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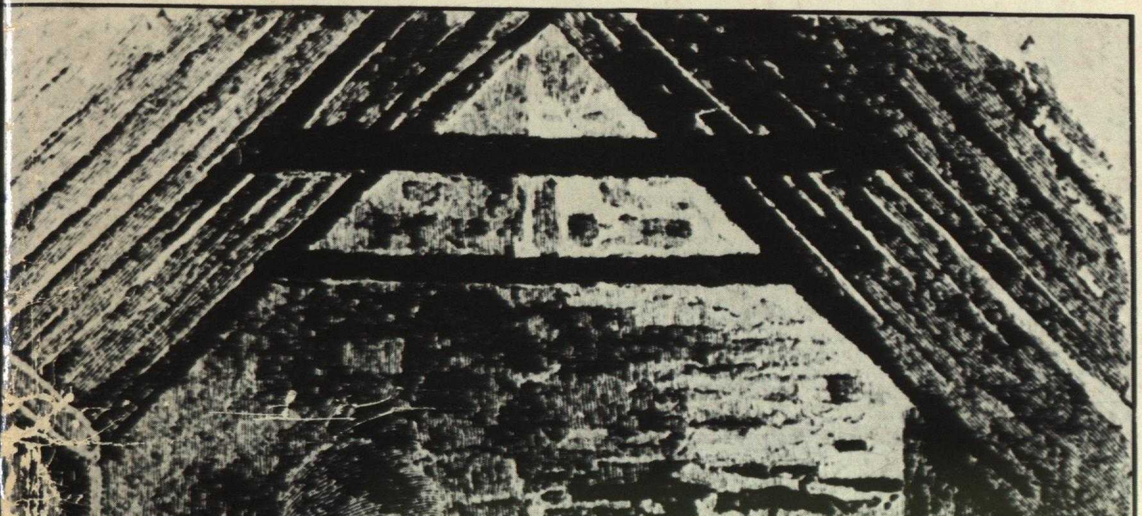
Canada's Historic First Iron Castings

Harry Miller
Sutton, Quebec



Les Forges Saint-Maurice, 1738 – 1883

Mines Branch
Information Circular
IC 209

Department of Energy, Mines and Resources, Ottawa
December 1968

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Queen's Printer and Controller of Stationery
Ottawa, Canada
1968

Canada's Historic

First Iron Castings

FIGURE 1: POTASH KETTLE and CAST-IN TRADE MARK, F S^t M .

Made at Canada's Historic First Ironworks, Les Forges Saint-Maurice, near Trois-Rivières, Quebec, about 1840; diameter 43 3/4 inches, weight 500 pounds. Kettles of this design were the largest castings made in Canada before Confederation Year 1867.

Shown with author's grand-daughter at his home in Sutton, Brome County, Eastern Townships of Quebec.

CANADA

Department of

Energy, Mines and Resources

Mines Branch

Ottawa

Canada's Historic First Iron Castings

Harry Miller

Sutton, Quebec

Information Circular IC 209

A Contribution to Canadian History and Iron Technology

December 1968

FOREWORD

Canada's iron and potash resources have been developed into two of its major industries comparatively recently. The stories of the pioneering of such industries are too often forgotten unless old accounts are carefully scanned and related by knowledgeable historians.

The Mines Branch appreciates a serious technological history and, assuming no credit or responsibility for its content, has undertaken to publish Mr. Harry Miller's book on 'Canada's Historic First Iron Castings'.

It might be said that Mr. Miller was predestined to write this absorbing history of Canada's first iron industry and, incidentally, its first potash industry. He was born in South Lancashire, a cradle of the iron-casting art, and emigrated to spend his early childhood in the potash area, then unknown as such, of Saskatchewan. He retired from mechanical engineering to reside in the Eastern Townships of Quebec. His book, as its title implies, is a carefully authenticated account of the charcoal smelting of bog-iron ore and the casting of iron utensils, which, for making potash in particular, had to be large and of high quality. He has duly complimented the early smelter and foundry men of Les Vieilles Forges at Saint-Maurice, Quebec, on meeting this specification.

Mr. Miller is preparing a similar account of Canada's potash industry. Since the early art of making potash from wood ashes is a related incidental in 'Canada's Historic First Iron Castings', serious readers await his further writing on potash.

John Convey,
Director,
Mines Branch.

Ottawa, December, 1968.

AVANT - PROPOS

Les ressources canadiennes de fer et de potasse ont donné naissance, assez récemment, à deux des plus importantes industries de ce pays. L'histoire du lancement de telles industries tombe trop souvent dans l'oubli, à moins que des historiens compétents n'explorent en détail les vieux récits pour les rapporter ensuite.

La Direction des mines reconnaît la valeur d'études histoires sérieuses sur la technologie et elle a entrepris, sans s'en attribuer le mérite ni la responsabilité, la publication du livre de M. Harry Miller, "Canada's Historic First Iron Castings".

D'aucuns diront que M. Miller était né pour écrire cette passionnante histoire de la première industrie de la potasse. Né dans le sud du Lancashire, berceau de l'art du coulage du fer, il émigra et passa sa prime jeunesse dans le pays de la potasse, la Saskatchewan, dont cette richesse n'était pas encore connue. Au terme de sa carrière d'ingénieur mécanicien, il se fixa dans les Cantons de l'Est de la province de Québec. Son livre, comme son titre l'indique, est une histoire bien documentée de l'affinage du fer des marais au charbon de bois, et du coulage de chaudrons en fer qui, dans l'industrie de la potasse en particulier, devaient allier l'importance de leurs dimensions à l'excellence de leur qualité. Il fait l'éloge des premiers fondeurs des Vieilles Forges du Saint-Maurice, au Québec, qui ont su satisfaire à ces exigences.

M. Miller prépare actuellement un récit semblable sur l'industrie de la potasse. Les gens dont l'attention a été éveillée par la lecture, dans le "Canada's Historic First Iron Castings", des allusions à l'art ancien de la fabrication de la potasse à partir des cendres de bois, guettent la sortie de ce nouvel écrit.

John Convey,
Directeur,
Direction des mines

Ottawa, decembre 1968

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SUMMARY

This publication throws new light on the remarkable quality of the iron castings made at Canada's historic first ironworks, Les Forges Saint-Maurice.

A brief outline is provided of the history of that famous enterprise, located eight miles from Trois-Rivières, Province of Quebec. It was founded in the days of New France, over two hundred and thirty years ago (1738). The blast furnace was finally closed down for good in the year 1883. A few rough stone foundations are all that remain today on that historic site.

This new information on early cast iron in Canada is the outcome of an investigation, by the Mines Branch, of the exact nature of the iron in the Potash Kettle shown in Figure 1. This remarkable large casting is fully authenticated as a product of Les Forges Saint-Maurice, by the cast-in foundry mark, F S^{t} M , clearly to be seen on the lip of the vessel. Castings, of any kind, bearing this trade mark are exceedingly rare. There are only a few such pieces, mostly stoves, in museums and with private collectors.

This design of kettle is believed to be the largest casting made in Canada, before Confederation Year 1867, using iron smelted from native ore.

This study at the Mines Branch Research Laboratories was undertaken as part of an investigation by the author into the use, by pioneer settlers in Canada, of large cast iron vessels in their making of potash alkali from hardwood ashes. The description of that process, given in Chapter II, contributes considerable new information on the history of the little known technology of that pioneer pursuit.

Some historical perspective is provided in a brief review of the role of modern potash from Saskatchewan mines as the 'commercial successor' of the potash made from wood-ashes in settlement days.

The iron made at Saint-Maurice was smelted with charcoal from a very pure bog-iron ore found nearby. The Research Laboratory reports (Chapter III) show this iron has a composition very low in harmful impurities

and favourably compares with historic Swedish charcoal irons, which were the world's standard of excellence for several hundred years (Chapter IV).

The investigation revealed that the iron in the potash kettle, now at Sutton, Quebec, has outstanding quality in its resistance to red-heat temperatures and corrosion. This is demonstrated by a detailed comparison with modern foundry practice in the making of chemical processing vessels (Chapter V).

* * * *

This publication is specifically designed to serve two groups of readers. The general text with illustrations is for that growing group of Canadians with a broad general interest in reading the story of pioneer times in this country. The annotated bibliography supplements the text, especially for that smaller group of readers in Canada and elsewhere whose interest is the detailed history of technology of pioneer pursuits. Up to now, that has been a neglected field in Canadian history.

* * * *

There is much enthusiasm, to-day, among prominent citizens of the thriving city of Trois-Rivières, for more formal recognition of their cultural heritage in what has been described as 'The Romantic Birthplace of Canadian Industry'. Their suggested program takes the form of restorations on the site of Les Forges Saint-Maurice, along with a museum for historical articles and documents.

For the past three summers, archeological teams of The Quebec Provincial Authorities have been doing significant work on the site, which was acquired, a few years ago, by the Quebec Historical Monuments Commission.

It is the hope of the author and the research scientists at the Mines Branch that this publication may assist in such a commendable project by contributing to a better understanding of the history of charcoal-iron technologies at Canada's **historic first ironworks**, Les Vieilles Forges, at Saint-Maurice.

RÉSUMÉ

La présente publication projette une nouvelle lumière sur la qualité remarquable des objets en fonte executés aux Forges Saint-Maurice, premières installations d'une fonderie dans l'histoire du Canada.

Une brève esquisse est faite sur l'histoire de cette fameuse entreprise, située à huit miles de Trois-Rivières dans la Province de Québec. Celle-ci fût fondée du temps de la Nouvelle-France, soit plus de deux cent et trente ans (1738). Le haut-fourneau a été finalement et définitivement fermé en 1883. Quelques grosses pierres de fondation sont tout ce qui reste aujourd'hui comme vestiges de ce site historique.

Cette nouvelle contribution sur les debuts de l'industrie de fonte au Canada est le résultat d'une recherche faite par la Direction des Mines sur la nature exacte du fer d'un chaudron à potasse, representé à la Figure 1. Cette coulée, remarquable par sa grandeur, est reconnue avec certitude, comme étant un produit des Forges Saint-Maurice, par une estampille de fonderie " F S^{t} M ", que l'on peut voir facilement sur le bord du chaudron Les pièces coulées de formes diverses portant cette marque de fabrique sont extrêmement rares; il n'en existe que quelques pièces semblables, pour la plupart des poêles conservés soit dans les musées, soit dans les collections privées.

Ce modèle de chaudron est supposé être la plus grande pièce de fonderie faite au Canada avant l'année de la Confédération 1867 en utilisant le fer produit avec le minerai du pays.

L'étude aux laboratoires des recherches de la Direction des Mines, a été entreprise comme une partie d'une recherche faite par l'auteur pour retrouver l'usage fait par les occupants pionniers au Canada, de grands récipients en fonte pour leur production de la potasse produite des cendres de bois dur. La description de ce procédé, donnée au chapitre II, donne beaucoup de nouvelles informations sur l'histoire d'une technique très peu connue des pionniers.

Une perspective historique est donnée dans une brève revue du rôle joué à l'heure actuelle par la potasse des mines du Saskatchewan, comme un 'successeur commercial' de la potasse produite à partir des cendres de bois du temps des pionniers.

Le fer produit à Saint-Maurice a été fondu utilisant le charbon de bois et un minerai de marais très pur que l'on trouvait dans le voisinage. Les rapports du laboratoire des recherches (chapitre III) montrent que ce fer avait une teneur très basse en impuretés nuisibles et qu'il se compare avantageusement avec les vieux fers au charbon de bois des Suédois qui ont été les standards d'excellence dans le monde pendant plusieurs centaines d'années (chapitre IV).

L'investigation a relevé que le fer du chaudron à potasse, actuellement à Sutton, Québec, avait une excellente qualité de résistance à la température du rouge et aussi à la corrosion. Ceci a été démontré par une comparaison méticuleuse avec la fabrication des chaudrons pour les procédés chimiques telle que pratiquée dans les fonderies modernes (chapitre V).

* * * *

Cette publication est spécialement destinée à servir deux groupes de lecteurs. Le texte général avec les illustrations est pour ce groupe, toujours grandissant, des Canadiens ayant un interêt général marqué pour la lecture de l'histoire de leur pays du temps des pionniers. La bibliographie annotée augmente le texte, spécialement pour ce petit groupe des lecteurs au Canada et ailleurs, dont l'interêt est de détailler l'histoire des pratiques des pionniers. Jusqu'à présent ce fût un champs négligé dans l'histoire Canadienne.

* * * *

A présent, les éminents citoyens de la prospère ville de Trois-Rivières montrent beaucoup d'enthousiasme pour une reconnaissance plus formelle de leur héritage culturel, de ce qui a été décrit comme "Le Berceau Romantique de l'Industrie Canadienne". Leur programme suggère la restauration du site des Forges Saint-Maurice et la construction d'un musée pour les objets et documents historiques.

Pendant trois étés consécutifs, les équipes archéologiques du Gouvernement Provincial de Québec ont fait des travaux importants sur le site, qui a été acheté il y a quelques années par la Commission des Monuments Historiques du Québec.

L'auteur et les chercheurs scientifiques de la Direction des Mines espèrent que cette publication pourra venir en aide à un projet si louable en contribuant à une meilleure compréhension de l'histoire des techniques de fer au charbon de bois aux Vieilles Forges de Saint-Maurice, première fonderie dans l'histoire du Canada.

* * * *

Les Forges Saint-Maurice

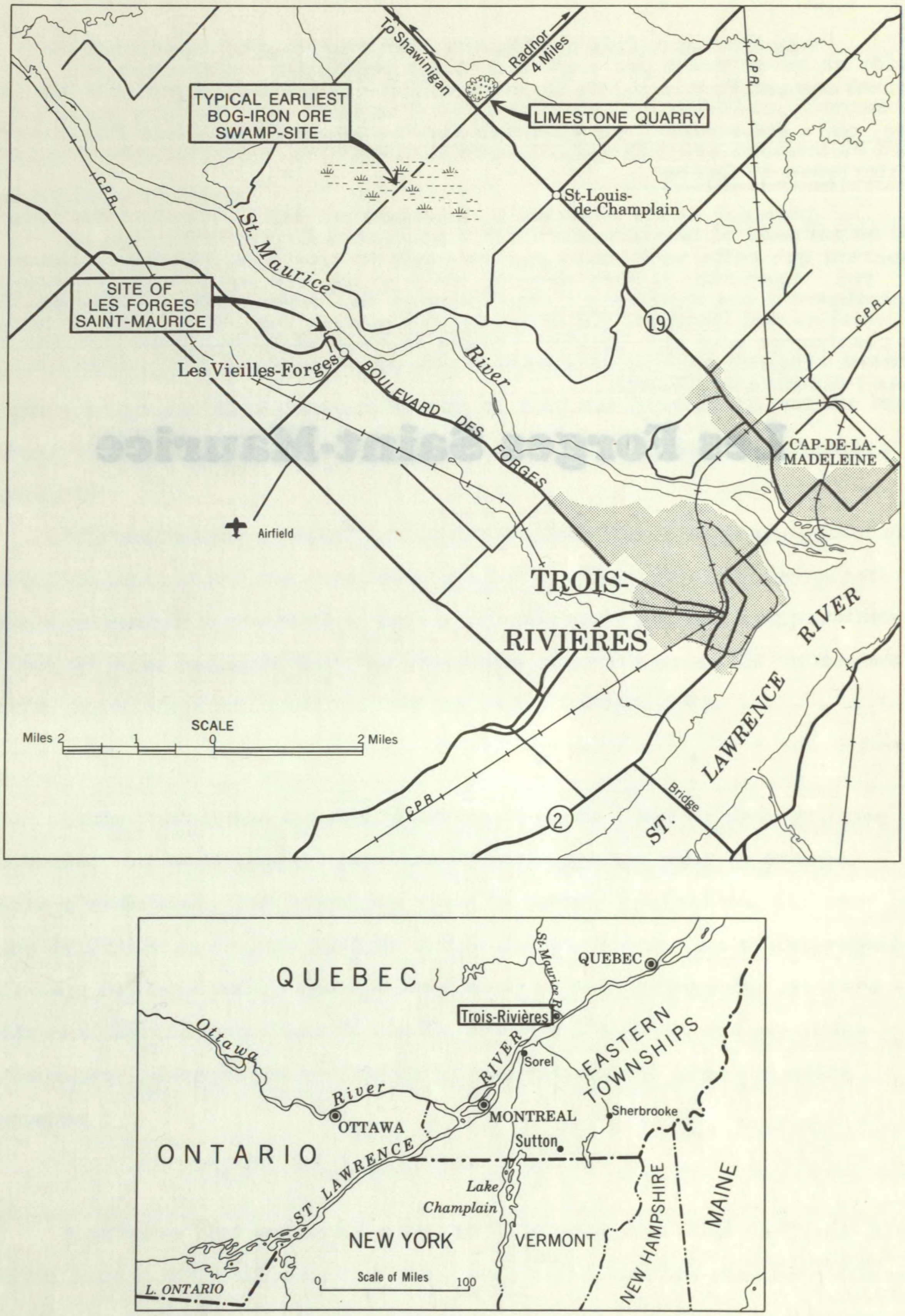

FIGURE 2: LOCATION OF LES FORGES SAINT-MAURICE, CANADA'S HISTORIC FIRST IRONWORKS

CHAPTER I

LES FORGES SAINT-MAURICE

A. CANADA'S HISTORIC FIRST IRONWORKS

It is a significant fact of Canadian history that the smelting of iron ore and the making of cast iron articles and wrought iron bars were this country's very first industrial enterprise.

Les Forges Saint-Maurice (1) located near Trois-Rivières, Province of Quebec (map, Figure 2) was Canada's historic first ironworks. Actually, it was the only industrial venture of any nature, whose active life spanned parts of all three periods of Canada's political history, the French Regime, the British Colonial Period and then a few years of Confederated Canada.

Iron was first produced at a charcoal-fired blast furnace at Saint-Maurice in the year 1738. There were to be 145 years of periodic operation before the last iron was cast there in 1883, see cover illustration (2). The establishment was then abandoned due to exhaustion of local raw materials. A few rough stone foundations are all that remain today on the site of Les Forges Saint-Maurice.

In a technical publication such as this, space does not permit of more than the briefest summary of the economic and political history of the enterprise. For the benefit of such readers as may be interested in greater detail, the first comprehensive bibliography of major writings in both the French and English languages, on the history of Les Forges Saint-Maurice, is provided by the numbered references in the 'Notes to the Text and Bibliography' on page 54 of this publication.

The early annals of the enterprise, through periods of wars and good and bad times, have been carefully researched. This is particularly true of the founding and earliest years in the days of New France, as recorded by French Canadian historians (3). Some facts about the ironworks in its later years have been given by a few nineteenth century writers in English (4). However, there are many gaps still to be filled in this overall historical record.

In particular, the technological history of Les Forges Saint-Maurice has not, heretofore, been studied critically. There is no previous published scientific study of a fully authenticated cast iron product of the enterprise.

This historic first ironworks was located eight miles up the St. Maurice River from the Village of Trois-Rivières, now a thriving city of over fifty thousand inhabitants (map, Figure 2). The importance of the ironworks to the economic life of that early village, and a constant reminder to the present generation of citizens (5), is the fact that one of the main thoroughfares of the City, and the highway to the site of the old ironworks, is now called 'Boulevard Des Forges'.

This actual site(6) was on a small swift stream that flows from the west into the St. Maurice River. The once thriving community of several hundred people, grouped around the furnace a hundred-odd years ago, is now only a small hamlet, summer-cottage colony, winter-sports site and a prestige restaurant. These modern activities are shown on today's maps under the romantic name of 'Les Vieilles Forges' , for which the best English translation is 'The Old-Time Ironworks'(7).

It is now a little over three hundred years since the first interest was displayed, by successive Governors of New France, in the rich bog-iron ore deposits of the Lower St. Maurice Region. The famed Comte de Frontenac was quite enthusiastic in his report, in 1672, on the potentials of this ore for starting a local iron industry.

It was not until the decade of the 1730's that such a project was actively underway. Skilled workmen were brought over from France, where there was a long heritage of experience in smelting iron with charcoal fuel. Historical records establish that the first successful batch of usable iron was made at a blast furnace at Les Forges Saint-Maurice in the summer of 1738.

During the next twenty-odd years, despite setbacks and early financing difficulties, Les Forges had one of its most successful periods of operation[8]. Under the guidance of the French Colonial Authorities in Quebec, it provided the settlers of New France with much needed wrought iron bars and iron castings.

On the coming of the British Colonial Regime in the early 1760's, the ownership of the ironworks passed to the new administration. For the next eighty-odd years the facilities at Les Forges along with the adjacent Seigneury of St. Maurice were leased to tenant operators. Unfortunately, the historical records are quite sketchy(9) for this period (1760-1846) at Les Forges.

Following thirty years of spasmodic and not very successful operation, under a succession of tenants, the lease on the ironworks was obtained, in 1793, by the partnership of Munro and Bell, merchants of Quebec. In many ways, the history of the next half-century at Les Forges is the story of one man, Mathew Bell(10). He was to remain the guiding spirit of the enterprise for the next fifty-three years, until he gave up the venture in 1846.

We know, from the writings(11) of one overseas visitor to Les Forges in 1808, that the ironworks had been established as a very successful enterprise and employed three hundred men, including those supplying the raw materials.

The products of Les Forges, i.e. castings and wrought iron bars, were transported by boat down the St. Maurice River to Mathew Bell's store in Trois-Rivières, and thence sold widely by merchants of Quebec, Montreal and villages throughout the vast area then being opened up for settlement along the St. Lawrence, its tributary rivers and the Lower Great Lakes as far west as Detroit.

The period of Bell's greatest prosperity at Les Forges was during the twenty-year period from 1817 to 1837 after the Napoleonic Wars. Immigration to Canada was reaching flood-tide proportions and generating great demand for iron goods on the settlement frontier.

At this period the products of Les Forges were successfully competing with a limited volume of imports from Britain and United States and with the products of a few other pioneer Canadian charcoal ironworks(12).

By the late 1830's and the early 1840's the economic conditions had changed completely for the iron industry in Canada. The market for cast iron sagged as a result of rigorous competition from imports following a world-wide depression in 1837. Hard times fell on Les Forges Saint-Maurice. Mathew Bell, by then over seventy years of age, was forced to give up the enterprise. In 1846 the Colonial Government sold the ironworks by auction for much less than its former value.

The eclipse of Les Vieilles Forges at Saint-Maurice was hastened by a great increase in the cost of operations, mainly due to the shortage of accessible wood to make charcoal(13) and the difficulty of transporting bog-iron ore from greater and greater distances.

The heyday of Les Forges had now passed. There was only intermittent operation(14) for another thirty-seven years until the blast furnace was finally abandoned in 1883. In the final decade, the operation was limited to the making of iron for a few products for which there was a premium-price market for high-quality metal. These were axes for lumbermen and wheels for railroad cars(15).

With the final closing down of this historic first ironworks at Saint-Maurice in 1883, a significant Canadian pioneer industrial era came to an end(16).

B. SMELTING IRON WITH CHARCOAL AT LES FORGES SAINT-MAURICE

All the necessary raw materials for the manufacture of iron were found in abundance within a few miles of the blast furnace at 'Les Vieilles Forges' at Saint-Maurice.

Bog-iron ore was dug from swampy areas. When Les Forges was founded, in the 1730's, this ore was available quite near the furnace site; see map, Figure 2. In later years these beds were exhausted and the ore had to be brought from up to ten miles away(18).

The fuel used to smelt this ore was charcoal. In the early days, the nearby forest of maple, birch and pine(19) seemed inexhaustible. In later years, the wood had to be hauled from greater and greater distances. Many men were required, in winter time, for the tasks of cutting and hauling the wood on sleds to supply the charcoal burners, usually located near the blast furnace. This provided off-season, part-time work for the first settlers of the region. The wood was charred in open piles.

A good-quality limestone, for use as flux in the furnace charge, was found in a quarry a few miles away, across the St. Maurice River(20) (map, Figure 2).

The blast furnace (haut fourneau) at Les Forges Saint-Maurice is known to have been thirty feet in height. It was similar in general type to eighteenth and early nineteenth century furnaces in all countries where wood for charcoal was abundant(21), as in Colonial America, Sweden and several other European Countries. It can be described briefly as a cold-blast, charcoal-fired furnace employing water power for the air blast and the associated forge hammer, for making wrought iron bars.

There is fairly conclusive evidence that the original 'haut fourneau' at Saint-Maurice, built by skilled workmen from France in the 1730's, and the blast furnace that was eventually abandoned in 1883, were both on the same foundation base-blocks of local stone. The arched front of this is shown in the cover illustration(22). Our source of information on this point is the most authoritative history of the early iron industry in North America, published in 1892(23). It has this to say about 'The First Ironworks in Canada': "At the time of its abandonment in 1883, the Saint-Maurice furnace was the oldest active furnace on the American Continent. In that year there were still standing two very old furnaces in United States, both built in 1742, but neither of these was in blast in 1883".

*   *   *   *

FIGURE 3: CAST IRON STOVE MADE AT LES FORGES SAINT-MAURICE

Rare cast-in trade mark, F S^{t} M , between doors on right side; on display at Manoir Lachine, the fine folk-lore museum at Lachine, Quebec.

C. THE MAKING OF IRON CASTINGS AT LES FORGES SAINT-MAURICE

Castings were made by the 'furnace-metal-cast' procedure(24), i.e., with molten iron taken from the blast furnace and poured directly into sand moulds. This was the method used throughout the complete lifetime of Les Vieilles Forges at Saint-Maurice.

Early settlers in Canada had two major requirements that could only be filled by good-quality iron castings. These were stoves for heating and cooking and 'hollow ware'(25) (pots and kettles) for cooking and domestic uses generally; see Figures 3 and 4. Medium-size hollow ware (say up to two feet in diameter) was needed for essential pioneer barnyard tasks(26) such as making maple sugar, preparing soft soap, butchering hogs and boiling lye for black salts(27).

Stoves and hollow ware were the important cast end-products(28) of Les Forges Saint-Maurice, as they were of all early charcoal ironworks in newly settled regions of North America.

In terms of tonnage of output of castings, stoves were the most important products of Les Forges(29). The four sides, the top, the bottom, the doors, etc., of the box-shaped stoves were all cast separately and then, quite ingeniously, fitted together in assembly. However, despite the decorative designs on one side of each wooden pattern, the major components of the earliest stoves, being quite thick and flat on the inside, could be moulded and cast, in a relatively simple manner, in damp foundry sand(30).

However, for the making of cast iron pots and kettles, of a wide range of shapes, sizes and applications, much greater craft skills were required of the men of the ironworks, especially those in the moulding shop.

We know from various historical writings(31) that a range of cast iron hollow ware was made at Les Vieilles Forges at Saint-Maurice, but much detail as to sizes, etc. is still unknown to historians.

Unfortunately, small cast iron pots and kettles almost never carry any identifying trade mark. Hence museums and private collectors can have only the vaguest notion of the exact source of their display items(32).

FIGURE 4: TYPICAL CAST IRON HOLLOW WARE

Display at Upper Canada Village, Morrisburg, Ontario; foundry sources not identified.

Some may well have come from Saint-Maurice, but many were imported from Britain. Some were undoubtedly cast at early American charcoal ironworks and brought into Canada by settlers emigrating from Vermont and other Northern States.

The reader will readily appreciate, from a study of the museum display in Figure 4, just how dependent on good-quality cast iron utensils were the women in pioneer homes. Their constant daily use of these pots and kettles implied major problems for the frontier ironworks that produced them.

The utensil had to be as light in weight as possible, for ease of carrying around. This implied a minimum wall-thickness, often somewhat less than one-quarter inch. The vessels must not be easily cracked or broken. This implied a good grade of cast iron, one which was not very brittle. Pots used for cooking had to be particularly smooth on the inside to facilitate scouring of heat-hardened food particles. This implied a fine-surfaced sand mould and casting with a free-running molten iron, clean of slag.

In our analysis of the technologies employed at Les Vieilles Forges at Saint-Maurice, this publication will put particular emphasis on the making of cast pioneer hollow ware. They were the products requiring the greatest craft skills in smelting, moulding and casting at that historic first ironworks.

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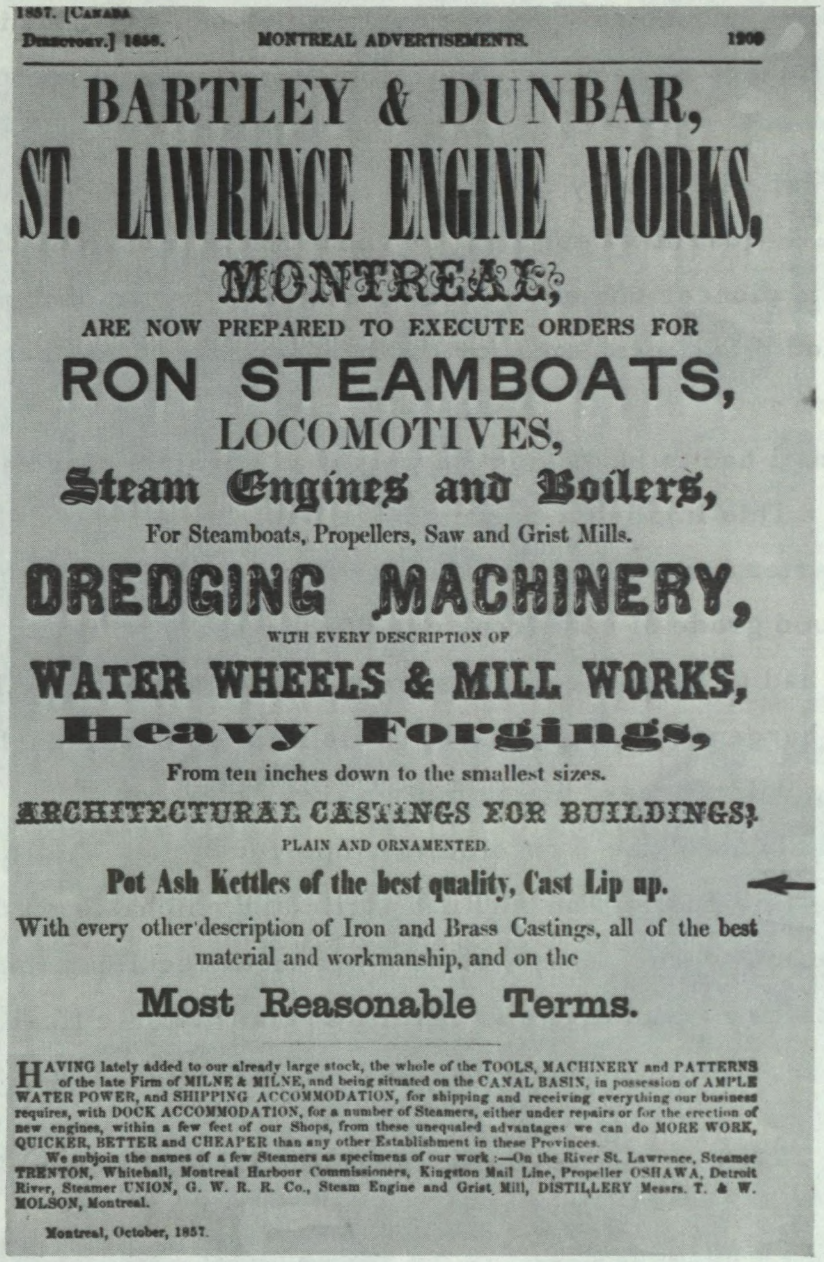

FIGURE 5: MONTREAL ADVERTISEMENT, YEAR 1857, POT ASH KETTLES CAST LIP UP

D. THE POTASH KETTLE: LARGEST CASTING MADE AT LES FORGES SAINT-MAURICE

The potash kettle shown in Figure 1 is an outstanding example of the largest type of cast iron hollow ware. It is very heavy, weighing five hundred pounds. The iron is fully an inch-and-a-half thick on the hemispherical bottom. The detailed dimensions of this unusual flared-lip vessel are shown in Figure 6.

This remarkable large casting is fully authenticated, as a product of Les Forges Saint-Maurice, by the cast-in foundry mark, F S^{t} M , clearly to be seen on the lip of the vessel (33). Castings, of any kind, bearing this historic trade mark are now exceedingly rare.

There is quite conclusive historical evidence that this particular kettle was cast at Les Forges at some time between 1835 and 1845. This evidence takes four forms: the period of settlement of the district where the kettle was found(34); the known period of use of this exact design of trade mark, F S^{t} M (35); the date of the development of the special method of moulding and casting as outlined below; and, finally, the limit set by the ending, in 1846, of any major scale of activity at Les Vieilles Forges at Saint-Maurice.

This design of potash kettle is believed to be the largest casting made in Canada before Confederation Year 1867, using iron smelted from native ore (36).

In order to appreciate the special problems of making such a large, thick-walled vessel, we must first briefly review foundry methods of moulding and casting deeply dished hollow ware shapes of all kinds (37).

For any small- or medium-size pot, such as those shown in the museum display in Figure 4, a pattern was employed of the same shape as the vessel. The moulding in damp sand was done in the 'bottom-up' posture. This was the obvious and simple way to mould any usual hollow-ware piece, so as to 'draw' the pattern and leave the required smooth impressions.

For the average domestic and barn-yard hollow ware (say up to twenty-four inches in diameter and half-inch thick), this bottom-up moulding procedure produced a perfectly adequate vessel for all the various pioneer uses of boiling liquids over open fires. However, exposure to red-heat would soon crack and destroy such relatively thin-walled vessels.

There was, in Canadian pioneer days, one major requirement for cast iron vessels of much larger diameter and greater wall-thickness and soundness of metal, so as to withstand long exposure to red-heats. Such a vessel was the potash kettle illustrated in Figures 1 and 6.

To make such a casting required vastly different procedures in the moulding shop and on the foundry floor. It necessitated the use of 'sweeps' instead of patterns. These very large vessels were cast in the 'lip-up' posture(38).

In Figure 5 is reproduced a page of advertisements from a mid-nineteenth century Canadian commercial publication, Canada Directory, 1857-1858(39). Note the item, 'Pot Ash Kettles of the best quality, Cast Lip up'.

This type of large, heavy-walled iron kettle was the major production facility employed in the pioneer backwoods pursuit of making potash alkali from hardwood ashes. The very nature of that process was such as to require a cast iron vessel of outstanding metallurgical quality.

To fully appreciate the significance of this need for a high-quality casting, the reader must first have some essential background on that early process for making potash. This is provided in Chapter II.

* * * *

Potash from Wood-Ashes

CHAPTER II

POTASH FROM WOOD-ASHES

A. POTASH AND PIONEER SETTLEMENT - A SUMMARY

The making and exporting of potash by Canadian pioneer settlements in the early nineteenth century is a phase of Canadian economic development that has been comparatively neglected by historians. At best, they devote a few brief paragraphs to the matter as an historical curiosity(1).

This early Canadian potash was a byproduct of clearing the land. The hardwood ashes from the backwoods settlers' log-pile burnings and their shanty fireplaces contained a fair proportion of soluble potassium salts. The potash was recovered by leaching these ashes with water to give a strong lye. This was then boiled down in a big iron kettle (Figure 1) to produce a very crude form of potash.

Further firing to red-heat in the same kettle refined the crude product to an acceptable potash for the overseas market. A variation in the heating procedure gave a better coloured product known as 'pearlash'(2). Both were packed, at the kettle site, into barrels and destined for shipment through the ports of Montreal and Quebec City.

The first 'potasheries', meaning a set-up of leaches and kettle, were usually operated by village merchants, though some established settlers acquired their own kettle. Newly arrived immigrant settlers merely traded the fluffy grey 'fire ashes' to the storekeeper.

There was a brisk demand for Canadian potash in Britain. In those days, wood-ashes potash was one of the world's major sources of alkali(3), an essential raw material for the making of cotton and woolen goods, soap, glass, etc. All of those industries were then experiencing phenomenal growth under the impetus of the Industrial Revolution.

The year 1850 marked the peak of the Canadian export(4) of 'Ashes, Pot and Pearl', as the official trade records called them. In that year their value was approximately $1,200,000 (5), a truly amazing sum, considering that Canada's total exports of all commodities was only $ 11,600,000. In other words, potash made from wood-ashes in the frontier backwoods, constituted over ten percent of Canada's export trade at that mid-century point, just seventeen years before Confederation - a historical curiosity? - perhaps, but by no means an insignificant item in our pre-Confederation economy.

By the 1860's radically different sources of alkali had become abundant in Europe. A process developed by the French chemist Leblanc produced soda, a competing alkali, from inexpensive raw materials. By 1830 Britain was manufacturing soda in considerable quantity (6).

In 1861 the first potash salts were recovered from deep mines in Germany (7). The world price soon fell to less than half its former figure. With this market situation and the fact that the pioneer phase in the hardwood areas of Eastern Canada was pretty well completed, our potash exports went into a rapid decline and died out completely soon after the turn of this century.

Potash making was carried on, to a greater or lesser extent, over the whole of the region broadly described as 'The Great Lakes and St. Lawrence Lowlands'. This is the area where the hardwood growth of Eastern Canada was found. It stretched in a narrow belt, seldom more than fifty miles wide, for seven hundred miles from Quebec City(8) to Lake Huron. Potash making was particularly active in the Eastern Townships of Quebec and along the Ottawa Valley(9), see map, Figure 2.

It is difficult for our generation of mid-twentieth century Canadians to realize that, when the first immigration flowed into the St. Lawrence lowlands, the greater part of the land now under cultivation was unbroken forest. For each of the immigrant settlers the immediate task at hand was the clearing of a few acres for a log shanty and some crop.

Virgin forest is not easily cleared with nothing more than a crude axe and human determination. For the great majority of those settlers, there were several years of back-breaking work before any great amount of land could be in a condition to return a crop. Often those immigrant families did not have enough food to carry them through those first hard winters.

It was, literally, nothing less than providential that the slashing and burning of the brush and the timber in clearing the land provided those settlers with their very first 'cash crop'. After carefully collecting the ashes from the burnt heaps, they carried them to the nearest merchant and his potashery in trade for bare essentials, usually flour and salt pork.

The highlight of the story of 'Potash and the Pioneers' is that it was a backwoods 'industry' which gave first subsistence employment, and hence a means of survival, to many thousands of near-destitute immigrant settlers. Its product was an important 'staple' in the struggling export trade of pre-Confederation Canada.

B. RELATION TO MODERN POTASH FROM SASKATCHEWAN MINES

The transition from wood-ashes potash of pioneer days to modern mineral potash is one of the truly 'romantic' stories occasionally found when one delves into the obscure history of early Canadian industries.

We have seen that the Canadian export trade in potash, made from wood-ashes,passed its peak in the mid-nineteenth century and eventually died out completely. Almost exactly one hundred years later, the Canadian potash industry passed through an amazing rebirth and explosive growth. The discovery, in the early 1940's of extensive underground deposits of very high-grade potash in south central Saskatchewan (some of it over one mile below the surface) has been followed by rapid development and the employment of large amounts of capital. By 1966 the annual output was valued at over sixty million dollars and constituted over twelve percent of world production of potash salts.

It is foreseen that this modern Canadian potash industry will play an increasingly important role in man's affairs on a world-wide scale. Over ninety-five percent of the world production of potash is now used in the making of fertilizers. Improvement in agriculture by the wider use of chemical fertilizers is one important approach to the awesome problem of providing an adequate food supply for the growing population in underdeveloped countries.

A student of Canadian commercial history will now realize that potash, considered simply as a commodity of world trade, has had a curious see-saw history in this country. The decade of the 1860's marked a critical milestone. The development of the first potash from deep mines took place in Germany after 1861. That spelled the 'beginning-of-the-end' of what we may well term the 'wood-ashes phase' of the industry. From a position of being one of the world's major sources of potash alkali in the 1850's, Canada soon became an importer of foreign mineral potash salts. That adverse trade situation persisted from the 1880's down to the early 1960's when Saskatchewan mineral potash became a significant export to world markets. Here we see a full circle of supply and demand in exactly one hundred years !!

It therefore seems appropriate that the decade of the 1960's, which marks a significant centenary in the overall history of potash in Canada, should be the occasion of a study, in much greater depth than heretofore, of the almost forgotten story of that pioneer potash from the backwoods of Central Canada of pre-Confederation days. It was truly the predecessor, product-wise, of one of today's industrial giants of the Canadian Mid-West.

These days, the story of modern potash from Saskatchewan mines is being recorded in full and capable manner by economists and engineers(10). So let us return, in this publication, to our study of the history of the process and equipment used in the making of the 'grand-daddy' of all Canadian potashes, that from hardwood ashes in backwoods settlements, over one hundred years ago.

C. THE POTASH KETTLE IN USE

Let us now take a harder look at just how the large, thick-walled, flared-lip kettles were used in the actual potash making (11).

The location where the operation was carried out was popularly known as a 'boiling-camp'. The kettle was mounted about two feet off the ground, on a roughly circular, crude masonry structure known as an 'arch'. This was built of flat field stones ledging under the flared lip. An opening at one side at ground level allowed for stoking with dry birch and maple logs. A vent higher up, at the opposite side, provided for smoke and a cross-draft for the fire.

As potash kettles were costly and scarce on the pioneer frontier, it was usual to operate them more or less continuously in non-freezing weather. The kettle was first filled with strong lye from the leaches (12). This was boiled down to a dark-colored residue of syrupy consistency. This was not only the potassium and other salts from the wood-ashes, but much contaminating matter, such as soil and bits of charcoal, from the rough-shod collection of the bonfire ashes and the careless operation of the crudely made leaches. This residue, very aptly, was known as 'black salts' or merely as 'salts'.

At this stage the 'salts' were ladled out into a series of smaller, thin-walled, cast iron vessels called 'coolers'. The kettle was then refilled with lye for the second batch boiling, and so on. When a full kettle-load of salts had thus been accumulated in coolers, the whole was dumped back into the kettle. The complete boiling of all the batches of lye took several days of round-the-clock operation(13).

The fire was now stoked up diligently and brought to a truly roaring condition. The bottom of the kettle and its contents were raised to a red-heat. The salts were, by now, a bubbling molten mass and all the charcoal was soon burned out of it. Much inorganic contaminant was scummed off. This 'fusion-boil' was continued until the molten mass was quiescent. This took about two hours.

Now again the coolers were brought into use. The molten potash was carefully ladled into them, after pre-heating to minimize hazards, and then allowed to cool overnight. In appearance, the finished potash resembled stone and was almost as hard. It could be broken with an axe into large chunks, which were grey on the outside and pinkish within. This was quickly packed into barrels, to minimize absorption of moisture, as the potash was exceedingly deliquescent. The barrels, each weighing about five hundred-weight (560 pounds) were the recognized form of the potash of world commerce in the early nineteenth century.

D. THE RIGOROUS PROCESS ENVIRONMENT

Let us now review the engineering aspects of the iron kettle, as it was employed in the backwoods potashery. There are four significant points:

1. The kettle and contents were subjected to heating and cooling through a wide range of temperatures. These were from about 240°F (boiling concentrated lye) to over 1100°F (red-hot fused potash)(14). Each cycle lasted several days and was repeated thirty to forty times each summer season, during the first settlement of the locality, say five to ten years.

2. The maximum temperature to which the hemispherical bottom of the kettle was subjected, in the combustion space, during the final 'fusion-boil', exceeded the metallurgical critical temperature of 1330°F. (approximately cherry-red). At that temperature serious permanent change takes place in the iron-carbon matrix of all cast irons; see photomicrographs, Figure 9.

3. The kettle was subjected to rigorous corrosion conditions. These were: internally, fused caustic alkali; and externally, a vigorous fire of hardwood logs, which caused an atmosphere with a high concentration of carbon dioxide.

4. Being of very cumbersome shape and weight, the kettle was doubtless subjected to considerable rough handling during its lifetime. It had to be transported some hundreds of miles from the foundry to the backwoods potashery (upside-down on a sled over the snow was the usual way), and then set on the stone arch. For a cast iron vessel, all this implies the need for a tough grey iron with excellent resistance to shock; i.e. something that would unlikely be fractured by anything less than a blow from a sledge hammer(15).

* * * *

E. THE SAINT-MAURICE KETTLE AT SUTTON, QUEBEC

Now that the reader has this background on the making of potash from wood-ashes, let us return to specific consideration of the authenticated Forges Saint-Maurice kettle shown in Figure 1 (16).

This is the author's prized possession and nowadays, having graduated from the role of 'essential pioneer utensil' to that of 'historical curiosity' (17), it serves as a lawn ornament at our home in the town of Sutton, Brome County, in the Eastern Townships of Quebec; see map, Figure 2.

This kettle, as will be seen from the photograph in Figure 1, is still in excellent condition. All surfaces, naturally, show some corrosion, a dark brown rusting, from over one hundred years of exposure to the elements. Most of that time was, I suspect, spent in the remote pasture where, abandoned, it was my good fortune to find it, some thirty years ago(18). This surface corrosion is a thin film and does not take the form of extensive pitting or scaling, such as accompanies deep rust penetration.

It seemed a reasonable conclusion that my 'big iron kettle' (as my neighbors call it) had survived a lifetime that included the rigorous corrosion, heat shock and rough handling of a frontier backwoods potashery. However, by way of verification, there appeared to be three questions needing to be answered:

1. Could it be established, by some scientific tests on the iron, that this particular kettle had indeed been used for making potash from wood-ashes?
2. Metallurgically speaking, what is so special about the iron from which this Forges Saint-Maurice kettle was cast?
3. How could Canada's historic first ironworks, Les Vieilles Forges at Saint-Maurice, with its small, old-style, charcoal-fired blast furnace, have cast this remarkable large vessel, which has survived, in such excellent condition, despite its rigorous service in a backwoods potashery?

Because the recorded details of ironworks technologies in early Canada are so very meagre, does the history of charcoal-fired blast furnaces and cast iron foundry practice in other countries assist in finding logical answers to these questions?

Similarly, can a study of the evolution of modern foundry practice, for making large cast iron vessels for chemical processing at red-heat temperatures, throw any light on how a high-quality potash kettle must have been made over one hundred years ago?

A search for answers to the first two questions is, obviously, in the realm of scientific metallurgy. For the third question, any significant conclusions must be arrived at from a study of the history of technology of charcoal-iron smelting and cast iron foundry practice.

The balance of this publication will be devoted to an outline of the author's answers to those three questions.

For outstanding assistance in this search for information, I have been fortunate in enlisting the interest and co-operation of two organizations, which are known world-wide, each in its own field - a metallurgical research laboratory (19), and a manufacturer of modern cast iron chemical processing equipment (20).

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Scientific Investigation of Kettle Iron

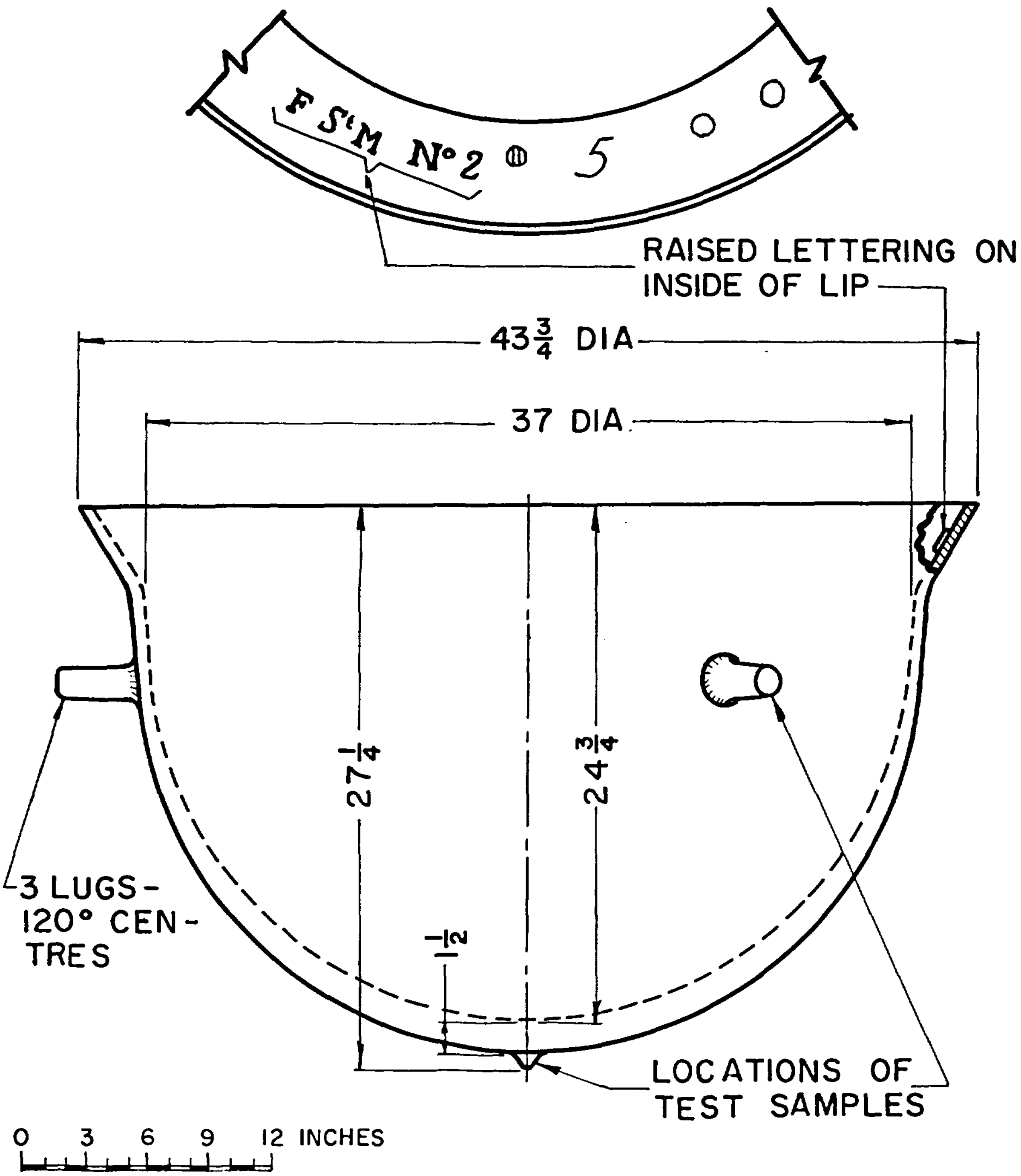


FIGURE 6: DIMENSIONS OF POTASH KETTLE AND LOCATIONS OF METALLURGICAL TEST SAMPLES

CHAPTER III

SCIENTIFIC INVESTIGATION OF KETTLE IRON

A. MINES BRANCH RESEARCH PROGRAM

A scientific investigation was undertaken by the Physical Metallurgy Division of the Mines Branch, in Ottawa (1), to provide clear answers to the first two problems posed on page 21.

Two series of tests were carried out in the years 1965 and 1966 (2). For these, test samples were hacksawn by the author from the potash kettle at Sutton, Quebec. The exact location of these samples is shown on the sketch of the kettle in Figure 6.

The first series of tests (3) at the Mines Branch laboratories were designed to clearly define the chemical and metallurgical qualities of the iron in the 'as-cast' condition. For this it was essential to choose a sample from a part of the kettle which would have received a minimum of heating in the potash-making process; see Chapter II, Section D. The sample was therefore cut from the end of one of the side lugs. These were normally embedded in the masonry of the supporting arch and thus well out of the combustion space.

The second series of tests (4) were designed to disclose the metallurgical condition of the iron in an area which would receive maximum heating during the process of making potash, thereby establishing whether the kettle at Sutton, Quebec, had been extensively used in this pioneer backwoods pursuit.

For these tests a sample was taken from the conical-shaped boss which projects from the exact center of the bottom of the kettle; see Figure 7. This was the hottest spot in the combustion space. From its shape and precise location, this boss is identified (5) as a 'remnant' from the use of a spindle in 'strickling' (sweeping) the mould. This is an essential feature of the highly skilled craft of loam-moulding any large vessel in the 'lip-up posture'(6).

It is quite surprising to find how minor is the increase in corrosion from the process firing against the kettle bottom (Figure 7).

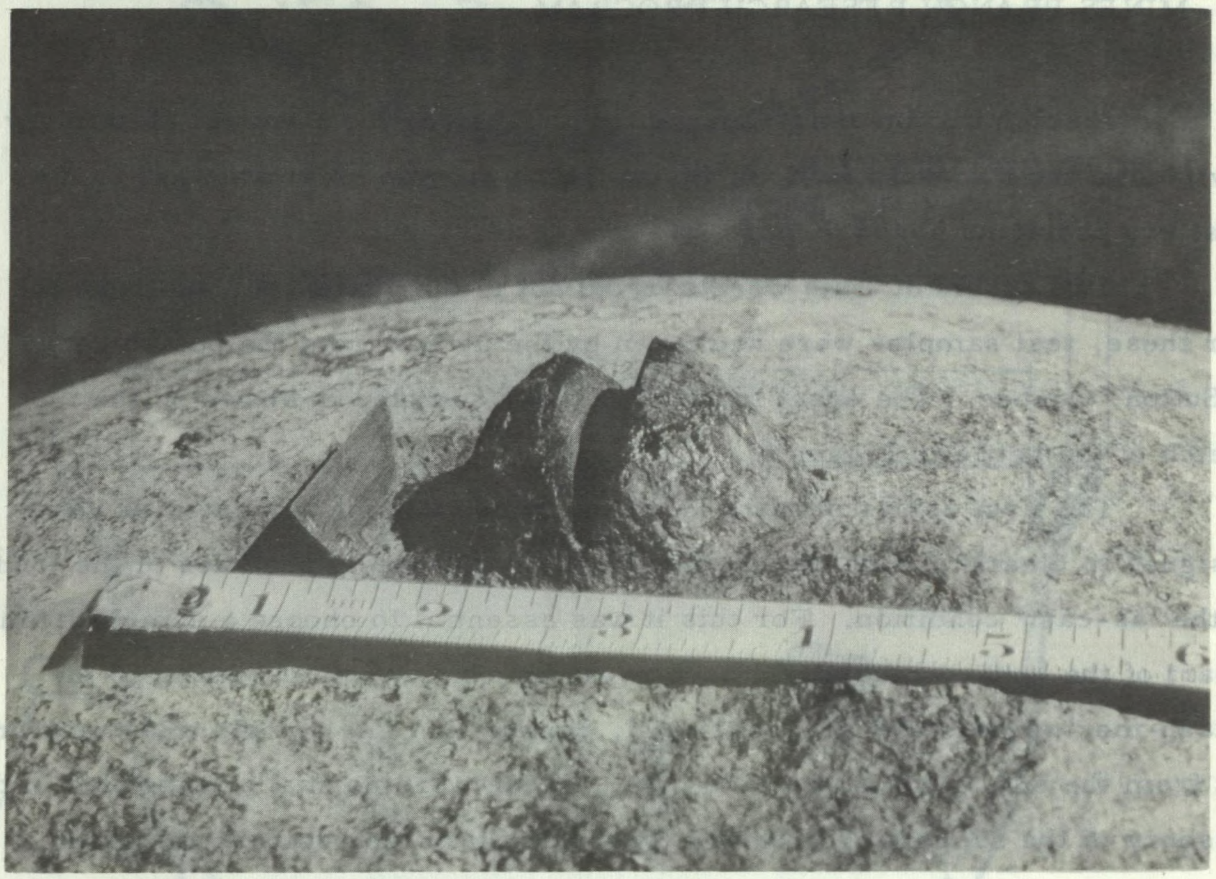


FIGURE 7: MOULDED BOSS ON KETTLE BOTTOM WITH SAMPLE REMOVED

See nature of corrosion from process heating.

B. REPORT OF TESTS ON IRON IN AS-CAST CONDITION(3)

Metallographic examination of a transverse section through the kettle lug shows a microstructure as illustrated in Figure 8. Samples were made up according to standard procedure for mounting, polishing and etching.

The hardness of the sample was B-89 (BHN-180). A chemical analysis is shown in Table I.

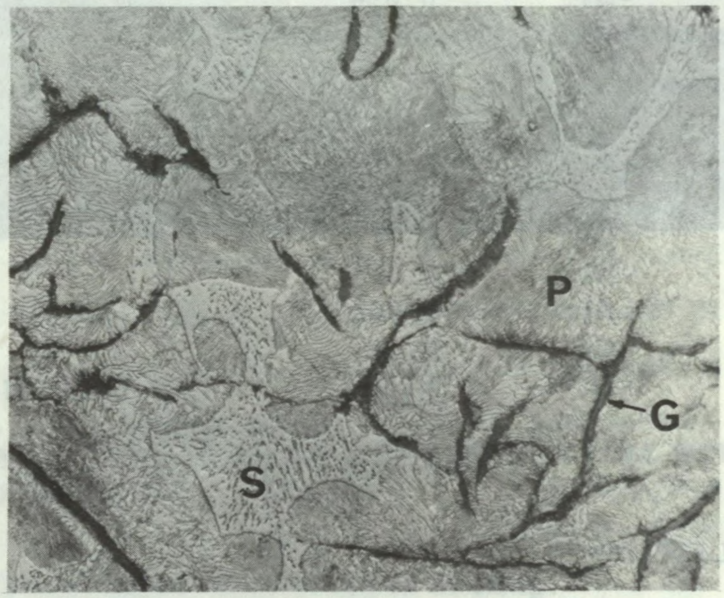
TABLE I

Element		Percent		Modern Comparison
CARBON	-C-			Class 25
Graphitic		2.85		Grey Iron (7)
Combined		0.82		
Total			3.67	3.00-3.30
USUAL IMPURITIES				
Silicon	-Si	1.15		1.90-2.20
Phosphorus	-P	0.41		0.15-0.25
Manganese	-Mn	0.23		0.50-0.80
Sulphur	-S	0.054		0.08-0.12
			1.844	
TRACE IMPURITIES*				-------------
Titanium	-Ti	0.03		
Cobalt	-Co	0.004		
Molybdenum	-Mo	< 0.01		
Copper	-Cu	< 0.01		
Nickel	-Ni	< 0.01		
Aluminum	-Al	< 0.002		
Chromium	-Cr	N. D.		
Tin	-Sn	N. D.		N. D. =Not Detected
			0.046 approx.	
IRON - Balance;			94.44	
CARBON EQUIVALENT:**			4.19	

* Millings from the sample were analysed by the wet chemical method

** i.e. - Total Carbon + 1/3 (% Si. + %P.) A formula used by metallurgists to co-relate with mechanical properties.

MAGNIFICATION - 100 TIMES



MAGNIFICATION - 500 TIMES

FIGURE 8: PHOTOMICROGRAPHS OF KETTLE IRON, AS CAST

LABORATORY CONCLUSIONS ON AS-CAST METAL(3)

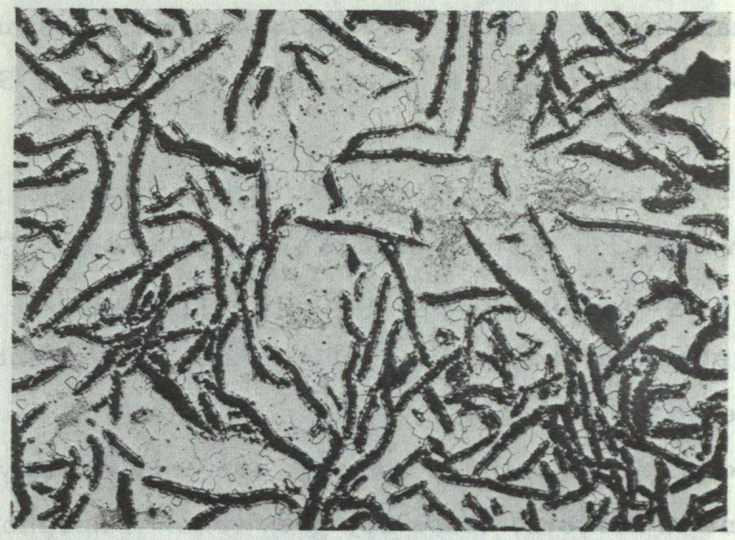
This potash kettle casting corresponds in hardness and microstructure to a modern high-quality, class 25, pearlitic grey iron of A.S.T.M. Specification A-48-64.

The microstructure consists of uniformly dispersed graphite flakes (G in Figure 8) in a matrix of fine pearlite (P in Figure 8). Considerable phosphorus-rich eutectic (steadite) is visible (S in Figure 8). No ferrite is visible. This is obviously a structure that has not been affected by prolonged heating in service.

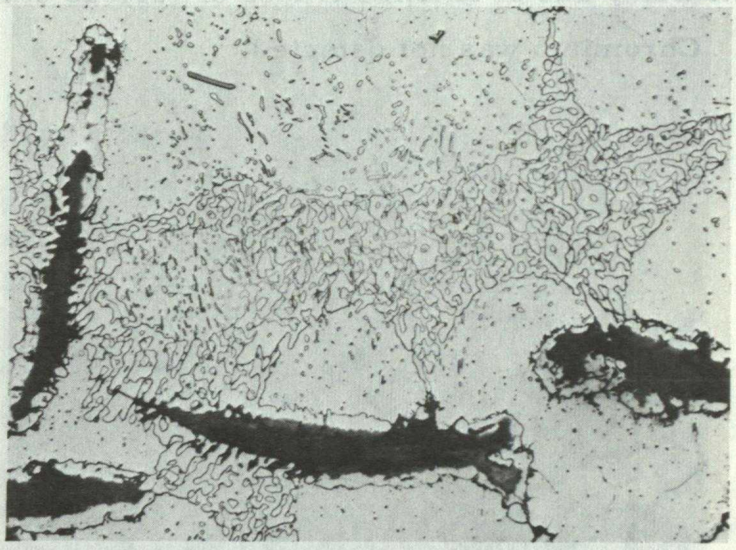
The silicon and manganese contents are considerably lower than those usually found in modern, class 25, grey iron. Phosphorus is slightly above the range of modern practice for castings of over one-inch thickness. Sulphur content is low. The low manganese appears to have been sufficient to combine with the relatively low sulphur.

The residual-element content is characterized by the presence of a strong trace of titanium, and of smaller traces of various other elements as shown in Table I. Chromium was not detected.

* * * *



MAGNIFICATION - 100 TIMES



MAGNIFICATION - 500 TIMES

FIGURE 9: PHOTOMICROGRAPHS OF KETTLE IRON AFTER PROCESS HEATING

C. REPORT OF TESTS ON PROCESS-HEATED METAL (3)

A check chemical analysis on the sample from the boss on the bottom of the kettle (Figure 7) showed silicon 1.04%, similar to the as-cast condition. The hardness of the boss sample was found to be Rockwell B-77 (BHN-140).

Metallographic examination reveals a microstructure as in Figure 9.

LABORATORY CONCLUSIONS ON PROCESS-HEATED METAL

The appearance of the photomicrographs of the bottom boss clearly establishes that this part of the potash kettle has been subjected to prolonged heating at high temperatures.

The maximum service condition has likely been above the critical temperature of 1330°F (cherry red), although similar decarburization might be obtained by heating for long periods at lower temperature in the range 1000 (dull red) to 1330°F.

The boss iron is now very soft, having decreased from BHN-180 to BHN-140 after service heating.

The evidence of oxidation of the graphite-metal interface and the coalescence of the phosphide eutectic are consistent with firing at temperatures similar to those experienced by cast iron furnace grates; see appearance of kettle bottom after firing in Figure 7.

* * * *

These Research Laboratory conclusions confirm the author's contention that the Forges Saint-Maurice potash kettle, now at Sutton, Quebec, had been extensively used in the pioneer pursuit of making potash from wood-ashes.

* * * *

Charcoal Iron Technology

CHAPTER IV

CHARCOAL IRON TECHNOLOGY

A. THE IMPORTANCE OF PURE ORE

The scientific investigation of the iron in the Saint-Maurice potash kettle, as outlined in Chapter III, has provided us with much basic knowledge. As a result, we can now study the history of charcoal-iron smelting and of Les Forges Saint-Maurice operations in particular, with a much clearer understanding of the significance of the technologies employed.

We have seen (Chapter I, Section C) that many iron castings, which were necessities in Canadian pioneer homes (stoves, hollow ware), were made at Les Vieilles Forges at Saint-Maurice by the 'furnace-metal-cast' procedure, i.e. with molten iron taken from the charcoal-fired blast furnace and poured directly into sand moulds(1).

It was a fundamental fact of life of all such early charcoal ironworks that their cast products could be no better than the raw materials they found ready at hand, plus the craft skills of the ironworkers in the operation of the blast furnace and the moulding shop.

All the usual impurities in cast iron (Table I) have their source in the ore, in the fuel used in the blast furnace and, only rarely, the limestone flux. Generally speaking, the lower the impurities the better the quality of the castings.

Charcoal is inherently a 'clean' fuel for smelting iron ore. There are very small amounts of sulphur and phosphorus which are harmful and often called the embrittlement impurities. The ash from the charcoal was highly alkaline and such an excellent flux that only a small amount of limestone had to be added to the furnace charge.

Thus we can see that the 'purity' of a cast iron, made by the 'furnace-metal-cast' procedure, with molten iron from a charcoal-fired blast furnace would depend, almost exclusively, on the purity of the ore that was used (2).

B. THE ORE AT SAINT-MAURICE

At Canada's historic first ironworks, Les Forges Saint-Maurice, the ore is known to have been of very high quality. For information on this we are fortunate to have the personal observations of a very capable scientist(3). The following is a quote from the official report of his visit to Les Forges in the summer of 1873:

"The ore is entirely the bog ore of the region(4); a specimen was selected from a pile which had been taken from a bed two feet thick and underlying three feet of peat. This ore is partly compact, partly ochreous and of dark brown color. The results of an analysis show it to be exceedingly pure ore:

peroxide of iron	69.64 percent	
protoxide of iron	7.25	
protoxide of manganese	0.05	
alumina	0.90	
lime	0.53	
magnesia	traces	
phosphoric acid	traces	
sulphuric acid	0.05	
silica	1.93	
water and organic matter	22.04	102.39
metallic iron		54.27".

Despite the lesser accuracy of all laboratory test methods in the 1870's, the same relative absence of harmful impurities is clearly apparent in this ore analysis, as was disclosed by the modern analysis of the iron in the potash kettle (Table I).

* * * *

C. THE SCIENCE OF METALLURGY AND EARLY CHARCOAL IRONWORKS(5)

The laboratory tests on the iron in the potash kettle have established that it is a high-quality grey iron, having a comparatively low silicon content, approximating one percent (1.0%). From its present excellent physical condition and its life history we know that this very large piece of pioneer hollow ware has outstanding resistance to corrosion and high temperatures.

It is obvious therefore that the ironmaster and his men, who operated the blast furnace, the moulding shop and the foundry at Les Forges Saint-Maurice, were skilled in the craft of making high-quality castings from the very pure raw materials they found nearby. In other words, they were well versed in the 'how' of that craft.

The fact was, however, they could only have the vaguest notion of the 'why' of the matter. For the practical foundryman, any reasoned explanation of the effect of various impurities on the iron in his castings, i.e. the science of metallurgy, was practically unknown until the second half of last century.

This was particularly true of the importance of limiting the silicon content to improve the properties of iron castings for difficult applications. Practical foundrymen were just beginning to appreciate the role of silicon by the decade of the 1860's (6). By that time Les Forges Saint-Maurice was a full generation past its nineteenth century heyday and periodically closed down by its financial and raw-material supply problems (7).

As regards silicon, the old-time ironmaster had certain inherent advantages working in his favour. The lesser height and lower operating temperature of old-style, cold-blast, charcoal-fired furnaces, when employing bog-iron ore containing little gangue (sand and rock matter), all tended to give less absorption of silicon during the smelting. This is in distinct contrast to the greater silicon which is inevitable in large modern blast furnaces using ore from mines and fired by coke fuel.

Modern metallurgical science now tells us that, given a low level of other impurities, then the silicon content is the most important factor in determining the quality of an iron casting. To metallurgists, 'quality' in this sense, means the form and distribution of the carbon present in the iron, as evidenced by microscopic examination.

The photomicrographs of the structure of the 'as-cast' iron in the potash kettle (Figure 8) clearly shows 'uniformly dispersed graphite flakes in a matrix of fine pearlite'. Such a grey iron casting not only has fine mechanical properties (resistance to shock, machinability, etc.), but also has outstanding resistance to corrosion and to the destructive effects of long exposure at elevated temperatures (red heat); see Chapter V for elaboration.

D. COMPARISON WITH HISTORIC CHARCOAL IRONS FROM OTHER COUNTRIES

It is not surprising that an investigation of Canada's historic first iron castings should have aroused curiosity about what is known of the compositions of historic charcoal irons from other countries(8).

In Table II is recorded such information as I have been able to locate, in English language publications(9), on the compositions of historic cast irons from Sweden, Britain and Early America (Columns I, II and III). The composition of the iron in the Saint-Maurice potash kettle is given in Column IV. Note the low level of harmful impurities in these historic charcoal irons from all four countries. (See Chapter V for discussion of heat-resisting properties and comparison with modern metallurgical practice.)

* * * *

TABLE II

COMPARISON OF HISTORIC CHARCOAL IRONS FROM VARIOUS COUNTRIES AND MODERN HEAT-RESISTANT PEARLITIC GREY IRON

		HISTORIC				MODERN
		SWEDEN $F^{L}M$	BRITAIN Sussex	EARLY AMERICA Salisbury	CANADA F S^{t} M	A. S. T. M. A-319-53 Class I
		I (10)	II (11)	III (12)	IV (13)	V (14)
Carbon	- C					
Graphitic		3.22	2.89	N. S.**	2.85	N. S.
Combined		0.33	0.32	N. S.	0.82	N. S.
Total		3.55	3.21	N. S.	3.67	3.50 min.
Silicon	- Si	1.25	0.62	0.90-1.35	1.15	0.90-2.10
Phosphorus	- P	0.08	0.56	0.19-0.28	0.41	0.60 max.
Manganese	- Mn	0.19	0.77	0.70-1.00	0.23	N. S.
Sulphur	- S	0.04	0.08	0.03	0.054	0.12 max.
Carbon Equivalent*		3.99	3.59	N. S.	4.19	3.81-4.40

* Carbon Equivalent = Total Carbon + 1/3 (%Si. + %P.); this formula is used by metallurgists to co-relate with mechanical properties.

**N. S. =Not Specified.

Cast Iron Vessels for Use at High Temperatures

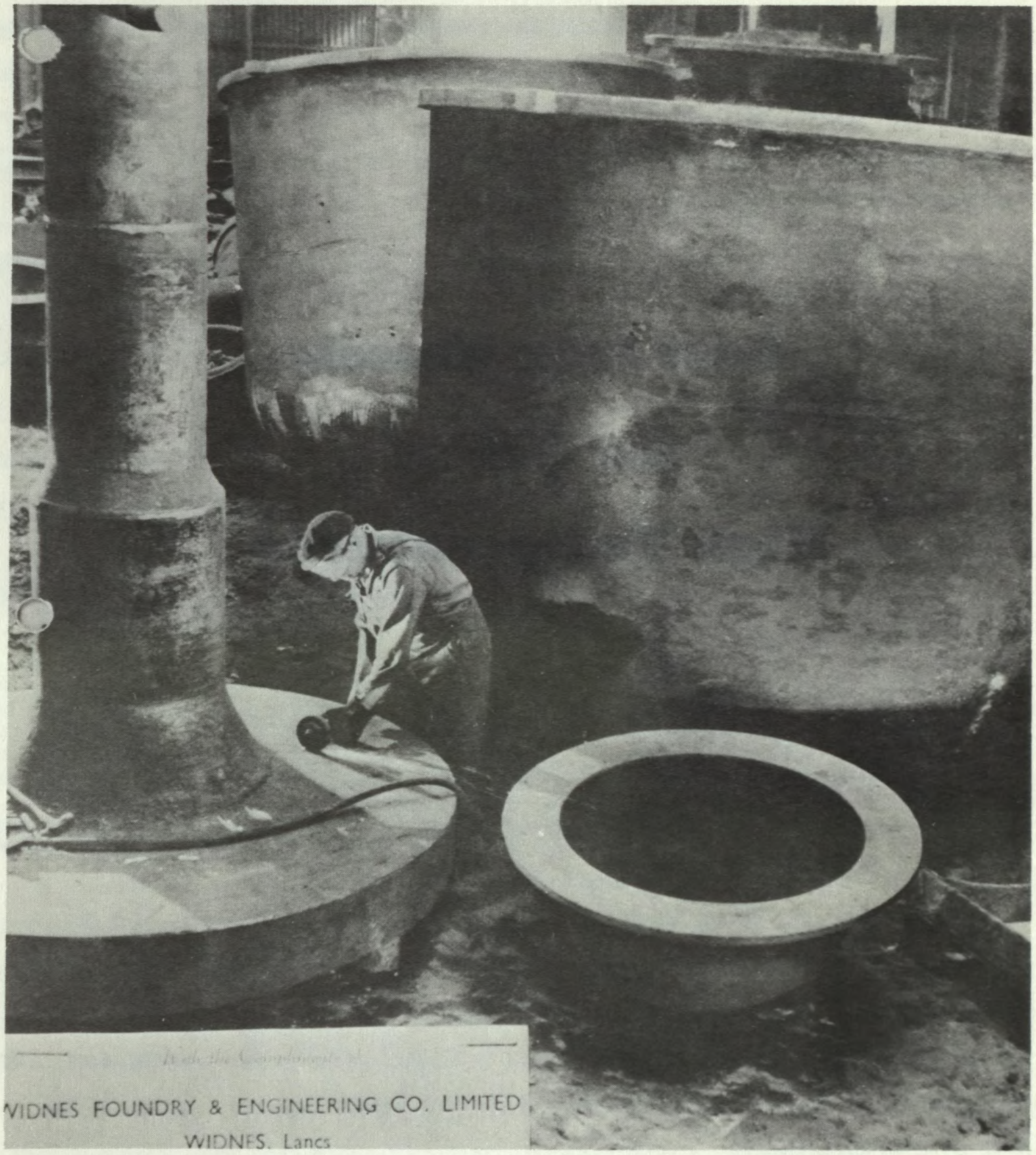


FIGURE 10: LARGE AND SMALL CHEMICAL PROCESSING VESSELS AT MODERN FOUNDRY, 1962

CHAPTER V

CAST IRON VESSELS FOR USE AT HIGH TEMPERATURES

A. ENGINEERING REQUIREMENTS

In modern chemical processing industries, many huge vessels are required with resistance to elevated temperatures (red heats). Cast iron, widely used by chemists for centuries, is still the most versatile material for such rigorous applications. See Figure 10. Today, cast irons for such service conditions are often alloyed with chromium, nickel, etc. This has been a metallurgical development of only the last forty years or so. However, high-quality, low-impurity, un-alloyed pearlitic grey iron tenaciously continues to hold a definite place in the making of large cast iron vessels for high-temperature applications (1).

For such rigorous service, a silicon content of one per cent (1.0%), in un-alloyed iron castings, is considered just about ideal, in today's foundry practice (2) for a vessel of the general proportions of our century-old potash kettle: i.e. relatively heavy wall section of fully an inch-and-a-half at the bottom; see Figure 6.

Long exposure to elevated temperatures (red heats) has a destructive effect on cast irons. Only careful choice of metal composition can minimize the phenomenon of 'growth' and the resulting cracking and general deterioration of the casting (3). For this reason, industry's requirements for cast irons for high-temperature services have been translated into an American Society for Testing Materials (A. S. T. M.) specification for the guidance of equipment users and manufacturers. This was adopted in the year 1953 and covers both alloy cast irons and un-alloyed pearlitic grey irons. The following is a summary of this specification, A. S. T. M. A-319-53, which lists ranges for carbon, carbon equivalent and usual impurities (Column V, Table II):

Grey iron castings for elevated temperatures for non-pressure containing parts; Class I is defined as 'Possessing superior resistance to thermal shock'. Castings exposed to temperatures encountered in such service as grate bars, stoker links, stoker parts, oil-still furnace parts, firebox parts, ingot moulds, glass moulds, caustic pots and metal-melting pots.

B. THE SAINT-MAURICE KETTLE ACCOMPLISHMENT - LONG LIFE DESPITE USE AT RED HEATS

Although some simple hack-saw tests had suggested that my Saint-Maurice potash kettle was an excellent grey iron, the final reports from the Mines Branch Research Laboratories were indeed a surprise, see Chapter III. I was amazed to find that, in every single respect, the composition of the iron in this kettle falls within Class I of the modern engineering specificiation for cast irons for use at elevated temperatures. This can be clearly seen by comparing Columns IV and V in Table II.

It is also significant that the high-quality Swedish pig iron of the year 1885 (Column I, Table II) fully meets this same modern specification (4).

The implication of all this is quite startling, at least in terms of the history of technologies of the early iron industry in Canada.

It is thus disclosed that the Iron-Master at Canada's Historic First Ironworks had produced, fully 125 years ago, a cast iron vessel for making potash from wood-ashes (a corrosive, high-temperature refining process); which vessel is now found to fully meet an exacting modern specification adopted by American metallurgists in the year 1953 (5). Furthermore, that feat was accomplished with nothing more than the very pure raw materials found nearby and the craft skills of the men at the blast furnace and in the moulding shop.

We engineers in this mid-twentieth century, with all our metallurgical knowledge and scientific facilities for research and process control, may well take off our hats in silent tribute to that anonymous Iron-Master of pre-Confederation days at Les Forges Saint-Maurice !!

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Quality of Iron from Les Forges Saint-Maurice

CHAPTER VI

QUALITY OF IRON FROM LES FORGES SAINT-MAURICE

A. RECORDED HISTORICAL EVIDENCE

A careful reading of the history of pioneer times in Canada, in both the French and English Colonial Regimes, discloses some specific references to 'quality' of the iron made at Les Forges Saint-Maurice.

To understand these comments we must first appreciate one basic fact. Before the days of scientific metallurgy (roughly the latter part of the nineteenth century), observers of the quality of the products of contemporary ironworks had only one way of making a meaningful appraisal. This was to make a performance comparison, in very general terms, with recognized high-quality irons from other countries, particularly the iron from Sweden, which was the world's accepted standard of excellence for several hundred years (1).

The following six historical references are particularly significant for our study of the quality of the iron made at Canada's historic first ironworks - Les Forges Saint-Maurice (2).

Year:

1731 - Marquis de Beauharnois (In the days of, as Governor of New France)(3):

"Le fer - - - fut jugé excellent. Il avait la qualité du fer de Suède qui forgeait facilement et celle du fer d'Espagne, qui etait très doux battu à froid. - - - On en envoya, aussi des morceaux en France".

(author's translation). The iron was considered to be excellent, having the qualities of Swedish iron, which is readily forged and of Spanish iron, which is malleable when worked cold. Furthermore, samples were sent to France.

1749 - Peter Kalm (4):

"The iron which is here made was to me described as soft, pliable and tough and is said to have the quality of not being attacked by rust as easily as other irons".

1763 - Colonel R. Burton (5):

"The iron made from this ore is so excellent in quality that in the late trial, made by order of His Excellency, General Amherst, it was found greatly superior to any made in America and even exceeds that imported from Sweden".

1808 - John Lambert (6):

"The Saint-Maurice iron has a reputation of being equal, if not superior, to the best that is produced in Sweden; it is extremely malleable and rusts very little. The Canadians prefer it to all other irons".

1830 - Robert Sellar (Quoting John Symons, pioneer settler in Chateaugay, Eastern Townships of Quebec) (7):

"I was most anxious to get a kettle and begin making potash - - - - - a Three Rivers kettle, which are the best, for they are thickest at the bottom".

1873 - J. B. Harrington (8):

"Nearly all the iron produced is sent to Montreal and there manufactured into car wheels, although formerly it was made into castings on the spot".

The reader will note the continued awareness of outstanding qualities in the Saint-Maurice iron. It is emphasized in all these comments, ranging over almost a century-and-a-half of settlement days in this country, from 1731 to 1873.

One might be inclined to discount these comparisons, with 'the best Swedish iron', as being merely over-enthusiasms for the local product. However, the modern scientific investigation of Canada's first iron castings, as reported in this publication, rather tends to confirm these historic enthusiasms; see Chapter V, Section B.

B. SUMMARY OF NEW EVIDENCE AND CONCLUSIONS

This publication has followed the Forges Saint-Maurice potash kettle through the history of its use in pioneer times and its scientific investigation in modern times. In this narrative, it has been the author's purpose to spotlight, for historians and for engineers, the several pieces of evidence which throw new light on the remarkable quality of the cast iron products of Les Forges. On concluding, let us summarize the five points of evidence:

1. The written history of a century and a half at Les Forges Saint-Maurice provides impressive comments about the high quality of the ore and of the iron (Chapter VI, Section A).

2. A potash kettle, weighing five hundred pounds, the largest cast product of Les Forges, is still in excellent condition after 125 years. In its early days it was exposed to the corrosion and heat shock of a red-heat fusion process for making potash from wood-ashes (Chapter II, Section D and Figure 1).

3. Recent scientific tests show the metal in this potash kettle to be a high-quality pearlitic grey iron, with micro-structure comparable to the best modern cast irons for making machinery parts (Chapter III, Section B).

4. The chemical composition of the iron in this kettle is found to have the same general low level of harmful impurities as historic charcoal irons from Sweden, Britain and Early America (Chapter IV, Section D).

5. Using the very pure bog-iron ore found nearby and having only the empirical craft skills of 125 years ago, at a cold-blast charcoal-fired blast furnace, Les Vieilles Forges at Saint-Maurice produced a low-impurity iron containing one per cent (1.0%) silicon.

This composition makes an ideal thick-walled vessel for operation at red-heat temperatures. It is still the basis for modern foundry practice for huge cast iron vessels for chemical processing (Chapter V and Figure 10).

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Notes to the Text

and

Bibliography

NOTES TO THE TEXT AND BIBLIOGRAPHY

CHAPTER I

LES FORGES SAINT-MAURICE

1. It seems particularly appropriate that Canada's historic first ironworks, founded in the days of New France, shall continue to be identified by its original name, 'Les Forges Saint-Maurice', in all historical writings in both the French and the English languages.

In this publication, the author will frequently adopt the local custom of today's citizens of Trois-Rivières and refer simply to 'Les Forges' or 'Les Vieilles Forges'.

Care must be taken to distinguish between the French term 'Les Forges' and the English word 'Forge' (blacksmithing).

In French historical writings, 'Les Forges' has a very broad meaning. It signifies a complete ironworks establishment. This included the blast furnace (haut fourneau) as well as the foundry and pattern shop and all the facilities for re-heating pig iron and hammering out wrought iron bars. Usually the term also included the associated ore collection, charcoal burning, storehouses, workmen's quarters, etc., i.e. the whole pioneer industrial community.

2. The cover illustration reproduces an early etching showing the tapping of molten iron from the blast furnace at Les Forges Saint-Maurice.

Authentic contemporary illustrations showing any structural and technical detail at Les Forges are quite rare. This view of the arched base of the furnace is probably very accurate because of the time and circumstances of its first publication.

The artist was L.R. O'Brien R.C.A., one of the founders and the First President (1880-1890) of The Royal Canadian Academy of Arts. O'Brien was outstanding in his portrayal of exact structural detail of what he observed, having been trained, in his younger days, as an architect and civil engineer.

This etching was first published in 1882, just one year before the ironworks was abandoned: This was in Picturesque Canada, G.M. Grant, Editor, Vol. 1, p. 97. In later years it was a favorite illustration in historical works on Les Forges Saint-Maurice.

3. Joseph-Noel Fauteux, Essai sur L'Industrie au Canada sous Le Régime Français , Quebec, 1927, I, 55-124; Benjamin Sulte, annotées et publiées par Gérard Malchelosse, Les Forges Saint-Maurice, Mélanges Historique, Vol. 6, Montreal, 1920; Albert Tessier, Les Forges Saint-Maurice, 1729-1883, Trois-Rivières, 1952; and some early issues of Bulletin des Recherches Historiques, Vol. X (1909), pp. 318-9; Vol. XXIII (1917), pp. 287-8; Vol. XXIV (1918), pp. 257-269.

Other writings are: Dollard Dubé, Les Vieilles Forges, Il y a 60 Ans, Trois-Rivières, 1933; Albert Tessier, Aux Sources de L'Industrie Américaine, Les Vieilles Forges, Les Cahiers Reflets, Trois-Rivières, 1945; Albert Tessier, "Les Trifluviens S'Échauffent Le Dernier Demi-Siècle des Forges, 1833-1883", Les Cahiers Des Dix, Montreal, 1950, numero quinze, pp. 163-183; and N. LeVasseur, "Mines de Marais et les Anciennes Forges de Radnor", Bulletin de la Société de Géographie de Québec, Vol. 5, No. 3 (1911) pp. 185-192.

4. Joseph Bouchette (Surveyor-General), A Topographical Dictionary of The Province of Lower Canada, London, 1832 (pages are un-numbered, localities being listed alphabetically; detail on Les Forges is given under "St. Maurice seigniory" and also under "St. Etienne fief"); G.H. Macaulay, "The Iron Mines of the St. Maurice Territory", British Canadian Review, Vol. I (1863), No. 2, pp. 42-52 and No. 3, pp. 95-103; B.J. Harrington, "Notes on The Iron Ores of Canada and Their Development", Geological Survey of Canada, Report of Progress, 1873-74, Ottawa, 1874, pp. 234 and 247; James Bartlett, "The Manufacture of Iron in Canada", Transactions of the American Institute of Mining Engineers, XIV (1885-86), 508-542; F.C. Wurtele, "Historical Record of The St. Maurice Forges", Proceedings and Transactions of The Royal Society of Canada, 1886, IV, Section II, 77-89; and James M. Swank, "The First Ironworks in Canada" (this is a short chapter, XL, pp. 348-51, of Swank's outstanding reference text, The History of The

Manufacture of Iron in All Ages, 2nd ed.), Philadelphia, 1892; Leland H. Ausman, "The St. Maurice Forges" (this is an unpublished thesis (1929), Department of Commerce and Finance, University of Toronto, typescript, 109 pages, available only at the University Library, which provides a useful summary, in English, of the earliest French-language histories of Les Forges Saint-Maurice. See also records of early travellers in Canada; Peter Kalm and John Lambert, as outlined in Notes 4 and 6 of Chapter VI.

5. La Chambre de Commerce, Trois-Rivières, actively encourages interest in the history of Les Forges Saint-Maurice. Their brochure (out of print), Projet de Reconstruction, Les Forges Saint-Maurice, 1729-1883, 1963 (bilingual text), includes much valuable detail on the plan of the site as it was believed to be during the years immediately preceding the shut-down in 1883.

The proposal of La Chambre for restoration on the site, along with a brief review of the history of the enterprise, was reported to the Montreal Meeting of the American Foundrymen's Society in 1965, by J. Robert Loranger, Chairman of the Committee of La Chambre. It was printed in the program of that meeting.

6. For the past three summers, archeological teams of the Quebec Department of Cultural Affairs have been doing significant work on the site, which was acquired, a few years ago, by the Quebec Historical Monuments Commission.

Feature articles reporting on the progress of the archeological restorations appear in the local press and subsequently are often reprinted for a wider audience; e.g. see - Le Nouvelliste, Trois-Rivières, September 27, 1967.

7. For providing visits to these localities and for a fine general review of the history of the Region, the author wishes to express his appreciation of the help of Jacques Lacoursière, Professeur-Archiviste at Séminaire St. Joseph de Trois-Rivières. That institution has a fine collection of historical records and artifacts.

8. See especially: Fauteux, p. 112, Sulte, p. 117, and Tessier, p. 89 (Note 3 above).

9. One of those 'romantic' episodes which seem to capture the imagination of political historians were the viscissitudes of Les Forges Saint-Maurice during the invasion of the St. Lawrence Valley and the occupation of the Village of Trois-Rivières by the Revolutionary Army in the year 1775. One of the current partners of the enterprise was an American sympathizer and supplied them with cast iron shells. When the Army retired south after the abortive campaign, that enterprising individual fled the country. See Sulte, p. 148, and Wurtele, p. 85 (Notes 3 and 4 above).

10. Mathew Bell appears to have been a very remarkable man. We run across the trail of his wide-ranging, financial, political and social sctivities in the scattered writings on the history of Les Forges Saint-Maurice; see Notes 3 and 4 above; see also Merrill Denison, <u>Canada's First Bank,</u> Montreal, 1966, pp. 27, 229.

11. See Lambert, p. 486, per Note 6 of Chapter VI.

12. Canada's first ironworks at Saint-Maurice is the best known pioneer Canadian metal-working industry of the period before the year 1850. However, in the areas then known as Upper and Lower Canada, there were other efforts at smelting local ores with charcoal fuel. The earliest appears to have been in the year 1798 at Batiscan (between Quebec and Trois-Rivières). None of these attained any scale of production comparable with Les Forges Saint-Maurice. Many of them were short-lived and commercially unsuccessful. In this publication space limits us to merely indicating the best sources of information on all the other early Canadian charcoal ironworks:

See: W. J. Patterson, 'The Long Point Furnace', <u>Papers and Records of The Ontario Historical Society</u>, XXXVI, Toronto, 1944, pp. 70-8; W. J. A. Donald, <u>The Canadian Iron and Steel Industry, A Study in Economic History,</u> Boston, 1915, p. 46; R. J. Harrington, <u>Iron Ores of Canada and Their Development,</u> Geological Survey of Canada, 1873-74, p. 246; Bartlett, p. 518, see Note 4 above; and T. Ritchie, 'Joseph Van Norman, Iron-master of Upper Canada'; <u>Canadian Geographical Journal</u>, August 1968, pp. 46-51.

13. During the later years of Bell's various lease renewals, from about the year 1832, the urgent need for more land for settlement of the growing population of the region made for a legitimate and often bitter grievance of the inhabitants of Trois-Rivières against the reserving (under Government lease) of so much land along the River for the sole purpose of cutting wood for charcoal for the ironworks.

This aspect of the history of Trois-Rivières and Les Forges has been fully documented by Monseigneur Tessier, a native of the Region; see Note 3 above.

14. The best summary of the somewhat involved sequence of owners, tenants, etc., from the sale of the property at auction in 1846 until the final close-down in 1883, is provided by Geological Survey of Canada; Annual Report 1888-89, Vol. IV. (new series) p. 22-K; see also Bartlett, p. 517 (Note 4 above).

15. See Harrington, p. 248 (Note 4 above).

16. In the years 1854-1860 a blast furnace, known as the 'Radnor' Ironworks, was built on a small swift stream located about ten miles north-east of the site of Les Vieilles Forges; see map, Figure 2. Wood for charcoal and bog-iron ore were both more accessible at this new site. This first small furnace appears to have operated until the early 1890's. It was then replaced by a much larger smelting operation, but still employing the same high-grade local bog-iron ore and charcoal fuel.

The larger furnace appears to have continued in use until the 1908-1910 period, as part of the operations of The Canada Iron Furnace Company, the predecessor of the present Canada Iron Foundries Limited.

For a good history of the inception of this more modern phase in the economic life of the Lower Saint-Maurice Region, see: P. H. Griffin, M. E., Buffalo, N. Y., 'The Manufacture of Charcoal Iron from the Bog and Lake-Ores of The Three Rivers District, Province of Quebec, Canada', Transactions of American Institute of Mining Engineers, XXI, 1892-93, pp. 974-992; and Bartlett, p. 518 (Note 4 above).

17. Very little technical detail is given, in early historical writings on Les Forges Saint-Maurice, as to details of construction and method of operation of the blast furnace. Fortunately, we can fall back on the well-documented history of the iron industry in Colonial America to provide us with a broader understanding of the technology of smelting iron with charcoal fuel.

Pioneer settlement conditions, as well as the first 'frontier industries', in Canada in the eighteenth and early nineteenth centuries, very frequently paralleled those south of the International Border, but usually with a lag of one or two generations.

Of the many publications, the following six are particularly helpful: Arthur Cecil Bining, Pennsylvania Iron Manufacture in the Eighteenth Century, Pennsylvania Historical Commission, Vol. IV, 1938; James D. Norris, Frontier Iron, State Historical Society of Wisconsin, 1964; Richard Moldenke, Charcoal Iron, privately published by Salisbury Iron Corporation, Lime Rock, Connecticut, 1920; and James M. Swank, History of The Manufacture of Iron in All Ages, 2nd ed., Philadelphia, 1892;

Bruce L. Simpson, Development of The Metal Casting Industry, American Foundrymen's Association, Chicago, 1948; and E.N. Hartley, Ironworks on the Saugus, University of Oklahoma Press, 1957. This outlines the restoration program of the first ironworks in Massachusetts in the 1640's.

18. In this publication, space limitations do not permit description of the beds of ore or the manner in which it was gathered and brought to the furnace site. Good detail on these matters can be found in Harrington, Iron Ores of Canada, p. 247, see note 3, Chapter IV; and in Griffin, p. 977 (Note 16 above).

For location of the earliest bog-ore areas, see curious small French sketch-map, dated 1735, at Public Archives of Canada, Ottawa, Map Division, item H/3-340 (Trois-Rivières).

The composition of the bog-iron ore of the Saint-Maurice Region is discussed in Chapter IV, Section B, of this publication.

19. At early ironworks, in all countries, charcoal made from hardwoods was preferred for the blast furnace, but that made from softwoods was commonly used in the forge for processing wrought iron; see Griffin, p. 981, Note 16 above.

For a detailed description of the actual process of charcoal burning,see Bining, p. 73, per Note 17 above.

20. As of the year 1968, there is still a very active commercial quarrying and crushed-stone enterprise on this very site (St. Louis de France community).

The limestone in this area has been the subject of recent detailed scientific study and can be briefly described as 'pure high-calcium limestone from the Trenton formation', see Limestones in Canada; Their Occurrence and Characteristics; Part III, Quebec, Ottawa, 1935, pp. 49-52; 19-21,13,7.

21. The very recent surge of interest, internationally, in History of Technologies is beginning to provide publications giving much-needed perspective on the evolution of charcoal-iron furnaces in all countries. An excellent recent example of this is by Ivo Krulis-Randa, 'Le Développement des Fourneaux à Fer et L'Introduction de Haut Fourneau Wallon en Bohême', Revue D'Histoire de la Sidérurgie, Nancy, France, Tome VIII, 1967-4, pp. 245-75. The scope of this scholarly paper is much broader than the title implies.

One recent book is particularly helpful, Theodore A. Wertime, The Coming of the Age of Steel, University of Chicago Press, 1962. This provides an outstanding bibliography of both books and periodical technical literature.

Useful background on the early iron industry in Britain is to be found in H. R. Schubert, History of The British Iron and Steel Industry to 1775, London, 1957; Thomas S. Ashton, Iron and Steel in the Industrial Revolution, Manchester, 1924; and W. K. V. Gale, The British Iron and Steel Industry, A Technical History, 1967.

22. See notes on cover illustration, artist, authenticity, etc., in Note 2 above.

23. Swank, History of Iron, etc., p. 351, see Note 4 above. James W. Swank was for thirty-nine years (1873-1912) an officer, statistician and editor for The American Iron and Steel Association.

24. This 'furnace-metal-cast' procedure was a brief phase in the early days of many charcoal ironworks. It was soon superseded, in most countries, by the casting of pig iron at the blast furnace. Then, in a separate operation, mixtures of selected pig from various sources (including imported Swedish pig iron in very special instances) were remelted in cupolas, by the many foundries that specialized in producing iron castings. This selection of pig provided considerable control over the mechanical properties of the castings. See Simpson, p. 157, Note 17 above.

In a modern steel industry, so-called 'furnace-metal' direct from the blast furnace is rarely used for making castings, with the possible exception of expendable ingot moulds for their own use.

25. 'Hollow Ware' was a well known term among Canadians in pioneer communities of over a hundred years ago. By this was meant the complete range of cast iron pots and kettles sold by every village merchant for both household and barnyard use. The term hollow ware has gone into comparative disuse in the twentieth century and is now only used as a wholesaler's expression to denote the complete range of modern enamelled iron, aluminum, stainless steel, copper and other deep, concave domestic utensils.

26. Even today, an observant tourist will occasionally see cast iron vessels of this size range, relics of pioneer days, in farm yards of the St. Lawrence Lowlands Region, on both sides of the International Border. If one examines them carefully, the thickness of the iron is rarely found to be over one-half inch; see also Note 13, Chapter II.

27. This pioneer activity is described in some detail in Chapter II, Section C, of this publication.

28. They also cast pig iron which was subsequently processed at one or more adjacent re-heat furnaces and huge forge hammers. Here they produced various-sized wrought iron bars, so greatly in demand in all pioneer settlements for local blacksmithing into hardware, nails, hand-tools and simple agricultural implements.

In this publication, we must limit our discussion to the cast end-products of early charcoal ironworks. For good descriptions of the process and equipment for making wrought iron; see Norris, Frontier Iron, Note 17 above, and Gale, British Iron, Note 21 above.

Much fine historical work on pioneer settlers' facilities, including devices made of wrought iron, is done by the enthusiastic membership of The Early American Industries Association; see their publication, The Chronicle.

29. In view of the historical reputation for outstanding quality of the cast iron stoves made at Les Forges Saint-Maurice, there is a fruitful field for research for some technical historian, in the study of the design and metallurgical-quality aspects of the various makes of domestic and imported cast iron stoves used by early settlers in Canada.

As yet, very few of our folklore museums have on display early cast iron stoves that can be identified, unquestionably, as having been cast at Les Forges Saint-Maurice. One of the finest of these is shown in Figure 3. Note the cast-in trade mark, F S^{t} M , under the door showing the 'lion' crest.

The author wishes to acknowledge his endebtedness to Mr. A.J.H. Richardson, Senior Historical Advisor, Canadian Historic Sites Division, Ottawa, for information about historic castings in museums in Lachine, Quebec City, and elsewhere. For many years, 'Jack' Richardson, formerly of The Public Archives of Canada, has been the valued friend and research adviser of that small, but growing, group of Canadians interested in delving into obscure aspects of the history of pioneer days in this country.

Edgar Andrew Collard of Montreal has long been interested in Canadian folklore history; see his article, 'The Old St. Maurice Stoves', The Gazette, May 9, 1964. Some non-technical aspects of stoves and Les Forges Saint-Maurice are woven into the story in a recent book by Merrill Denison, Canada's First Bank , Montreal, 1966, p. 27; see also William Kirby, 'The Story of The Range or Cooking Stove', Ontario Historical Society Papers and Records, Toronto, 1923. XX, 92.

30. See Simpson, p. 130, Note 17 above.

31. See Sulte, p. 176, Note 3 above; Bouchette and Macaulay, p. 100, and Wurtele, p. 83, see Note 4 above.

32. It would be an interesting project for some folklore museum or historical society to systematically catalogue the amazing variety in cast iron hollow ware to be found among Canadian collectors, museums, and antique dealers. Hopefully, this might disclose something significant about their technological history, foundry source, etc.

The author wishes to thank the Curators at Upper Canada Village in Morrisburg, Ontario, for their courtesy in setting up and photographing a display of cast iron hollow ware for use in this publication - see Figure 4.

33. The complete lettering on the inner lip of the kettle reads " F S^t M No 2 ℔ 500"; see Figure 1.

The author can only surmise as to the significance of the cast-in raised letters, "No 2". It is established (Bouchette, see Note 4 above) that Les Forges Saint-Maurice had previously been making an earlier version of a potash kettle. As to what had been its shape or size, we have no knowledge. Hopefully a wider search of pioneer hollow ware will someday disclose an answer; see Note 32 above.

The lettering " ℔ 500" is obviously a size designation, as that is the approximate weight of the casting, i.e. five hundred pounds. It must have been a considerable convenience for the selling agents and for transportation charges.

This portion of the lettering is indented and roughly formed. It is the opinion of foundrymen with experience in this type of work, that these letters were hand-chiselled into the hot casting before it was removed from the mould. The three cast-in side lugs would be of great assistance in this final foundry task; see Note 2, Chapter V.

34. See Note 18, Chapter II.

35. The exact shape of the cast-in letters " F S^t M ", resembling runic type-face, is found on a stove in a fine old home at 17 Rue St. Louis in Quebec City. This particular house is known to have been built in the period 1828-1831 (personal communication from A. J. H. Richardson, see Note 29 above).

36. In claiming this design of potash kettle to be the largest pre-Confederation casting, a historian of technologies must, of necessity, use this qualification, 'iron smelted from native ore', pending more information on the history of early metal-fabricating industries in Canada.

Although the author considers it unlikely, we cannot be absolutely certain that some heavier casting for a machinery component was not made from imported pig iron, at some foundry in Montreal, with a remelt cupola, in the late 1850's or early 1860's.

It was in this period that there was being undertaken, for the first time in Canada, such major jobs as the repair of engines for river steamboats and the making of drive units for saw mills and grist mills. However, the foundry work was based on remelted pig iron from Britain; see Gerald Craig, Ed., Early Travellers in the Canadas, Toronto, 1955, pp. 265; this is quoting S.P. Day, an overseas visitor to Montreal in the year 1862; see also small type at bottom of advertisement reproduced in Figure 5.

37. The actual methods used for the preparation of sand moulds for pots and kettles were, for many generations, carefully guarded craft secrets; see Arthur Raistrick, Dynasty of Iron Founders, The Darbys and Coalbrookdale, London, 1953, p. 20.

There has never been any comprehensive publication, in any country, on the technology of the making of cast iron hollow ware; per Encyclopaedia Britannica, 1941 ed., Vol. eleven, p. 675.

38. This moulding and casting of large vessels in a 'lip-up' posture was an important development that took place in foundries in the South Lancashire Region of England between 1830 and 1840; see Note 2, Chapter V. It was a special adaptation of techniques, used since medieval times, for the making of large church bells (cast lip-down).

The first major quantity-production of synthetic soda in Britain, in the decades following the Napoleonic Wars, brought an urgent need for vastly improved processing vessels that could withstand the corrosion and red-heat of the Leblanc process; see also Note 6, Chapter II.

The answer was thick-walled cast iron vessels, made in the 'lip-up' posture. This insured the cleanest metal and hence the soundest casting at the bottom of the kettle.

This lip-up casting required a loam-moulding procedure (often termed 'sweep moulding' in America). Instead of employing a pattern, the foundryman made two wooden sweeps, one the shape of the outside and one the shape of the inside of the vessel. These were pivotted to revolve and literally cut their shape into previously prepared masses of brickwork, coated with thick pasty loam. This type of work was done in quite an elaborate pit below the foundry floor.

The above is a very much over-simplified description of what is actually a very skilled foundry moulding procedure. This same basic principle is still employed in those few foundries in the world that specialize in making huge cast iron vessels for chemical and metallurgical processing; see Figure 10.

To the author's knowledge, there is only one early text-book on foundry practice that provides a simplified illustration of this procedure; see A. McWilliam and Percy Longmuir, General Foundry Practice, 3rd ed., London, 1920, pp. 159-60.

It is the author's conclusion, from a study of the flared lip, the very sound metal in the thick bottom and the shape of the remnant boss (Figures 6 and 7, and Note 17 Chapter II), that the Saint-Maurice potash kettle, shown in Figure 1, was cast in the lip-up posture using the loam-moulding techniques. We have already described the evidence which clearly indicates that this vessel was produced sometime between 1835 and 1845.

It is intriguing to surmise just how these special craft secrets and foundry skills could have been transplanted to a small charcoal ironworks in Colonial Canada within a few years of their first use in Europe. Migration of skilled ironworkers is the logical conclusion.

The best contemporary comments on the history of Les Forges Saint-Maurice (written in 1832, Bouchette, see Note 4 above) confirm this conclusion in these words:

> "The overseers and persons employed in the construction of models (patterns) are English and Scotch ------- sand used in casting is imported from England".

We cannot help wondering whether some form of enticement was perhaps offered to these immigrant foundry craftsmen by that enterprising individual, Mathew Bell; see Note 10 above.

39. The Public Archives of Canada in Ottawa has one of the few complete sets of the Canada Directory, Montreal, John Lovell. This was published irregularly in the period 1850 to 1866. This typical gazetteer-type of popular reference book includes many pages of commercial advertisements.

The firm of Bartley and Dunbar was agent for a wide variety of British iron and steel goods and machinery. At this period their St. Lawrence Engine Works was commencing the repair of engines for steamboats. Their advertisement, shown in Figure 5, is reproduced from page 1209 of the 1857-1858 issue of the Canada Directory, see also Note 36 above.

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CHAPTER II

POTASH FROM WOOD-ASHES

1. The only authoritative texts that put the economic importance of this early Canadian potash into any reasonable perspective are H.A. Innis and A.R.M. Lower, Select Documents in Canadian Economic History, 1783-1885, Toronto, 1933, pp. 280-3; and Mary Q. Innis, An Economic History of Canada, Toronto, 1935, pp. 97-102, 155, 162. The coverages, however, are brief.

It was the author's privilege to discuss his interest in the history of potash from wood-ashes with the late Professor Harold Innis in the late 1930's. He warmly encouraged study of the history of lesser known pursuits and crafts of Canadian pioneer days.

Some general comments on potash in early Canada are given by C.J.S. Warrington and R.V.V. Nicholls, A History of Chemistry in Canada, Toronto, The Chemical Institute of Canada, 1949, pp. 77-9.

2. The exact technology of how the whiter granular pearlash was processed in the kettle is somewhat obscure. It seems to have involved careful heating and stirring at temperatures just below the red-heat fusion point, but hot enough to burn out the bits of charcoal, etc.

Some recent writers on the history of pioneer times have stated that the pearlash, made in backwoods settlements, employed a furnace hearth to refine crude potash, as was often done in Europe. This is quite incorrect. Under North American pioneer conditions, pearlash was produced in the same big iron kettle as was used for the making of fused potash.

3. It is more broadly correct to say that various 'incinerated vegetable matters' were the world's primary source of alkali. In addition to the wood-ashes potash and pearlash imported by Britain and Western Europe from North America, Russia, Poland and Hungary, there were also large quantities of 'barilla' used. This was imported from Spain and The Canary Islands. It was the ash of plants growing near the seacoast.

In addition, British soap-boilers, textile-processors and glass-makers used large quanitities of 'kelp' (the ash of dried seaweed). The history of kelp has been carefully documented by Archibald Clow and Nan L. Clow, "The Natural and Economic History of Kelp", Annals of Science, V (1947), No. 4, pp. 297-316. No work of comparable quality appears to have been published on the history of barilla.

4. The first significant dribble of exports of Canadian wood-ashes potash appeared in the late 1760's; see Public Archives of Canada, Haldimand Papers, B-201, p. 41.

5. Journals of The Legislative Assembly of The Province of Canada; session of 1851; Appendix A-17. Actually these trade records of exports for 1850 are reported in 'Pounds, Halifax Currency'. This was the curious monetary unit of all official records of that period of Canadian history. These have been converted into dollars at a rate of $3.89 per pound currency. This is the factor adopted by K. W. Taylor and H. Mitchell in Statistical Contributions to Canadian Economic History, Vol. II, 1931, p. 47.

6. The history of the rise of the synthetic soda industry in Britain has been carefully researched in quite recent years. The following publications are notable: T. C. Barker, R. Dickinson, and D. W. F. Hardie, 'The Origins of the Synthetic Alkali Industry in Britain', Economica, Vol. 23, May, 1956, pp. 158-171; and L. F. Haber, The Chemical Industry During the Nineteenth Century, Oxford, 1958, pp. 5; D. W. F. Hardie and J. Davidson Pratt, A History of the Modern British Chemical Industry, Oxford, 1966, pp. 21; and L. Gittins, 'The Manufacture of Alkali in Britain, 1779-1789', Annals of Science, Vol. 22, September 1966, pp. 175-189.

7. Much has been written on the rise of the German mining industry to a dominant position in the world potash market in the years before World War I. A good summary is provided by J. W. Turrentine, Potash, A Review, Estimate and Forecast, New York, 1926, pp. 9. At that time Turrentine was head of potash investigation for the United States Department of Agriculture. In later years, as President of The American Potash Institute, Washington, D.C., he published works on the special problems of the U.S. mineral potash industry; see also

Williams Haynes, American Chemical Industry, A History, New York, 1954, Vol. II, pp. 141, and bibliography, p. 154.

8. In this publication space does not permit of elaboration on the very earliest efforts to make wood-ashes potash in the days of New France. There is a very interesting story surrounding the endeavors of the French Colonial Authorities to get a potash enterprise going at Quebec. This was in the 1670's, under Intendant Talon, in the days of the famous Colbert, Minister to Louis XIV. The efforts appear to have been abandoned in a few years' time. This episode is carefully documented by Joseph-Noël Fauteux, Essai sur L'Industrie au Canada sous le Régime Français, Quebec, 1927, Vol. II, pp. 332-44. An earlier publication is Pierre-George Roy, 'La Fabrication de la Potasse au Canada', Bulletin des Recherches Historiques, Vol. 10 (1904), pp. 277-79.

9. Vermont and Northern New York State pioneer settlers actively engaged in the making of potash. The St. Lawrence River route to Europe, via Quebec, was their only means of shipment to market in the earliest years of last century.

However, wood-ashes potash was, relatively, of much greater importance to the pioneer economy of early Canada than it was in United States. In this publication the discussion is limited to the Canadian potash trade. Later an opportunity may be found, elsewhere, to document pioneer potash as a 'cross-border' regional enterprise.

I particularly wish to express my appreciation to Dr. Paul D. Evans, Emeritus Professor of History, and to Dr. T. D. Seymour Bassett, Curator and University Archivist, and their associates at the Bailey Memorial Library of The University of Vermont, in Burlington, Vt.

With their help I have obtained much relatively inaccessible source material from various university and other libraries throughout United States. This covered the role of wood-ashes potash in frontier days in New England, as well as the history of charcoal-iron and the history of alkali chemistry.

10. An up-to-date review of the Canadian potash industry is published annually in Canadian Minerals Yearbook, The Queen's Printer, Ottawa. A small separate booklet, covering only the chapter on Potash, can be purchased

separately, and somewhat in advance of the date of publication of the complete yearbook, from The Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, for 25 cents.

The story of the early development of the Saskatchewan mineral potash region was outlined to the 74th Annual General Meeting of The Engineering Institute of Canada, Winnipeg, May, 1960, by W. J. Pearson, of the Department of Mineral Resources, Province of Saskatchewan. See: 'Western Canada Potash and its Future Prospects'; The Engineering Journal, August, 1960, pp. 68-72. Dr. Pearson's paper includes a comprehensive bibliography of early publications on the geology of the region.

A general-interest article on Potash in Canada, both in pioneer days and in modern times, was published in Canadian Geographical Journal, Vol. LXVIII, No. 6, June, 1964, pp. 177-187.

11. It is not practical, in this publication, to provide any comprehensive list of source references to accompany such brief summaries of the technology and economics of wood-ashes potash. Such a bibliography is planned for later phases of the publication of the story of 'Potash and the Pioneers'.

Reliable recorded information on the wood-ashes potash process is quite meagre and widely dispersed in a variety of early county and regional histories, old chemical treatises, and the like. However, three publications are particularly useful:

(a) Dominique-Marie Doyon, O.P., 'La Fabrication de la Potasse au Canada et Spécialement à Saint-François de Beauce'; Les Archives de Folklore, L'Université Laval, Quebec, 1949, pp. 29-41. This article provides good detail of a short-lived effort to resurrect the making of potash from wood-ashes in rural Quebec Province. This was in the brief period, 1915-1919, when the world price of potash skyrocketted, due to World War I cutting off the supply from the mines in Germany.

(b) S.D. Holmes, 'The Potash Industry in the Settlement of Upper Canada', The School, published by Ontario Department of Education, Vol. XXV, No. 4, Dec. 1936, pp. 312-16, 321-23. This excellent but brief article was prepared for the use of teachers of science and history.

(c) Theodore J. Kreps, 'Vicissitudes of the American Potash Industry', Journal of Economic and Business History, Vol. III, No. 4, Aug. 1931, pp. 630-66. This carefully researched thesis provides good detail, with accent on economics rather than technology, about potash making in the southern watershed of the St. Lawrence Lowlands, Northern New England, etc. The methods used by settlers in those areas were essentially similar to those employed by the Canadian pioneers. Kreps' paper has a particularly fine bibliography of quite rare source materials.

12. The usual 'leach' in a backwoods potashery was made of battered boards, or even of strips of elm bark, in the form of a hopper four or five feet high and several feet wide at the top, with sloping sides to a perforated bottom. The hardwood ashes were damped down and rammed into the hopper. Then buckets of water were periodically poured on, to percolate through. The lye trickled out the bottom. There was considerable local variation in leaching practice over the hundred-odd years of the Canadian export of wood-ashes potash. This included the use, in some instances, of lime to increase the causticity of the lye. The author's study of the evolution of efficient leaching practices is continuing.

13. There is some confusion, in historical writings on pioneer times, particularly in the northern parts of The New England States, about the meaning of the terms: lye, salts, potash, and potash kettle.

In many remote frontier areas the boiling-down of lye from the leach was a separate operation which the settlers were able to do for themselves. This produced what this publication refers to as 'salts' or 'black salts'. For this job the settler could use a relatively inexpensive, thin-walled, cast iron vessel about two feet in diameter. These kettles were slung by chain or bale over an open fire of hardwood logs. Shapes and sizes of such kettles were as numerous as the ingenuity of the many iron foundries that cast them; see Section C and notes 24 and 26 of Chapter I.

Where salts were thus prepared in a separate operation, the red-heat fusion refining of them into a potash acceptable for foreign markets, was carried out, in a final operation, in a much larger, thick-walled kettle at some distant village merchant's potashery. Of this somewhat more professional set-up, the frontier settlers had little interest or knowledge, except as a place to barter their salts for 'store-goods'.

It was probably inevitable that these settlers in remote areas would come to refer to their boiling-down of the run-off from their crude leach as having been done in their 'potash kettle', as we often find described in some write-ups on pioneer times. For historical analyses, the author feels the term 'lye-boiler' to be a more accurate description of these smaller kettles.

I am endebted to the enthusiastic membership and officers of The Green Mountain Folklore Society, in the State of Vermont, for help in collecting information about local pioneer practices in the use of cast iron hollow ware.

14. Today's industrial chemical engineers encounter serious problems in providing reliable vessels, of reasonably long life, for the more rigorous process-conditions in bulk-chemical industries. One difficult situation arises when 'molten caustic is often processed in a large cast iron pot subject to red heat or above, in direct contact with 'furnace gas'.

Readers with engineering background will appreciate that this concise description of a difficult modern chemical process can be applied, almost intact, to the situation existing in a backwoods potashery of one hundred-odd years ago. See Thorpe's Dictionary of Applied Chemistry, 4th ed., London, 1950, Vol. X, p. 868; H.L. Maxwell, 'Cast Iron in Chemical Equipment', Mechanical Engineering, Dec. 1936, pp. 803-8, 845; Willard H. Rother, 'Utilizing Cast Iron in Chemical Equipment', Chemical and Metallurgical Engineering, Vol. 40, No. 7, July 1933, pp. 350-2; Cast Metals Handbook, pp. 114, 127; and note 5, Chapter IV.

15. 'Broken-up by sledge hammer' is, actually, what happened to much pioneer hollow ware. In my search for relics of the making of potash from wood-ashes, in my home region, the Eastern Townships of Quebec, I ran

across a few 'old-timers' who fondly remembered iron 'kittles' (sic) that were sold, for a pittance to itinerant dealers, during the patriotic drive to collect scrap iron for the war effort in the years 1915-1918.

As a result, for the historian of settlement days, significant cast iron pioneer ware is much more difficult to find today. Fortunately, many of the smaller pots and kettles have now become collectors' pieces with suburbanites and the antique dealers who cater to them.

16. It is reasonable to expect that a few other potash kettles of this F S[t] M design will eventually be identified in the regions where potash making was an active pursuit of Canadian pioneer settlers.

The author would welcome communication from anyone with personal knowledge of the present whereabouts of cast iron kettles, of any size, bearing the historic F S[t] M trade mark. Similarly, information is solicited on large cast iron vessels, authenticated as to source by foundry marks of any type.

Dr. B.R. MacKay, President of The Historical Society of Ottawa, has provided preliminary information about an interesting kettle which recently attracted public notice in their Bytown Museum.

17. A few flared-lip potash kettles, from various foundry sources, are still to be found on farms in the Eastern Townships of Quebec and in Eastern Ontario. Some are already in the hands of folklore museums and private collectors. These kettles range in (estimated) weight from 500 to 1000 pounds. They vary considerably in contour and in the number, shape and location of side lugs.

A rare few such kettles have cast-in marks identifying their source; but the majority are unmarked. To date, the author has located and photographed five different foundry trade marks on large cast iron hollow ware. Four of these are from early foundries in Scotland. The other one is the potash kettle from Les Vieilles Forges at Saint-Maurice (Figure 1).

One of the finest examples of flared-lip potash kettle is on display in front of the museum in Knowlton, Quebec. It has a cast-in trade mark reading FALKIRK, showing it to be a product of the historically world-renowned 'Carron Works' near Glasgow, Scotland (from correspondence with Harry B. Shufelt, for many years an officer and source of inspiration to the membership of that fine regional folklore group, The Brome County Historical Society).

One of the largest, unmarked, flared-lip potash kettles is the property of that enthusiastic collector and authority on 'Les Outils Québecois', Robert-Lionel Séguin of Rigaud, Quebec. He has documented scholarly studies on Quebec Folklore, which have been published by The National Museum of Canada.

A few thick-walled potash fusion vessels, relics of pioneer days in Northern New England and New York States, are to be found in museums, etc. in those regions. All those examined have been 'coffee-cup' in general shape, i.e. having no cast 'lip' whatsoever.

The author's research is continuing into the history of regional foundry practices in the making of large cast iron vessels at early charcoal ironworks; see also note 16 above.

18. This was an area of marginal farming north of the Town of Brownsburg, Quebec. This is back-country from the north shore of the Ottawa River, roughly midway between Montreal and Ottawa. There is well-recorded evidence that this area was first settled in the 1830-1840 period. See C. T. Thomas, History of The Counties of Argenteuil, Quebec and Prescott, Ontario (Montreal, 1896) p. 205.

19. Mines Branch, Ottawa and see Note 1, Chapter III.

20. Widnes Foundry Company and see Note 2, Chapter V.

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CHAPTER III

SCIENTIFIC INVESTIGATION OF KETTLE IRON

1. The author wishes to express his appreciation for the encouragement of this investigation of 'Potash and the Pioneers' by Dr. John Convey, Director of the Mines Branch, Department of Energy, Mines and Resources, of the Canadian Government in Ottawa, and by Mr. S. L. Gertsman, Chief of the Physical Metallurgy Division of the Mines Branch.

The courtesy of providing metallographic, chemical and spectrographic studies was extended by the Mines Branch because of the 'cultural and historic value' of the author's investigation of a rare authenticated large casting from Canada's historic first ironworks. Such test work is time-consuming and must await convenient opportunities to be fitted in with the heavily loaded programs of the various laboratories, which have been established to serve Canada's vast mineral industries.

2. The detailed scientific study of the kettle iron, as reported in this publication, was carried out under the personal supervision of Mr. D. E. Parsons, Research Scientist of the Physical Metallurgy Division, Mines Branch, Ottawa.

However, the author alone is responsible for the accuracy, or otherwise, of historical and scientific conclusions of a more general nature throughout the publication.

3. Detail is available at The Physical Metallurgy Division, Mines Branch, 568 Booth Street, Ottawa (Report No. PM-66-9).

4. Detail is available at the Mines Branch, Report No. PM-66-26.

5. Personal communication to the author from The Widnes Foundry and Engineering Company, Widnes, Lancashire, England; see Note 2, Chapter V.

6. See Note 38, Chapter I.

7. From Metals Handbook, 8th ed., American Society for Metals, p. 355, 'Properties and Selection of Metals'; the composition quoted is class 25, heavy metal section, i.e. one inch and up.

CHAPTER IV

CHARCOAL IRON TECHNOLOGY

1. See Note 24, Chapter I.

2. Poor casting results with local ores were blamed for many failures of ambitious plans to start up charcoal ironworks in pioneer days, in both Canada and United States; see W. J. A. Donald, The Canadian Iron and Steel Industry, Boston, 1915, pp. 49; and Swank, p. 197, see Note 17, Chapter I.

3. B. J. Harrington, 'Notes on the Iron Ores of Canada and Their Development', Geological Survey of Canada, Report of Progress, 1873-1874, Ottawa, 1874, pp. 234, 247. Dr. Harrington (1848-1907) later became Professor of Chemistry and Mineralogy at McGill University and one of the pioneers of mineral sciences in Canada.

Although rather brief, this record of the observations of an outstanding scientist about the ore, the process and the products at Les Forges in 1873, constitutes the only reputable contemporary published technical detail on that establishment as it was in the last half-century of its operations. This fruitful source of information appears to have been overlooked by most later writers on the history of Les Forges Saint-Maurice.

4. See Note 18, Chapter I.

5. The metallurgy of cast iron is a rather involved subject. No useful purpose would be served by burdening this publication with any greater technical detail than is required as background for our historical subject, 'Cast Pioneer Utensils'.

For those who might wish to go deeper into the matter, precise technical and practical foundry information is best presented by Cast Metals Handbook. American Foundrymen's Society; present revision is 4th edition, 1957; pp. 82, 114, 121.

If still greater detail is needed, any particular aspect of the metallurgy of cast iron can be followed in the periodical technical journals by starting with the comprehensive bibliography provided by the Handbook, pp. 168-175.

6. The writings of John Percy and David Mushet, as quoted by Wertime, p. 278; see Note 21, Chapter I.

7. See Wurtele, pp. 88-9; and Macaulay, p. 103, and Ausman, p. 102, all in Note 4, Chapter I.

8. Increasing attention is being given by historians, in recent years, to the scientific study of historic metal objects. See Earle R. Caley, Analysis of Ancient Metals, New York, 1964. A bibliography of studies of iron artifacts is provided (pp 145-8).

Technology and Culture, The International Quarterly of The Society for the History of Technology, University of Chicago Press, sometimes includes papers on the history of Iron and Steel Technologies, e.g. Cyril Stanley Smith, 'Methods of Making Chain Mail (14th to 18th centuries), a Metallographic Note', Technology and Culture, Vol. I, No. 1, winter 1960, pp 60-7.

9. A careful search of historical works in Sweden and some other countries would doubtless disclose much additional significant information on the compositions of historic irons. Such a 'comparative' approach might well be a fruitful field for future students of the history of iron technologies, in all countries where there was an early commercial iron industry based on charcoal fuel.

There is a valuable new French Historical Journal in this field, Revue D'Histoire De La Sidérurgie, published quarterly in Nancy since 1960; Editor, Bertrand Gille. Also, there is a long-forgotten old periodical, Journal of The United States Association of Charcoal Ironworkers, published only from 1880 to 1891. Copies are now very rare; even The Library of Congress in Washington, D. C., has only a much broken set.

10. Column I, Table II, Swedish pig iron; this was type $F^{L}M$ from The Laxa Works. This analysis was made in the year 1885 and reported in an early metallurgical text-book, William J. Keep, Cast Iron (New York, 1902), pp. 11, 102.

Swedish pig iron, smelted with charcoal fuel from exceptionally pure ores, was the world's standard of excellence for several hundred years.

'Dannemora' brand was the most famous in foreign markets, where the best Swedish pig irons were long the basis for some of the world's finest crucible steels. See Gunnar Löwegren, Swedish Iron and Steel, A Historical Survey (Stockholm, 1948); English version by Nils G. Sahlin, pp. 61, 114.

The very last charcoal-fired blast furnace in Sweden is reported to have closed down in the year 1966; The Newcomen Bulletin, No. 80, March 1967.

11. Column II, Table II, Sussex Iron, Britain, as reported by Schubert, Appendix VIII, pp. 398; see Note 21, Chapter I. This analysis was made about 1886 on iron estimated to be of the 17th century. The making of charcoal iron flourished in the south of England for several hundred years before the iron industry became significant elsewhere in Britain. Sussex iron was famous for casting guns for the Royal Navy in the days of Queen Elizabeth The First.

12. Column III, Table II, Salisbury iron, Litchfield County, Connecticut, U.S.A. This analysis is Salisbury charcoal-iron, type 3, as reported by Moldenke, p. 61; see Note 17, Chapter I.

There was a simple charcoal ironworks at Salisbury as early as 1730-40 (Swank, p. 128); see Note 17, Chapter I. They were still smelting a very pure local ore in a charcoal-fired furnace (warm blast), as late as the year 1920. Their carefully controlled pig irons commanded premium prices for such special applications as the making of railroad car wheels and large machinery rolls for paper making, etc.

13. Column IV, Table II, Les Forges Saint-Maurice, Canada. This is the analysis of the iron in the potash kettle as reported in Table I of this publication.

14. Column V, Table II. This is the A. S. T. M. specification for modern heat-resistant cast irons, as discussed in Chapter V, Section A, of this publication.

CHAPTER V

CAST IRON VESSELS FOR USE AT HIGH TEMPERATURES

1. The extensive Iron Foundry Industry in Canada in the 1960's is well equipped to produce large iron castings of many tons in weight and to do 'sweep' moulding of large circular pieces. Many fine foundries have advanced shop practice and careful metallurgical controls. However, at the present time, mostly because of limited demand in this country, large vessels for certain rigorous applications, such as high temperature and corrosion, are not normally cast in Canada.

I wish to express my appreciation to several prominent industrial metallurgists for useful guidance on the range of current Canadian foundry work; in particular, Robert Thompson, Chief Metallurgist, Dominion Engineering Works, Lachine, Quebec; J. E. Rehder, Pointe Claire, Quebec, Consulting Metallurgical Engineer and formerly Vice-President, Technology, Canada Iron Foundries Limited; and J. W. Tibbits, formerly Manager of Metallurgy, Canadian Steel Foundries.

2. The author is indebted to Mr. A. Whitfield, Managing Director of The Widnes Foundry and Engineering Company of Widnes, Lancashire, England; and to his predecessor, the late Mr. R. Credland, for the opportunity to visit their foundry in Widnes.

It has been my privilege to discuss the conclusions of my pioneer potash kettle investigation with that Group. They have over one hundred years of experience in making cast iron vessels for high-temperature and corrosive applications in the bulk-chemical and metal-refining industries in many parts of the world; see Figure 10.

A search in 1951, on the author's behalf, by the Board of Trade of the British Government disclosed that the Widnes foundry is the only shop, still operating, which was making cast iron processing vessels for the synthetic soda industry in Britain in the mid-nineteenth century. All those early foundries, engaged in that special work, are listed, by name, in the most important early text-book on alkali manufacture, George Lunge, The Manufacture of Sulphuric Acid and Alkali, first edition, London, 1880, Vol. II, pp. 64-9.

The first iron foundry at Widnes was built by Thomas Robinson. He is credited, according to a fine recent industrial history of South Lancashire, with having devised, about 1830-1840, "an improved method of making caustic pots, salt cake pans, and other vessels for the alkali trade"; see T. C. Barker and J. R. Harris, A Merseyside Town in The Industrial Revolution, St. Helens, 1750-1900, Liverpool, 1954, p. 364.

3. I have photographed several old potash kettles, in Eastern Canada and Northern New England, which had badly corroded and fractured bottoms. The metallurgical explanation for this type of deterioration in service, i.e. the phenomenon of 'growth', only became known in the twentieth century.

An authoritative early text on the metallurgy of cast iron, published in 1902, makes no mention whatever of the growth phenomenon in cast irons exposed to red-heats; see Note 10, Chapter IV. That subject now receives considerable attention in foundry and metallurgical publications. See J. Laing and R. T. Rolfe, A Manual of Foundry Practice (London, 1934), p. 198; and Cast Metals Handbook, p. 114, see Note 5, Chapter IV; and I. C. H. Hughes, 'Growth and Scaling of Cast Iron', British Cast Iron Research Association Journal, Report 526, Vol. 8, 1960, pp. 7-28; in addition, see bibliography items quoted in Note 14, Chapter II.

4. The author feels that available published information on the composition of historic British and Early American charcoal irons is, as yet, too meagre and inconclusive to draw meaningful comparisons. However, the need for further historical research is indicated; see Note 9, Chapter IV.

5. In this publication, space limitations have precluded any detailed discussion of the properties of the iron in small-size hollow ware, with their much thinner wall-sections and resulting faster cooling rates. Discussion on this point can be found in Cast Metals Handbook p. 83 (Note 5, Chapter IV).

CHAPTER VI

QUALITY OF IRON FROM LES FORGES SAINT-MAURICE

1. See Note 10, Chapter IV.

2. It is not intended to imply that the historical references given here are the only ones to be found in reputable primary source material; merely that they are those comments that the author has found to contribute directly to a better understanding of charcoal-iron technology at Les Forges Saint-Maurice.

3. From Fauteux, Vol. 1, p. 58, see Note 3, Chapter I, it would appear that it was on the basis of tests such as this that the final decision was taken to embark on the building of an ironworks near Trois-Rivières between 1732 and 1738.

Skilled workmen were brought over from the charcoal iron industry in France, where it flourished in the 18th and earlier centuries; see writings of Bertrand Gille (Note 9, Chapter IV).

4. Peter Kalm was a Swedish scientist, a colleague of Carl Linnaeus. He visited both the French and English Colonies in North America in 1749-1750, one of the rare periods of peace. Kalm's comments about Les Forges Saint-Maurice have been widely quoted by historians of the enterprise; see Notes 3 and 4, Chapter I. I have chosen to use a quotation from a recent authoritative edition of Kalm's works, which was checked with the original Swedish version; Adolph B. Benson, editor and translator, <u>Peter Kalm's Travels in North America</u>, New York, 1937, p. 420.

5. As per Wurtele, p. 83, see Note 4. Chapter I, Colonel Burton was a deputy to General Murray during the brief Military Government of Canada following the Peace of Paris in 1763, by which Canada was ceded by France to England. Burton visited Les Forges Saint-Maurice and made a comprehensive report on the condition of the facilities there.

6. John Lambert, <u>Travels Through Canada and the United States in the Years 1806, 1807, 1808,</u> second ed., London, 1813, pp. 484. Useful back-

ground on Lambert, who was a keen observer and careful chronicler, is given by Gerald Craig, editor, Early Travellers in the Canadas, 1791-1867, Toronto, 1955, p. 28.

7. Robert Sellar, The History of The County of Huntingdon and The Seigniories of Chateaugay and Beauharnois, Huntingdon, Quebec, 1888, p. 280.

For practical details of settlement days, this is one of the most valuable of the early Canadian county histories. Unfortunately, it has a very biased approach to political events.

Sellar was a newspaper editor in a small Eastern Townships town. Over a period of years in the decade of the 1880's, he interviewed and recorded the comments, verbatim, of the old-timers who had pioneered in the region, fifty years before.

8. J. B. Harrington, Iron Ores of Canada ; see Note 3, Chapter IV. In the nineteenth century, railroad-car wheels were recognized as the ultimate in 'quality' products for the protection of life and limb. They were required to be made from charcoal-iron from a cold-blast furnace.

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