282.5	23.54	864.94	.7902
"	18.34	230	280.5	19.65	742.22	.7611
"	18.44	165	241.5	12.05	562.20	.6175

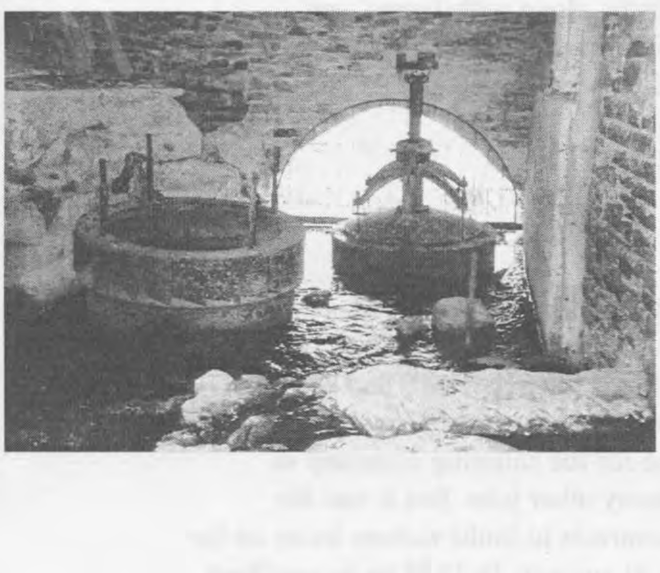


Fig.36 Mill turbines

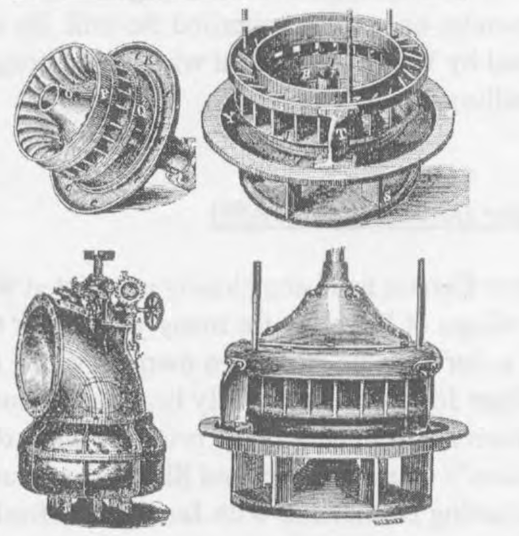


Fig.37 Swain turbine from Emerson (Treatise relative to the testing of Waterwheels)

38 Felicity Leung, Grist and Flour Mills of Ontario (Hull, Supply and Services Canada, 1981.) p.87.

The existing turbines at the mill have been positively identified as 48" Swain units. The Swain design was unique in that flow was controlled by a cylinder gate which is lowered to permit flow into the runner as is the case at the Stone Mills. The Swain turbine was designed by A.M Swain in 1855, making it quite early in the history of the technology. Swain was based in Lowell, Mass., the centre of the water power manufacturing industry at that time and it is probable that the turbines at Delta were manufactured there. If the turbines were installed at the mill in 1861 it would be a very early installation given the relative newness of the design. Indeed though it came to be well respected as a high efficiency unit other types such as the Leffel and Little Giant were always much more common. It is possible, in fact. that these may be the only Swain turbines still extant in Ontario.[39]

The turbines were housed in a new stone addition constructed for that purpose which took up the area of the former timber frame sawmill, though with a higher shed roof, necessitating closing in the second storey windows at the west elevation of the original mill. As well the eastern section of the dam would have been removed to allow for the stone foundation and headrace of the turbine shed and the original headrace arch plugged. A timber sawmill was then again constructed to the west of the turbine shed over the remaining stream channel. Maintaining the sawmill component of the mill complex was always part of the design intent as can be readily seen in the dedication of one of the new turbines (downstream unit) to its running and the building in of a shoulder in the stonework of the west wall of the turbine shed for the sawmill floor. Fig. 14 indicates that the sawmill was largely an open shed to the north which continued the roofline of the turbine shed with a fully enclosed gable roofed structure at the south end forming an 'L'.

The stonework of the turbine shed was much rougher than that of the mill itself, clearly being viewed as a utilitarian structure rather than an architectural statement. A wider range of local stone has been accepted by the mason, particularly more of the reddish sandstone (as opposed to the rust coloured material), and there is a greater variation in unit size with only the worst angles and knobs pitched off. The coursing is much less regular and there is no attempt at quoining (Fig.38). The window and door at the north are original openings the latter opening on to the footbridge over the dam. They are arched with voussoirs. The other original openings were a window and door (still existing) at the west, the latter lintelled by the building top plate. The south did not then have any windows as it was covered by the timber 'L'. Fig.39 shows the north window of the turbine shed to have been a multi-pane casement with its light division per leaf asymmetrical in the picturesque mode.

The wide 'raceway' arches are extremely well executed, with special support wedging designed into the springing. The headrace arch would have been gated while at the south the arch, served a relieving function supporting the main walling with further infill stonework within the arch to enclose the turbine. This was supported by a lintel at the waterline. Of note too is the manner in which the corners of the stone walling have been

---

39 William Trick Reporting Letter, January, 1996 (appended).

buttressed, particularly on the stream side. The turbine bulkhead was enclosed with a wooden deck and ceiling, vestiges of which remain.

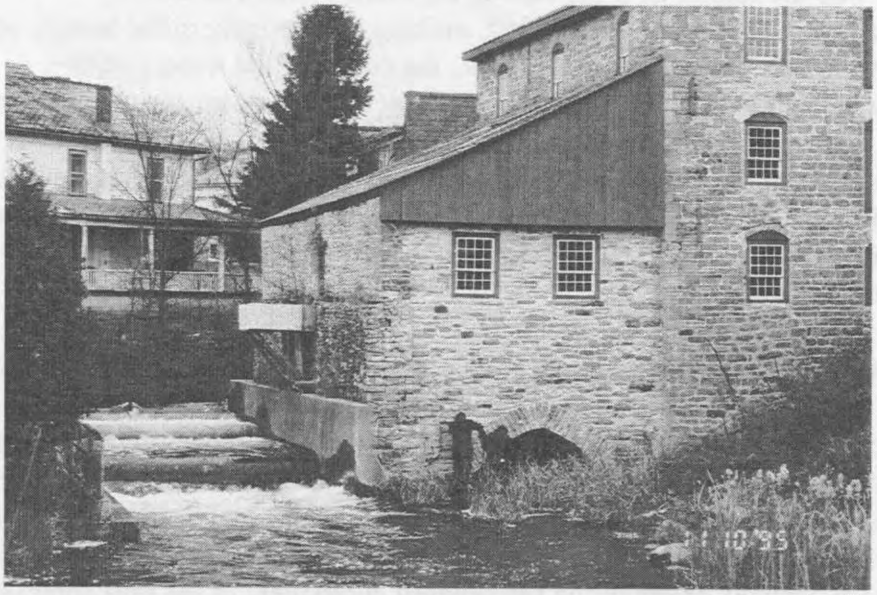


Fig.38 Turbine shed

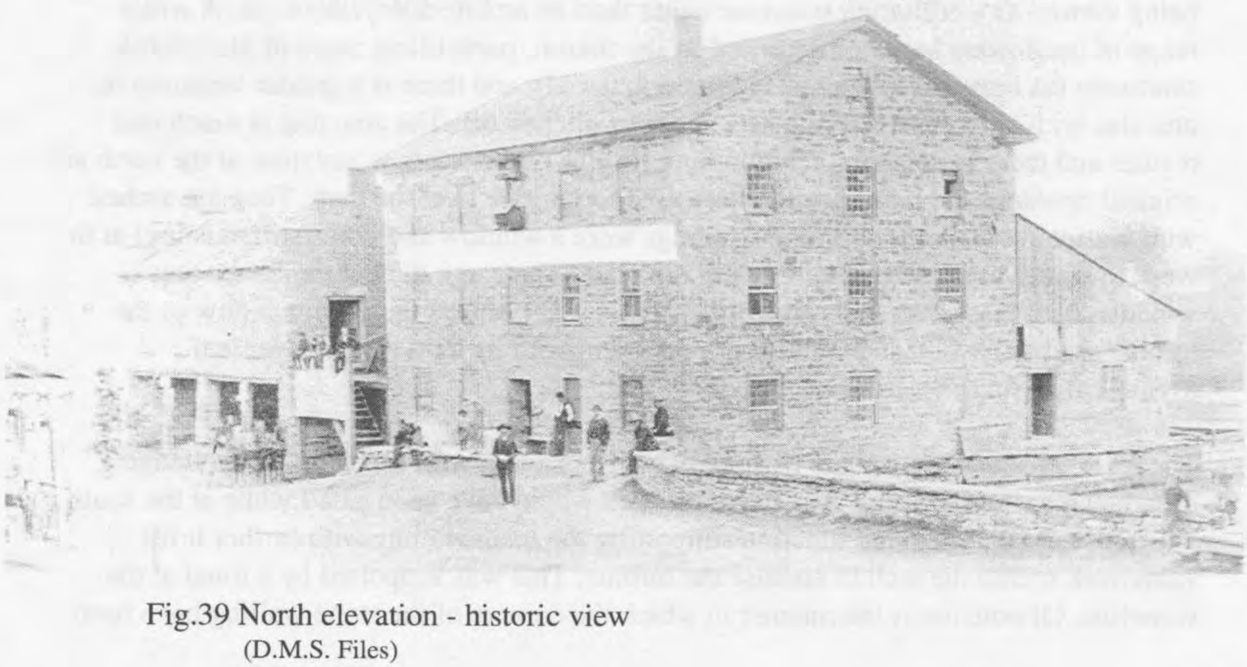


Fig.39 North elevation - historic view
(D.M.S. Files)

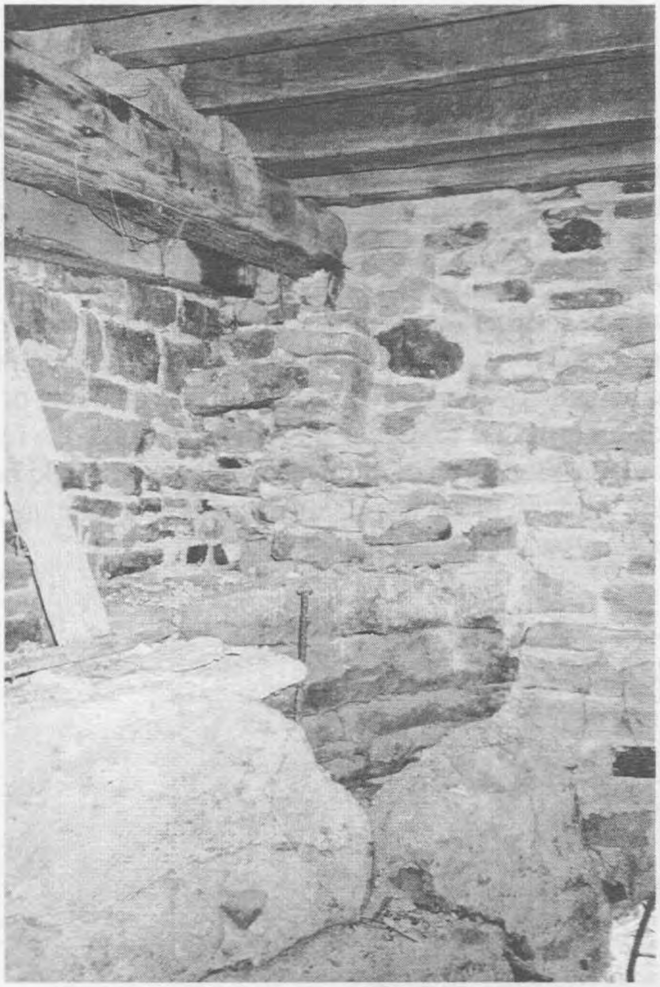


Fig.40 Turbine shed raceway, southeast corner

The floor and roof framing of the turbine shed would have been similar in form to that extant. The floor structure is composed simply of hewn beams carried at a shoulder in the masonry of the east and west walls. Long rafters are supported at a mid-slope purlin carried 11' o.c. by braced hewn columns. Tie beams housed in the mill masonry carry braced columns which support the top plate. However very little original material remains (several of the braced columns at the east wall). The door to the turbine shed from the mill probably reused the opening to the original sawmill.

Milling Innovations and Interior Renovations

It is probable that the program of renovations within the original mill followed the addition of the turbine shed and the shift to turbine power. The waterwheel was dismantled and removed and the waterhouse door opening closed in to window size. This then allowed the possibility of moving the husk to the west (which would have shortened the horizontal drives) though it would still be required to be at its original height.

The 1865-80 period was one of significant change in the grist milling industry beginning with the introduction of the process of gradual reduction and high grinding which came to replace the earlier fast reduction low grind methodology at many progressive mills. This method involved having the millstones run high and slow which created more middlings and gradually reducing the middlings in a series of grindings which allowed the 'gluten' to survive improving the quality of the flour.[40] This process involved an increased number of steps and machines such as the middlings purifier. Fig.41 gives a sense of a typical arrangement of machinery at that time. Modifications in operation attempting to incorporate new, efficiency improving innovations necessitated the reorganizing of the internal lay-out, probably into something close to its current form. To realize the full benefit of the new process utilizing the purifier an additional run of stones would have been necessary. It is likely that the third run of stones, smaller in diameter than the original (as was typical at mid-century) was added at this time.

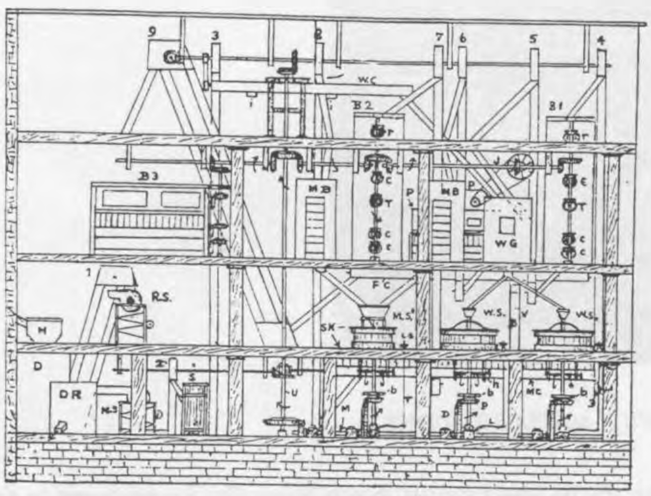


Fig. 13—An Old Buhr Stone Mill

Fig.41 Typ. mill lay-out c.1860 (from Dedrick, Practical Milling)

A change in the position of the vertical shaft could explain the removal of the large third floor beam which extended from the south wall to the transverse beam, as well as moving the column (above) which this beam had formerly supported north approx. 2' where it was then supported by the full length transverse beam still extant. Columns which were moved had to be cut from their tenons and have generally been shimmed into their new positions (Fig.42). At the third floor the northern half of the spine beam was cut to almost half its section and rebated to take some form of wall of storage bins, as the need for seasonal grain storage increased. This included removing the most northerly column and cutting the tie beams though they may still have borne on the spine beam from the east at that time. The remaining sections of the tie beams were supported on beams carried by new columns to which they were mortised and tenoned. The columns, which featured a cyma stop chamfer were placed directly below the purlin brace as some compensation for the loss of tying. One of the new columns has inscribed an 1881 date and also 'Jas. L.

40 Leung, Grist mills of Ontario, p.146

Denaut, Miller, June 5, 1888. The western section originally had three Denaut replacement columns as remains extant at the east. (Fig.43).

The relocation and/or addition of equipment and gearing can be traced structurally through the lower floors as well where again original columns were relocated (as noted on plan) from their central axis to free up a 'centre aisle', and along with several new columns assist in carrying equipment or picking up new loads from above. There were associated modifications to the beams of the third floor as well (Fig.26-28) .

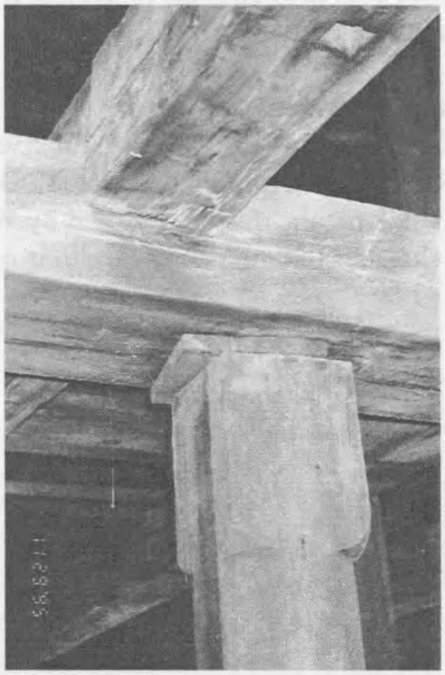


Fig.42 Relocated column detail

Fig.43 Denaut column detail

An object of much interest and speculation is the iron shaft of 4" square section with journal formed ends still extant at the base of the turbine shed tailrace arch. Clearly a remnant of earlier shafting it has been speculated that it may even be the original waterwheel shaft, possibly produced at the Lyndhurst Ironworks.[41] Fascinating as this postulation may be there are a number of difficulties with it. Firstly no other iron waterwheel shafts of that date are known in Upper Canada. This is not only due to the difficulty of manufacture but also because of the problems of integration of the shaft with the waterwheels themselves. While mechanical connections could be (and were later) employed the mortising of the wheel spokes into an oak shaft was most typical and considered the most secure connection at that time. Furthermore the extent of item types manufactured at Lyndhurst is unknown and even whether it was still smelting at the time of Stone Mill construction is unclear. While this theory should continue to be explored (including testing iron scrapings and removal of the shaft from its current position during stabilization to allow for further examination) it would appear at this stage that the shaft

41 Art Shaw, Memo to the Mill Restoration Committee, February 21, 1995.

is a component section of the line shaft (albeit of particularly heavy section) from this mid-19th century period and, as such is still a significant artefact.

Though typically attributed to George Haskins it is possible that sometime during his tenure Denaut introduced steam power to the mill as an auxiliary power source. The engine was located at the west wall of the turbine shed its chimney visible in early photographs. Steam helped free the mill from any inconsistency in the water power supply and utilizing the sawmill waste as fuel would have been relatively economical. How much of the operation was tied into this power source is difficult to access. It may be that Haskins did utilize this power source to a greater extent.

Perhaps due to the loss of the earlier finished space at the third floor Denaut created a Miller's room on the second floor with plastered interior, relatively ornate window, door casings and base (Fig.44). On the exterior boarding Jas. L. Denaut has again written his name this time in 1891, (at this time the mill was owned by W.H. Denaut's widow) . There also seems to be some sketches of chute configurations on the horizontal tongue and groove boarding.

Fig.44 Denaut's 'Miller's Study'

Denaut constructed a carriage shed and hall adjacent to the mill. With stabling below for his customers and entertainment or meeting space above the building was originally quite elegant. It had a parapeted gable roof, a brick upper storey and stone first floor/foundation with cut stone quoins corbelled at the parapet. The brickwork rested on a heavy timber plate at the street face supported by cut stone columns with two sets of carriage doors (possibly added later). The eaves were bracketed and the upper storey had large 6/6 windows (Fig.39).

Fig.45 Delta, c.1861 (from Walling)

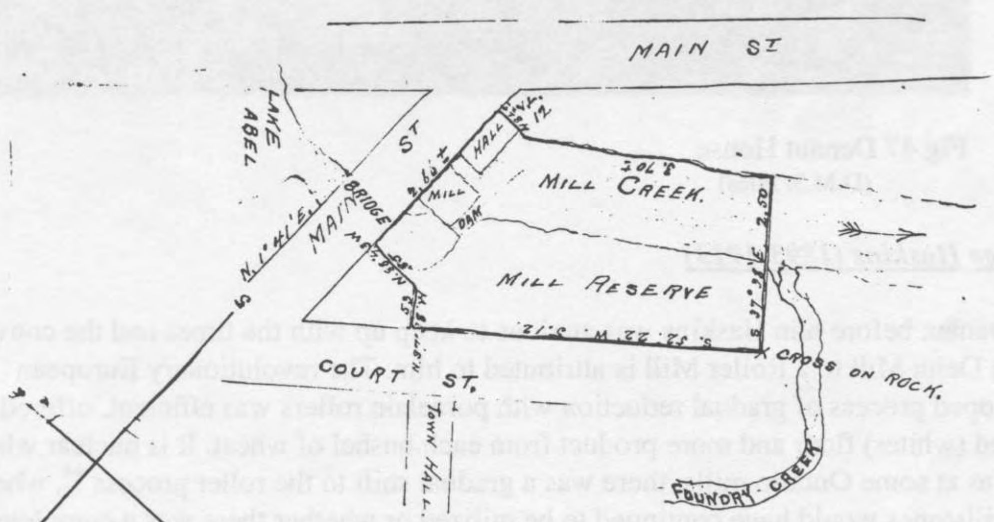


Fig.46 Sketch of Mill property (from 1891 Deed)

Denaut also built himself the quintessential miller's house, a large, picturesque, rambling structure of brick and stone by Upper Beverley Lake (Fig.47).

Denaut died in 1889. In his forty years of ownership he had significantly improved the mill and made it once again a successful business and a centre of community life. At his death the mill was willed to his third wife Caroline Denaut who sold it in 1893 to George Haskins. In the interim Jas. Denaut, Walter's son appears to have been Miller. Alice Webster indicates that through much of the Denaut era Charlie VanLuven was miller with Jas as assistant[42]. Another son Mathew, managed the office. Both these sons later became doctors in Indiana[43].

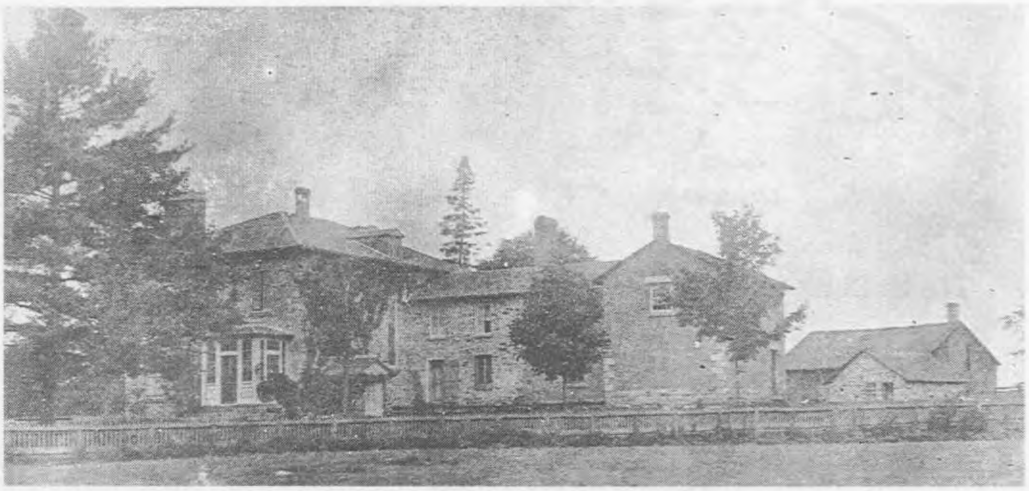


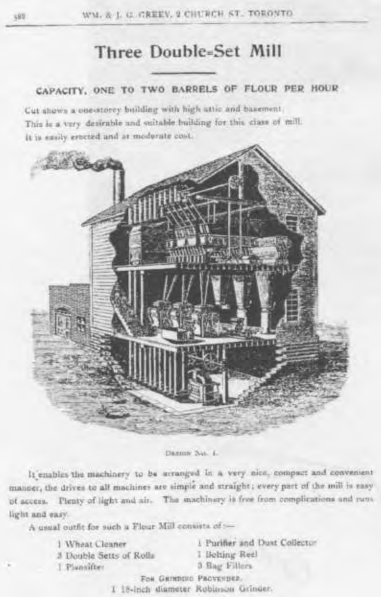
Fig.47 Denaut House
(D.M.S. Files)

George Haskins (1893-1913)

As Denaut before him Haskins was anxious to keep up with the times and the conversion of the Delta Mill to a Roller Mill is attributed to him. The revolutionary European developed process of gradual reduction with porcelain rollers was efficient, offered more refined (whiter) flour and more product from each bushel of wheat. It is unclear whether here, as at some Ontario mills, there was a gradual shift to the roller process [44], whereby the millstones would have continued to be utilized or whether there was a complete change to the roller system in which case the millstones would have been immediately redundant. However given the relatively recent replacement of the westernmost stone support timbers of the husk the stones may well have been retained into this century even after some rollers were set in place.

42 Webster, 'The Old Mill', Athens Reporter (as above)
43 Elizabeth Marsh (Denaut grandaughter). Family reminiscence of Walter Denaut, 1970.
44 Leung, (as above), p.186

No residual components remain from the Roller Mill era but a full roller mill would have required a considerable complement of downstream equipment as the old bolters and reels associated with stone grinding would have mostly been redundant. A minimum of three sets of double reduction rollers would have been necessary to achieve the yield and quality benefits of the progressive reduction process. Considering structural support for the roller stands, it is unlikely that a prudent owner or experienced millwright would find the millstone husk in its current position adequately supported, since each stand could weigh up to one tonne. Therefore it is reasonable to assume that the husk and its foundation remained more or less in their original position. The illustration from the 1901 Greey Catalogue shows a typical arrangement for a three double stand mill and lists the equipment complement.(Fig.48)


388 WM. & J. G. GREEY, 2 CHURCH ST., TORONTO

Three Double-Set Mill

CAPACITY, ONE TO TWO BARRELS OF FLOUR PER HOUR

Cut shows a one-storey building with high attic and basement. This is a very desirable and suitable building for this class of mill. It is easily erected and at moderate cost.

Design No. 1.

It enables the machinery to be arranged in a very nice, compact and convenient manner, the drives to all machines are simple and straight; every part of the mill is easy of access. Plenty of light and air. The machinery is free from complications and runs light and easy.

A usual outfit for such a Flour Mill consists of :—

1 Wheat Cleaner	1 Purifier and Dust Collector
3 Double Setts of Rolls	1 Bolting Reel
1 Plansifter	3 Bag Fillers

For Grinding Provender.
1 18-inch diameter Robinson Grinder.

Fig.48 Typ. roller mill set-up (from Greey, Illustrated Catalogue)

At the Delta Mill it is postulated that the main drive for the rollers would be similar to that above. The horizontal layshaft of the mill drive turbine would have originally extended to the east sufficiently to permit belt drives to each roller stand, which in turn were located on the millstone husk.

The mill drive turbines and its horizontal layshaft would have been generally unchanged in location for this updating, although new pulleys would have been installed, and it is possible that the layshaft itself may have been replaced.

The size of the installation was limited to match the available water power and turbine capacity. Some sources suggest that it was Haskins who introduced steam power to the Mill. Haskins also apparently installed a Dynamo at the Mill in 1911 linked to the steam engine which provided electrical power to the Village.

On the exterior it seems from early photos that the gable roofed 'L' of the sawmill had been removed in favour of an extended shed. The opening which had originally been the waterhouse door and then a window had been infilled with stone. A number of the multi-paned sash had been replaced with sash of two/two configuration and the era of cedar roofs had given way to a metal batten-seam treatment.

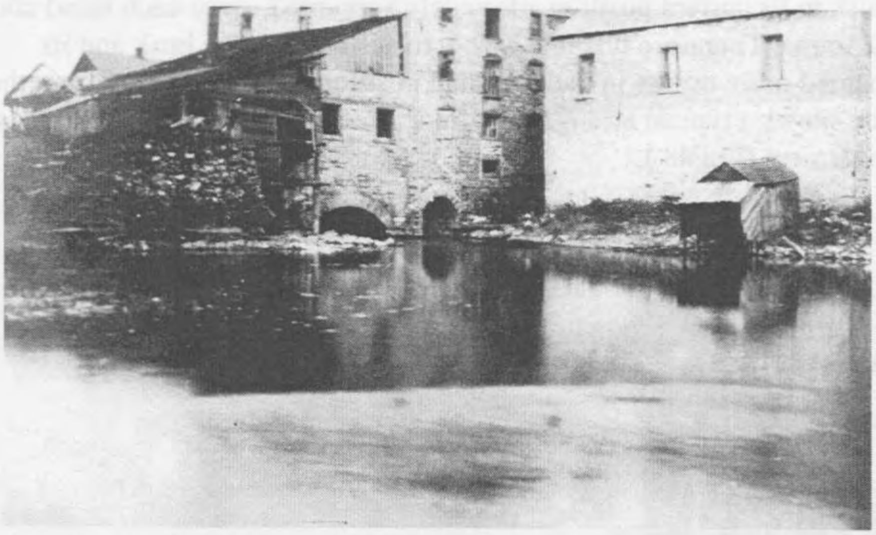


Fig. 49 Historic photo c.1900
(D.M.S. Files)

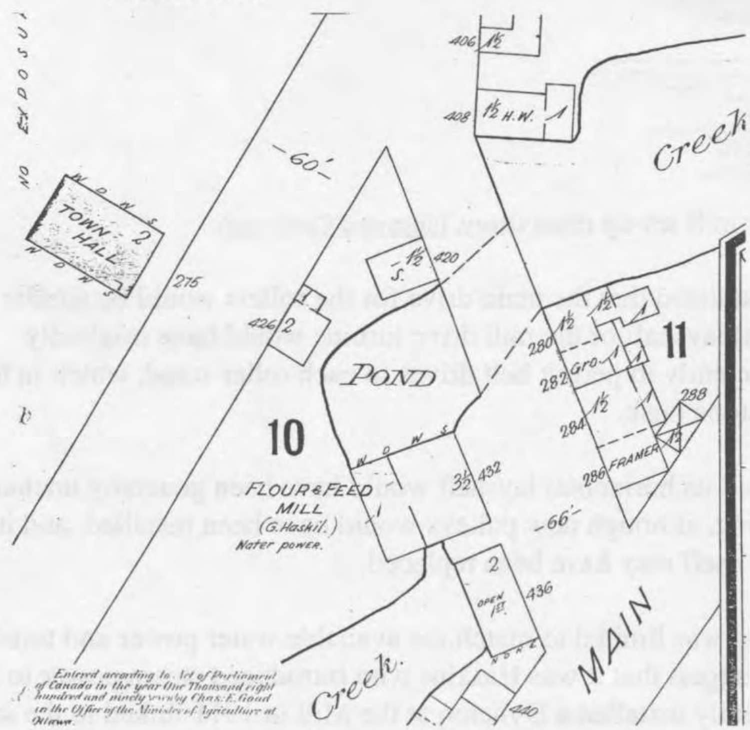


Fig.50 Goad's Fire Insurance Plan 1897.
(Ontario Archives Delta F.P. C234-1-109-1 Sheet I)

Hastings Steele (1913-1964)

In 1913 Haskins sold the Mill to Hastings Steele and James Huffman. Steele and Omer Arnold bought out Huffman in 1918 and by 1921 Steele was sole owner of the operation. It would appear that after aquiring full ownership Steele embarked on major renovations to the mill associated with changing its major function to the production of feed rather than flour. As a feed mill the historic husk arrangement was no longer required. Indeed it was much more convenient to grind and bag on the main floor. It is likely for these reasons (and perhaps advanced decay to husk foundation cribbing) which led to dropping the husk to its current position. It seems some further excavation to improve headroom at the basement was undertaken at that time and a stair from the main floor installed. The stair carriage is inscribed with the date 1922. The husk was roughly accommodated within the basement space, and basic repairs made to husk timbers where required. In general the work appears to have been done quickly and with minimum investment. The eastern end of the husk, no longer necessary and possibly rotting, was cut away to allow more room at the bottom of the basement stairs. While the timber joinery of the general repairs undertaken at this time is crude compared to the original husk workmanship when it came to accommodating the new vertical shaft some finely planed new wood members were set in place at all floor levels. The basement member is inscribed with the date of installation as noted earlier - '1922'. Except as required to allow for the vertical shafts the husk was floored over at the first floor and thus accommodated the grinding operations. Here a single head grain chopper was operated to service local farmers with grist for livestock feed. The process equipment for this service was a receiving or scalping shoe (to remove rough material from the whole grain before passing it through the grinder), several elevators to handle the whole grain to one of several overhead bins, a chopper (still extant at the mill), a mixer and a bagging hopper on the main floor. It would have been common to have a set of oat rollers in a mill of this size to service horse owners.

The single head chopper (Champion Grinder with 1923 nameplate) still stored in the mill uses ball bearings which is typical of a post 1900 design. It would have required 15 to 20 horsepower to operate at reasonable capacity, which is within the capacity of the turbine provided water was available. The upstream turbine was used for this purpose, coupled to a vertical shaft extension, which carried a bevel mortise gear (the mortise gear which is presently broken). The mortise gear then meshed with a pinion on a horizontal layshaft which extended through to a pillow block support (still existing) on the mill wall cutout. The pinion associated with this gear set and the horizontal layshaft are both stored loose in the turbine shed. A flat pulley installed on the layshaft and inside the mill wall would have been belted to the chopper on the main floor. There was a further shaft extension to the turbine shaft up through the present floor level in the turbine shed, and a pulley installed thereon to drive through two slots in the mill wall. This belt must have driven another vertical shaft inside the mill which extended to upper levels for other accessories such as elevators or the mixer. The width of the belt, and the belt speed indicate a capacity of 10-15 horsepower at best. The turbine curb and its location, the bevel mortise gear set and the horizontal layshaft would have been basically unchanged at this time.[45] Fig.51 is a sketch of the main floor plan of the mill in this period by Steele's grandson.

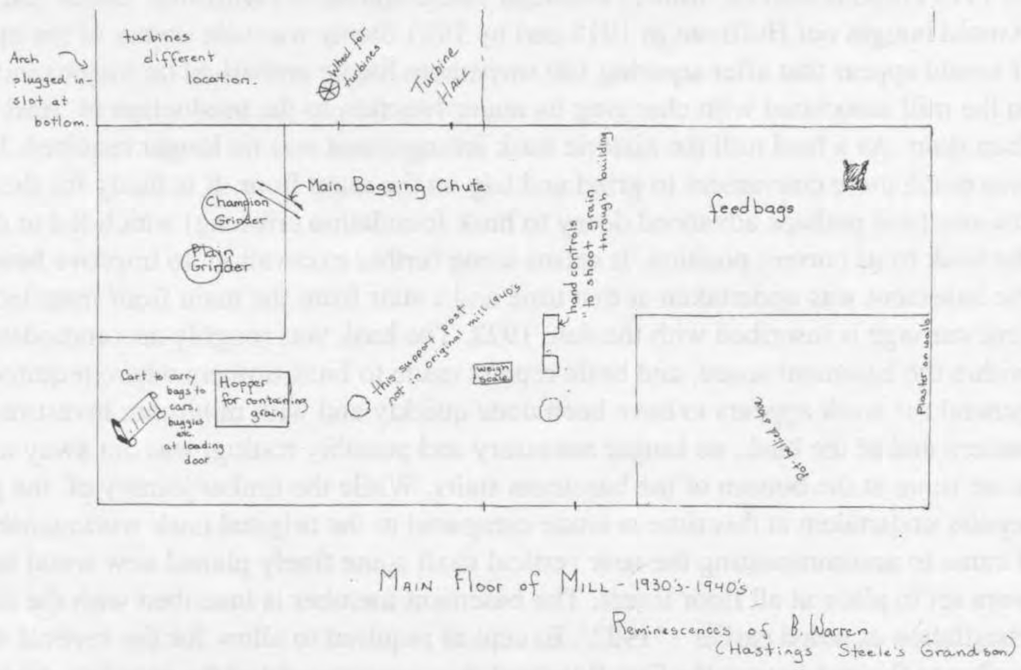


Fig.51 Sketch Plan c.1930 by Steele's grandson

Steele continued to operate the sawmill and grinding mill until 1949. At that time he solicited a proposal from Charles Barber and Sons for the replacement/upgrading of the turbines. He decided not to proceed with this major renovation however and milling thus ceased at the StoneMills after close to 150 years.

Steele also ran an electrical contracting business (1938-1952) from the mill and sold feed (produced by others) from the mill until 1960.

Changes at the Dam

Up until 1962 the mill dam still controlled the level of Upper Beverley Lake. However there had been increasing concern regarding the dam's ability to control the spring freshet and also concerns about low summer levels causing the death of bass and pike in the upper lake. Apparently Hastings Steele even built a dyke at personal expense to attempt to prevent the worst of the spring flooding.

While initially consideration was given to repairing the historic milldam it was felt to be not a practical long-term solution and Dept. of Lands and Forests reported on March 27,

45 Trick (as above)

1962 that "Hasings Steele was agreeable to new dam provided that the millpond between his house and the mill not become and eyesore". [46]

The construction process was relatively swift and included documentation of the then existing condition at the Mill (Fig.52). The process required coffer damming upstream revealing the dry stream bed adjacent to the mill. (Fig.53,54) On August 31, 1962 the new concrete dam was completed.[47]

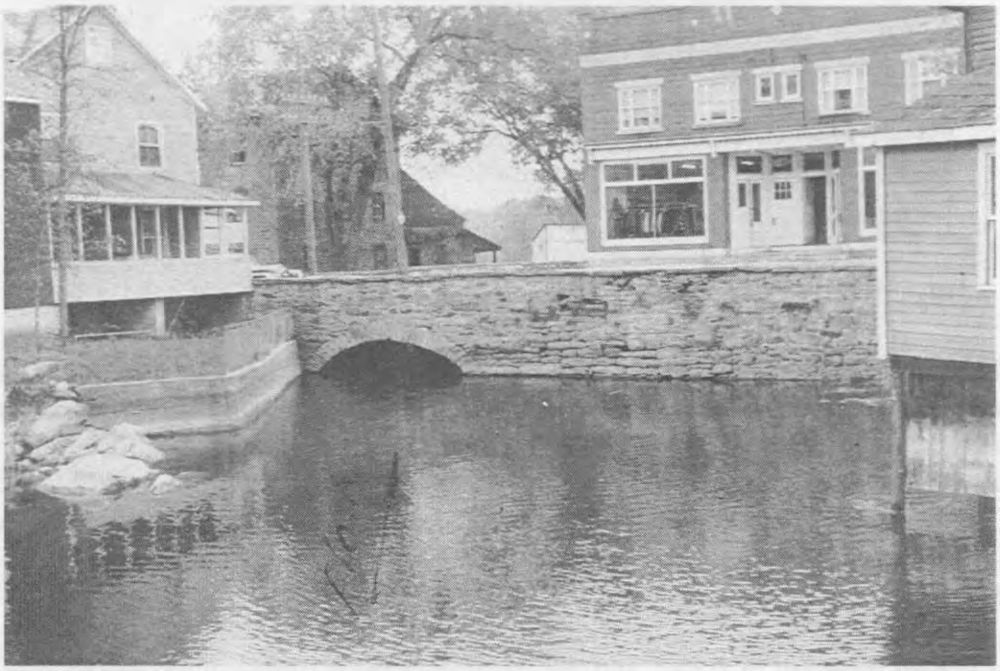


Fig.52 The Mill c.1960: Last record of historic configuration (MNR Files)

In failing health and conscious of its historic importance Hastings Steele deeded the Mill to four trustees for $1.00 on condition that it become a museum and they in turn deeded the Mill to the newly formed Delta Mill Society with a mandate to preserve the historic structure. However the old mill dam, the sawmill remains and the turbine shed were purchased by the Ontario Department of Public Works due to their concern for hydrological improvement and public safety at the creek[48]. In this regard a number of initiatives for channel improvement adjacent to the mill and stabilization of the stone shed were considered. At one point the shed was going to be demolished and was saved, in part, because of the efforts of James Auld, MPP for Leeds and then Provincial Environment Minister.

46 Internal Correspondance Ontario Dept. of Public Works (ODPW)
47 ODPW memo
48 Memo to J.V. Shanks, Hydraulic Engineer from B. Paget, Maintenance Supervisor, August 13, 1964

Fig.53 Mill from south-west during dam construction (MNR Files)

Photos of the complex at this time (Fig.55) reveal it to have been in very poor condition with unsecured windows at the mill and the shed and much loose masonry including large gaps on the streamside walls of the turbine shed. Many of the gable boards at the turbine shed were missing. The rendered infilling of the arch for the turbine was still in place. The top window at the southwest had been infilled with masonry. The building was, by then, roofed in corrugated metal, badly corroded with many patched sections over the shed.

The sawmill floor fell in 1968[49] and the clearing of the resulting debris in the channel revived consideration of associated improvements.

In 1973 the Delta Mill Society with support from the federal and provincial governments, including the newly formed Ontario Heritage Foundation embarked on the stabilization and restoration of the Mill. This involved the replacement of the roof in new cedar shingles; attempted consolidation of the original tailrace arch with concrete; concrete repairs around base of arches; general masonry repair including resetting of loose stones and repointing in masonry cement; jacking of floors to level and replacement of two columns at the first storey as well as other structural members; replacement of window frames, sash and glazing; repair to wood trim as required; placement of steel tie rods[50].

The Ministry of Natural Resources (who had assumed responsibility for the Dam) were impressed with the dedication of the Society and their commitment to preserving the stone shed along with the mill itself and undertook channel improvements, stabilization of the shed including rebuilding the tailrace arch and a reinforced concrete protective skirt to the streamside of the turbine shed. They then deeded the stabilized shed to the Delta

49 MNR files

50 From partial letter of construction progress inspection apparently from V.N. Styrmo, then of the Historical and Museum's Branch of the Province.

Mill Society for further restoration. This latter work would appear to have involved the rebuilding of much of the wood frame structure.

Fig.54 Northwest corner and dam frame during new dam construction
(MNR Files)

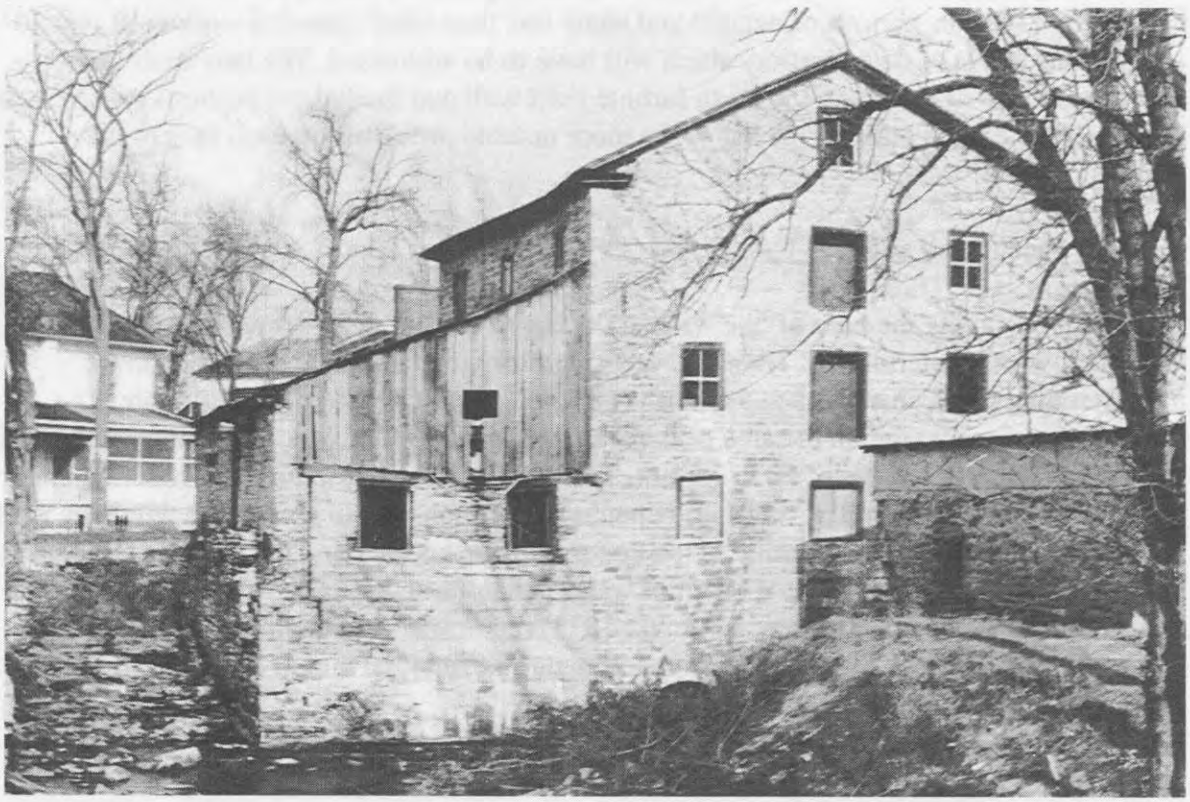


Fig.55 Mill c.1963 (MNR Files)

VI. BUILDING CONDITION SURVEY AND ANALYSIS

Given its 185 years, almost 140 in industrial service, the Delta Mill is generally relatively stable. However there are a number of significant areas of concern which do threaten the long term integrity of the structure. An inventory of the areas of deterioration is presented below with some comment, where relevant, on the agents/causes of the problem. In **Section VII** these items are prioritized, and solutions/interventions recommended in developing a scope of work.

Masonry

As has been noted earlier the stonework of the mill exhibits a high degree of skill and careful choice of locally available material, while at the turbine shed a wider range of material type and size has been utilized in a somewhat more utilitarian manner. Both sections of the building are of two wythe construction (inner and outer layer of face stone with a rubble core), jointed in a lime mortar. It should be noted that the lime, made from the local crystalline limestone, was historically considered of relatively high quality.

Despite the generally high quality of the original work, the difficult environment of moving water at the foundation level; weather exposure at the upper levels exacerbated by hard service, periods of neglect and some less than ideal remedial work have caused various levels of deterioration which will have to be addressed. The two areas in most urgent need of repair are the north turbine shed wall and the bulged portions of the south wall of the main building. A list of the more notable problems on each face of the building follows:

East Face (Front or Street Face)

The joints along the base of the wall, at the top of the northeast corner and under the windows are deteriorated. There are vertical cracks under several of the windows, extending between storeys at the north (Fig.56), and at the base of the structure. The exterior stone wythe, in the area of the second and third floor windows at the south end is bulged out in the order of 50 to 75 mm. The deterioration of jointing and cracking under the windows is a result of moisture penetration through the sill area of the windows while the deterioration of the jointing in the upper northeast corner and the bulge in the wall at the south end appears to be a result of water penetration through deteriorated roofing over these areas in past years. Recent (c.1973) repointing appears to have been executed in masonry cement and was superficial in nature i.e. applied directly over deteriorated joint without proper raking out etc.

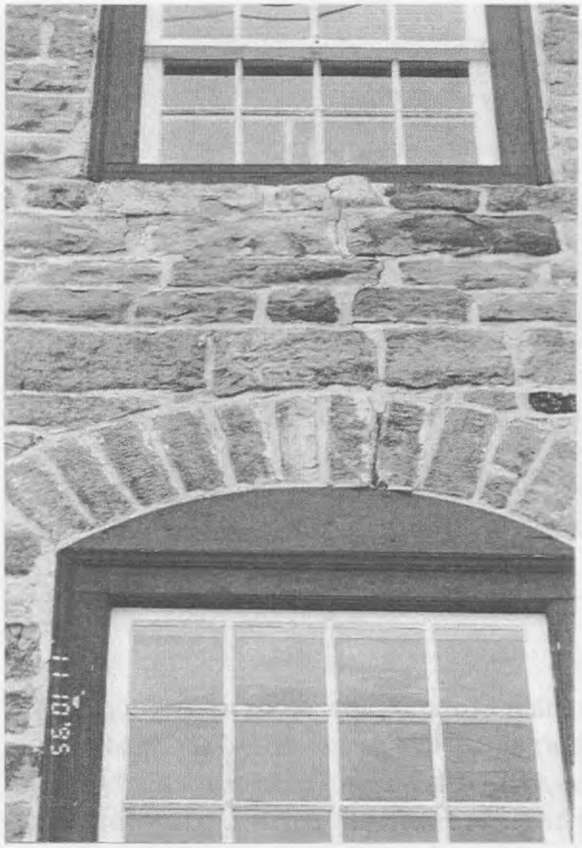


Fig.56 Fig.57

North Face

Joint deterioration was noted in the central upper portion of the wall and in the east corner. There is vertical cracking above and below the windows again as a result of water penetration at sill areas. On the north face of the turbine shed there is joint deterioration, major cracking and an unstable area at the arches over the doorway and window. Much of the deterioration in the upper portion of the turbine shed stone work can be attributed to the fact that the stone projects 100-150 mm beyond the vertical siding of the gable above and this allows water to readily penetrate the masonry below. This condition in turn seems to be the result of a discrepancy in planes between the west and north walls which relates to the original angled face at this corner at the conjunction of dam abutment, and sawmill framing.(Fig.58) In any case a ledge exists at the bottom corner and the masonry below is not coursed into the main walling. Between this area and the window a crack radiates. As well the lower portions of this wall experience severe exposure from water in the creek running immediately at the base of the wall. (Fig.57)

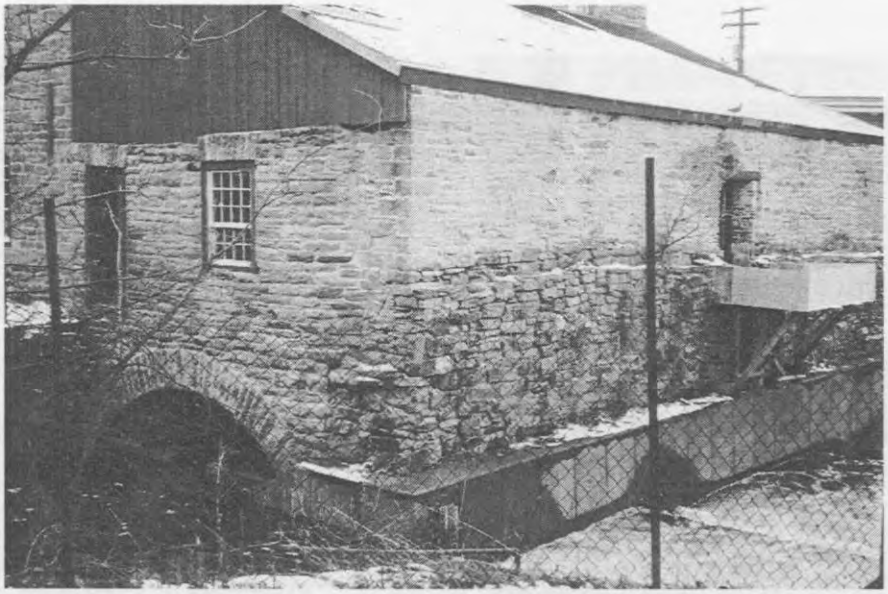


Fig.58

West Face

There is a sag in the southwest corner of the main Mill roof apparently associated with the major masonry deterioration below this corner.i.e. The movement of the west wall as a result of the long term destabilization of the southwest corner (most particularly arch abutment - see below) due to erosion of mortar at the foundation in the area of the wheel-pit largely attributable to the action of running water originally against, and later also through the raceway walling. This condition continues today, the inexorable action of the stream only partially inhibited by the plugging of the inlet.

The stone wall of the turbine shed, above the concrete facing is badly weathered with many open joints. Several ledges exist which allow water and snow to remain, draining into the masonry. This, as well as occassional breaches of the concrete skirt by the spring freshet have resulted in accelerated deterioration of this area,. The main problematic ledge is the shoulder which formerly supported the sawmill floor framing. Vegetation is growing from between cracks in the ledge surface. Even the upper area which was repointed c.1974 has many gaps, particularly toward the south. The concrete skirt put in place in 1975 by MNR remains, in itself, sound.

South Face

The most serious condition at the mill is the failure of the tailrace arch abutment ('arch failure'- see also above) reflected in the wide settlement cracks extending through the full height of the wall at the southwest corner and causing rotation away from the general wall plane. Early photos and layers of crack patching show that this has been a long-time condition. The failure of this arch seems due initially to the erosion of mortar at the west abutment caused by ongoing water action (with occassional surface frost) on, and eventually through the masonry. This corner, with the arch opening, the waterhouse door and windows above becomes essentially a tall stone column and at the same time is most exposed to water action (both from inside and originally also from out) at the base and was thus inherently most susceptible to failure. Added to these factors is the significant vibration caused by the working waterwheel. (When building the turbine shed Denaut attempted to buttress the original abutment area thickening the masonry wall substantially in that location and there has been a more recent attempt to tie this corner back with steel rods.) Though the forces acting against the corner of the original mill have lessened i.e. no waterwheel, less water force, they are still present and the abutment failure has, as yet not been fully resolved e.g. mortar joints above and below the waterline remain open. This will be a significant challenge of the upcoming restoration program (Fig.59,60).

Currently the arch repair over the window at the former waterhouse door area is roughly executed in part because of the lack of a consistent wall plane. The areas under the western windows are generally seriously bulged and have a mixture of poorly patched, deteriorated and open joints. There is a large gap adjacent to the plate of the upper tie rod, perhaps due to the oxide jacking of corroded iron within the wall. There are gaps at the quoin joints just below the west eave.

There is some joint deterioration in all other areas of this face as well. Vertical cracking occurs above and below the easterly and central windows and doors. A glass telltale over the east window of the first storey has cracked indicating active wall movement in that location.The masonry in the southwest corner of the turbine shed is badly deteriorated with open joints and cracked stones.

Fig.59

Fig.60

Interior

Many of the cracks, under the windows, visible from the exterior, are 'reflected' on the interior of the wall i.e. run right through the wall. A number of these have been monitored for movement with glass tell-tales placed on the interior. When recently checked, only one on the interior had cracked, that being, not surprisingly at the second storey, west of the middle window, on the South Elevation. The interior of the arches over the windows are significantly deteriorated and have been inadequately repaired.

There are open mortar joints at the west wheelpit wall just above and below the waterline to the inside of the tailrace arch.

Timber Structure

Note: See Fig. 26-28 for original column/beam positions. The shifting of significant framing members and stairs over the life of the building is discussed in detail in the **Architectural Evolution** section. The observations/comments below focus on the existing configuration.

As has been described in the previous section the original timber structural elements of the building i.e. roof and floor framing displayed a high degree of joinery skill, within an age old tradition of timber framing practise executed with the premium quality wood then available. This original system has been subject over the years to consistent degradation associated with later renovations to accommodate new machinery, storage areas etc.; decay and insect attack due to what appears to have been a long period of roof leakage and unsecured windows as well as the generally humid environment.

Roof

The pentagonal ridge beam remains in remarkably good condition given the incursions of moisture known to have occurred. However there are two cracks in the member close to the north wall adjacent to where the diagonal wind braces are framed into it.

The purlins are generally sound except for a significant decayed and cracked area at the west purlin at the mortise for the south strut of the third brace from the south. Decay appears to be active. Of the two rafters bearing on this area one has been sistered and one has been replaced.(Fig.61)

While purlin support braces remain in place a number have lost struts or have poor replacement components.The southeast brace is missing its rear strut; the second (from south) set of braces (both west and east) are missing their north diagonal struts; the third east brace has been reassembled without diagonal struts and the brace itself is of modern conventional lumber of smaller section with the rear strut affixed to the side.(Fig.62)

Roof sheathing is of various periods with isolated areas of decay noted most particularly at the southwest quadrant.

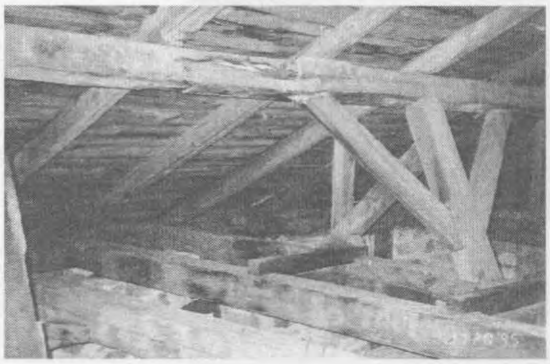


Fig.61

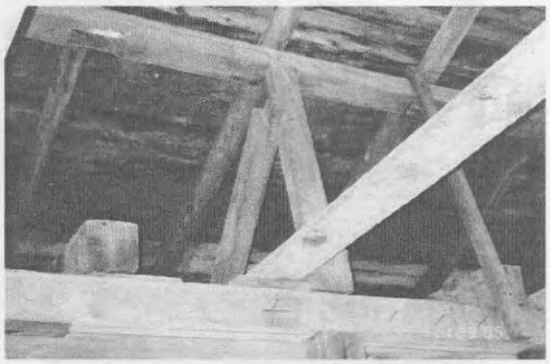


Fig.62

Most significant is the loss of the tie beams across the northern half of the structure. In this area the building relies on the masonry walls to contain the thrust from the roof. In the long term, the thrust from the trusses will accelerate the deterioration of the upper portions of the stone wall. In the south half the tie beams remain in place but serious decay and insect infestation (seemingly related to an extended period when moisture from roof leakage pooled on the attic floor) have greatly reduced the section of four of the eight remaining full-span members (Fig.63). Fungal decay and carpenter ant attack seem to have halted in this area after a long drying-out period.

Decay is evident at the northeast corner of the top plate adjacent to the brick chimney indicating leakage at the chimney flashing at various times. It should be noted that this area is directly above a section of bulged masonry on the front wall.

The massive spine beam/tie support remains generally in good condition given the surrounding moisture damage and that its north half was diminished significantly more than a century ago. The columns which support it exhibit insect activity at their capitals and in small isolated areas of their bases. That these are active infestations, though now quite limited, is indicated by the presence of frass. Given the tiny flight holes the culprit would appear to be Furniture Beetle (Anobium punctatum).

Two of the Denaut columns (northeast quadrant) are riddled with large elliptical exit holes which appear to have been caused by the Round-headed Wood Borer (Monochamus). As this family is not known to attack wood in service, but rather newly felled timber it suggests that the timber for these columns was not subject to proper debarking and drying practice prior to installation. Insect activity seems to have long since ceased however.

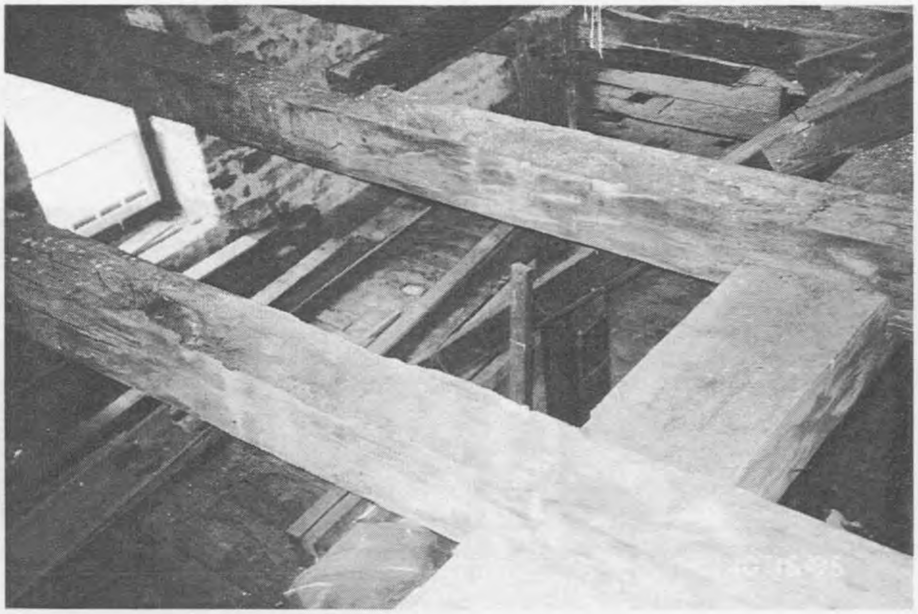


Fig.63

The net result of the above described loss of members and/or sectional integrity is sagging and deformation of the roof. Preliminary analysis indicates that the existing roof structure is marginally adequate in the short term but conditions such as the lack of cross-tying at the plates and loss of strutting to the purlin braces indicate that stabilization (at minimum) is essential.

<u>Third Floor Framing</u>

Essentially the third floor structure is sound, despite there being a number of isolated areas where structural changes and/or modifications for equipment have resulted in loss of timber section. However there is a seriously deteriorated joist extending from the south wall, west of the centre of the south wall. Oval holes and honeycombing indicate the work of Carpenter Ants. At the north wall almost directly across there is an area of similarly deteriorated 'ceiling' i.e. third floor sub-floor. There are two inadequately sistered joists located in this area as well. Other areas of the decking have been attacked by Lyctus (Powder-Post Beetle).

Second Floor Framing

Insect attack to joists and decking is evident directly below that of the third floor structure (south wall just west of centre) and of a similar nature. The two storey column as well shows evidence of minor, apparently superficial, attack at its base.

Four of the columns appear to date from the 1973-74 restoration and, at least the easterly of the two beams they carry may also date from that time, being of different section than is typical.

The flooring over of the former husk area at the second floor caused the joist span to be particularly long, even for the full 3" x 8" material used. Thus, while certainly adequate for most usage preliminary calculations indicate that it is slightly below the strength required under the Building Code for assembly areas.

First Floor Framing

In general the framing for the first floor is sound (though there are signs of incipient insect activity).

Husk

Note: Letter designations follow those utilized in the Archaeological Report.

A number of the most significant (earliest) timbers are seriously deteriorated.
The south longitudinal lower husk beam is badly decayed from its insertion into the west wall to under the west tentering post. The beam pocket, being not far above the waterline traps moisture and with little chance to dry out makes the onset of fungal decay inevitable (Fig.64). The base of the tentering posts are likewise affected. The section along the beam between the two tentering posts was found to be relatively sound while to the east of the east tentering post insect activity of a hitherto minor nature was noted. Infestation appears to be by Furniture Beetles (Anobium punctatum). The other lower husk beam appears to be relatively sound.

The upper husk shows many areas of insect activity particularly at the northern section. The empty mortises at both sides of 'E' and at 'F' have become the entry points for extensive insect infestation. (Fig.65). Much of member 'F' south of 'G' is just a shell. Both Carpenter Ant and Furniture Beetles seem to have been at work judging from the shape and size of flight holes and the fine dust like frass and the infestation appears to be active in certain areas.

As noted earlier the transverse husk beams and millstone support timbers in the 'D' and 'C' regions are much more recent material possibly replacing material which was already extensively deteriorated many years ago.

The state of infestation also puts at risk the remaining timber elements within the basement, crawlspace, raceway and turbine pit areas which include the first floor structure and the composite timber lintel (three beams) at the communicating 'cutout' between the mill and the turbine shed. The lintel currently does exhibit the pinhole sized borings of insect attack at a wany region of the member but so far is otherwise sound. (The lintel bearing and the 'design' of the lintel itself require improvement given the load which it carries over the opening.) The risk of fungal and insect attack is always present where wood bears directly on masonry or is housed into it in a moist environment.

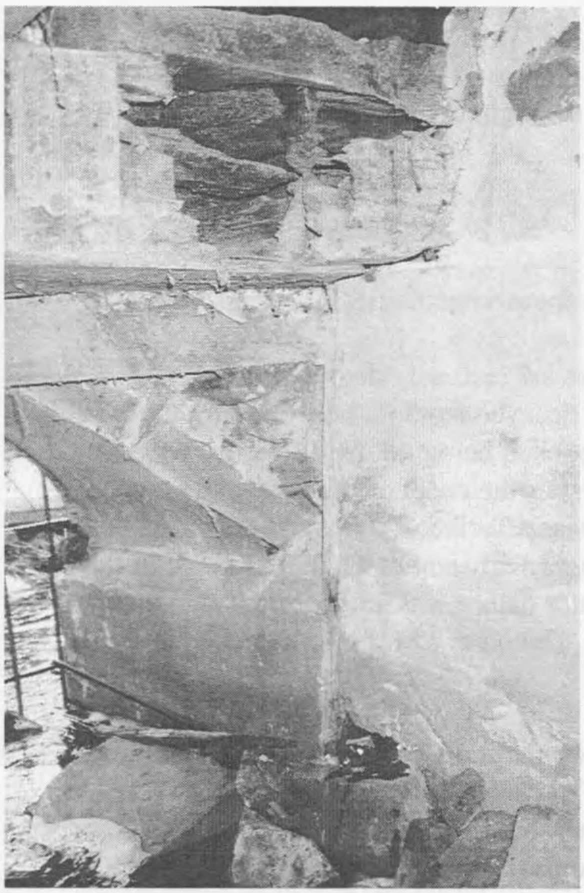


Fig.64

Fig.65

Other Elements

As Weaver points out[51] there is active insect infestation of other wood elements such as chutes, machinery (particularly wood gears) and other artifacts including attacks by Powder post Beetle (Lyctus) in addition to the Furniture Beetle. The early millstone crane, one of the Mill's prime artifacts, evidences Powder Post and Anobid activity, not surprisingly given its proximity to affected joists and decking. The storage of wooden artifacts in close proximity to each other in the Turbine Shed, while virtually impossible to avoid, also makes an epidemic of insect attack also a possibility.

Roofing

The cedar shingle roofing of the main building, undertaken in 1973, still appears to be generally weathertight although some warping and curling was noted. As well the rough ridgeboards may no longer be fully secure. The sags at the ridge and across the slope relate to the roof structure and walling problems noted above. Though it is reasonable to expect a longer service life from this material (possibly 15 years) it should be monitored from this time onward.

The roofing of the turbine shed, also red cedar, is in the process of being replaced. Its service life was apparently shortened by the application of fire retardant.

Chimney

The brick with which the chimney was rebuilt, presumably in 1973, is a typical modern brick and takes away from the appearance of the facade. The poor pointing of the chimney, parged area at the base and heavily caulked unpainted galvanized apron flashing all further denigrate the otherwise handsome front elevation. Historic photos clearly show a much taller chimney with a more extensively corbelled cap. The decision to scale it down during the '73 renovation may have been based on an attempt at the assumed appearance of the earliest period. Of more significance is that there is no flashed saddle behind the chimney making the eventual incursion of moisture at that point inevitable as well as shortening the life of the brickwork itself. There is evidence of past leakage in the form of decay at the timber top plates in the area directly below and adjacent to the chimney.

---

[51] Martin Weaver, Conservation Study of the Delta Mill, December, 1987.

Other Flashing

As well as the flashing and potential flashing areas discussed above there is also an apron flashing at the junction of the turbine shed roof with the main building. This will presumably be renewed and improved with the roofing work which is proceeding at this time.

Windows

Serious masonry problems have resulted from the existing window frame design where the sill finishes flush to the masonry. Moisture does not therefore drip free of the masonry but is rather carried into the joint below the sill or, at best, over the face of the stone (Fig.66). Window sills and the base of the jambs of many windows have decayed due to the pooling of moisture as there is virtually no slope to the sill. The window at the north elevation of the turbine shed does not reflect the original window type for that opening.

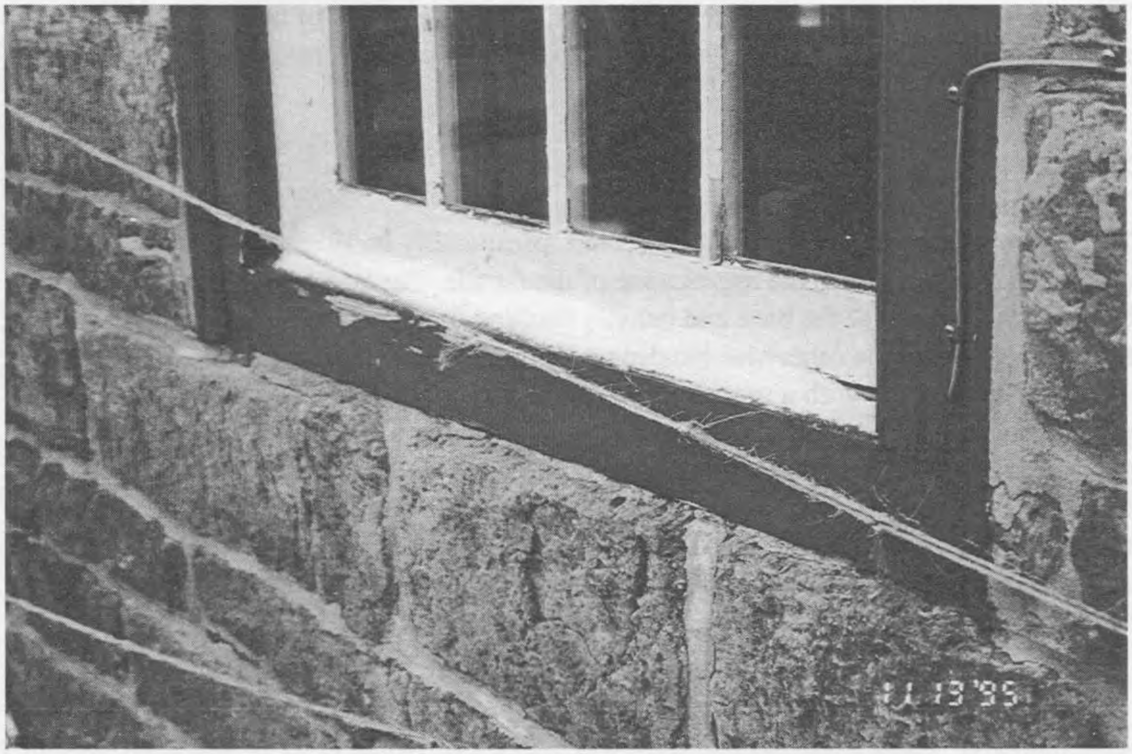


Fig.66

Doors

The importance of the main mill door has been discussed. While the historic door is itself remarkably sound, the base of the side jambs has decayed to a height of approx. 18" (Fig.67). The office door is not historically accurate (panel door was original Fig.68)., the office area being generally 'fitted out' and finished to a higher degree than the industrial areas of the mill. The north door frame is badly decayed as is the base of the door itself. The west door, similarly, is decayed at the bottom.

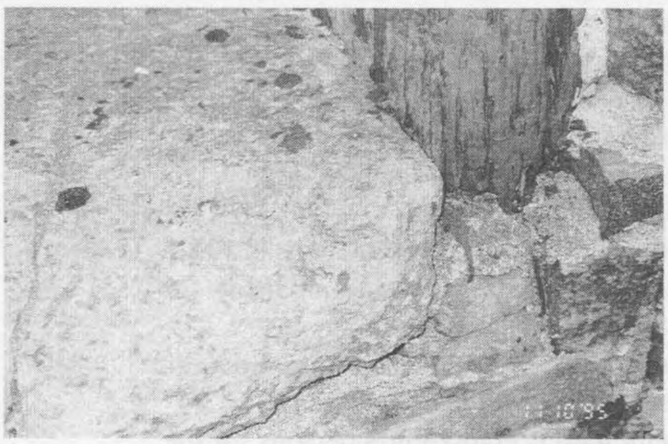


Fig.67

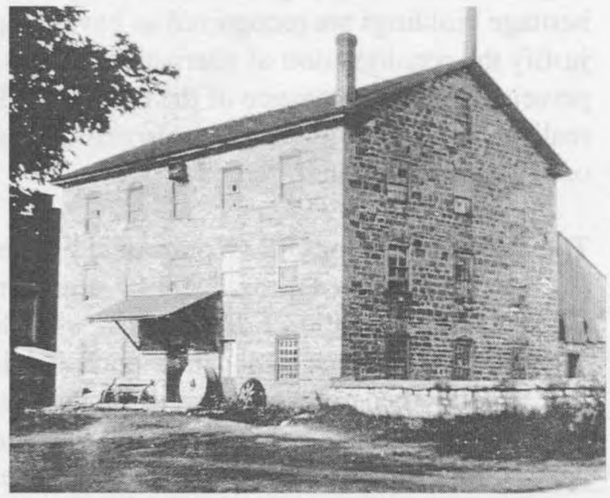


Fig.68

Wood Trim

The surviving moulded cornice, verge with returned cornice at the front of the building is a fine feature. There are now however a number of splits and gaps (including and approximately 10' long split at the soffit) as well as decay at both corners (at the verge just above the return.) Paint finish has worn off in a number of areas also. At the rear there is now simply a box eave and return. At the southwest there is a large gap between the return and the fascia allowing significant moisture entry . The lack of guttering (unless the greek ovolo at the cornice was originally part of a built- in gutter) means that water from the roof runs against the masonry of the building particularly in driving winds.

Upgrading Considerations

Fire Safety

The typical difficulty of 'fit' between life safety standards generally designed to govern new construction and older structures has been recognized in recent years resulting in Part 11 of the Ontario Building Code. This section is intended to more realistically deal with the renovation of existing structures by indicating possible 'compliance alternatives' and allowing for the possibility of 'alternative measures' to certain code requirements which might allow for less or gentler intervention in an existing structure. Within it designated heritage buildings are recognized as having 'special characteristics' which may further justify the consideration of alternative options or, where no threat to life safety is perceived, the maintenance of the status quo. Part 11 allows for the possibility of looking realistically at the life safety requirements presented by a particular building rather than only generic solutions.

The Delta Mill is, for O.B.C. purposes, a three storey structure of approximately 1750 s.f. per upper floor with approx. 2800 s.f. on the main floor (including the Turbine Shed) for a total of approx. 6300 s.f. It is classed as a Group A, Division 2 Assembly type Occupancy. The stone shell can be considered *non-combustible* while the timber floor and roof structure generally conform to the requirements of *heavy timber construction* (a *3/4 hr. fire resistance rating*). The code derived *occupant load* is eighty-eight persons for the upper floors and one hundred and forty for the ground floor.

Though a relatively small building (in square footage) for an Assembly structure, the Mill's architecturally significant vertical emphasis creates some complexities in meeting conventional Code requirements. While a two storey structure in this occupancy class can be of a '*combination of combustible and non-combustible construction*' a third storey calls for *non-combustible construction*. This implies a replacement and/or casing in of the exposed wooden elements of the structure, which of course, if undertaken, would destroy a significant aspect of the character of the Mill. A third storey also requires that there be two *exits* from each floor. Thus one option for minimizing intervention while basically gaining code compliance would be to not have the third floor open to the public but rather simply for offices and/or storage. However the third floor, as has been described earlier, is a significant component of the viewing public's experience of the mill both in terms of the timber joinery exhibited and its exemplification of the Oliver Evan's automatic milling process. Another option or perspectives needs then to be considered. The key lies in early detection and quick exiting.

In fact, given the relatively small size of each floor, the short max. travel distance of approx. 55' to an exit, the three potential main floor exits to the exterior, the acknowledged slow-burning nature of the heavy timber construction; and the potential full fire separation between the mill proper and the turbine shed it appears that actual life safety objectives could be achieved with a well-placed, properly designed *exit stair* from each upper floor to exit directly to the exterior as shown on Fig.73 . As well a comprehensive fire alarm system (smoke detectors, pull stations, alarm bells, possibly including annunciator panel) allowing for early detection and quick fire department response (the fire station is located within two blocks of the structure) essential to life, building and artifact safety. In conjunction with the above the *occupant load* of the upper floors would be limited to approx. 50 people.

Fig.69 Location sketch of proposed fire exit

As proposed this new stair would be fully fire separated from the rest of the building to the exit door to the exterior, designed generally to conform to code requirements and placed to minimize its impact on the historic interior. As shown, its placement at the northwest corner of the original mill at the upper storeys allows the utilization of the former second storey window opening at the rear wall to allow the stair to descend through the turbine shed (thereby keeping the main mill first floor space intact) and exiting via an upgraded version of the north door of the turbine shed. The concept calls for providing a secure walkway to main street from the point of exit which would be designed to be reminiscent of the original walkway/footbridge that occupied this area. The stairs for the public would maintain their heritage character and at the third floor could have a fire-‘stopping’ trap door which could be closed to inhibit fire spread and allow increased exit time. As well the door between the turbine shed and the main building could be constructed to maintain fire separation utilizing traditional tongue and groove 'skins' as for the original main door and paying attention to closeness of fit (perhaps using some form of gasketing).

The chutes and other elements which extend between floors make complete inhibition of smoke/flame spread difficult but care can be taken to minimize the extent. Until such time as the chutes are required for active display they can be provided with stops which could continue to be used whenever they are not in service.

If and/when millstone milling is again undertaken on the premises for display the set of the stones must be carefully monitored and properly maintained to ensure there is no possibility of sparks being created.

Though not absolutely necessary and therefore not practical at this stage in the long term the provision of a sprinkler system is worth consideration.

General Safety

At such time as the mill would undertake display milling involving a typical arrangement of period machines a balance will have to be struck between the appearance of authenticity and the need to maintain the public at a safe distance from potentially dangerous aspects of the process.

Security

The Mill remains closed through the winter with only ad hoc surveillance during that time. There is no-one there through the night. Furthermore the collection of artifacts is ongoing, thus increasing the potential extent of loss through burglary and/or vandalism. For these reasons, at minimum, a system of 'contacts' at the openings accessible at ground level should be put in place which would sound an alarm when moved. Typically the system is activated and de-activated by a code known to the appropriate individuals.

Barrier Free Access

It has become a reasonable responsibility of owners of public buildings to attempt to ensure accessibility to all. Unfortunately, in the case of historic buildings this can prove very difficult and sometimes impossible. At the Delta Mill access for those confined to wheelchairs to the full main floor can be provided through the main mill (as opposed to office) door. Currently, though there is an existing step, approx. 8" high, the Mill staff provides a removable ramp. While it is understood that a permanent ramp is more desirable from the perspective of the wheelchair using community given the relatively small number of visitors and the extent of negative impact on the facade it is felt that the removable ramp is a reasonable compromise. Unfortunately access to the upper storeys and wheelpit are impossible to achieve at this time, though provision of a small hydraulic elevator could be considered in the long term. In lieu of access to the upper storeys and wheelpit the significant aspects of the mill (and associated themes) which are presented there should be concisely interpreted as part of a general orientation display at the main floor level.

HVAC

Given its location relative to main population centres and therefore expected low visitation through the winter it remains most reasonable for the mill to continue in seasonal operation. There would be no payback to investing in the heating/heat retention requirements of year round operation and the operating costs would escalate enormously. Not encumbered with the paraphenalia of heating, insulation etc. the building retains much more closely its original character. The provision of minimal heating in the office area via an electric baseboard is a reasonable amenity to staff and much safer than the construction site style space heater currently used for that purpose. The Mill has a 400 amp.service already in place. An interesting alternative for heating however is the restoration of a stove to the office area which would not only provide warmth but be an integral part of the historic ambience.This approach would require lining the chimney and necessitate proper care and handling by staff.

Mechanical cooling is not considered viable at the facility. Ventilation will continue to be achieved with the operable window units balanced against artifact conservation concerns regarding dust. If required ventilation could be enhanced with strategic placement of fans.

Visitor Amenity

There are currently no lavatory facilities at the Mill and their provision on site is made virtually impossible by the lack of services in the Village and the proximity of the mill stream. However public washrooms are currently being planned for the nearby Delta Recreation Centre as a cooperative project of the Township and the businesses and organizations in Delta including The Delta Mill Society.

APPENDICES

INSPEC-SOL (ONTARIO) LTD.
Unit 9, 626 Cataraqui Woods Drive, Kingston, Ontario K7P 1T8 Tel.: (613) 389-9812 Fax: (613) 389-5287

Member

Association of Consulting Engineers of Canada

Canadian Standard Association Certified Concrete Testing Laboratory

Canadian Council of Independent Laboratories

Report No. 8857-K4283A

FAXED 11-13-95

November 13, 1995

André Scheinman, Architect
Heritage Preservation Consultant
36 Copperfield Drive
Kingston, Ontario
K7M 1M4

ATTENTION: MR. ANDRÉ SCHEINMAN, ARCHITECT

RE: Delta Mill Conservation Study
Delta, Ontario

Dear Sir:

In accordance with your recent request and further discussions at a November 7, 1995, site visit we have performed a geotechnical investigation at the above-captioned site and are pleased to present a report of results.

We trust this information is satisfactory. Please do not hesitate to call if any questions arise.

Yours very truly,
INSPEC-SOL (ONT.) LTD.

Robert K. Cole, C.E.T.
General Manager

Encl. Fax

1.0 INTRODUCTION

After recent discussions and meetings with André Scheinman, Architect, Inspec-Sol (Ont.) Ltd. (ISO) has carried out a geotechnical investigation by means of probe holes at the Delta Mill in the village of Delta, Ontario.

The Delta Mill has been the subject of various renovation projects over the years, including the construction of a retaining wall and the repointing of some of the mortar. It has been documented that the southwest portion of the mill has been subjected to noticeable settlement over the years. The purpose of this study was to determine whether the settlement was due to soil failure, masonry failure, or a combination of both.

For the purposes of the study the stream side wall of the turbine shed was called the west wall while the upstream and downstream ends of the building were respectively called north and south. Part of the river still runs through the two existing raceways. A total of seven probe holes were carried out at the site, five in the stream along the south wall where significant masonry failure can be observed and two inside the older raceway, adjacent to and within the wheel pit. The probe holes were carried down to the inferred native granite bedrock in order to determine its depth and, if possible, the depth of the footings. For reference purposes, the top of the south end of an existing protective concrete jacket along the west wall was used as a temporary benchmark and given an arbitrary elevation of 91.5 feet. This elevation was taken from proposed plans for the jacket, dating back to 1974 and may not be the true elevation.

2.0 DISCUSSION OF FINDINGS

Probings underwater along the south end of the building yielded refusal on inferred granite bedrock at elevations (depths) of 82.0 to 82.8 feet (30 to 40 inches) below the surface of the river. These depths suggest that the mill was founded directly on the bedrock. Furthermore, visual inspection of the surroundings of the mill and the bedrock outcroppings in the stream along the west wall and just inside the south wall of the mill indicate that most if not all of the building is founded on bedrock.

Bedrock was also observed to outcrop in the mill's basement and within the runway north of the wheel pit. Probing in the wheel pit area yielded no refusal at a depth of three feet, indicating, along with the presence of a rock cut immediately east of the wheel pit, that the wheel pit had been excavated into bedrock and then filled with sediments over the years after the removal of the wheel.

According to our probing results and visual inspection of the walls at the Delta Mill, we are of the opinion that the settlement of the southwest portion of the mill was caused by weathering of the mortar and masonry failure which took place since the early days of the mill.

Based on our findings, we recommend that the condition of the masonry be further investigated in order to identify causes of the masonry failure whether they may be physical or chemical or a combination of the two, and to suggest methods of remediation.

3.0 LIMITATION OF THE INVESTIGATION

The comments made in this report are in accordance with our present understanding of the project.

A subsurface investigation is a random sampling of the site and the conditions described only apply to the probe holes themselves. Should any conditions at the site be encountered, which differ from those at the test locations, we request that we be notified immediately in order to permit a reassessment of our comments in light of the changed conditions and exact project details.

We trust that this report is to your satisfaction. Please do not hesitate to contact our office should further questions arise.

Yours very truly,

INSPEC-SOL (ONTARIO) LTD.

Prepared by: André Perreault, B.Sc.Eng.

Approved by: Gordon A. Thompson, P. Eng.
Vice-President

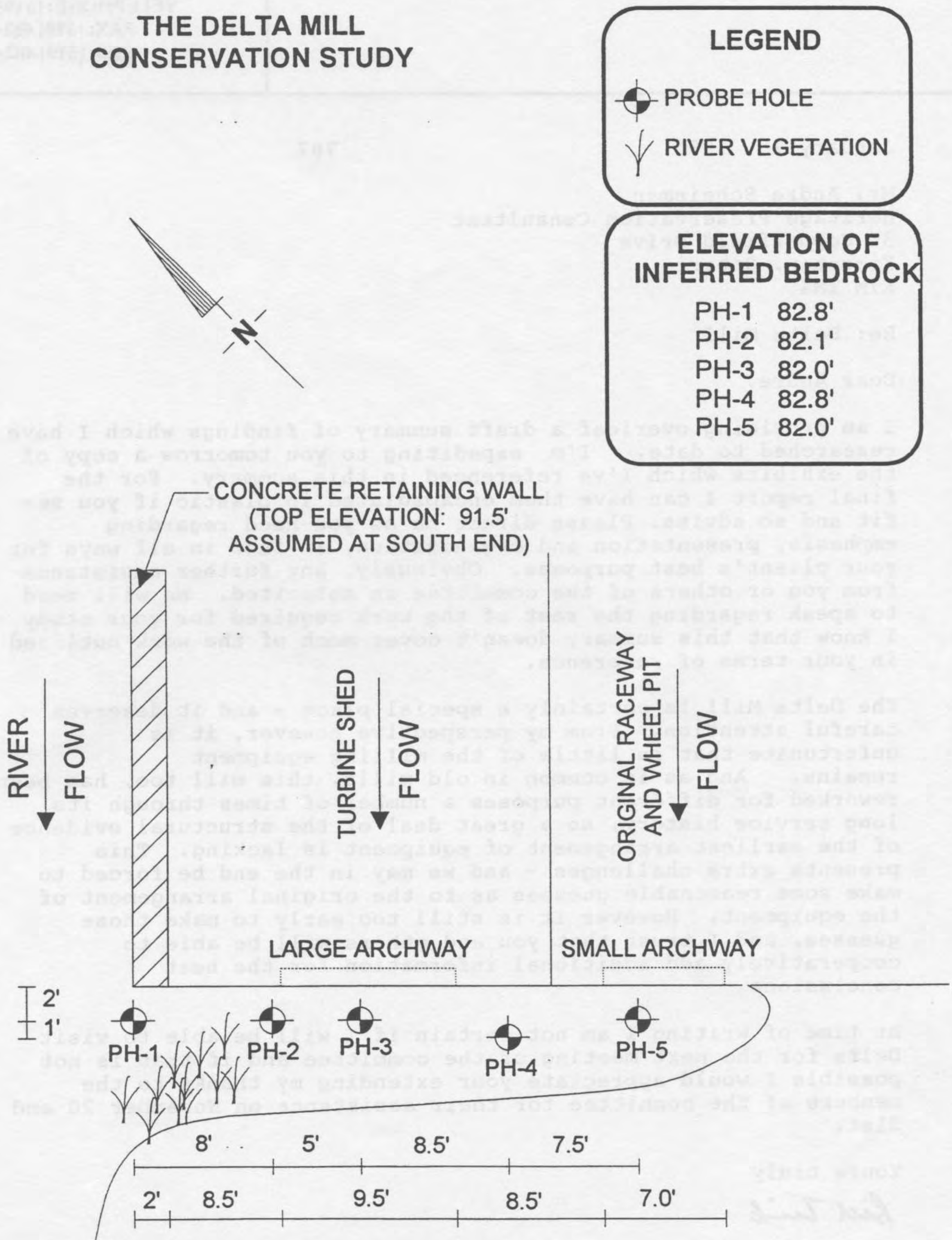
In Duplicate
Encl.

AP/lcp

REPORT NO. 8857-k4283A

ENCLOSURE NO. 1

THE DELTA MILL CONSERVATION STUDY



DRAWING NOT TO SCALE

INSPEC-SOL (ONT.) LTD.

WILLIAM T. TRICK ENGINEERING INC.

P.O. BOX 1071
CLINTON, ONTARIO
N0M 1L0
TELEPHONE: [519] 482-3195
FAX: [519] 482-3195
RES: [519] 482-5349

January 15, 1996 707

Mr. Andre Scheinman
Heritage Preservation Consultant
36 Copperfield Drive
Kingston, Ontario
K7M 1M4

Re: Delta Mill

Dear Andre,

I am providing overleaf a draft summary of findings which I have researched to date. I'm expediting to you tomorrow a copy of the exhibits which I've referenced in this summary. For the final report I can have them encapsulated in plastic if you see fit and so advise. Please direct me as you need regarding emphasis, presentation and organization, in fact in all ways for your client's best purposes. Obviously, any further assistance from you or others of the committee is solicited. We will need to speak regarding the rest of the work required for your study - I know that this summary doesn't cover much of the work outlined in your terms of reference.

The Delta Mill is certainly a special place - and it deserves careful attention. From my perspective however, it is unfortunate that so little of the milling equipment remains. And as is common in old mills, this mill too, has been reworked for different purposes a number of times through its long service history, so a great deal of the structural evidence of the earliest arrangement of equipment is lacking. This presents extra challenges - and we may in the end be forced to make some reasonable guesses as to the original arrangement of the equipment. However it is still too early to make those guesses, and I trust that you and others will be able to cooperatively add additional information for the best conclusions.

At time of writing I am not certain if I will be able to visit Delta for the next meeting of the committee and if that is not possible I would appreciate your extending my thanks to the members of the committee for their assistance on November 20 and 21st.

Yours truly

Bill Trick

William T. Trick P. Eng.

Items to date - and these may take the form of Appendices?

1. Tailwater levels at the Mill

The opinion has been expressed that the Delta Mill site may have originally operated under a lower tailwater level than that which is presently available. The support for this position arises from exploratory probing in the area of the water wheel pit which found a relieved area in the rock below the present tailwater level and it is proposed that this provided the location and clearance for the original water wheel. Since a millwright builder of that period would never have set a water wheel to wade in the tailwater, this would require a substantially lower tailwater level than prevails at present. If this thesis is incorrect then there should be an sound explanation for the purpose of the relieved area, since undertaking the rock work by handtools and black powder would be an extended and difficult exercise if not for good purpose. Furthermore, if the water level prevailed as now, that excavation would have needed cofferdams and pumping during construction and the latter equipment was not easily available for portable use at that time. This is an important issue since it relates directly to the location and elevation of the millstone husk, which will be discussed in more detail later in this report.

We have the following evidence of the operating water levels.

As of November 20th, 1995 and for reference, and according to survey levels established by others, the gross head between Upper Beverley Lake and the standing tailwater at the wheel pit was 2.34 meters (7.7 Feet)

On June 22, 1949, Mr. Herbert Hall, Manager and Owner of the company, Charles Barber and Sons of Meaford, Ontario sent a letter proposal to the then owner of the Delta Mill, Mr. Steeles, to supply a new turbine to replace the existing units at the site. He offered power ratings and shaft speeds for the new turbine using a net head of 7 feet. He would have accounted for some head loss through trash racks and intake channels, so the net head used by Herbert Hall would have been consistent with a gross head of 7.5 to 8 feet. (This letter is in the Delta Mill archives). The writer, having personally known Mr. Hall, would trust his assessment of the available head.

An inspection of the turbine pit which is said to date to 1860 shows that the turbine curbs upon which the turbines were set is consistent with the present standing tailwater level. Turbines of this type are always set with the underwater lignum thrust bearing immersed in the standing tailwater, so it would be our conclusion that at least from that period to the present, the tailwater level has been generally unchanged.

However this evidence does not answer the question of tailwater level in the period prior to 1860 and that remains of interest.

It may be possible to do water depth soundings downstream of the Mill and into the River channel, and relate these to the Mill elevations. In fact soundings done in the 1960's by the Ministry of Natural Resources (which have not yet been reviewed by the writer) may provide definitive evidence. Also a better definition of the size of the rock cut in the wheel area is required. If the tailwater is higher now than in the early part of the 1800'3 then that would have been the result of a dam constructed downstream, which created the ponding back to the Delta Mill, and this can be investigated.

2. The Turbines and driving harness.

The turbines at Delta are 48" Swain units.

Emerson (1) on page 8 writes of undertaking power and efficiency testing for Mr. A. M. Swain in 1868, at Putnam, Connecticut, and subsequently of testing a 42" Swain turbine at Lowell Massachusetts in a test flume built for the purpose. Exhibit 1 is an extract from Emerson (1) and pages 77 and 78 give testing data and a cut of the Swain turbine. However the test curves are dated 1871 and 1874 and refer to 30" and 36" turbines.

Additional comments regarding this testing are given in Horton (2), pages 21-24. Horton worked for the US Department of the Interior at at the early part of this century doing river and stream flow gauging and often had occasion to use existing turbine installations to measuring the flow. He accumulated and compiled turbine data from the popular manufacturers for that purpose. Vigreux (3) provides a cut of the Swain unit and credits it as one of the first mixed flow turbines constructed in America. Another cut of the Swain unit is given in Mead (4). The flow is controlled by means of a cylinder gate which is lowered to permit flow into the runner, and this feature is unique to the Swain design and serves to confirm identification of the Delta units.

The Swain was quite an early turbine of the North American water power technology. Mead points out that the Howd turbine which was a primitive ancestor of the "American" type turbine was patented in 1838. Francis had further refined the design following scientific principles by 1849. Mead further stated that the Swain turbine was designed by Mr. A. M. Swain's in 1855. See Mead (4) pages 12 & 13. Mr. Emerson, Mr. Francis and Mr. Swain were all at this time active at Lowell, Massachusetts, which was considered the centre of the water power manufacturing industry. Horton(2) in a footnote gives the address for the Swain Turbine and Manufacturing Company as Lowell, Mass, and it is probably that the turbines at Delta were manufactured there. It is noteworthy that a number of the Loyalists moved from this area of the USA and it is conceivable that business relations between the Loyalists and the Americans still persisted through to the

1860's. While the Swain was a well respected unit of high efficiency for at this time, other types such as the Leffel and the Little Giant turbine were much more common. Unpublished and incomplete records of turbine installations in Ontario in the writer's possession show Swain turbines in use at Blair, Guelph, Rockwood, Ayr, Galt, New Dundee, Teeswater and at Hillsburg, Ontario in the period 1902 through 1913. The writer believes all the above are now destroyed. The Delta units are sufficiently rare to warrant preservation.

The Delta Mill is said to have been turbine powered from 1860, and it is further believed that the headrace and turbine bulkhead was built then. However the stone arch at the downstream end of the bulkhead, which was filled in to form the closed bulkhead necessary for the turbines, is inconsistent with this thesis. It would not be reasonable to have constructed the arch, then at the same time filled it in to contain the water for the turbines.

Rather, the construction of the arch would have been consistent with an earlier water wheel installation, with the filling in of the arch following at a later date. Despite the fact that the Swain turbine was invented in 1855, we question that the turbines now at Delta were installed as early as 1860. It is possible but the writer is skeptical. For historical correctness, the support for the 1860 installation of the present turbines needs review by others.

The residuals of two turbines and their associated driving harness is in the turbine bulkhead and on the floor above. The restoration of one or the other of the turbines to an operating display would not be unduly difficult from a mechanical standpoint, since the major and critical components are present, and no major breakages were noted. However the restoration of the headrace to provide even a low head would require considerable civil work.

The letter from H. Hall of Charles Barber and Sons of 1949 and previously mentioned, implies that both turbines where either operable or nearly so at that time, with the downstream unit being used to operate the saw mill, and the other turbine being used to operate a chopper for gristing.

Using the Emerson data from Exhibit 1, and scaling for 7 foot net head and 48" runner diameter as at Delta, each Swain unit would rate at full load at approximately 33 horsepower, give best efficiency if speeded at 75 RPM under the 7 foot head, and require 1.45 cubic meters per second water flow (3050 Cubic feet per minute).

Both of these turbines rotated clockwise when viewed from above. The drive to the flour mill layshaft rotated clockwise at 225 RPM when viewed from the turbine pit, and with the turbine at proper speed.

3. The old shaft now installed in arch in the turbine house

It has been suggested that the steel shaft used to reinforce the arch in the turbine house served originally as the water wheel shaft.

Metallurgical investigations would be informative.

Others have expressed their opinions on this matter and we trust that we too can offer comment.

Insofar as using the this member as a wheel shaft, the following confounding aspects arise. Firstly a precedent example has not be noted in our findings in the research to date. At the time Delta mill was being built, millwrights tended to be conservative and follow established practices rather than explore new approaches.

Secondly, water wheel construction at this time used one of two methods of securing the wheel arms to the shaft, either by mortising the arms into the wheel shaft or by passing them by and clamping them to the large wheel shaft. While it is conceivable that the arms could be passed by and clamped to this small steel shaft, it would be our opinion that an design check would show the wood to be overloaded. While other methods could be devised to solve this problem, other castings would probably be necessary.

((We will review the structural capability of the shaft to withstand the weight of a synthesized water wheel for the final report))

That the shaft was used in the Mill prior to 1860 is probable, but it may have been used for in locations and for purposes other than the main wheel shaft. Later in the report we refer to Glynn (8) and attach a cut showing a possible driving harness arrangement. It is interesting to note that the vertical second shaft in this cut is of square cross section.

4. Flour Mill Considerations

The scrapping of mechanical equipment by earlier owners and the structural renewals of the floors in the mill and in the turbine pit area has removed evidence of the kind of milling equipment, its placement and arrangement and the associated mechanical drives. As is know by others and as is partly supported by visible evidence and records, the mill proper has had not less than three major modifications from the original erection.

In all cases, the following requirements were necessary - practical mechanical drives from the prime mover to the driven machine must have existed - feedstock and product needed to be handled through the process and a complement of equipment was necessary - and adequate foundations and supports for the prime movers and main equipment existed in each case. We have attempted to describe herein how each of these requirements were met, using existing documents, and residual mechanical equipment and structural evidence in the mill to the extent possible. In addition, if evidence lacked, speculation prevailed, which was based upon historical practices as evidenced in other mills with which the writer is familiar and by reference to writings on the subject. Others will need to comment on the speculations.

4.1 Most recent Use - Chop Mill for local farmers. (1930?- 1949?)

In the last active use of the Mill, a single head grain chopper was operated to service local farmers with grist for livestock feed. The process equipment required for this service was a receiving or scalping shoe (to remove rough material from the whole grain before passing it through the grinder), several elevators to handle the whole grain to one of a several overhead grain bins, a chopper (which is still in the mill), a mixer and a bagging hopper on the main floor. It would have been common to have a set of oat rollers in a mill of this size to service horse owners. There may have been some bin storage in the mill so that the operator could buy and sell small amounts of whole grains for subsequent reselling to the local farmers for blending with their own grains. "Concentrates" to enhance protein content would have been provided by a larger feed supply house, which would also provide ration recipes to permit the miller to customize the livestock feed for the intended purpose. Mill accessories would include wheeled bag carts, floor or portable scales, a grain tester set, belt lacing equipment

The single head chopper still stored in the mill uses ball bearings which is typical of a post 1900 design. It would have required 15 to 20 horsepower to operate at reasonable capacity, which is within the capacity of the turbine provided water was available. The elevators, mixers and other equipment would require a nominal amount of power.

The upstream turbine was used for this purpose, coupled to a vertical shaft extension, which carried a bevel mortise gear (the mortise gear which is presently broken). The mortise gear then meshed with a pinion on a horizontal layshaft which extended through to a pillow block support (still existing) on the mill wall cutout. The pinion associated with this gear set and the horizontal layshaft are both stored loose in the turbine shed. A flat pulley installed on the layshaft and inside the mill wall would have been belted to the chopper on the main floor. There was a further shaft extension to the turbine shaft up through the present floor level in the turbine shed, and a pulley installed thereon to drive through 2 slots in the mill wall. This belt must have driven another vertical shaft inside the mill which extending to upper levels for other accessories such as elevators or the mixer. The width of the belt, and the belt speed indicate (per Haven and Swift See ref 5) a capacity of 10 to 15 horsepower at best. The drives to the elevators in the upper levels have been generally removed and although some evidence by way of bolt holes and mortises in columns and timbers remain, this has not been investigated in detail at this time. A flow process for the gristing operations could be synthesized by using the elevator legs in their present locations. There is also evidence of locations of bins and chutes on the floors and in the framing in the upper levels of the mill.

None of the equipment used for the chopping operation would require special foundations - rather the installation would have proceeded by making best use of that which existed at the time of conversion. There is some possibility that the millstone husk was modified and lowered down at this time - possibly to obtain a common main floor level for convenience and stability. But it is also our postulate that the millstone husk must have been considerably higher when the millstones /rollers were in operation, and it is conceivable that a still lower level of timber framing (which had originally carried layshafts for millstone / roller drives and no longer existing) had deteriorated by rotting. The present support for the lower husk members is inadequately done and is indicative of work done quickly and probably under financial duress.

The turbine curb and its location, the bevel mortise gear set and the horizontal layshaft would have been basically unchanged at this time.

4.2 Roller Mill Operation for Domestic Flour production (1893? - 1930?)

No residual machinery existant in the mill, other than the prime movers, can be clearly related to the roller mill period. All the process equipment is gone, so the type of equipment and its arrangement in the mill at that period must rely on informed speculation. As flour milling technology advanced through to the late 1800's, the gritty and off white flour product quality available from the old style flat grinding (or once through) process would have been increasingly uncompetitive compared to product from the new progressive reduction systems. These systems which became available from the 1870's, also offered the miller more product from each bushel of wheat. A considerable complement of downstream process equipment would have been necessary to support the progressive reduction process, and the old bolters and reels remaining from the millstone period would have been for the most part not reusable. A minimum of 3 sets of double reduction rollers stands would have been necessary to achieve the yield and quality benefits of the progressive reduction process. It was also probable that the size of installation was limited to match the available water power and installed turbine capacity. That a steam engine was said to have been installed at this time indicates that at least seasonal water shortages had occurred in the past. An illustration attached and taken from the Greey catalog of 1901 (See ref 6) Page 588 shows a typical arrangement for a three double stand mill and lists the equipment complement. The Greey illustration shows a horizontal layshaft in the basement of the mill to drive the roller stands on the next higher floor level.

At the Delta Mill it is postulated that the main drive for the rollers would be similar to that shown in the Greey illustration. The horizontal layshaft of the mill drive turbine would have originally extended to the east sufficiently to permit belt drives to each roller stand, which in turn were located on the millstone husk.

Considering structural support for the roller stands, it is unlikely that a prudent owner or experienced millwright would find the millstone husk in its present location adequately supported, since each stand could weigh up to 1 tonne.

The mill drive turbine and its associated horizontal layshaft would have been generally unchanged in location for this updating, although new pulleys would have been installed, and it is possible that the layshaft itself may have been replaced.

It is interesting to consider the annual production of the mill as it relates to grain storage. If the mill operated at its design capacity of 1.5 barrels of flour per hour for 10 hours for 6 days each week, the mill would use approximately 20,000 bushels of wheat annually. Modest though this is, it would have required approximately 30,000 cubic feet of seasonal grain storage capacity.

4.3 Millstone Mill for Domestic Flour Production - Turbine Power (1860? to 1893?)

This time period encompassed an era of rapid technical development in milling technology. In 1860, the Delta Mill would have been arranged for the flat grinding or once through process and it would have used the original equipment complement of Oliver Evans's designs. However, by 1870 the middlings purifier was developed, which was a major advance towards modern milling. The important developer of that machine and processes using that machine was a Mr. George T. Smith, who formed a manufacturing company in the Stratford area in that period. This firm was quite successful throughout Ontario and into the USA in the mill machinery business. It is reasonable to speculate that the Delta Mill might have been updated through installing a purifier and ancillary equipment before the installation of the roller stands. With a purifier in the process,and to gain the benefit possible an additional run of millstones would have been necessary. On can speculate that the third run of stones might have been added at the westerly end of the husk at that time. An illustrative cut from Dedrick (7) Page 25 shows a mill of 1885 using a purifier and three run of stones.

However there is no clear physical evidence to support the thesis of modernization using a purifier. As is pointed out in earlier studies done by others on the Delta Mill (   ),the most Easterly run of stones may have been moved to the Westerly end of the husk solely to simply the driving harness when the mill was converted to turbine power in 1860.

Physical evidence of the kind and arrangement of ancillaries on the upper floor levels is quite limited. The building is amply large to contain all the equipment as shown in Dedrick, reference above mentioned.

Another critical factor overhanging all potential modernizations at the Delta mill is the modest power capacity of the site. Both flow and head are quite modest and this would limit development alternatives. Realizing that the mill would have been in operation some 60 years by this time, albeit using a water wheel, the then Owner, through experience and/or hearsay knowledge would have a good understanding of the runoff of the stream. This certainly would been used in selecting the appropriate size of turbine. Once the turbine was selected all other equipment choices would need to match the turbine capacity.

Residuals of the upstream timber turbine seat and discharge tailrace still exist at and below standing water level in the bulkhead in the turbine house, and these can be used to establish the approximate centreline of the turbine shaft. Fortunately, part of the driving harness for this turbine is still stored in the turbine house, and the dimensions of the turbine vertical extension shaft (complete with bevel mortise gear and its companion pinion gear) can be used to establish the elevation of the horizontal layshaft which extended into the mill to drive the millstones. The reality of the drive would require that the vertical axis through turbine, the horizontal layshaft, the axis of each millstone, and the vertical shaft extending to upper levels of the mill all need to fall in a common plane. A practical drive would be similar to the one pictured in Dedrick(7). However it is also possible that an alternative drive to the two Easterly millstones could have made reuse of the original spur gear drive (which was the probable drive from the original waterwheel) - and this has been suggested by others. See the layout in Glynn(8) Page 127 Figure 45, for a typical water wheel drive suitable to the Delta Mill arrangement.

A pillow block for the layshaft still remains on the Mill wall cutout, and this is probably in or close to the original location. Several additional pillow blocks further to the East would would have been required to carry the layshaft. The lower husk members do not show the mortises or bolt holes for these blocks and their absence is significant. Furthermore the horizontal layshaft would have needed to pass below the millstone drive spindles and their tentering beams for both the centre and most westerly millstones. The lower timbers of the millstone husk are now too low to be consistent with the known elevation of the horizontal layshaft. It seems inescapable that an additional level of timbering, which no longer exists, originally supported the present husk and the pillow blocks of the layshaft, and that the husk was considerably higher than at present. Further, note that the window on the South mill wall in the vicinity of the husk is presently interfered by the lower member of the husk, which would not be expected.

The present structural support for the millstone husk would not have been satisfactory. Further site investigations may further define the location of the husk foundations, but the details are not now evident.

4.4 Original Arrangement, Water wheel with one or two run of Millstones (1810? - 1860?)

At this time of the study it is still not possible to be definitive on the original arrangement of the water wheel and its drives. The location of the headrace channel and the tailrace arch in the South wall approximately fix the location of the wheel, and the headrace channel and other evidence give reasonable confidence in the headwater level.

Soundings in the wheel pit area have given preliminary evidence that the bedrock was removed below the present tailwater level. Rock excavation would not be undertaken unless for good purpose, and there would seem to be no reason for this work other than for wheel clearance. Yet if the rock excavation is found it to be of the sufficient extent in width and form to be part of the wheel pit, then the tailwater level is confounding. No millwright of any period would knowingly set a wheel to wade in the water, and that would certainly be the case with the present water level. As was mentioned previously, the elevation of the turbine curbs in the adjacent turbine bulkhead supports a tailwater level comparable to the present. However in the period prior to 1860 the tailwater level may have differed. For historical correctness the tailwater issue can and should be settled, since any significant change in tailwater elevation will be the result of a dam constructed downstream, and it adds unnecessary uncertainty to the water wheel and mill layout. On the other hand, if the ultimate objective is to restore the Delta Mill to either an active or passive status, then any new wheel must accommodate the present prevailing tailwater level.

It is speculated that at most only two run of millstones were originally installed, at the Easterly end of the husk, and there is some possibility (according to a newspaper sales notice) that only one run of stones was used. If one presumes that the millstones were originally installed parallel to the South wall as presently located, then few alternatives exist for the drive harness between the water wheel and the millstones. The drive was probably similar to that shown in Glynn (8) Page 127, Figure 45, in a two millstone configuration. The water wheel shaft extended from the wheel pit to the East to terminate between the two millstones. A crown gear near the end of the wheel shaft meshed with a pinion on a vertical second shaft. The vertical second shaft carried a driven pinion near the bottom end and a large spur gear above to provide the drives to the millstones. This second shaft was reduced in size and extended to the upper levels, to drive ancillary machines on each floor. The location of this shaft is evidenced by bearing locations on the top frame of the husk, and on the 2nd and 3rd floor timber framing.

In 1810, one would expect that the crown gear and water wheel shaft be constructed of wood with cast iron journal gudgeons inset in the end of the shaft. The pinion on the vertical second shaft would have been of the trundle type with wooden rounds, but it is conceivable that a cast iron pinion was used against a bevel mortised gear with wooden teeth. It is probable that cast spur gears on each millstone spindle meshed with a wooden toothed spur mortise master gear on the vertical second shaft.

The driving harness described above would impart a counterclockwise rotation to the runner stones. It would be worthwhile to examine the pieces of millstones still present in Delta mill to see if the direction of rotation can be determined from the dress of the stones. One bed stone laid out on the second floor appears to be nearly complete.

The millstone husk must have been located considerably higher than at present, since the wheel shaft passed beneath the spindle and tentering beam of the Westerly millstone of the Easterly pair. It is not obvious now that sufficient clearance for the crown gear or the wheel shaft exists since that area is backfilled with rubble. It would be worthwhile to undertake a confirmatory dig in the vicinity of the vertical second shaft to try to find the support for the Easterly end of the water wheel shaft.

While the investigative work and synthesizing of the equipment arrangements is historically worthwhile and most interesting, one should realize that a wooden water wheel, the shaft and wooden sluices had a short lifetime under the difficult conditions of alternating wet and dry and freezing conditions. A wheel seldom lasted more than 15 or 20 years, and there may have been 3 or more wheels installed at the Delta mill. It is quite unlikely that the same pattern was followed each case.

References cited.

1. Emerson, James, Treatise Relative to the Testing of Water Wheels and Machinery with Various other matters Pertaining to Hydrodynamics, Third Edition, Weaver Shipman & Co, Printers, Springfield Mass.,1881. pp. various

2. Horton, Robert E., Turbine Water Wheel Tests and Power Tables, US Department of the Interior, United States Geological Survey, Government Printing Office, Washington, USA, 1906,pp various

3. Vigreux, Ch., Art de L'ingenieur - Partie Didiactique - Turbines Centripetes, mixtes, Americaines et al; E. Bernard et Cie Impreneurs-Editeurs, 29 Quai des Grands-Augustins, Paris, 1899, pp various

4. Mead, Daniel W., Water Power Engineering, McGraw Publishing, New York, 1st edition, 1908

5. Haven G. B., Swift G. W., Treatise on Leather Belting, Technical Composition, Cambridge Mass, First edition, 1931

6. Greey Wm & J. G., Illustrated General Catalogue of Mill Machinery and Supplies, Toronto, Canada, 1901

7.Dedrick, B. W., Practical Milling, National Miller, Chicago Illinois, First edition, 1924.

8. Glynn, J., Rudimentary Treatise on the Power of Water as Applied ot drive Flour Mills, and to give Motion to Turbines and other Hydrostatic Engines, John Weal, 59 High Holborn, London England, 1853

TREATISE

RELATIVE TO THE

Testing of Water-Wheels

AND

MACHINERY,

WITH

Various Other Matters Pertaining to Hydrodynamics.

BY JAMES EMERSON.

1881.

THIRD EDITION.

SPRINGFIELD, MASS.:
WEAVER, SHIPMAN & COMPANY, PRINTERS.
1881.

The Testing System.

Having terminated my connection with the business of testing turbines, it may be well to give a brief account of the conception of the business as a system.

Such tests were made in Europe early in the present century; in this country, by Uriah A. Boyden, from 1843 to 1859. I have found it impossible to obtain any authentic record of Mr. Boyden's tests, though there are rumors of fabulous results. Mr. Francis, in the work called "Lowell Hydraulic Experiments," states that data furnished him for computation gave 88 per cent. He does not vouch for the data furnished, nor does it appear that such data was furnished by a disinterested engineer in any case. Mr. Francis followed Mr. Boyden in making such tests, but he, like the former, made them so expensive as to be beyond the reach of any but wealthy corporations, while the manufacturing interest required a definite knowledge of the efficiency of the various kinds of turbine plans then springing into existence.

In 1859-60, the city of Philadelphia gratuitously tested a variety of small wheels for different builders, but the plan for doing it was so defective that the tests had but little influence. In 1867, the Chase Turbine Co., of Orange, Mass., employed me to construct a dynamometer or brake for testing turbines. The friction bands that may be seen on the ship windlass, in another part of this work, gave me the idea of controlling a turbine in that way, for I had brought many a ship to by such bands. The Prony brake had never been heard of by me at that time, nor until my brake was completed.

In 1868, A. M. Swain asked me to get up a suitable brake, and test one of his wheels at Putnam, Ct. Six months' time and $1,700 were expended in preparing the instrument. The company was persuaded to construct a flume at the "overflow" of the Wamesit Power Co., Lowell, Mass. A 42-inch Swain wheel was set, and tested by Mr. Swain and myself. The results were such that the company was urged to employ an engineer with at least a theoretical knowledge of such tests. H. F. Mills, then of Boston, was selected for the purpose. The company then held a meeting and authorized Mr. Swain and myself to make arrangements for a public trial, and the following notice was issued:

IMPORTANT TEST OF TURBINE WATER WHEELS, AT LOWELL, MASS., JUNE 16, 1869.

SIR: The Swain Turbine Co. has just completed extensive arrangements for a competitive test of Turbine Water Wheels. A flume and weir of the most approved plan, to supply and measure the water used, has been constructed. Emerson's Dynamometer will be used to test the power of the wheels.

The "pit" is fourteen feet in width; head of water varying from twelve to sixteen feet. Each competitor will select size and finish of wheel to suit himself. The Swain Wheel to be tested was built before the test was thought of, and is in no way superior to the average of wheels furnished by the company. It is forty-two inches in diameter, and will be tested on the 16th day of this month.

The Swain, Leffel, Bodine-Jonval and Bryson Turret wheels were entered. The measuring pit was fourteen feet wide, thirty in length and at first a little over three feet in depth below crest of weir—the wheels, standing inside at the upper end in a quarter turn or iron flume, being about twenty feet from the weir. In this distance there were three separate racks to check the rushing water.

The Swain wheel had thin sheet steel buckets, which made it very light for its diameter; yet, when set, it was barely possible to turn it by the coupling upon the top of its shaft—the coupling being twenty inches in diameter, made that size to connect with brake. Mr. Swain "guessed the wheel would go, only put the water to it."

The Leffels knew better than to lose fifty or a hundred pounds in that way, so, when their wheel was set, it turned about as easy as a child's top. Of course, an engineer of experience would have refused to have tested a wheel running as hard as the Swain did, or to have tested a wheel of that size at all in a pit so small and filled with racks, for a good wheel would have little chance against one of low efficiency. The working surfaces of the brake and band were made of steel and iron. Both being fibrous, little strips tore from each, often checking, and at times bringing the wheel to a sudden stop, so that it was difficult to make steady tests of many minutes' duration. A bell was connected to the wheel-shaft, which struck at each fifty revolutions of the wheel. Instead of making each test with a given weight separate and distinct by itself, observers were placed at the different gauges, with watches set to the same time. As the wheel ran very unsteady at the best—often stopping entirely—it was necessary to reject many of the observations, and it will readily be seen that the difficulty would be in placing the right patches together. That this is not imaginary, the following tables of results are given. The first is a copy of Mr. Mills' report, the second is a record of tests taken by myself, the same gauge hands being employed in each case, and the conditions being precisely the same for both. My tests, however, were taken upon the same plan that I have followed continuously for more than ten years: that is, to make each test for a given weight complete and distinct in itself. Mr. E. A. Thissel made a record of the gauges, as given by each of the hands employed, and as it agreed exactly with the notes I had taken of all, his record is given in the table.

MODE OF CONDUCTING THE EXPERIMENTS.

Observers were stationed at various points, as follows:

Mr. J. B. Hale, at the hook-gauge, observed every minute, and a part of the time every thirty seconds, the reading of the hook-gauge, which indicated the depth of water upon the weir.

Mr. R. A. Hale observed the height of the water in the forebay and in the pit, by means of the scale (D) passing from the lower box to the upper every minute.

Mr. E. A. Thissel noted the time of the striking of the bell, which indicated the speed of the wheel, to the nearest quarter second.

Mr. James Emerson, by means of the hand-wheel (M) regulated the friction so that the index (E) should be kept as near to zero as possible, and thus the scale beam be kept level.

Another assistant observed as rapidly as possible the actual position of the index during the experiment.

Another kept the oil cups (T) supplied with oil, and, by a cock attached to each, regulated the amount flowing upon the friction surfaces.

Another attended the gate and kept the racks clear of obstructions.

The writer kept a record of the weights in the scale-pan, the heights of gate, all irregularities in the motion or disturbing causes of any kind that would affect the results of the experiment, and sufficient observations of each class to check the accuracy of all of the notes.

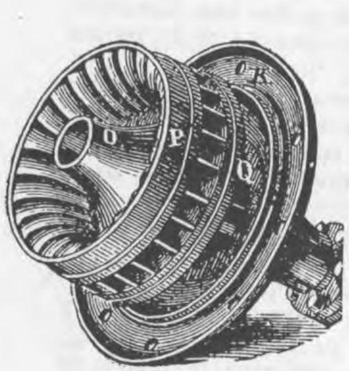
At intervals, during a series of experiments, all of the watches were compared with the standard, and differences noted, that there might be no difficulty in selecting the observations which applied to the time when the conditions for accurate results obtained. Recorded in the following manner:

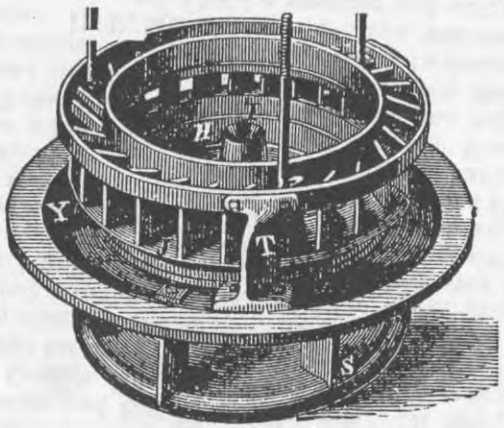
A. M. Swain, North Chelmsford, Mass.

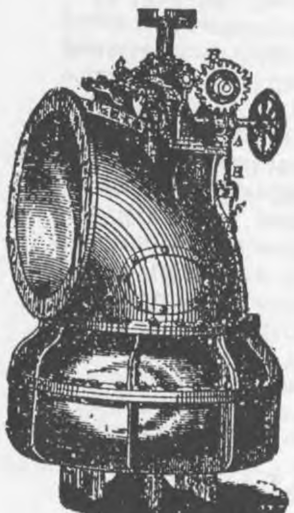
SWAIN TURBINE.

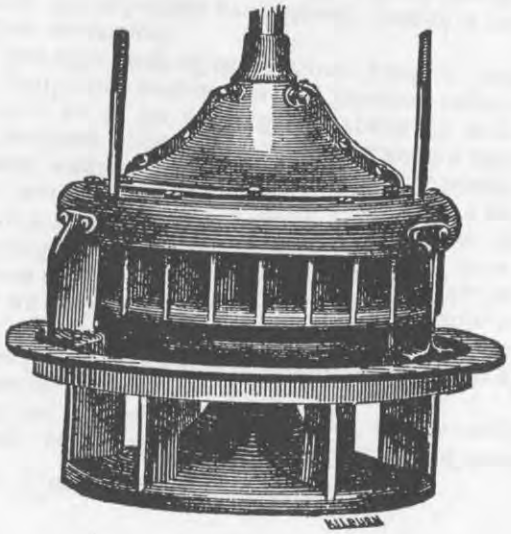
One of the earlier high class wheels, made with many buckets and small openings, placed in "quarter turn" or "flume curb." Mr. Swain had much to do about starting the testing system. Quite a number of these wheels, ranging in size from 18 to 42 inches in diameter have been tested.

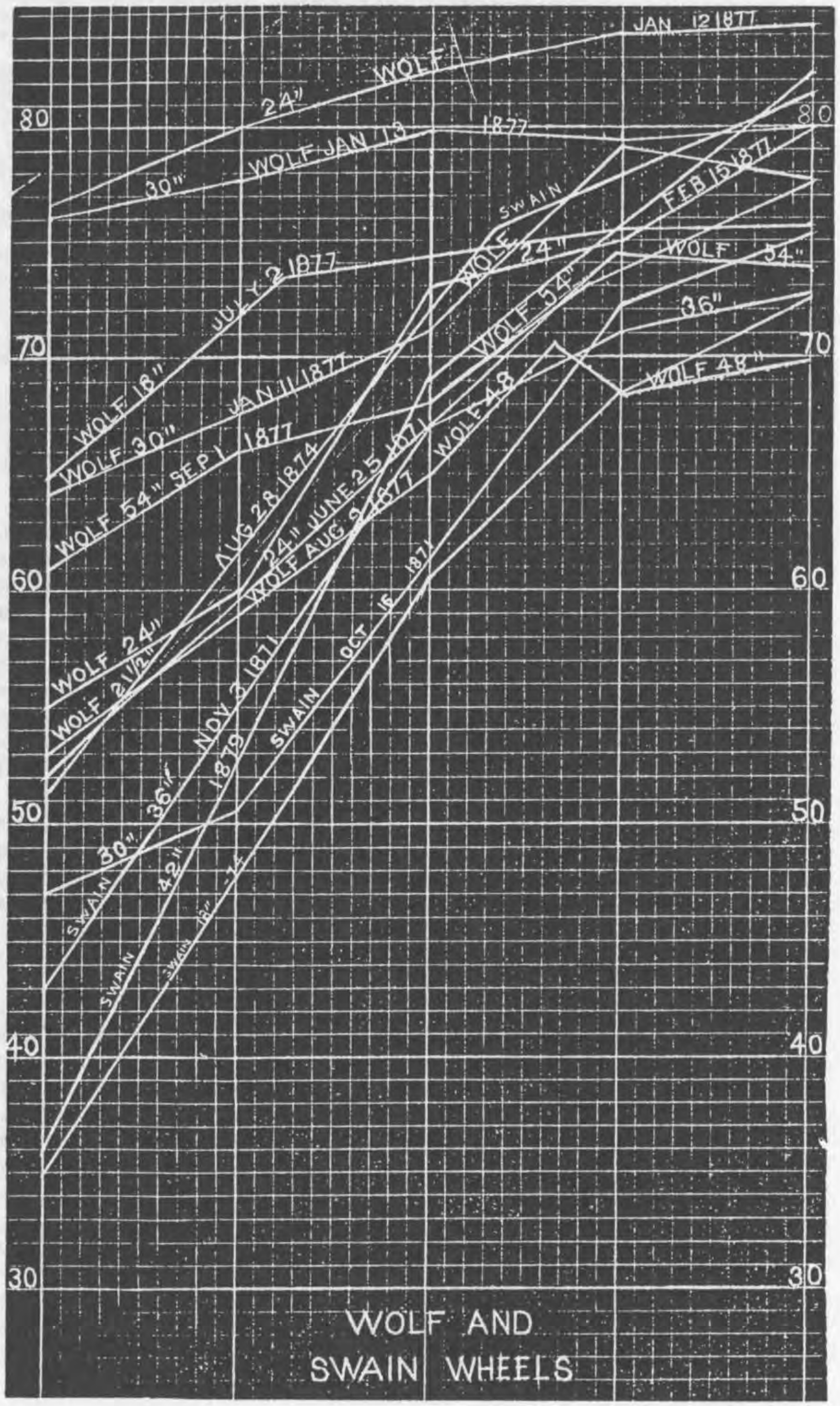
Test of a 21-inch.	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,................	17.91	300	281	25.55	936.55	.8072
Part Gate,.................	18.25	275	282.5	23 54	864.94	.7902
"	18.34	230	280 5	19.55	742.22	.7611
"	18.44	165	241.5	12.08	562.20	.6175











Water-Supply and Irrigation Paper No. 180 Series M, General Hydrographic Investigations, 18

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

TURBINE WATER-WHEEL TESTS

AND

POWER TABLES

BY

ROBERT E. HORTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1906

The horsepower of a stream decreases about one-fourth of 1 per cent with a variation of the temperature of the water from 40° to 75° F.

For precise calculations the exact weight of pure water may be useful.

Weight and dimensions of distilled water at stated temperatures.[a]

[Weight in pounds.]

Temperature, degrees Fahrenheit.	Relative density.	Weight per cubic foot.	Weight per cubic inch.	Weight of column 1 inch square, 1 foot high.	Weight per U.S. gallon.	Cubic feet per ton.	Weight per cubic yard.
32	0.99987	62.416	0.0361	0.4334	8.345	32.043	1,685.232
[b]39.3	1.00000	62.424	.0361	.4335	8.3454	32.039	1,685.448
50	.99975	62.408	.0361	.4333	8.3433	32.047	1,684.908
60	.99907	62.366	.0361	.4330	8.3383	32.069	1,683.882
70	.99802	62.300	.03607	.4326	8.3295	32.103	1,682.100
80	.99669	62.217	.03602	.4320	8.3184	32.145	1,679.850

[a] Smith, Hamilton, Hydraulics.

[b] Maximum density.

In practice the theoretical power is always to be multiplied by an efficiency factor E to obtain the net power available on the turbine shaft as determinable by dynamometrical test.

Manufacturers' rating tables are based on efficiencies usually between 75 and 85 per cent. In selecting turbines from a maker's list it is often important to know the rated efficiency. This may be obtained by the following formula:

E=tabled efficiency.

H. P.=tabled horsepower, and

Q=tabled discharge (C. F. M.) for any head H.

$$E=\frac{33{,}000\times H.P.}{62.4\times Q\times H}=528.8\,\frac{H.P.}{Q\times H}$$

The tabled efficiencies for a number of styles and sizes of turbines are shown in the accompanying table.

Rated efficiency of water wheels.

From manufacturers' power tables.]

Name of wheel.	Diameter in inches.	Percentage of efficiency at 10-foot head.	Percentage of efficiency at 40-foot head.
Hercules	24	81.520	79.856
Do	48	79.855	79.856
Samson	20	80.800	80.800
Do	45	80.754	80.887
United States (Camden)	24	79.877	79.944
Do	48	79.869	79.931
Smith-McCormick	24	80.004	79.013
Do	48	79.915	79.907
New Success	24	80.000	79.906
Do	48	79.937	79.907
Losner No. 1	22	80.110	79.841
Do	44	80.010	80.126
New American	25	79.830	79.890
Do	48	79.905	79.776
Victor	24	79.014	79.936
Do	48	79.014	79.933

The efficiency at which wheels are rated by the builders varies slightly with the size of the wheel, as well as with the head, in many cases. Owing to the different weights of water assumed, etc., the efficiencies of wheels intended to be rated at 80 per cent differ slightly from that amount where computed from the manufacturer's power tables.

Prior to the classical experiments of James B. Francis on the flow of water over weirs in 1852 at the lower locks in Lowell, the diversity of formulas used for calculating flow through turbines makes the results of early tests incomparable one with another, and the accuracy of some later experiments preceding the building of the present Holyoke testing flume is somewhat in doubt.

It can hardly be said that there has been a progressive growth in the efficiency of turbines, as the following outline of the results of successive series of tests will show:

In 1759 James Smeaton reported tests of 27 undershot water wheels showing efficiencies varying from 28 to 32 per cent. Similar tests of 16 overshot wheels showed efficiencies varying from 76 to 94 per cent.[a]

In 1837 M. Morin tested several Fourneyron turbines. One at St. Blaise showed an efficiency of 85 per cent under 354 feet head. For another, under a lower fall, 88 per cent efficiency is claimed.[b]

In 1843 Elwood Morris introduced and tested Fourneyron turbines in the United States. Turbines in Rockland mills and Dupont powder mills, Wilmington, Del., showed 70 and 75 per cent maximum efficiency, respectively.

In 1844 Uriah A. Boyden built at Lowell the first Fourneyron turbine used in New England, which showed on completion an efficiency of 78 per cent.[c] It is claimed that some of Boyden's later turbines showed an efficiency, on test, of 88 to 92 per cent.

In 1859 and 1860 competitive tests of 19 wheels at Fairmount Park waterworks showed efficiencies as follows:

Results of tests of turbines at Fairmount Park, Philadelphia, Pa., in 1859–60.

Efficiency.	Number of turbines.	Efficiency.	Number of turbines.
50 per cent or less	1	70 to 75 per cent	4
50 to 55 per cent	2	75 to 80 per cent	3
55 to 60 per cent	0	80 to 85 per cent	2
60 to 65 per cent	4	Over 85 per cent	1
65 to 70 per cent	2		

In 1876 Centennial tests showed maximum efficiencies as follows for 17 wheels:

Results of tests of turbines at Centennial Exposition, at Philadelphia, in 1876.

Efficiency.	Number of turbines.	Efficiency.	Number of turbines.
60 to 65 per cent	1	75 to 80 per cent	5
65 to 70 per cent	3	80 to 85 per cent	4
70 to 75 per cent	4	Over 85 per cent	1

The large majority of turbines sold at the present time are made at the shops of five or six builders whose wheels have been frequently tested. The average full-gate efficiency shown in recent Holyoke tests of standard patterns is close to 80 per cent.

Some early wheels showed very high efficiencies, but prior to the building of the Holyoke flume the large majority were of low efficiencies.

[a] Evans, Oliver, Millwright's Guide, Philadelphia, 1853, pp. 131–154.

[b] Journal Franklin Institute, October to December, 1843.

[c] Francis, J. B., Lowell Hydraulic Experiments.

During the past thirty years the general standard of efficiency of turbines has been steadily raised, although the maximum attained may not exceed that of some early forms. The uniformity of each maker's wheels, as well as their strength and durability, has increased. This increase in uniformity and durability has been accompanied by a marked development in capacity and by the production of good part-gate efficiencies.

From 15 to 25 per cent of the gross power of the water is wasted by the better class of turbines. This waste is due to the following causes:

1. Shaft friction.
2. Skin friction on the guide and bucket surfaces.
3. Leakage through clearance spaces, etc.
4. Terminal velocity of the water on leaving the wheel.
5. Production of swirls, or vortices, in the water within the turbine, some of the energy of the water being thus converted into internal motion, which is ineffectual in producing power. How this occurs is illustrated in figure 12 (after Vigreux).

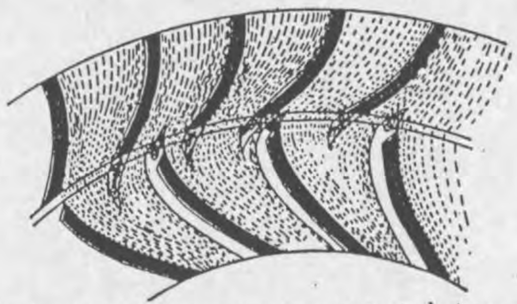


FIG. 12.—Diagram showing interference and formation of eddies in a turbine. (After Vigreux.)

Unwin classifies the lost energy of turbines as follows:[a]

Classification of lost energy of turbines.

Character of loss.	Per cent.
Shaft friction and leakage	10-15
Unutilized energy	3-7
Friction and shock in guide and wheel passages (i. e., skin friction and internal motion)	10-15
Total	26-37

There appears to be little probability of further marked increase in turbine efficiency. Compared with steam engines or other forms of prime movers, water wheels yield a larger percentage of the gross power available than any other type of machine or power-yielding medium. The accompanying diagram (fig. 13) shows the efficiency of various prime movers.

TURBINE TESTING.

GENERAL REVIEW.

The testing of water wheels may be considered to have begun with the work of James Smeaton, whose results of tests of undershot and overshot water wheels were communicated to the Royal Society of London in May, 1759.

The next important results are those of General Morin, in 1837, from early turbines of the Fourneyron type. General Morin's experiments represent a very high grade of scien-

[a] Unwin, W. C., On the Development and Transmission of Power, p. 104.

tific research and have formed the pattern for later work. These results have been translated into English by Elwood Morris, and are worthy of examination by students of hydromechanics.[a]

Tests of American Fourneyron turbines were made by Elwood Morris in 1843. From 1844 to 1851 important tests of Fourneyron and Francis turbines were made by Uriah A. Boyden and James B. Francis. These tests included Boyden-Fourneyron turbines con-

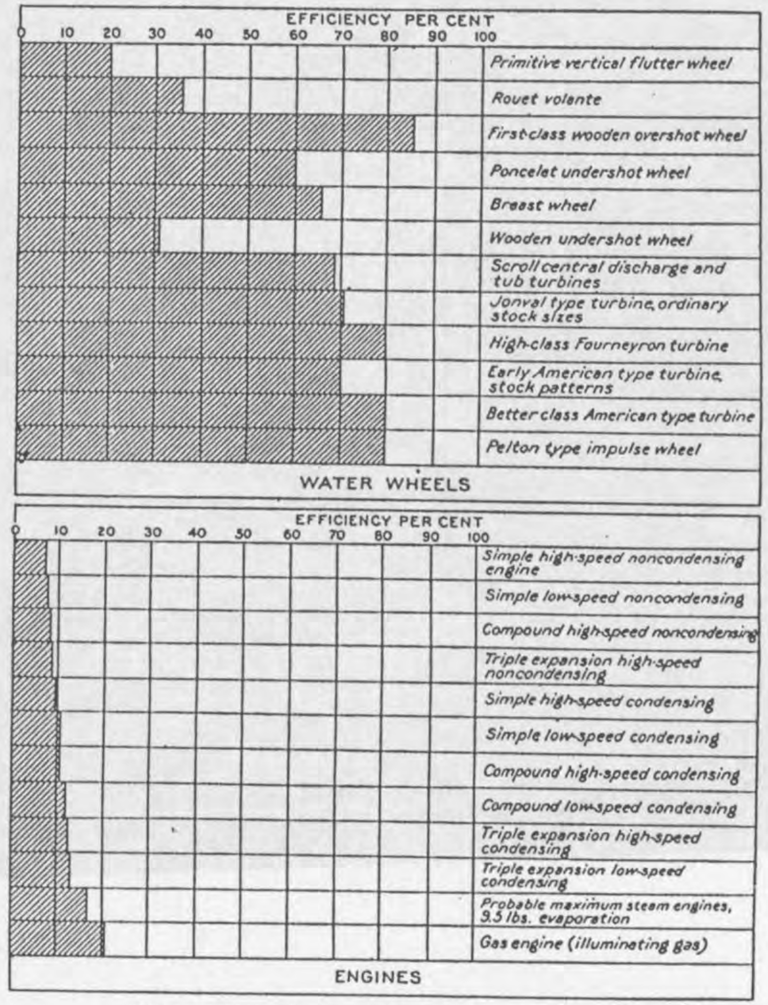


FIG. 13.—Diagram showing efficiency of various prime movers.

structed for the Appleton Mills in 1846, under an agreement in which Mr. Boyden was to receive a bonus of $400 for every 1 per cent of power in excess of 78 per cent efficiency. The computations of these tests were made by James B. Francis, who found a mean maximum efficiency of 88 per cent. Mr. Boyden was accordingly awarded $4,000 premium.

In 1859 and 1860 a series of competitive tests was carried out by the city of Philadel-

[a] Journal Franklin Institute, October to December, 1843.

[illegible]

PARTIE DIDACTIQUE

TURBINES

[illegible] centripètes, Turbines mixtes, dites Américaines

[illegible] vives à réaction (Pelton etc.)

EN COLLABORATION AVEC

M. Ch. MILANDRE, INGÉNIEUR CIVIL

PARIS

[illegible] BERNARD et Cie, IMPRIMEURS-ÉDITEURS

29, *Quai des Grands-Augustins*, 29

1899

Amérique ; elles développent une puissance d'environ 500.000 chevaux-vapeur.

Turbine Swain.

La turbine Swain est une des premières turbines mixtes construites en Amérique.

Les figures 81 et 82 en donnent la coupe en élévation et la vue schématique en plan.

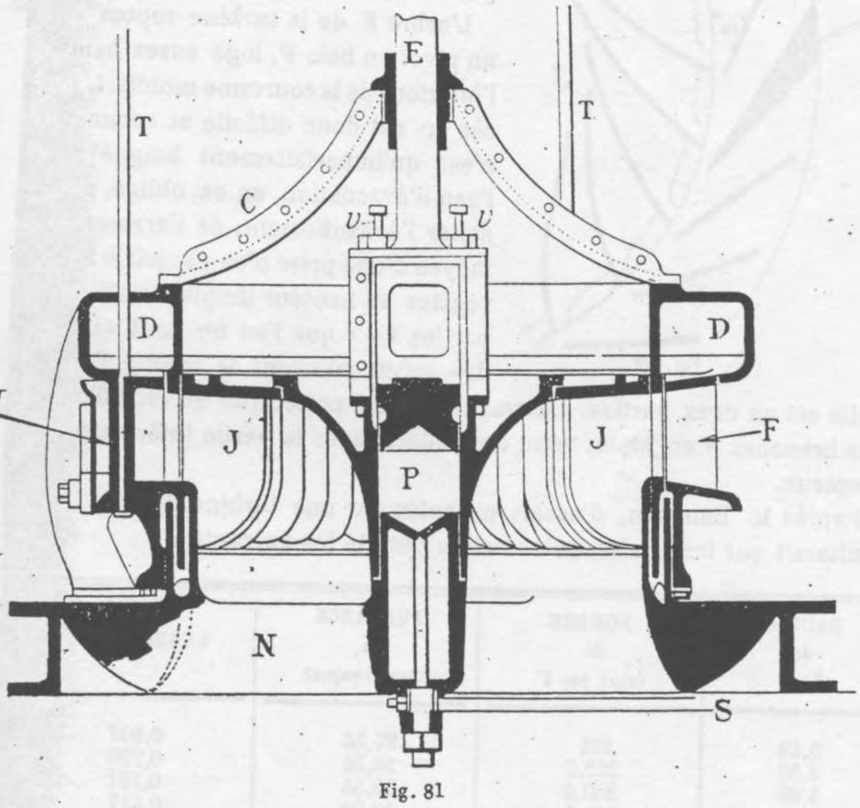


Fig. 81

Les aubes de la couronne directrice sont rectilignes; elle en comporte 24 dont 21 F sont en bronze de 6 millimètres d'épaisseur et rapportées, les trois autres étant venues de fonte avec les plateaux supérieur et inférieur et affectant la forme F' représentée sur la vue en plan. L'angle de sortie des directrices est :

$$\alpha = 14^\circ$$

La couronne mobile J comporte des aubes en bronze, à double courbure, au nombre de 25; leur hauteur est de 0m,595.

Le vannage V offre ceci de particulier qu'il est constitué par la couronne directrice elle-même et le cylindre G qui la prolonge, que l'on relève à l'aide des barres de traction T; un espace D est ménagé dans l'enveloppe où se loge la couronne quand elle est relevée.

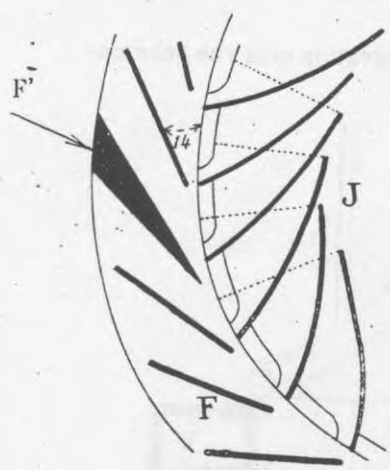


Fig. 82.

L'arbre E de la turbine repose sur un pivot en bois P, logé assez haut à l'intérieur de la couronne mobile. L'accès en est donc difficile et comme il n'est qu'imparfaitement baigné par l'eau d'évacuation, on est obligé, pour éviter l'échauffement, de l'arroser au moyen d'une prise d'eau spéciale S. Le réglage en hauteur du pivot s'effectue par les vis v que l'on ne peut atteindre qu'en enlevant la calotte C, laquelle est en deux parties. La crapaudine est portée par un croisillon à trois branches N, en fonte, venu de fonderie avec la partie inférieure du récepteur.

D'après M. Emerson, d'essais exécutés sur une turbine de 0m,52, il résulterait que les rendements atteints ont été les suivants :

HAUTEUR de chute	NOMBRE de tours par 1'	PUISSANCE en chevaux-vapeur	RENDEMENTS
5,48	281	25,55	0,807
5,50	282,5	23,54	0,790
5,60	280,5	19,55	0,761
»	241,5	12,08	0,617

Ces chiffres correspondent à des rendements français (voir page 82) d'environ 0,72 à 0,54; ils sont un peu meilleurs que ceux de la turbine précédente, mais nous reprochons au moteur qui nous occupe, d'être pourvu d'un pivot mal étudié dont l'usure doit certainement être rapide et dont le remplacement ou le réglage sont très difficiles à exécuter.

WATER POWER ENGINEERING

THE THEORY, INVESTIGATION AND DEVELOPMENT
OF WATER POWERS.

BY

DANIEL W. MEAD.

Member American Society Civil Engineers

Consulting Engineer

Professor of Hydraulic and Sanitary Engineering

University of Wisconsin

NEW YORK

McGRAW PUBLISHING CO.

1908

parts of the country. They are known in some places as the Howd wheel, in others as the United States wheel. They have uniformly been constructed in a very simple and cheap manner in order to meet the demands of the numerous classes of millers and manufacturers who must have cheap wheels if they have any."

Fig. 13 shows a plan and vertical section of the Howd wheels as constructed by the owners of the patent rights for a portion of the New England states. In this cut g indicates the wooden

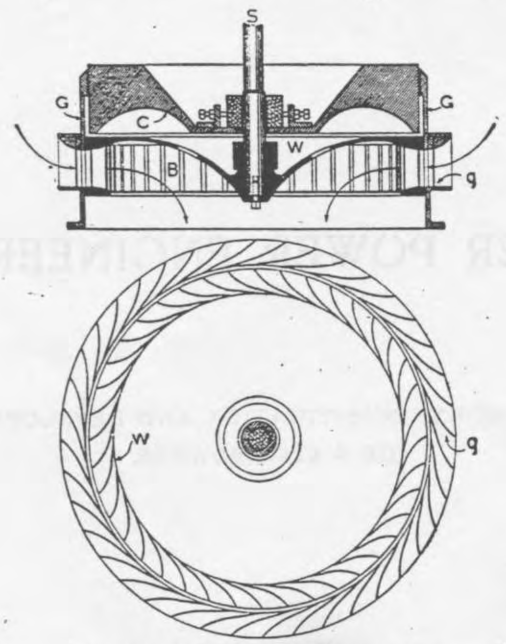


Fig. 14.—Original Francis Turbine.

guides by which the water is directed on to the buckets; W indicates the wheel which is composed of buckets of cast iron fastened to the upper and lower crowns of the wheel by bolts. The upright crown is connected with the vertical shaft S by arms. The regulating gate is placed outside of the guides and is made of wood. The upright shaft S runs on a step at the bottom (not shown in the cut). The projections on one side of the buckets, it was claimed, increased the efficiency of the wheel by diminishing the waste of the water.

The wheel designed by Francis was on more scientific lines, of better mechanical construction (see Fig. 14) and is regarded by many as the origin of the American turbine. The credit of this design is freely awarded to Francis by German engineers, this type of wheel being known in Germany as the Francis Turbine. The Francis wheel was followed by other inward flow wheels of a more or less similar type. The Swain wheel was designed by A. M. Swain in 1855. The American turbine of Stout, Mills and Temple (1859), the Leffel wheel, designed by James Leffel in 1860, and the Hercules wheel, designed by John B. McCormick in 1876, are among the best known and earliest of the wheels of this class.

9. Modern Changes in Turbine Practice.—A radical change has taken place in later years in the design of turbines by the adoption of deeper, wider and fewer buckets which has resulted in a great increase of power as shown by the following table from a paper by Samuel Webber (Transactions of Am. Soc. M. E. Vol. XVII):

TABLE I.—*Showing Size, Capacity and Power of Various Turbines Under a 26-foot Head.*

	Inches Diameter.	Cubic Feet Water per Second.	Horse Power.
Boyden-Fourneyron	36	22.95	55
Risdon	36	35.45	89
Risdon "L. C."	36	48.27	121
Risdon "L. D."	36	80.	199
Leffel, Standard	36	40.45	96
Leffel, Special	35	60.	148
Tyler	36	40.7	95.8
Swain	36	58.2	140
Hunt, "Swain bucket"	36	48.8	121
Hunt, New Style	36	98.	239.74
Leffel, "Samson"	35	109.1	264
"Hercules"	36	107.6	253.5
"Victor"	25	108.8	266
New Swain	36	89.5	215

By 1870 the turbine had largely superseded the water wheel for manufacturing purposes at the principal water power plants in this country. The old time water wheel has since become of comparatively small importance, but it is still used in many isolated places where it is constructed by local talent, and adapted to local conditions and necessities.

strength to sustain the weight of the turbine wheel and so that the step bearings are accessible and can be readily replaced or adjusted. The arrangement of the case must also be such that the openings between the wheel and the case are as small as practicable and the line of possible leakage will be as indirect as possible so as to avoid leakage loss.

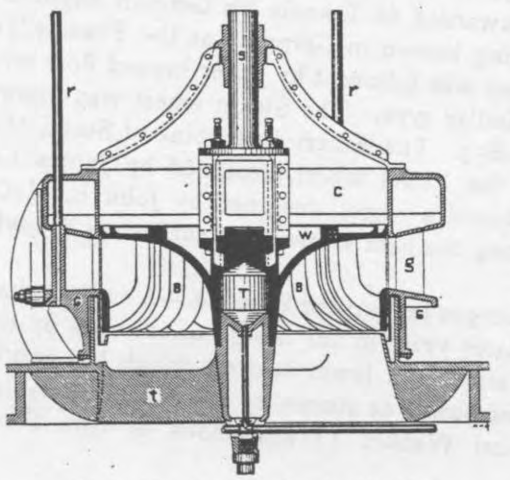


Fig. 185.—Section Swain Turbine.

Most chute cases are either cast or wrought iron. Cast iron usually lends itself to a more satisfactory design for receiving and passing the water without sudden enlargement and opportunities for losses by sharp angles and irregular passageways. Wrought iron, while not always lending itself readily to designs which eliminate all such losses, possesses much greater strength for a given weight which is a great advantage under some conditions.

146. Turbine Gates.—Three forms of gates are in common use for controlling the admission of water into reaction turbines. The cylinder gate consists of a cylinder closely fitting the guide that by its position admits or restricts the flow of water into the buckets. Fig. 184 is a section of a turbine of the McCormick type, manufactured by the Wellman-Seaver-Morgan Company, having a gate of this type, GG, between the guides and runners, which is shown closed in the cut. The gate is operated by the gearing, Gr., which raises it into the dome, O, through connection with the governor shaft, P. This same type of gate is used over the discharge of the Niagara-Fourneyron turbine (see GG, Fig. 134), over the inlet of the Geylin-Jonval turbine, GG, Figs. 135 and 137, and between the guides and buckets of the Niagara turbine. shown in Fig. 101.

A modified form of the cylinder gate is that used by the Swain Turbine Company (see Fig. 185), which is lowered instead of being raised into the dome as in Fig. 184.

TREATISE
ON
LEATHER BELTING

BY

GEORGE B. HAVEN, S.B.

Professor of Advanced Machine Design
In Charge of Textile Research

AND

GEORGE W. SWETT, S.B.

Professor of Machine Design

BOTH OF

Massachusetts Institute of Technology
Cambridge, Mass.

FIRST EDITION
THIRTEEN THOUSAND

PRICE $1.50

CAMBRIDGE, MASS.
TECHNICAL COMPOSITION COMPANY
1931

PUBLISHED BY THE
AMERICAN LEATHER BELTING ASSOCIATION, NEW YORK CITY

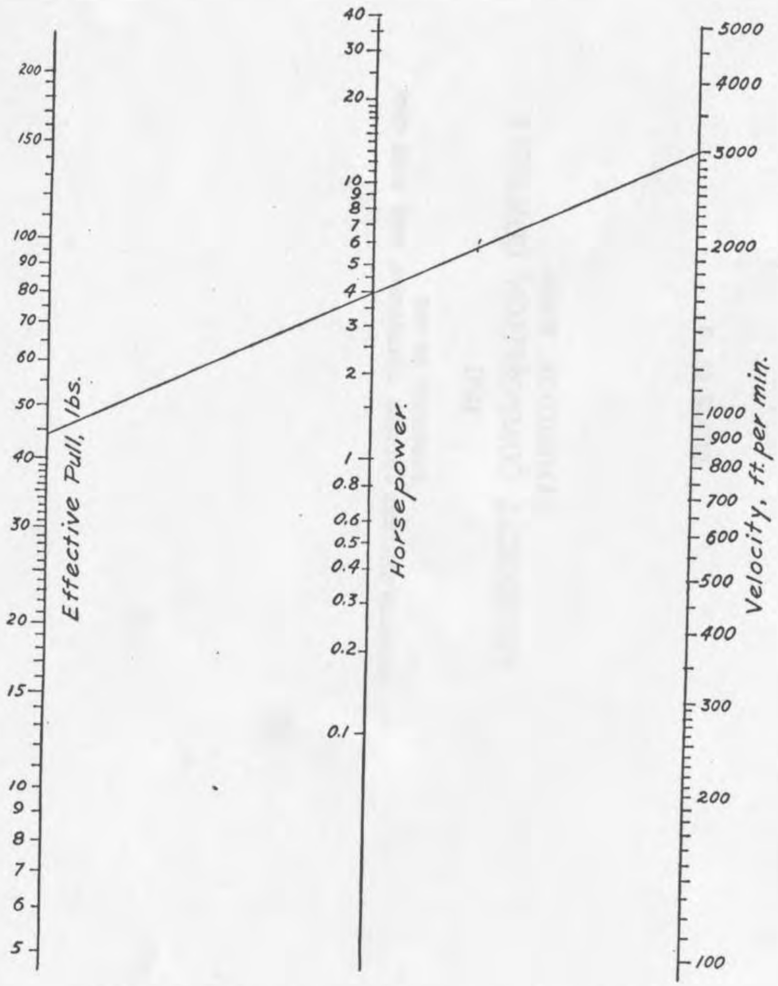


FIG. 75. Relation between effective pull, belt velocity and horse power.

The relation between the effective pull, velocity and horse power is readily shown by Fig. 75. For example, a belt traveling 3000 feet per minute and transmitting 4 horse power must have an effective pull of 44 lbs.

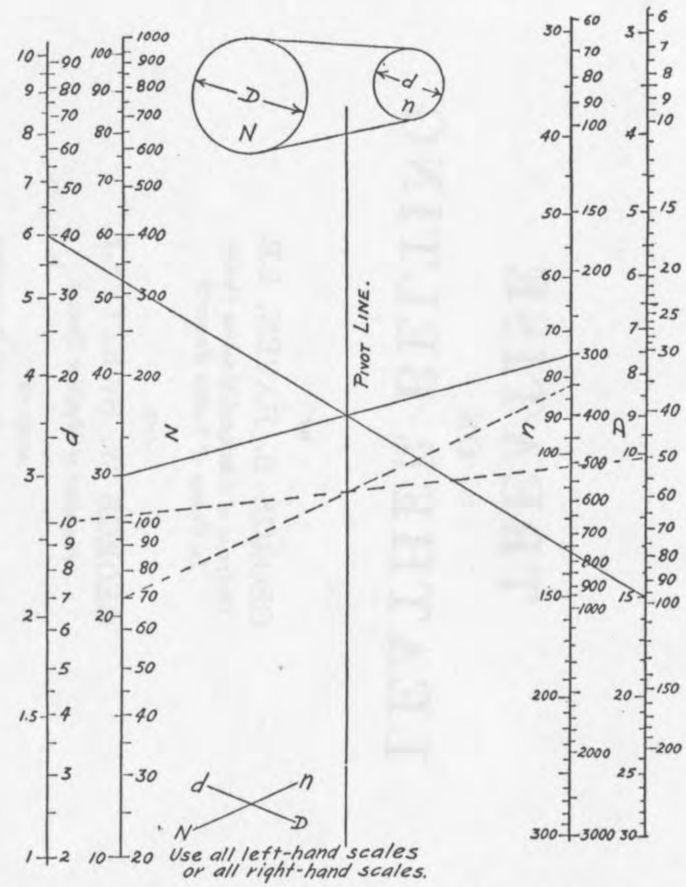


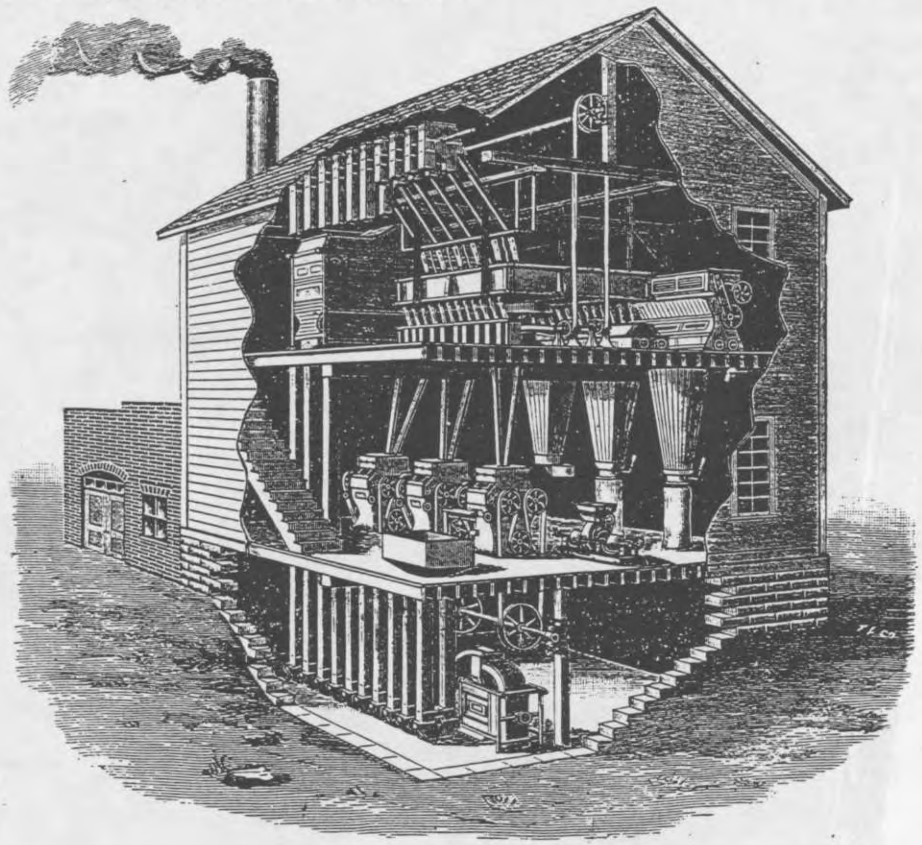
FIG. 76. Relation between pulley diameters and revolutions per minute.

The chart of Fig. 76 gives an extended relation between pulley diameters and speeds. The left-hand scales give the relationship for low speeds. Thus, with the index line shown full, the inter section on the pivot line indicates that a driving pulley (d) 6 ins. in diameter running 75 r.p.m. (n) will drive a pulley (D) 15 ins. in diameter at a speed of 30 r.p.m. (N). In this case all the numerical values are those given on the left-hand side of the scales. The figures at the right side of the scales are for use with higher speeds. The index line shown dotted connects values reading in terms of the numbers at the right hand of the scales. The dotted setting shows that for $D = 50$ ins., $d = 10$ ins., and $N = 70$ r.p.m., the value of n is 350 r.p.m.

Three Double=Set Mill

CAPACITY, ONE TO TWO BARRELS OF FLOUR PER HOUR

Cut shows a one-storey building with high attic and basement.
This is a very desirable and suitable building for this class of mill.
It is easily erected and at moderate cost.



DESIGN No. 1.

It enables the machinery to be arranged in a very nice, compact and convenient manner, the drives to all machines are simple and straight; every part of the mill is easy of access. Plenty of light and air. The machinery is free from complications and runs light and easy.

A usual outfit for such a Flour Mill consists of:—

1 Wheat Cleaner	1 Purifier and Dust Collector
3 Double Setts of Rolls	1 Bolting Reel
1 Plansifter	3 Bag Fillers

FOR GRINDING PROVENDER.

1 18-inch diameter Robinson Grinder.

PRACTICAL MILLING

By

PROF. B. W. DEDRICK
Head of Mill Engineering School
Pennsylvania State College

FIRST EDITION

Published By
NATIONAL MILLER
Chicago, Ill.

the wheat is dumped into a chute to a hopper suspended from a beam scale, weighed and let into another hopper or bin from whence it is conveyed by an elevator to bins on the upper floors.

From the boat the wheat is taken by means of an elevator let down into the hold. This elevator (now called the marine elevator leg) was so arranged that it could be drawn up or let down from the top, and swung outward at the same time. The elevator discharged into the conveyor on the third floor.

The Hopper-Boy or Cooler—This device was usually enclosed in a circular or octagonal room, in order to prevent dust from spreading over the mill and thus causing a

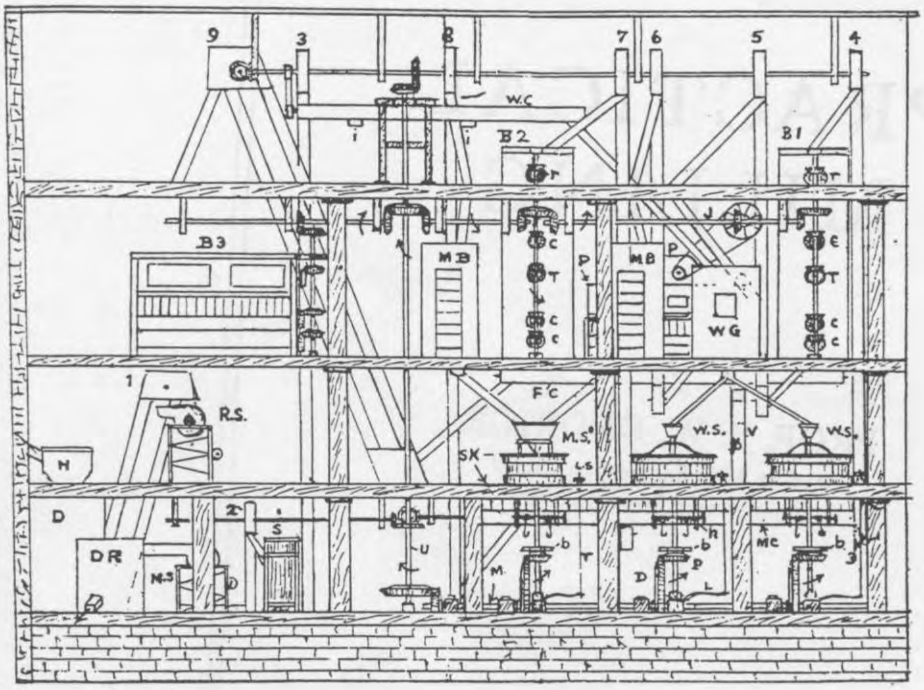


Fig. 13—An Old Buhr Stone Mill

loss. In the plan of the Oliver Evans mill the hopper-boy is open and shown at *25*, where the spout is led from the elevator that discharges the chop from the stones at the end of the rake.

The chop from the stone would be allowed to accumulate in the cooler for three or more hours. Then the miller would stop grinding by cutting off the feed and raising the stones higher or disconnecting them when occasion required. After this the bolts were started, if out of gear, or the shoe let in contact with the knocker, and bolting commenced and continued until the hopper-boy was about empty.

As the chop would accumulate in the cooler, the rake or gatherer would be raised on top of the chop, the weights attached to it and passing over pulleys on an arm or beam above, counter balancing the weight of the rake. The teeth or flights of the rake were disposed tangentially and were set a certain distance apart from the outer end of the