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The Development of Chemical Industries in Australia and Canada 1850-1950

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Introduction

The much quoted dictum attributed to Disraeli, but adumbrated clearly by Liebig in his *Familiar Letters on Chemistry,* that sulphuric acid consumption is a good indicator of a country's material progress, draws our attention to a study of the state of development of chemical industry as an key indicator of the development of society in general, and of Canada and Australia in particular. Certainly, the gales of the Second Industrial Revolution which blew through the mature capitalist economies of Europe and the United States also transformed the industrial and technological structures of the Australasian and British North American colonies. Industrial chemistry, followed by electricity and the internal combustion engine, were as important to western society as the steam engine and textile machinery a century earlier.

Chemical and chemical process industries take natural materials and with energy inputs refine or otherwise transform them into more valuable products. These can be final consumer products, or producer goods used as inputs into other industrial processes either alone or in conjunction with the products of other industries. At first, the various industrial chemical activities are distinct but over time they have more and more to do with each other as the economy becomes more complex and industry matures. Similarly, most of these activities begin as family enterprises, partnerships or small companies. Many grow no further, and most disappear, but some expand or are absorbed into the large multi-unit chemical corporations which eventually dominate their respective industries.

Among the simplest operations are the purification of materials, such as fats and common salt, and the production of charcoal and potash from wood. At a somewhat more sophisticated level are the production of solid materials such as lime, nitrogenous and phosphatic manures, ceramics, and cements and pigments, along with the fermentation and distillation of liquids. Many of these processes were widely understood and practiced in pioneer or settler economies at the level of the household, or by small-scale entrepreneurs possessing a site and access to raw materials. Capital costs were low and distribution was subsidiary to the needs of a dominant agricultural or pastoral economy. Entrepreneurs could be motivated by the prospect of immediate home consumption, of product substitution for costly imports or, more rarely, by opportunities for export.

Next in order of complexity come those industries concerned with the refining of metallic ores, either entirely to the stage of pure metals, or to an intermediate stage of concentration for export, combining lower transport costs with added value. At about this level of complexity, lie the combinations of already refined substances, including those — nitre, charcoal and sulphur — which make gunpowder. Next comes the splitting of fats to give soaps, and later the fatty acids themselves (stearine for example), and the production of sulphuric acid by oxidation of sulphur either native or derived from sulphides occurring in ore bodies. Alkali production by the Le Blanc process was prominent in European development, but played little part in colonial chemical industry. However, in this early stage, sulpheric acid is prepared for use as a raw material in the manufacture of improved fertilizers, the preparation of volatile (such as hydrochloric and nitric) acids, in making useful sulphate salts, and in refining crude petroleum.

These steps were accomplished by the middle of the nineteenth century in Britain, Western Europe and North America, and over the next two decades in Australia. From this point the chemical industry grew rapidly, and saw many amalgamations and consolidation of resources and manufactures. Some concentration made possible the development, through prolonged and systematic effort, of new methods for producing sodium carbonate and sodium hydroxide (caustic soda). Corporate concentration also saw multinational companies (largely British-based in Australia and U.S.-based in Canada) buying up local operators or initiating local manufacture. By the end of the century, the worldwide chemical industry came to be dominated by a few giants, notably Du Pont in the United States and I.G. Farben in Germany.

The basic technology for all these activities was European, or later American, in origin. This fact should not, however, blind us to the degree of technological creativity involved in applying such technology to local conditions differing radically from those of Europe. Later still, technology in chemical industry became international and in such areas as mining (Australia) and forest products (Canada), industrial scientists in the new Dominions would, after the turn of the century, make internationally significant contributions of their own.

Beginning in the 1870s, the practice of industrial chemistry became professionalized in Britain Western Europe, and the United States. In Europe and the United States, university-trained chemists increasingly came to direct the productive processes of industry. A number of factors help explain this development. The day of the inventor-entrepreneur was fading, while industrial chemists were growing in number, and entering industrial hierarchies. Chemists with university training or higher educational qualifications from technical institutions and schools of mines began to distance themselves from foremen and supervisors who lacked formal training. While remaining in industry, they sought links to similarly educated colleagues in government and university as well as the relatively small numbers of independant consulting chemists. Many other groups in society — teachers, librarians, architects — were seeking to emulate the traditional professions, with the promise of higher status and greater remuneration. Finally, the forging of formal links among technical people across company boundaries was acceptable to senior managers as a part of the secondary organization of industry which also featured trade associations, export agencies and cartels. Some professional associations were industry based, some local, some disciplinary, while others sought to embrace all branches of the profession. In Europe and the U.K. this development was most evident during the period 1840-1870 when academic as well as professional communities were expanding and consolidating, and in the United States for 20 years from 1876 when the American Chemical Society was founded. It came later to Canada and Australia, beginning around the turn of the century and occupying the next two decades and beyond.

The First World War is frequently taken as a watershed in the history of industrial chemistry. Careful study, however, reveals that much of what might have appeared new should be understood as an acceleration of trends already evident before August 1914. Certainly the real or perceived superiority of German chemical industry threw Allied nations into a panic. Cut off from the products of that industry, they scrambled to produce substitutes. Germany, for its part, overcame the loss of its Chilean nitrate supply by applying Haber's process for nitrogen fixation, which gave it explosives and nitrogeneous fertilizers by synthetic means. Both sides developed and deployed chemical weapons. Following the war, the Allies took stock of their chemical industries and saw them, for the first time, as national resources which they must develop if they were to survive as independent nations and win in the peaceful struggle for international markets. Germany of course pursued the same line and so in all developed countries the growth and diversification of chemical industry became a focus of government policy. So did the production of chemical engineers — of which Britain had few, Germany many, North America a reasonable number, and Australia, a growing community.

This harnessing of chemistry in the national interest took several forms. Industrial research meant first and foremost chemical research. Scientific and technical education received increased attention and, when economic conditions permitted, so did the budgets of national research institutions such as the CSIR (later CSIRO) in Australia and the NRC in Canada. Countries with resource based economies aimed at capturing more of the benefits of those resources in preference to exporting them in raw or semi-processed form. It became a measure of national independence, as well as of defence preparedness, for a country to fix its own nitrogen, generate chlorine and caustic soda by electrolysis of brine, refine its own metals, synthesize dyes and drugs, and make glass. In most countries, oil refining and downstream petrochemical industries post-dated the Second World War, but in more advanced nations, their importance was recognized in the 1930s, as witness the successful German program for synthetic fuel production and its imitators in Britain and the United States. We can also see clearly in this period crucial differences in the Australian and Canadian experiences. For Australia and for Canada, an acute awareness of strategic vulnerability and the constant threat of economic integration with the United States, were, respectively, to exercise a dominant influence in the technological history of the two countries.

We present three studies which trace these patterns of development in the chemical and chemical process industries of Canada and Australia. Each study is national, but all are linked by a common concern with the growth and increasing sophistication of industry, the motivations and mechanisms for such changes, and the role of the State. The studies begin with an account of the embryo chemical industry in Victoria, the earliest colony in Australia to industrialise, and with the efforts of that colony's government to promote new industrial endeavours. This is followed by a case history of Canadian industry, focussing on business-government-academic relations in the pulp and paper industry. The last section offers some summary comparisons of the Australian and Canadian chemical industries during the period 1860-1939.

I. Chemistry and Industry in Australia: Victoria in the 1860s

Historians who write about the science of nineteenth century Australia either ignore the chemical industry or begin their tales with the industries of the late 1860s. Among the few exceptions are the histories of food preservation, and the sugar and gas industries.[1]

Much happened before 1870: many companies were formed and some disappeared, but their experience was not always reflected in those who went on to grandeur in the 1880s.

Victoria started well behind the parent colony of New South Wales, and even after Victoria became a separate colony in 1850, there was a lag of several years before real manufacturing industries were established.[2]

With the gold rush, however, Victoria's increasing population needed soap and candles, sulphuric acid — the most important basic chemical of the time — as well as gunpowder for civil and military purposes, beverages, manures and

1 K.H. Farrer, *A Settlement Amply Supplied: Food Technology in Nineteenth Century Australia* (Melbourne: Melbourne University Press, 1980); A.G. Lowndes, *South Pacific Enterprise* (Sydney: Colonial Sugar Refining Company, 1956); George Bindon and D. P. Miller, 'Sweetness and Light: Industrial Research in the Colonial Sugar Refining Company, 1855-1900,' in R.W. Home (ed.), *Australian Science in the Making* (Sydney: Cambridge University Press, 1988); R. Proudley, *Circle of Influence: A History of the Gas Industry in Victoria* (Melbourne: Hargreen Publishing Company, 1987).

2 G.J.R. Linge, *Industrial Awakening. A Geography of Australian Manufacturing 1788 to 1890* (Canberra: Australian National University Press, 1979).

essential oils. Faced with pressure for import substitution, the colonial government did some obvious things. They offered prizes for gold discoveries, rewarding discoverers with substantial sums, and spending nearly £15,000 in the period 1855-1863.[3]

Agriculture fared similarly, with rewards for the establishment of new industries drawing their sustenance from the land. In some cases, these were developed more with an eye to export than to satisfying local demand. This, of course, was the direction which had been taken by producers of wool and meat, whose dominance seemed not to deter the promoters of a scheme to breed the alpaca.[4]

The 'reward' culture so engendered was to persist for many years. The Royal Commission on Gold Mining (1890) devoted two of its thirty-one recommendations to rewards and premiums.[5]

There were never enough rewards, of course, or they were never made in fields where universal approval could be taken for granted. R.M. Serjeant, giving evidence to the Commission, noted that 'you can get £250 from the government for the invention of a potato-digger, but I do not know of any instance where there has been £250 offered for any invention connected with the mining industry.' In 1864 the parliament of Victoria voted £5000 for the promotion of new manufactures and industries, and empowered the Governor in Council, through an appointed Board, to promote ventures in new fields, specifying those to which precedence was to be given 'and the reward measured by the excellence and extent of the manufacture or article produced.' The manufactures for which submissions were invited included woollen goods, paper, glass, crockery, leather, olive oil, flax, flax (or linseed) oil, hemp, cotton, hops, and silk. Some of these, such as the manufacture of glass and crockery, were simple cases of import replacement, while others represented more complex attempts to encourage secondary industries to use such raw materials as wool and hides before they were exported from the colony. Still others, such as cotton and silk, today appear pious hopes, but were then based on real expectations undampened by a decade or more of only partial success by acclimatization societies.

Taken together, the list is decidedly rural in its emphasis on primary produce. The final clause of the regulations, however, permitted the Board 'to receive and, if approved of, to recommend rewards for other articles of local manufacture or production'. And just as well, for claimants proposed everything from axles to biscuits, explosives to an oratorio! In particular, several based their

3 *Rewards Allowed for Gold Discoveries, Parliamentary Papers of Victoria* (afterwards VPP), (1864-65), 3, 1-68.

4 *Report from the Select Committee of the Legislative Council on the Alpaca, VPP,* 1855-56, 2, 1023-1033.

5 *Victorian Year Book, 1890-91,* 352-354 (para 598); *Report of the Royal Commission on Gold Mining,* VPP, (1891), 5, 531.

cases on products which were easily identified as part of a nascent chemical industry. There are good reasons why personal, technical and quantitative data about these early firms are lacking. Company registration was not specifically legislated until 1864, and was recorded prior to that date only by special and separate acts of parliament.[6]

Even so, many firms in existence at the time of the Act of 1864 did not register, or did not register for some years. Moreover, in Victoria, unlike early Victorian Manchester, but like colonial America, proprietors of industrial firms were unlikely to contribute papers before such learned bodies as the Philosophical Society of Victoria, or to have their work published in academic or professional journals. We are thus left with few formal records.

Nevertheless, sufficient material exists in directories, parliamentary papers, patent lists, gazetteers, obituaries and occasional newspaper accounts to permit some analysis of the scheme of rewards for new manufactures and industries.This material lends us some insight into four key questions — what stage had been reached in chemical manufacture in Victoria by the mid-1860s? How did Victoria compare with northern hemisphere practice? Where did industrialists in Victoria get the technical and scientific knowledge which enabled them to operate chemical plants and processes? And what became of the claimants, both as to reward and future prosperity?

1. *Claimants and Procedures*

The Board appointed by the Victorian Government advertised the scheme in the *Government Gazette*, and sent information to the mayors of all boroughs for exhibition in town halls. In November, newspapers carried further notices. In response, came fifty-eight applications, of which the Board quickly disallowed 35 as not meeting the rules, or as not reaching specified standards of quantity or excellence. Detailed consideration of the rest led to the recommendation of the following rewards:

One hundred pounds	J. Miller (rope) J. Politz (cigars from colonial leaf) Urie, Munn and Young (starch/maizena)
Fifty pounds	F. Fordham (oilmen's stores) Clark, Hoffmann & Co (soda crystals) Hood & Co (white soft soap) J. Bosisto (essential oil from *Eucalyptus odorata*)

6 Act No. 190, Parliament of Victoria, 20 April 1864, published in *Government Gazette*, 26 April 1864.

Twenty five pounds W.R. Blazey (pianos from colonial woods)
W. Sloggatt (thumb, Prussian and ultramarine blue)
Boardman and Slater (cultivation of peppermint, lavender and roses for distillation)
J. Zevenboom (brushware)

The Board expressed regret that no claims had been substantiated for any articles specified in the original proclamation as deserving precedence. As there was reason to believe several undertakings of great promise would soon be established, they suggested to the Government that a similar grant should be placed on the estimates for 1865. They mentioned in particular the promising indications of paper manufacture by Thomas Kenny, of macaroni and vermicelli by Casassa, Ravenna & Co, and of Russian wheat and hemp by A. Martelli, who had imported mulberry trees with a view to sericulture.

Parliament responded by recommitting the scheme in July 1865, and the Board with £5000 at its disposal, proceeded again to advertise and receive submissions. This time, however, the second clause was changed to limit rewards to 'the persons or company who shall have, since the 1st January, 1864, first successfully established or may hereafter first successfully establish in Victoria any new manufacture or production.' This clearly acted to the disadvantage of those who had previously established manufactories or industries in the colony. However, there were sixty-eight applicants (Table 1) and nine more that arrived too late.[7]

The Board reported that they had laboured long, and made their decisions only after personal visits or exhibitions.[8]

They dealt with both agricultural and industrial pursuits, and made a plea for the vote to be continued — and preferably doubled — in 1867. A major change of government in 1867 put paid to this, however, and the scheme was never repeated.

Six of the nine claims which met with reward in the 1864 round were concerned with chemical industry — namely, those of Urie, Munn and Young (starch and maizena), Clark, Hoffmann & Co (soda crystals), Hood and Co (white soft soap), Bosisto (Eucalyptus oil), Sloggatt (blue pigments) and Boardman and Slater (essential oils). Setting boundaries on just what comprises a 'chemical industry' is an arbitrary process, but it is reasonable to exclude Boardman and Slater on the grounds that they claim only cultivation and not the actual

7 These included G. Tolhurst, Prahran, lithographing music; M. Murphy, Melbourne, portmanteaus; H. Robottom, Melbourne, silver chasing; H. Venables, first crop of madder produced in Victoria; George Heath, spirits; J.G. Miller, deep-sea fishing by galvanic currents; E.Geach, Richmond, gentlemen's ties; J.M. Greathead, Carlton, bonnet shapes; S. Henderson, crinolines.

8 *New Manufactures and Industries*, VPP, (1867), 3, 81-99.

distillation of oils of peppermint, lavender and rose. With the exception of Hood and Bosisto, all the other chemical claims reappear in the 1865 list with minor variations or requests for reconsideration of the claim, as did the non-chemical claimants of Miller and Blazey. Given the stated intention to disburse larger sums in the second round, the wonder is that more of the claimants did not reapply, especially as some, such as Zevenboom in the brush manufacturing business, had developed a base from which grew a company that lasted for over a century. The absence of the complete list of original applications from the Parliamentary Papers prevents further analysis of this interesting development.

2. *Pharmacists and their Products*

Joseph Bosisto (1824-1898), an Englishman, qualified as a pharmacist before emigrating to Adelaide in 1848 to take up a position with local druggists F.H. Faulding and Co.[9]

After four years, he moved from South Australia to Victoria, setting up his own pharmacy in one of Melbourne's inner suburbs and augmenting standard remedies with oil of eucalyptus which he prepared himself from local species. The subject of his claim was probably *E. odorata*, otherwise known as peppermint box, a medium sized tree which grows mainly in South Australia but is also found near Avoca in west-central Victoria, an occurrence presumably known to Bosisto from his botanising excursions to the goldfields of that region.

Bosisto's pharmacy training would have included techniques such as those used to separate essential oils from the plant materials which bear them. He was certainly not the first to prepare oil of eucalyptus. That honour belonged to Dennis Considen, surgeon to the First Fleet which brought European settlement to Australia in 1788. Considen distilled the oil of a similar species, *E. piperita*, and remarked upon its medicinal properties as a decongestant. Bosisto was also preceded by many small eucalyptus distilleries in south-eastern Australia, but he was the most successful and continued business for many years, in collaboration or partnership with Felton and Grimwade, whose large drug and chemical company eventually took over his firm in 1885.[10]

Through subsequent company realignments, Bosisto's 'Parrot' brand eucalytpus oil has survived and is still marketed in Australia under its colourful label. Bosisto himself remained interested in essential oils and their use as perfumes, but entered politics, beginning a long career in municipal government before moving into the Legislative Assembly. In 1865-7 he was mayor

9 J. Griffin, 'Bosisto, Joseph (1824-1898),' *Australian Dictionary of Biography,* 3 (1969), 197-199.

10 J.R. Poynter, *Russell Grimwade* (Melbourne: Melbourne University Press, 1967).

of his municipality, Richmond, and his failure to reapply for a reward might well reflect his growing distraction from business by the charm of politics.

Bosisto was undoubtedly a professional, trained in basic principles and proposing for reward a process which formed but a small part of his pharmaceutical business. About his fellow-claimants Boardman and Slater nothing has been discovered, and even Watts whose claim appeared in the 1865 list, is nothing like so substantial a figure as Bosisto. His claim to have grown flowers and distilled them for perfumery essences excells that of Boardman and Slater in going beyond floriculture. The early life of Henry Watts (1828-1889) is unknown, but he became well known in Victoria as a microscopist with an interest in the study of marine algae.[11]

He lived for some years at Warrnambool, on the coast 200 km south-west of Melbourne, where he discovered two new algae, which were later named after him by William Henry Harvey, the great marine botanist. Watts was an excellent naturalist who literally established a cottage industry. The Board reported that 'the premises used are his own residence. One room, part of the cellar, and a small outhouse, are devoted to the manufacture of perfumery, bottling, and getting up for sale. The still (two gallons) is in the out-house. The garden is barely a quarter of an acre in extent, and mostly planted with lavender. He depends almost entirely on other gardens for his flowers. The applicant, his wife, and one child, are all who are permanently employed, and in the season he has employed as many as twenty children to gather blackwood and wattle-blossom in the bush. The establishment is on a very limited scale; but it is considered that Mr Watts understands his business.' Watts was soon to abandon this semi-rural existence, since Melbourne directories for 1868 and 1869 list H. Watts, perfumer, as having premises in the city and in inner-suburban Fitzroy.

Pharmacists of the time were involved to a greater or lesser degree in the actual production of many of the drugs and medicaments they sold. One such was John Hood (1819-1877), who arrived in Melbourne from Ireland in June 1840, entering a local firm which soon took his name and survives to this day.[12]

He was prominent in local affairs, and sat in the upper house (1856-1859) and lower house (1859-1864) of the Victorian parliament. Accounts of his career

11 Anon., 'The Late Mr Henry Watts,' *Victorian Naturalist*, 6 (1889), 138-139; Anon., 'Watts, Henry (1828-1889),' *Victorian Naturalist*, 25, (1908), 115. Ferdinand von Mueller is also said to have named a South Australian acacia after Watts, but another source cites Alfred Watts, a South Australian member of parliament, as the source of the eponym.

12 K. Thomson and G. Serle, 'Hood, John,' in *A Biographical Register of the Victorian Parliament, 1859-1900* (Canberra: Australian National University Press, 1972); K. Attiwill, 'Historical Glimpses of Pharmacy in Australia. The Foundation Years, No. 14: As Old As Melbourne Itself,' *Australasian Journal of Pharmacy*, 38 (new series), (1957), 1036-1039.

contain no mention of manufacture, but it is entirely consistent with pharmacy of this period that the company should make its own soap, for which they received a minor reward in the first round. Certainly by 1877 their advertising described the firm as wholesale druggists and manufacturing chemists.

3. *Sulphuric Acid*

Clark and Company received £50 in the first group of rewards for their preparation of soda crystals and reappeared in 1865 on a broader front, with a claim for the 'manufacture of chemicals,' based on a number of submitted products, including 'white oxide and red and yellow sulphuret of antimony, and the sulphates of copper and iron. The products of the antimony were in the form of paints.' The company is best known for its early production of sulphuric acid; the two sulphates in the above list are evidence that the acid was used, if not actually produced, at their factory. Their production of sulphuric and nitric acids and other chemicals began in 1863 under licence from the Board of Lands and Works to the firm of Clark, Hoffmann.[13]

Directories record that James Robert Clark, William Brooks Hoffmann and E. Peters were proprietors, but it is Hoffmann about whom most information is available.

Hoffmann's obituary in 1902 states that he was born in Bytown (now Ottawa), Canada, and migrated to the goldfields. He developed timber interests in central Victoria which were to be his main business. His involvement in the chemical industry was peripheral, although his obituary claims that he was first to manufacture sulphuric acid in Melbourne, but he was active in the affairs of his municipality, Emerald Hill (later South Melbourne), in which his chemical factory was located. After serving on the Council in 1869, he moved socially and geographically upward to Studley Park. The company was reconstituted in 1865 as Clark and Company, although Peters was still a proprietor, but later the same year it was taken over by Robert Smith and Company and managed by George B. Smith (no relation). By the late 1860s they were producing sulphuric, nitric and muriatic (hydrochloric) acids, antimony, soda crystals, and sulphate and nitrate of potash. Both Clark and George Smith were related by marriage to James Cuming, who had arrived in the colony in 1862 from Scotland after spending some years in eastern Canada and was to emerge as the major manufacturer of sulphuric acid in Melbourne.

Sulphuric acid was first produced in the colony in the early 1860s by James Forbes and Company,[14] and Hoffmann established his business in close prox-

13 J.F. Lack (ed., after M.A. Cuming), *James Cuming: An Autobiography* (Footscray: City of Footscray Historical Society, 1987); 'Notes and Notices,' *The Australasian*, 16 August 1902, 3, 'At the Centennial Exhibition,' *Footscray Independent*, 13 October 1888, 3.

14 An advertisement offering Forbes' sulphuric acid for sale appeared in the Melbourne

imity to Forbes' on the south bank of the Yarra, opposite the city of Melbourne. Their two acid factories, and other noxious trades, were sited in a low-lying area prone to flooding, and they were continually harassed by citizens who resented the fumes and odours. For these reasons, Smith moved at the end of 1870 a few kilometres west onto the bank of the Maribyrnong River in Yarraville, to a site adjacent to that of his chief customer, McMeikan's bone fertiliser works. In 1872, Robert Smith sold out to a consortium formed by George Smith, James Cuming and Charles Campbell who became Victoria's principal manufacturers of sulphuric acid for many years. Forbes and Company remained on the river bank, under increasing pressure, and the fate of the company has not yet been clearly established.

That James Robert Clark was skilled in chemical arts is attested to by patents held by him under the crown in the Colony of Victoria, for improvements in preparing the oxide of antimony, a new improved mode of destroying and extracting burr and other vegetable matters from wool and other special purposes.[15]

In addition, Clark made another application which was not granted for an improved method of manufacturing and concentrating sulphuric acid.

McLeod gives some details of Smith and Company's Australian Chemical Works, successor to Clark, Hoffmann, and of the noisome process of concentrating acids by boiling them in open platinum vessels.[16]

Was this the Clark patent? If so, it could hardly have been original but standards applied to the registration of colonial patents have not been studied. The operation was on a considerable scale, with the lead chamber, in which sulphur dioxide was oxidized to sulphur trioxide by nitrogen oxides, occupying a volume of 15,000 cubic feet. Hoffman was co-patentee on the first two of Clark's patents, which is no guarantee of his technical expertise but does suggest that he was more than just a financial backer. Reflecting his withdrawal from the industry but continued interest in technology, his only other patent, #1527 granted 13 July 1871, contained a new method of indicating the weight of the contents of floating vessels.

4. *Mineral and Vegetable Chemistry*

The handling of corrosive chemicals, especially acids, required special materials. Platinum was used, but sparingly because it was expensive and difficult

Argus, 4 May 1863, 3.

15 In deburring of wool, the contaminated wool was immersed in dilute sulphuric acid, drained and then heated. The process does not harm the wool fibre but vegetable material is converted to brittle carbon which can be removed by crushing and blowing. The process, known as carbonization, is an old one and is still in use.

16 D. McLeod, 'Melbourne Factories,' *Victorian Pamphlets*, 77 (1868), No. 11, 51-52.

to work, and most equipment was constructed of, or lined with, glazed earthenware. Alfred Cornwell's successful claim was of this type, and was the only 'chemical' claim in one of the nominated categories, that of 'china, porcelain, or any of the finer classes of earthenware.' Noting that drainpipes, flower-pots and brown ware had long been manufactured in the colony, the committee commended Steiling, Cornwell, and Rhodes, although only the latter two received rewards. Cornwell arrived in Adelaide in 1853, presumably from Britain, and moved to Victoria in 1857.[17]

Cornwell held a number of patents; since there were many other manufacturers of earthenware, his gift lay in novelty, possibly stimulated by the embryo chemical enterprise of Forbes and of Clark, Hoffmann and Peters.

Heath's application arrived too late to receive full consideration by the Board, and his official position as inspector of distilleries suggests that he was not really in a position to establish an industry, but his engineering interests are revealed by a patent granted to him on 29 March 1870 (#1362) for a water or paddle-wheel gold collector. His claim was for a process that made spirits from the saccharine matter extracted from grasstree, and for a process that freed the spirit from a resinous and offensive smell that appeared in the course of manufacture. The Board considered that Mr Heath was among the first, if not the first, to make spirits from this apparently useless tree, and deserved great credit. In other parts of Australia, the grass tree, *Xanthorrhea australis*, was the source of methanol and acetic acid (obtained by destructive distillation of the stems) and of picric acid for the dyestuffs industry (obtained by oxidative nitration of the resin).[18]

Antimony played a major role in early mining and chemical industry in Victoria. Antimony metal was used for hardening lead to be used as shot, while the white oxide of antimony was used as a pigment in paints in much the same way as white lead was and is (to a limited extent) today. The oxide was also used to prepare the pharmaceutical, tartar emetic (potassium antimony tartrate). The antimony sulphide, stibnite, was present in a number of the central Victorian gold localities, but most production during this period came from a mine near Heathcote. The discoverers were Messrs Coster and Field who soon gave their names to the settlement, Costerfield, which remained an important producer of gold and antimony until just before World War II. The production figures make interesting reading:

17 A. Sutherland, *Victoria and its Metropolis* (Melbourne: McCarron, Bird and Co., 1888), vol. 2, 633, J. Allan (ed.), *Victorian Centenary Book* (Melbourne 1934), 56-57. The two accounts are similar and probably represent paid contributions rather than considered histories.

18 I.D. Rae, 'Wood Distillation in Australia: Adventures in Arcadian Chemistry,' *Hist. Rec.Aust. Science*, 6 (1987), 469-484.

	Produced (ton)	Exported (ton)
1862	*	154
1863	806	660
1864	578	400
1865	729	153
1866	435	114
1867	272	508
1868	841	867
Total	3661	2856

* [the 1862 and 1863 figures are combined)
Source: Annual Mining Reports to Victorian Government (VPP).

The dip in exports in the middle of the decade suggests local use of the ore, and possibly the advent of a smelting industry. Indeed, the mining reports from which the figures are drawn record that the Victorian Antimony Smelting Company had erected a furnace in 1864 but not yet smelted ore. During 1865, five tons were smelted on the land leased by Coster, Field and Martin. The Antimony and Sulfur Company Limited, possibly a successor, was registered on 8 February 1867. Its office was in Easy Street, Collingwood, and managing director was Edward Hughes. Among the shareholders were Edward Hughes, Simon Hughes, smelter, and twelve others who gave their occupations variously as miners, contractors and so on. The figures above suggest that it did not have much impact upon local production, and it was wound up in October 1869 with no obvious successor. Hughes was the holder of a patent, granted on 12 February 1864, for improvements in the treatment of antimony ore for the purpose of separating the metals.

Some evidence of a successor is provided by a patent, granted in 1873 to John Bromley Hughes for the extraction of antimony from ores.The Board went to some trouble to investigate Edward Hughes' claim before it turned him down. Sydney Gibbons, commissioned to analyse the ore and the antimony produced from it, he reported in February 1866 that both were of high purity.[19]

19 H.J. Gibbney and A.G. Smith (eds), 'Gibbons, William Stanley (1825-1917),' *A Biographical Register, 1788-1939* (Canberra: Australian National University Press, 1987).

Hughes claimed yields of 60-65%, which Gibbons felt were lower than might have been obtained, and novelty, in that his ore was roasted in the open to remove some of the sulphur before being further reduced in a closed furnace. However, Gibbons felt that little new had been disclosed, noting that he had carried out experiments himself to provide Messrs Cairns and other firms with a suitable process in 1859. Others were active in the field, as evidenced by the fact that Charles Watt's 1865 patent application for a process that oxidized 'antimony ore and [produced] therefrom white paint and sulphuric acid; also the extraction of the precious and other metals from antimony ores' was not granted. Gibbons noted that 'Mr Hughes speaks of ... sulphur and white paint—which he states he can make (not has made)—samples of these are not submitted.'

Two chemists from Ballarat, a gold-mining city some 100 km west of Melbourne, pressed their claims for rewards. John Christian Lyons was unsuccessful in his claim, and the Board's report contains little that helps us understand why. The 'ligneous potash deposits' from which he proposed to make manures are beds of brown coal (lignite) which were encountered by miners in the 1860s as they sank shafts through the basalt to reach gold-bearing gravels which were interbedded with the lignite. The beds thicken to the east of Ballarat and were later mined commercially at a number of locations. By the time of his application, Lyons had already secured several patents, including improvements in machinery for crushing quartz and for amalgamating, and a number relating to fuels and manures. His first patent demonstrates an acquaintance with the mining industry; the second and fourth, with fuels; and the fifth, with extraction of potash from wood ashes. Nearly half his patents are concerned with manures, and he was a proprietor of two registered companies whose business this was. The Ballarat Patent Fuel and Manure Company Limited was registered in January 1865 to manufacture his concentrated manure and universal fertilizer, and hydro-carbonic fuel — which was presumably water gas, a mixture of carbon monoxide, hydrogen and carbon dioxide manufactured by drawing water vapour through hot coals. Lyons describes himself as a chemist, and his co-proprietor A. Hibberson is 'patentee.' In December of the same year, Lyons registered the Victoria Patent Manure and Chemical Company Limited which used bones as its raw material. There were six proprietors, including managing director John Christian Lyons, agricultural chemist, and Frederic John Christian Lyons, clerk (possibly his son).

Nothing is said about Lyons the industrial chemist in any of the standard works on Ballarat, which in the mid-sixties was a prosperous town in the centre of Victoria's goldfields. The only industrial enterprises described are the city's breweries and distilleries, and it may be that lowly bone mills and their proprietors were beneath public comment. However, another possible reason was Lyons' behaviour during the Legislative Assembly election of August 1861. Referring to the 'inevitable' Mr Lyon, the Ballarat *Star* described the candidature of J. Christian Lyon (sic), a blacksmith, who claimed that 'if there was anything great, noble or dignified in the British people, he was the representative of it. [20]

They called for a doctor to test his sanity,' said the *Star*, 'and laughed him off the platform.' Lyons polled only twenty of the several thousand votes cast in the electorate of Ballarat East, and thereafter disappeared from public view. His first company was defunct by 1891 when a Registrar's letter was returned unclaimed, but nothing is known of the fate of his second company.

If Lyons, an outsider, did not receive a reward, nor did the other Ballarat claimant, closely connected with the manufacturing establishment. Eric Maynard Meyer's claim was listed as involving 'manufacture of chloroform, essences &c.' In Board reports, this is amplified slightly to include, on one occasion, spirits of wine (alcohol distilled from aqueous mixture), and on another ether in addition to chloroform. The presence of two anaesthetics on the list suggests that Meyer was connected with the pharmaceutical industry, a clue substantiated by evidence of his being one of the registrants of the Ballarat Chemical Manufacturing and Distillery Company Limited in October 1866. Two of the proprietors, Meyer and Henry Brind, are described as chemists. Brind was a well-known Ballarat pharmacist and manufacturer, whose career is described in Ballarat sources; and Meyer was probably a distiller whom he had interested in the preparation of chloroform and ether, both of which involve distillation.[21]

5. *Explosives*

John Cyrus Martin's successful claim for a £25 reward for a patent safety compound, a non-explosive substitute for blasting powder, was made on behalf of the Australasian Patent Blasting Compound Company. In the context, 'non-explosive' meant that the material would not explode spontaneously, but only when suitably triggered, making it safe to transport and load at the point of intended use. This was the main thrust of the Board's report on his blasting compound, 'of the excellence of which very satisfactory testimonials were produced, and of the merits of which, in at least one respect, that of safety, there can be no doubt.'

20 Ballarat *Star*, 29 July 1861, 2; Ballarat *Star*, 30 July 1861, 5 (Supplement).

21 Ether was introduced for surgery and the use patented by W.T.G. Morton (1819-1868) in 1846 in America, although it had been used earlier by other experimenters who then came forward. The practice was taken up in Britain by James Y. Simpson (1811-1870) who came to prefer chloroform which he introduced into obstetrics. Chloroform was manufactured in Victoria by 1848 but no details are available, although deaths from its use were reported in 1852: Melbourne *Argus*, 26 May 1848, 2; Melbourne *Argus*, 1 September 1852, 5.

For more information about Martin we turn to the second report of the Select Committee on National Defence, which was presented to the Victorian parliament in July 1865.[22]

This instalment deals mainly with munitions, including the local manufacture of gunpowder. Joseph Bosisto and the government botanist, Ferdinand von Mueller, presented evidence as to the suitability of local woods for the production of charcoal, an important ingredient of black powder. Analytical chemist George Foord confessed that he was little acquainted with powder manufacture, but contributed his opinion that (apparently, contrary to Lyons' claim) colonial woods would not yield potash. Martin introduced himself as one brought up in the powder industry for twenty five years, mainly at Kennell in Cornwall. He had been some time in Victoria, possibly attracted by gold mining since his patent list starts with that industry.[23]

Martin proposed sources of charcoal — wattle, willow and elder wood — and of sulfur from South Australia, and warned that skilled labour from Europe would be required for refining crude nitre and sulphur. His own manufactory was almost certainly not in South Yarra, the address given the Board, since that elegant Melbourne suburb was, as now, an upper-middle class residential district. The basalt plains west of Melbourne are more likely to have housed such a dangerous enterprise, but government records contain no registration of such a company. Neither does Martin appear in connection with the five explosives companies later established.[24]

The complete fabric of the industry is yet to be revealed, and nor is Martin's role clear, despite his being given a reward. An even more minor figure was Pedro Nisser, who received no reward nor is mentioned in any of the company

22 VPP, (1864-5), 2, 911.

23 Certain improvements in the arrangement of quartz-crushing machinery. The extraction of gold by means of a certain chemical process from the pyrites, sulphurets & co. Improved composition for explosive purposes.

24 Patent Safety Blasting Powder Company Limited, registered February 1871, wound up August 1871; Australian Lithofracteur and Nitroglycerine Company Limited, registered July 1874; Pyrolignone and Safety Cartridge Company Limited, registered October 1874; The Safety Powder Blasting Company, registered December 1876, wound up February 1878; Eclipse Safety Blasting Powder Company, registered March 1878, no response to registrar's letter, May 1891. Little is known of explosives manufacture in Melbourne in the 1860s and 1870s. It is clear, however, that Eclipse took over the plant and assetts of the Safety Powder Company and those of an unregistered Eclipse Blasting Powder Company. A history of ICI Australia records that Jones, Scott & Co began explosives manufacture in the western suburbs of Melbourne in 1874 and that their business was taken over in 1875 by Australian Lithofracteur (Krebs Patent) Ltd, which subsequently became part of the Nobel Group and eventually ICI Australia. John and Elizabeth Jones are listed among the proprietors of the Pyrolignone Company but do not appear in the registration details of any other company.

registrations referred to above. Like Martin, however, he held a variety of patents.[25]

Explosives were vital to the mining industry which had entered a hard-rock phase by the 1860s, as well as to road and railway construction. Always in the background were possible military uses in a colony which was increasingly giving an eye to self-defence.

6. *Animal Products*

In rewarding Honnens, Vockler and Company with a minor sum, the Board commented that their product was 'glue of very excellent quality, equal to the best imported ... which would have merited a higher reward if the manufacture had been commercially established.' Little detail is available, apart from the inference that the company did not strictly qualify for a reward for a product which must have been fairly common, given the material available for its production from hoof and horn. The company address is given as Maldon, a mining town in central Victoria, but Sutherland refers to John Vockler, gluemaker operating in Yarraville in 1871, who died in 1875.[26]

More sophisticated use of meat trade by-products was made by soap and candle companies, including Godfrey William Praagst. Proudley described Praagst as an engineer of English birth who had travelled widely in Europe before arriving in Victoria in 1856.[27]

Curiously, his obituary in a Melbourne newspaper in 1872 carried the request that 'Russian papers please copy,' which, together with his Germanic name begged the question of non-British origins. He became a substantial figure in Melbourne's chemical industry, and the Board's enthusiastic reward of £100 to 'G.W. Prangst' for manufacture of stearine candles is certainly his. The 'sterine (sic) candles for which the Melbourne Sterine (sic) Company made a claim, and have been awarded a premium, were superior to any description of candles previously made in the colony; but a still further improvement must be made before the imported article can be driven out of the market.'

25 582/538 (29 May1860), Improvements in the construction of generators for producing magneto-electric fluids, and in applying the same to new purposes; 852/837 (29 July 1865), A composition for blasting and other purposes; 853/838 (29 July 1865), A composition to be used as an explosive power for ordnance and fire-arms and other purposes.

26 Sutherland, *op. cit.* note 16, 621. The death notice refers to Johannes Vochler (sic), patent waterproof manufacturer, late of Luneberg, Germany, and a fuller obituary reveals that he was run down by a train while walking along the tracks late at night, returning from a business trip. In this latter account he was 'John Vauckler, glue manufacturer, residing at Yarraville: Melbourne,' *Argus*, 19 July 1875, 46. The municipality still has a Vockler street, near the site of the original factory.

27 Proudley, *op. cit.* note 1.

One of the listed patents represents Praagst making a contribution to the mining industry which seemed almost mandatory for Victorian inventors.[28]

Another, however, reveals his interest in the gas industry. The patent described a 'first, extraction by distillation of a spirito-oleaginous compound oil from gum-tree (Eucalypt) leaves; second, extraction of carburetted hydrogen, pyroligneous acid and tar.' Praagst's patent list shows his career as an industrialist. He described himself as a civil engineer, and was engineer to gas companies in Kyneton (1857) and Castlemaine (1858), both central Victorian goldfields towns, where he championed the use of gum-leaf gas — an alternative which soon gave way to more conventional coal. However, his main enterprise was in soap and candles. Animal fats contain glycerol (glycerine) which is chemically combined with fatty acids such as stearic, palmitic and oleic. Such fats are split (saponified) by heating with caustic soda solutions, the products being glycerol and mixed sodium salts of the fatty acids which are the common toilet soaps still in use today. This appears to have been the business of Praagst's Hobson's Bay Soap and Candle Works, established in 1860 at the bayside suburb of Williamstown. In 1863 the company moved to the city block, while leaving the noisome rendering and saponification plant on the Yarra bank south of the city. He enjoyed 'long experience throughout Russia and other parts of continental Europe,'and his products were awarded medals at a number of international exhibitions.[29]

In November 1865, Praagst registered his Melbourne Patent Stearine Candle Company Ltd. to exploit his patent and to purchase the premises of the Flemington Candle Works then owned by Praagst and Adalbert Kruge. The company was wound up voluntarily in August 1866, and Praagst began the Star Stearine Candle Works in March 1867. Since it was not separately registered, it must have been part of the Hobson's Bay Company which was located in an adjacent building. The new company was involved in acid-catalyzed splitting of fats which yielded glycerol and the component fatty acids. Oleic acid, being a liquid, was removed from the acid mixture by pressing and converted by the Hobson's Bay Company to its sodium salt which was marketed as soft soap. The solid acids were melted and cast around wicks to form superior candles.[30]

28 The manufacture of oil from a material not hitherto so used; A compound auriferous-soil washing, puddling, and amalgamating machine; Improvements in the manufacture of candles; Improvements in the manufacture of vegetable-gas for illuminating purposes; Improvements in treating fatty matter in the manufacture of stearine and sperm candles; Improvements in gas-burners; Improvements in preserving fowl, fish, meat and other animal food; Improvements in the manufacture of candles.

29 McLeod, *op. cit.* note 16.

30 Directories reveal many other manufacturers of soap and candles and there is one early patent application - by John Walter Osborne, John Thompson and Joseph Morgan, for stearine candles (539/493, 16 October 1861) but it was not granted.

Early candles were made from animal fat (tallow), which produced the acrid fumes characteristic of burning substrates which contain the glycerol moiety. Because the raw material, tallow, was easily come by, there were many soap and candle manufacturers. However, stearine (fatty acid) candles — harder, and burning with less smoky flame and without irritant fumes — were introduced in Europe early in the nineteenth century, following the work of French chemist M.E. Chevreul (1786-1889) and J.L. Gay-Lussac (1778-1850) who patented the invention in 1825. Stearine candles were eventually displaced by paraffin wax, first produced in the 1850s from Scottish shale oil and later from petroleum. Melbourne's most successful soap and candlemakers were the Appollo Stearine Candle Company Limited, founded in August 1872, and that of John Kitchen and sons, one of whom had arrived in Melbourne in 1854. Kitchen had learned his trade in England and began to make tallow candles in South Melbourne in 1856, moving in 1860 to establish his company and then seeing it prosper.[31]

He began stearine production in 1868, and in 1885 amalgamated with his rivals to form Kitchen and Apollo.

James Nelson's claim on account of salt produced from seawater at Hastings in Victoria was not rewarded, and it would be surprising if it were not until 1864 that someone had got around to practising this ancient art in Victoria. Linge notes the presence of a salt-works in Sydney at the turn of the nineteenth century.[32]

The sea-salt works operating today on the Victorian coast, to the south-west of Melbourne, are historic, but there were also small ventures in the Westernport region, south-east of Melbourne. Nelson's was one of these, and he had learned his trade in Blyth, Northumberland, before migrating to Tasmania in 1842 and then relocating in Victoria. The dominant saltmakers, Cheetham, established themselves at Geelong in 1888 and sea-salt is still produced at the old site and at two others, closer to Melbourne, which they developed a few years later. Before that, however, Richard Cheetham had been involved, in partnership with Felton, Grimwade and another firm, in a venture on French Island which is close to Hastings.[33]

7. *Pigments*

William Sloggatt is listed during this period as a thumb blue manufacturer residing in the Melbourne suburb of Malvern.[34]

31 Anon., 'The Story of John Ambrose Kitchen,' *The Unilever Australia Reporter*, September 1956, 20-23.

32 Linge, *op. cit.* note 2, 46.

33 E.A. Swinton, 'The Early Australian Chemical Industry. 3. Cheetham Salt Limited,' *Proc. Roy. Aust. Chem. Inst.*, 29 (1962), 356-370.

The blue powder was used as a pigment and added to water so as to improve the appearance of white goods. Textile yellowing is caused by substances which absorb blue light, thus rendering the colour of reflected light yellow. Small particles of blue (strictly speaking a pigment, not a dye, since it was present as tiny particles) causes some blue light to be reflected and thus restores the colour balance of the fabric. Such blues are chemically complex and do not rely upon metals such as copper for their colour. Mineral examples are lapis lazuli and sodalite, and early 'blues' were made by powdering the native minerals. Synthetic versions are derived from heating mixtures of kaolin, soda ash, sulphur and charcoal — probably the basis of Sloggatt's first patent.

Sloggatt held two Victorian patents[35] but credit for the discovery of the process goes to Jean Baptiste Guimet (1795-1871) who established its manufacture in France in 1828.[36]

Reckitt's, in England, began manufacture in about 1850, and in 1864 exported the product for the first time to 'the dominions,' in this case, Montreal. The company did not found an Australian branch until 1886, but annual Australian sales of their blue and blacklead amounted to £10,000 by 1877, although this declined thereafter.[37]

Sloggatt appears to have been advanced in his technology and one wonders that he did not receive a reward.

8. *Building Materials*

G.M. Stone, who discovered a material suitable for cement making near Geelong, was probably George Mitchell Stone, draper, of Collingwood. He was born in 1832 in London and was living in Ballarat in 1856. Geelong has been for many years the centre of Victoria's cement industry, with suitable limestone beds being exploited for the manufacture of Portland cement from carefully adjusted proportions of limestone and clay since 1890. From 1859, however, there had been experimentation with production of Roman cement (mostly lime, with perhaps a little clay) and there are several successful patent applications.[38]

34 The blue was so called because it was marketed in nodules of approximately thumb-size.

35 486/488 (30 August 1861), The application of a clay known as kaolin in the manufacture of various articles of commerce; 541/500 (2 October 1861), Improvements in the making and manufacturing of bricks, slabs, co. or for any decorating purposes either internally or externally.

36 D. Chapman-Huston, *Sir James Reckitt: a Memoir* (London: Faber and Gwyer, 1927).

37 J. Edwards, *Out of the Blue: A History of Reckitt & Colman in Australia* (Sydney: Reckitt & Colman, 1982), 1.

38 M. Lewis, *Two Hundred Years of Concrete in Australia* (Sydney: Concrete Institute of Australia, 1988); P. McKay, *The History of the Cement Industry to 1939* (1977) (unpublished manuscript in possession of the Cement and Concrete Association of Australia, Melbourne).

James Urie and Alexander Young were among the claimants who featured in the 1864 reward list, and who renewed their claim the next year, but without success. Sutherland describes Urie, of Flemington, as a glass-importer and stainer but Urie and Young shared a 1864 patent for 'Improvements in machining for the manufacture of maizena and of starch,' maizena being edible corn starch.' Even then Urie had other interests, as demonstrated by his 1865 patent for 'an improved and cheap method of converting basaltic rock into street flagging and other pavement.' To the west of Melbourne is a plain beneath which lies thirty metres of fine-grained bluestone (basalt) which was then, as now, worked for building stone and road metal.

9. *Review*

The search for information about applicants, successful and unsuccessful, who based their claims on practical chemistry helps us form a picture of the infant chemical industry in Melbourne. Like its descendants, it shows evidence of the interlocking which characterises the chemical industry.

Sulphuric acid production was at the heart of the industry. In Melbourne, there is evidence from 1862 for its production and use in the production of other chemicals such as sulphate salts and volatile acids, for the splitting of fats, the production of superphosphate manures and the carbonization of burrs in wool. Nitric acid so derived from sulphuric was the basis of the gunpowder industry and later of the manufacture of nitroglycerine. Animal wastes provided raw fat for conversion to soap and candles, as well as bones which were converted to low-grade fertilizers by grinding or, by treatment with sulphuric acid, to more soluble forms of phosphate fertilizer. The raw materials for glue also came from animal wastes.

Direct processing of minerals was the concern of the gold mining industry, but ores of other metals such as antimony were also worked and refined. More refractory minerals were used in the manufacture of pottery, cement, and blue pigments. The third leg of the animal-mineral-vegetable trilogy is represented by production of essential oils for perfumery and medicinal use, the manufacture of other plant-derived drugs, and brewing and distillation of alcoholic beverages.

Most proprietors were old enough to have brought with them from their countries of origin the basic tenets of their professions. Whether they actually did so or not is usually unclear. But the lists of patents held by these men reveal interests touching on several aspects of mining and chemical industry. Most major chemical enterprises of early Melbourne are represented among the claimants and those who were in competition with them.

The rules stipulated that only developments of new industry after 1 January 1864 could be considered for a reward. Some of the non-contenders, such as Kitchen Brothers, went from strength to strength in later years. McLeod commented upon his selection of factories that 'preference has been generally given to those established by private enterprise, and, on this account, some large manufacturies supported by Government or propped up by bankers or speculating capitalists have been excluded.'[39]

It would be unwise to assume that all omissions from McLeod's list were made on this basis alone, citing again the example of Kitchen's who appear not to have had speculative or government backing, nor patronage from those sources.

The Board was apparently not impressed by the procedures according to which new manufacturers were recognised at the International Exhibition of 1862. According to McLeod 'the manufacturers generally hold the awards of Jurers at the Intercolonial Exhibition in low estimation, from the inefficiency evinced; and this is openly ascribed to partiality, ignorance and negligence.'[40]

He even claimed that honourable mentions went to some exhibits that the jurors had never seen! The Exhibition followed preliminary work in the Australian colonies to gather and provide financial support for their exhibits. Reporting to the government on the successes enjoyed by Victorian exhibitors, Redmond Barry noted that the space occupied by Victoria was as great as that taken by the combined exhibits of New South Wales, South Australia and Queensland, and that awards to Victoria far exceeded those to other Australian colonies.[41]

Many of the firms favoured by the Victorian government in 1865 did not go on to continued success. Some like Bosisto's and Clark, Hoffmann changed hands and ultimately lived on through their successors. Others, like Vockler, carried on until death removed their driving force. There were others, like Slogatt, Henry Watts and Edward Hughes, who simply faded away. By limiting the time, the government predetermined that firms claiming reward would be new or beginning new ventures. Thus at risk, if not actually predisposed to failure, it is hardly surprising that few survived the intense development and competition which characterised the next two decades.

Victorian governments introduced tariffs in 1863 and then, unlike their sisters in Sydney, pursued protectionist policies. Consistently, they sought to foster local industries in positive ways through the offer of rewards. They sought to break a dependence upon, and taste for, imported goods among a community grown fat on the proceeds of early gold mining in the 1850s.[42]

Their efforts met with ridicule by free-traders who seized on the inability of local distillers to capture the local whiskey (sic) market despite a bounty of four shillings a gallon on the imported product. The two major newspapers

39 McLeod, *op. cit.* note 16.

40 *Ibid.*

41 *International Exhibition of 1862*, VPP, (1862-3), 4, 13-27.

42 E. A. Beever, 'The Pre-Gold Boom in Australia 1843-1851,' *Aust. Econ. Hist. Rev.*, 19 (1979), 1-25.

presented the opposing views with force and (occasionally) malice. David Syme's *Age* was strongly protectionist, but a long editorial in its competitor the Melbourne *Argus* deplored such interference with the economies of manufacturing, beginning gently enough with talk of 'kingly and noble patronage' but ending with denunciation of such 'vicious principles ... of economic legislation.' [43]

The development of the city of Melbourne, capital city of the colony of Victoria is described in the wealth of government and other published material which is available for study by historians. The surge of interest in Australian history since the 1980s has improved access to much of this local material, enabling us to provide an unusually detailed description of the foundations of the early colonial chemical industry. The next stage involved increasing professionalisation and organisation, and for this we turn to Australia's sister Dominion.

II.
Chemistry and Industry in Canada

In Canada, as elsewhere, industry, rather than government or the universities, has provided the occupational setting for most Canadian chemists and chemical engineers. To cite a single example, at the time of World War One, more chemists were employed in the food and drug industries in Canada than in all the Dominion's colleges and universities combined. It is in the daily work of those men and women that the story of Canadian chemistry lies.

As chemical industry expanded, work at the bench was supported by an increasingly elaborate infrastructure. Its purpose was to acquire, manage, disseminate and apply the chemical knowledge necessary for industrial production. The tangible aspects of this infrastructure, the 'hardware,' included new journals and texts, professional and technical associations, new or expanded educational institutions and new government science bodies. The equally important intangible aspects, the 'software.' included reformed curricula, new attitudes towards proprietary chemical knowledge on the part of the managers of firms, and improved status for university-trained chemists in industry.

1. *The Origins of Chemical Industry in Canada*

Thanks principally to the efforts of Warrington and his co-workers, the early growth of chemical industries in Canada is fairly clear.[44]

43 Melbourne Argus, 7 July 1866, 4.

44 Except where otherwise noted, this section is based on C.J.S. Warrington and R.V.V. Nicholls (comp.) *A History of Chemistry in Canada* (Toronto: Pitman, 1949). The interested reader should also consult C.J. Warrington and B.T. Newbold, *Chemical Canada* (Ottawa: Chemical Institute of Canada, 1970).

To a striking degree, the earliest depended on forest resources. Tanning, for example, became a pioneer industry wherever water, a supply of hides and appropriate bark were available. Potash (from wood ash) and the more refined product pearl ash also formed a vital component of the pioneer economy. The sale of these products often produced the settler's first — and badly needed — cash income. Together they constituted a major item in early nineteenth century exports. Canada's historic maple sugar industry was conducted by small operators throughout the eastern woodlands, and is only now succumbing to the effects of acid precipitation. Moreover, in contrast to the successive failures of small iron ventures in nineteenth century Australia, Canada boasted a remarkable, vigorous and lasting charcoal iron industry.[45]

The most famous ironworks must be Les Forges de St.-Maurice, encouraged by French colonial officials and not finally closed until 1883, by which time it was irrelevant in an age of giant integrated steel companies. Abundant limestone deposits were quarried and burned in simple kilns to produce the lime needed in construction.

Warrington and Nichols puckishly observe that 'the growth of population in this country can almost be traced by the incidence of its breweries'.[46]

By the nature of the product, a prohibitive 'tariff of bad roads' operated against beer, the brewing of which ranked among the earliest of local industrial activities. The Toronto distillery Gooderham and Worts, only recently closed, had its modest start as an adjunct to a Toronto flour mill in November 1837. Reinforcements in the campaign to slake Canadian thirsts arrived in the 1850s with the major distilling enterprises of Walker, in what is now Windsor, Seagram in Waterloo, and Corby near Belleville.

The development of a variety of publicly and privately owned utilities accompanied urban growth. Albert Furness started Canada's first gas works to light the streets of Montreal in 1838. Sydney's Australian Gas Light Company had begun the year before, but Melbournians waited until 1856 for their equivalent. The Australian scene was relatively untrammelled, but in Canada government regulation formed an early and persistant feature of this industry.[47]

Although most buildings in nineteenth century Canadian cities were constructed of wood, with inevitable consequences, the demand for cement and fear of fire sufficed to lead R. Wright to found Canada's first cement works in Hull in 1830. The industry had a number of modest-sized firms until consolidation by Canada Cement Co. in 1909.

45 K. Inwood, *The Canadian Charcoal Iron Industry, 1870-1914* (New York: Garland, 1986).

46 Warrington and Nicholls, *op. cit.* note 44, 268.

47 C. Armstrong and H.V. Nelles, *Monoploy's Moment* (Philadelphia: Temple University Press, 1986).

The 1840s, a time of painful readjustment following the end of the old Imperial economic system and the failed Canadian rebellions, saw trends in the chemical industry. Artisans and specialized shopkeepers moved into the manufacture of chemical products in a larger way. Master painters John McArthur and Alex Ramsey established themselves as building painters and paint manufacturers in Montreal in 1842. J.D.B. Fraser, a Pictou druggist, supplied chloroform to the medical profession of Nova Scotia from 1848, about the same time that anaesthetics became available in Australia. Household items once manufactured on the farmstead increasingly came to be produced by industry for sale to urban and rural markets. The first soap works, that of Darling and Brady, began in Montreal in 1840. Canada's first glass making enterprise began in St. Johns (Quebec) around 1845, as indicative of the increasing capabilities of Canadian industry as it was of urban affluence. One of Canada's most famous inventions, kerosene, was first made by Abraham Gesner in Nova Scotia in the 1850s. At about the same time, the Canada Powder Co. of Cumminsville, Ontario, operated by Charles Kelley, produced the first explosives made in Canada.

The decade of Confederation saw a quickened pace in new chemical enterprises as well as the greater integration of formerly isolated industries. Chemical pulping techniques migrated to Canada soon after their development, the Riordon family of St. Catharines being prominent. The still existing southwestern Ontario petroleum industry dates from the 1860s. Canadian petroleum technology was carried around the world in later years as the Ontario reserves were dwarfed by those elsewhere. The first sulphuric acid plant in Canada began operations at London, Ontario, in 1867. It was connected with London and Port Stanley Railway interests which helped link the southwestern part of the province to US markets across Lake Erie. It and three other plants in London in the 1870s provided a necessary input to both petroleum and explosives industries. The latter closely followed the routes of railroad construction and hardrock mining across the Canadian shield and through the western cordillera. While some minor commercial salt production had taken place on the Niagara Peninsula from early pioneer times, it did not become a major industry until 1866 near Goderich where it, too, related closely to the well drilling activities of the petroleum industry.[48]

Australia with its sunshine relied on slower, outdoor salt pans. The Brockville Chemical and Superphosphate Co., Canada's first superphosphate plant which also produced sulphuric acid, began in Brockville in 1869 and lasted until 1884. The Australian colonial equivalents, founded in the same decade, grew strongly over the next 70 years.

48 W.A.E. McBryde, 'Ontario: Early Pilot Plant for the Chemical Refining of Petroleum in North America,' *Ontario History*, 79 (September 1987), 203-230; Dianne Newell, *Technology on the Frontier* (Vancouver: University of British Columbia, 1986).

The years of Prime Minister Sir John A. Macdonald and his hapless successors have long been described as a period of economic doldrums. We now know that they were also years of modest if uneven growth, eclipsed by the spectacular takeoff which began in the late 1890s. Certainly both growth and development continued in the Canadian chemical industry throughout the last third of the century. New concerns not closely related to the traditional staples included the Dominion Oilcloth Co. of Montreal (1872) and Canada Printing Ink Co. of Toronto (1880). The development of peripheral institutions and professional associations — a stage along the way to scientific independence — may be noted, such as the founding of the *Canadian Pharmaceutical Journal* in 1868 and the Ontario College of Pharmacy in 1871. London, Ontario, pharmaceutical chemical manufacturer William Saunders went on to greater fame as first director of the Dominion Experimental Farm. New products came onto the market, such as asbestos from the Thetford, Quebec, mines beginning in 1878. New uses were made of old resources as in the first Canadian wood distillation plant — that of the Rathburn Co. of Deseronto, Ontario in 1887. New chemical processes were discovered, most notably Canadian Thomas L. Willson's invention of the modern process for calcium carbide manufacture, developed in the 1890s. Mining was the locus of tremendous innovative activity. The Frue Vanner, a gravity concentrating device for ore, was invented by an American in Canada in 1874 and used internationally. By the turn of the century, more-complex ores were being worked, and higher efficiency demanded, so chemistry joined and sometimes supplanted mechanical engineering at the forefront of technical advance in mining and metallurgy.

Entrepreneurs sought to prosper in an ever-changing atmosphere generated by government policy, transportation costs and market demands which informed decisions on importation, local production and processing. The industrialists used existing or imported technology with a few significant exceptions, but hard and creative work was needed to apply such technology to local conditions and to meet the demands of regional and international markets. So much local innovation was of this adaptive kind. Our focus here is the local effort which formed one side of the tension between local and imported goods and expertise.

2. *The Society of Chemical Industry*

In 1880, Professor W.H. Pike of the University of Toronto noted that chemistry had

> invaded the whole field of industry, and is transforming it: not only by improving traditional methods and introducing new ones for making old necessities ... or by originating new necessities ... but by introducing chemical control of raw materials, processes and products.[49]

49 Quoted in H.M. Tory, *A History of Science in Canada* (Toronto: Ryerson, 1939), 27. For a description of the 'scientization' process in European industry, see Robert R. Locke, *The*

One notable indication of the growth and maturity of industrial chemistry in Canada was the formation of a Canadian section of the British-based Society of Chemical Industry.[50]

In Australia, a branch was established in New South Wales in 1902 but Victoria had its own Society of Chemical Industry. The Canadian section had its origins at the second monthly dinner of the Canadian Manufacturers Association (CMA) at the Temple Cafe in Toronto on 25 April 1901, when a hundred members gathered to discuss 'chemistry in its relation to the arts and manufactures'. Also present at the meeting were Toronto Mayor Howland and several leading Canadian academics, among whom were Professors Lang and Wrong of the University of Toronto, Ellis of the School of Practical Science (Toronto) and Goodwin of the Ontario School of Mines (Kingston). Lang described the advantages of cooperative industrial research. In particular, he pointed to the success of R.K. Duncan, trained at the University of Toronto, in promoting a scheme of industry-endowed fellowships in chemistry at the University of Kansas. Lang observed that it was likely that holders of those fellowships would later move into responsible managerial positions in industry, bringing with them the benefits of a rigorous university science training combined with an exposure to industrial problems. A resolution was passed at the meeting that the CMA form a Canadian branch of the Society of Chemical Industry. The Executive of the CMA supported this resolution and appointed a committee headed by H. Van der Linde of the Gutta Percha and Rubber Co. of Toronto to work out the details.[51]

Canada proved to be fertile ground for the Society. Van der Linde and Ellis canvassed Canadian chemists about setting up a Canadian section of the Society, while both the CMA and the Toronto Board of Trade lent support. A first, informal, meeting of the Canadian section was held at the CMA's offices in October of 1901. Professor W.R. Lang applied to the British Society for section status which was granted on 24 January 1902. At the first Montreal meeting of the Section, held at McGill University on 23 December 1903, Lang was again the speaker. He stressed the need for close cooperation between industry and the universities, pointing out that the Society of Chemical Industry aimed at bringing 'before manufacturers the fact that a trained university graduate was a more suitable person to give suggestions and improve their processes of manufacture than the technical man without any scientific training.'[52]

End of the Practical Man (Greenwich: JAI Press, 1984), 58-81.

50 See reports in *Industrial Canada*, May 1901, 253-258; January 1902,195-196, and *Pulp and Paper Magazine of Canada*, 2 (January 1904), 15.

51 *Op. cit.* note 50.

52 Report in *Pulp and Paper Magazine of Canada*, 2 (January 1904), 15.

Apart from their substantive content, Lang's remarks illustrate a crucial point. Science had to be sold. Boosterism, science promotion — call it what you will — was necessary to increase the quantity and quality of science in industry. The Society of Chemical Industry played a significant role, not least by providing a common institutional meeting ground for university and industry science enthusiasts. The Ontario government supported this effort by providing grants for publication of their papers. By 1920 the Section had grown to such an extent that it was replaced by separate local sections in Montreal, Toronto, Ottawa, Shawinigan Falls and Vancouver.

3. *The Canadian Chemists' Crusade*

Rhees has written of a 'Chemists' Crusade' in American industry.[53]

In Canada, the crusaders included chemical consultants, entrepreneurs and journalists. Unquestionably such men as T.L. Crossely, J.A. De Cew, L.E. Westman, T.H. Wardleworth and others had a financial stake in promoting chemistry in industry. To ascribe so straightforward a motivation to their efforts, however, is to escape the Charybdis of naivety only to fall prey to the Scylla of cynicism.

Judson De Cew, a chemical engineer trained at Toronto's School of Practical Science (later the University of Toronto's Engineering Faculty), occupied a prominent place among these science boosters. In November 1905, at a time when he was with the Standard Inspection Bureau of Toronto, he wrote an article on chemical inspection in industry, which appealed for increased industrial attention to chemistry.[54]

The chemical profession, he insisted, was 'an important one in those countries where science and industry are now found working hand in hand in the production of progress and profits.' He argued that the application of analytical methods to the study of the raw materials of industry would yield a far higher rate of useful technical information than casual observation in the factory. Citing an example from the paper industry, De Cew stated that only close technical examination of paper products could provide satisfactory information about the nature of products and thus give buyers and sellers a sure and rational basis for their transactions. Moving from the particular to the general, he then told Canadian manufacturers that they should fear, not competition from other Canadian firms in their industry, but competition from abroad. This of course was precisely the argument which Canadian business *did* use to justify the maintenance of the protective tariff.[55]

53 David Jerome Rhees, 'The Chemists' Crusade: The Rise of an Industrial Science in Modern America, 1907-1922' (Unpublished PhD Dissertation, University of Pennsylvania, 1987).

54 *Industrial Canada*, November 1905, 272-273.

55 Michael Bliss, *A Living Profit* (Toronto: McClelland and Stewart, 1974); Tom Traves, *The*

De Cew was one of many who saw science as another or perhaps better form of protection. To meet the challenge of more technically advanced foreign competition, and not hide from it behind tariff walls, Canadian firms would themselves have to make a greater commitment to scientific methods.

Closely related to the campaign for more and better science in industry, and in particular for industrial research, was the contemporaneous movement for technical education — a movement to train a new workforce for the new industries. The efforts to promote technical education were seen as yet another aspect of industrial and economic development policies pursued by the state and private industry during the period of the National Policy.[56]

Both the pace of industrialization that quickened during the Laurier years, and the growth of new and more science-based industries — in particular the new staples (mining, pulp and paper, hydroelectricity) — exerted new demands for a labour force educated differently. These demands were met in various ways, within firms, locally, provincially and even nationally, in spite of constitutional problems raised by provincial authority over education. The issues pertaining to technical education were examined by the Royal Commission on Industrial Training and Technical Education which made its recommendations in 1913, although implementation was delayed until after the Great War. The Commission's report made it clear that technical education, along with university level education and scientific industrial research, was necessary to supply industry with knowledge and infrastructure.

The changing nature of Canadian universities, and the universities' changing relationships with industry and government, provide another useful context for understanding the role of industrial chemistry in Canada. Industrial chemistry found its way into the curricula of the major central Canadian universities — McGill, Queen's and Toronto — before the end of the nineteenth century. Francophone education in Quebec too was influenced by the growth of new resource industries in that province.[57]

It is important to note that these developments were not responses to the First World War, but to fundamental changes in Canadian industry already well underway before 1914. The traditional chemical focus on quantitative and

State and Enterprise (Toronto: University of Toronto Press, 1979).

56 The National Policy was a development program of the Conservative governments of Sir John A. Macdonald and his successors (1878-1896). Most notably, aspects of the policy included protective tariffs, the construction of the Canadian Pacific Railway, and the promotion of immigration to settle the prairies. Robert M. Stamp, 'Technical Education, the National Policy, and Federal-provincial Relations in Canadian Education, 1899-1919,' *Canadian Historical Review*, 52 (December 1971), 404-423.

57 Luc Chartrand *et al., Historie des Sciences au Quebec* (Montréal: Boreal, 1987).

qualitative analysis was supplemented with programmes of instruction in the dynamics of chemical systems.[58]

New courses in colloid chemistry and electrochemistry also related closely to the demands of specific Canadian industries. Academic chemists welcomed industry, as contracts meant prestige, funding and employment.[59]

By 1913, the importance of chemistry was so great that T. Linsey Crossley (with DeCew, one of the first chemists to be employed in a Canadian pulp and paper mill) made a call for a Canadian bureau of chemistry as a coordinating body for chemical research in the country.[60]

Canada, he warned, could not be content to skim off the results of other countries' research. Neither private consulting and analytical laboratories nor the universities provided an adequate institutional setting for the development of new chemical processes for industry. He argued that standardization, the development of Canadian technical personnel and the importance of international markets all demanded a national effort and government involvement. Certainly both academic chemists and the leaders of chemical industry played major roles in the founding of the Honorary Advisory Council for Scientific and Industrial Research (later the National Research Council) and the provincial research organizations. Similar Councils were established in other parts of the British Empire, following a 1915 call from the British Government to Dominions to reexamine their commitments to scientific and industrial research.[61]

No review of institutional developments would be complete without mentioning the Canadian Institute of Chemistry, chartered in 1921, the Canadian Chemical Association, formed in 1928 as 'a somewhat loose federation of a number of local chemical associations' and finally the Chemical Institute of Canada, founded in 1945.[62]

58 The point is made effectively in a U.S. context by Martha Moore Truscott, *The Rise of the American Electrochemicals Industry, 1880-1910* (Westport: Greenwood Press, 1981). A survey of chemistry department examination papers from the older central Canadian universities shows that the same was true for Canada.

59 For example, see McGill University Archives, Harold Hilbert Papers, Boxes 1 and 2.

60 *Industrial Canada* (May 1913), 1335.

61 J.P. Poole and K. Andrews (eds), *The Government of Science in Britain* (London: Weidenfeld and Nicolson, 1972). The still standard account of the founding of Canada's National Research Council is Mel Thistle, *The Inner Ring* (Toronto: University of Toronto Press, 1965). For the provinces, see Frances Anderson *et al.*, 'Le Developement des conseils de recherche provinciaux: quelques problematiques historiographiques,' *HSTC Bulletin*, 23 (January 1983), 27-44. For the Australian equivalent, see G. Currie and J. Graham, *The Origins of CSIRO* (Melbourne: CSIRO, 1966) and C.B. Schedvin, *Shaping Science and Industry* (Sydney: Allen and Unwin, 1987).

62 T.G.H. Michael, 'The Chemical Institute of Canada - Antecedents, Formation and Early

The Australian Chemical Institute was founded in 1917, thus stifling the growth of other organisations proposed during the war years.[63]

The Canadian chemists were also served by a new journal, the *Canadian Chemical Journal*, published by the Biggar Press, starting in early 1917. Its stated purpose was 'to advance the science and industries based upon chemistry.' An article in the first issue on the 'New Era in Chemistry' argued that conditions were especially good for Canada due to the nation's abundant water power, for electrochemical processes, and Canada's equally abundant mineral wealth. Thus the electrolytic production of chemicals from Canadian ores could be a fruitful area of enterprise for Canada.[64]

4. *Chemists' Work*

What were chemists doing in Canadian industry? In 1916 the Society of Chemical Industry produced a survey of chemists in Canada. This tally underestimates the number of chemists in Canada, but if it is skewed in any way it surely exaggerates the numbers of academic scientists, always more visible than those in industry. A number of important observations may be made. First, unlike the situation in Australia and Britain, the overwhelming majority of Canadian chemists worked in industry. Of those who did not, many academic chemists would have done some industry consulting work and many government chemists worked in industry-oriented scientific services. Second, chemists were widely distributed throughout the industrial structure of Canada; no one industrial category employed more than 20% of the total number of chemists. Similarly, chemists found employment in a range of occupational categories, giving a different but equally important measure of the penetration of science into the industrial structure of Canada. It would appear that about a quarter of all Canadian chemists were involved with the actual control of productive processes in the mills and factories of the nation. This confirms the pre-war observation of W.P. Cohoe, a member of the Committee of the Canadian Section of the Society of Chemical Industry, that 'the function of the chemists in industry consists in a scientific control of production.'[65]

development,' in W.A.E. McBryde (ed.), *Essays in Chemical History* (Ottawa: Canadian Society for Chemistry, 1988), 27-34.

63 For information about chemical societies in Australia and New Zealand, see I.D. Rae, 'Chemists at ANZAAS; Cabbages or Kings?' in R.M. MacLeod (ed.), *The Commonwealth of Science : ANZAAS and the Scientific Enterprise in Australasia, 1888-1988* (Melbourne: Oxford University Press, 1988), 166-195.

64 *Canadian Chemical Journal*, 1 (May 1917), 1-2.

65 Papers of the Canadian Section, Society of Chemical Industry, #6 (1913).

As Enros' *Biobibliography* has shown, Canadian chemists and other scientists were not only doing routine work but were conducting and publishing the results of original research.[66]

In a letter published in the *Canadian Chemical Journal* in early 1918, L.E. Westman pointed out that the older central Canadian universities were already turning out excellent research chemists.[67]

Such contentions, while true, obscure a more important point. In a great many instances, in a great many firms, chemists got a foot in the door by performing routine analytical testing of raw materials. From such mundane tasks, chemists then expanded their activities to embrace such other functions as quality control, process control and finally research and development. (Of course, in some cases scientific control of processes was built into plant design). On the one hand, chemists struggled for control over the sub-processes of industrial production with skilled workers who drew upon many years of experience. Thus, for instance, in a paper *The Crystallization of Sucrose in the Refinery,* H.I. Knowles of the Atlantic Sugar Refinery told delegates to the Maritime Chemical Association Convention that he was 'attempting to replace the time-honored rule-of-thumb art of the sugar boiler by scientific methods and principles of control.'[68]

On the other hand, chemists had to prove themselves to often skeptical, non-technically trained management, impressing on them the need for programmes of systematic data gathering and then formal industrial research as a basis for technical progress and commercial success.

Few issues so illustrate the success of professional chemists and engineers in industry as do changing attitudes to the public release of proprietary chemical knowledge. Managers were increasingly willing to place such knowledge into the public domain, rather than guard it as trade secrets, by allowing their chemists to publish and present papers and to work cooperatively with their peers in other firms and sectors. Intersectoral cooperation has indeed been a feature of Canadian industry-oriented science, encouraged by the easy mobility of scientists between sectors. However, it also recognized that the technical nature of industry provided great incentives to have a strong and regular flow of technical information among firms to reduce transaction costs and distribute overhead costs more optimally. Commercial disputes over technical points were reconceptualized as common technical problems and given to chemists and engineers to solve. So when John Grieve, the General Manager of the

66 Philip C. Enros, *Biobibliography of Publishing Scientists in Ontario Between 1914 and 1939* (Thornhill: HSTC Publications, 1985).

67 *Canadian Chemical Journal*, 2 (January 1918), 9.

68 His remarks were reported in *Canadian Chemistry and Metallurgy* (October 1930). For earlier but similar developments in Australia, see A.G. Lowndes, *op. cit.* note 1.

Dominion Paint Works wrote a paper on *Paint as a Protection for Steel Structures*, he stated his hope that the paper

> may awaken interest in this important subject and that an effort may be made to improve the general practice of protection. The results of service records are the base of all future economy and reliable records can be obtained only when an effort is made by everybody interested to co-operate in the selection and use of good paints and their proper application.[69]

It was a lesson which chemists taught their employers in Canadian industry as elsewhere.

5. *Pulp and Paper Industry*

During and after the First World War, pulp and paper manufacture experienced a tremendous expansion and climaxed a period of substantial growth in investment and output.[70]

Canada became a world leader in newsprint exports as physical plant of the most modern design, incorporating the most recent technological advances appeared at choice hydroelectric sites in the subboreal forests of the Canadian shield. A range of new, higher value-added products rolled out of these mills destined for both the domestic and export markets. Moreover, the nature of work and of the work force remained remarkably static in the forests themselves, but important changes occurred inside the mills, where chemists and engineers directed the conversion of trees to wood or cellulose fibres and thence to paper and other products.

The basic technological configuration changed little from 1870 to 1970, but a revolution was achieved through a long series of incremental changes. If the formal, highest level description of pulping and papermaking remained the same, the cumulative effect of these changes transformed these processes completely.[71]

Demand motivated these changes. To meet the demand for hugely increasing quantities of paper products, for more specialized products, and for products with precisely specified qualities, manufacturers of pulp and paper had to gain

69 John Grieve, 'Paint as a Protection for Steel Structures,'*Engineering Journal* (1922), 582-584.

70 Some useful surveys of the industry's history in Canada are: V.W. Bladen, *Introduction to Political Economy* (Toronto: University of Toronto Press, 1948); J.A. Guthrie, *The Newsprint Paper Industry* (Cambridge, Mass.: Harvard University Press, 1941); H.V. Nelles, *The Politics of Development* (Toronto: Macmillan, 1974); Carl Wiegman, *Trees to News* (Toronto: McClelland & Stewart, 1953).

71 Where not otherwise stated, material on the technology of the Canadian pulp and paper industry is taken from James P. Hull, 'Science and the Canadian Pulp and Paper Industry, 1903-1933' (Unpublished PhD dissertation, York University, Ontario, 1986).

far greater control over their productive processes. New means of generating technical knowledge and new means of applying that knowledge at critical points in the production process became keys to continued expansion and profitability.

A prerequisite to the reform of control techniques is the successful development and adoption of new, higher precision testing methods. Routine analytical chemistry, aimed at determining the quality and purity of secondary raw material inputs, formed the workload of the first university-trained chemists hired by pulp and paper firms. A number of trends are evident in the evolution of these testing techniques. First, there were simply a great many more tests performed and with greater frequency in the mills. Most testing procedures were designed to be conducted by workers or non-technically trained foremen. However, even these came increasingly to presume familiarity with laboratory apparatus and language. Qualitative tests and measurement by direct sensory observation gave way to quantitative tests and measurement by instruments, including continuous mechanical recording. Testing methodology became more standardized and universal, requiring and allowing for greater sharing of information. It became more and more common practice to keep careful records of the operation of machinery and the conditions and results of processes, not only for optimization within mills, but for the ready exchange of data among mills.

Over the decades, skilled workers and university-trained chemists and engineers shared and contested control over the sub-processes of production. In part these involved more complete monitoring and record keeping, automatic control and the use of charts which workers would refer to in conjunction with monitoring equipment in place of reliance on experience and observation. Further, they included a reduction in the number of control decisions and the achievement of more continuous flow production. The aim of greater uniformity and specificity of intermediate and final products was achieved by recognition of the range of factors involved andby technical assaults on each. Behind it all lay the discipline of demand — demand for higher output, higher quality of bulk products such as newsprint, more specialized products and for a wider range of products. The need for extremely high quality pulp-dissolving pulp or alpha cellulose — as an input into the rayon manufacturing process, proved of special importance in motivating higher levels of control.

The degree of control required to produce this high value-added product simply could not be attained by empirical methods regardless how skilled or experienced the workforce. Nonetheless, university trained chemists and chemical engineers had to fight their way into the pulp and paper industry, just as they had in other industries. Workers and traditional management resisted the gathering of skill and control into the hands of a new class of technical men. John S. Bates, the first PhD chemical engineer to be employed in a Canadian pulp mill, remembers the 'shoddy intrigues which disturbed one's determination to establish controls and to attempt in-plant research.'[72]

By the end of the 1920s, however, university-trained personnel had become entrenched throughout the industry.

Changing techniques in pulping and papermaking were accompanied by a changing institutional environment for the creation and dissemination of technical knowledge. A major step came in 1903 with the founding of the *Pulp and Paper Magazine of Canada.* Not only was *PPMC* the industry's technical journal but, in its editorial pages, played a major role as a promoter of science in the industry. At about the same time, McGill and Queen's universities began their involvement with pulp — and paper-related science. Both institutions played host to research work in their chemistry departments and engineering faculties. Along with other Canadian universities, they produced many of the chemists and engineers who designed and superintended the pulp and paper mills.

In 1913, the Dominion government authorized the creation of the Forest Products Laboratory of Canada (FPL) as part of the Forestry Branch of the Ministry of the Interior.[73]

The Pulp and Paper Division of the FPL served not only as a research and technical inquiry answering institution but also a training ground for industry research scientists. Industry provided an Advisory Council which both helped to set the research agenda of the Division and enlisted industry support for it. In late 1914, the newly founded trade association, the Canadian Pulp and Paper Association (CPPA) took steps to organise a Technical Section.[74]

Its purpose was 'to stimulate interest in the science of pulp and paper making in Canada, to provide means for the interchange of ideas among its members, and to encourage original investigation.'[75]

The membership consisted of chemists, engineers, managers, superintendents and others, with dues a token dollar a year. The Section recognised *PPMC* as its official journal. Within three years, the Section restricted full membership to those holding a university science degree or the equivalent.[76]

72 John S. Bates, 'Reminiscences of the Technical Section Early Days,' *Pulp and Paper Magazine of Canada*, 75 (January 1974), 20-25.

73 The Western Australian government began experiments with *Eucalyptus* hardwood pulp in 1918. Subsequent support from Australia's Federal Institute of Science and Industry, the forerunner of CSIRO, saw good quality paper produced within a decade. See Schedvin, *op. cit.* note 61, 103-105.

74 John S. Bates, *By the Way* (Hantsport: Lancelot Press, 1983).

75 Report in *Pulp and Paper Magazine of Canada* (1 March 1915), 123 ff.

76 James P. Hull, 'Early Membership of the Technical Section, Canadian Pulp & Paper

Co-operative research has long been a particular strength of the pulp and paper technical infrastructure. Such cooperation took place in a variety of formal and informal ways among individual firms, the CPPA, education institutions, the FPL and other government bodies. Pulp and paper researchers were well represented in the work of the National Research Council of Canada. John Bates, T.L. Crossley, George Tomlinson and Harold Hibbert all served on the NRC chemistry committee at various times. In 1925 a pair of bilateral agreements formalized a further measure of intersectoral cooperation. The CPPA and the Dominion government agreed to joint funding and control of the Pulp and Paper Division of the FPL. That Division would remain in Montreal while the other portions of the FPL moved to Ottawa. The CPPA and McGill agreed to joint funding of a chair of industrial and cellulose chemistry at the University. These two agreements were, literally and figuratively, brought under one roof with the creation of the Pulp and Paper Research Institute of Canada (PAPRICAN) later in the decade. That particular institutional evolution marked the recognition of changes in the knowledge base of the pulp and paper industry. That industry had become not so much a forest products industry as a chemical process industry.[77]

The need to train or retrain the new workforce in a rapdily changing industry resulted in several initiatives. These included the establishment of paper making programmes or even schools of pulp- and paper-making, in four of the principal pulp and paper districts of Canada.[78]

Individual firms also supported technical education for their employees in the schools of company towns. The Technical Section of the CPPA and its US counterpart the Technical Association of the Paper and Pulp Industry, jointly sponsored the production of a highly successful textbook of pulp and paper manufacture. This text formed the basis of a correspondence course offered by the Institute of Industrial Arts in Gardenvale, Quebec. Pulp and paper was among the most notably open industries with respect to the share of technical knowledge among firms. In part this simply represented participation in wider trends but was accentuated by the fact that Canadian pulp and paper firms saw their true competition as foreign firms and firms in industries using different raw materials for substitutable products.

The creation of PAPRICAN marked a strong commitment to advanced chemical research by the industry, in partnership with government and McGill, after the mid-1920s. Harold Hibbert, Otto Maass and their students investigated a

Association,' *Scientia Canadensis*, 26 (June 1984), 68-72.

77 James P. Hull, 'From the FPL to PAPRICAN: Science and the Pulp and Paper Industry,' *HSTC Bulletin* 23 (January 1983), 1-13; Charles A. Sankey, *Paprican: The First Fifty Years* (Pointe Claire: PAPRICAN, 1976).

78 Those regions were the Niagara Peninsula, the Ottawa Valley, La Mauricie, and northern New Brunswick.

variety of topics. These included studies of cellulose and lignin, analytic control methods, the form and size of wood chips in relation to cooking, and investigations relating to the lacquer, film and artificial silk industries. Important work was also done on the reactions involved in cooking pulp, including pressure-temperature relations of SO_2, the equilibrium existing among sulphur dioxide, water and calcium oxide, and the equilibrium $H_2O + SO_2 = H_2SO_3$ which was important to study acidity at working temperatures and pressures. Sankey calls the study by W. Boyd Campbell and others at PAPRICAN of 'The Cellulose-Water Relationship in Papermaking' a classic due to its precision and accuracy. Not just good science, this had considerable importance for the industry.[79]

At Queen's University, chemical research under the direction of Professor L.F. Goodwin addressed a number of pulp and paper industry problems including the manufacture of salt cake, the determination of the density of dry and wet chips, the composition of black ash from the kraft process, the prevention of sulphate fumes and the economical recovery of black liquors with the idea of utilizing as much as possible the heat values of the lignin. In private industry, important chemical contributions were made by George Tomlinson (father and son) of the Howard Smith company, John Bates at the Bathurst Co., Charles Sankey at Ontario Paper, H.J. Rowley of Anglo-Canadian and Abitibi, C.B. Decker of Price Brothers as well as Thorne, Wang and others at Riordon and later Canadian International Paper. The biochemical contributions of Clara Fritz at the Forest Products Laboratories should also not be overlooked.

Until the First World War, Canadian and Australian chemical industries had advanced to about the same extent. In both countries the industry was indigenous, although strongly influenced by extra-national technology. Australia, however, was slower to respond to the changes taking place in the 1920s, during which trans-national companies consolidated their activities and national differences began to disappear. This raises the question of just how 'national' the respective chemical industries were up to that time, given that much of their technology was adaptive. There is no need to search for 'firsts' in industrial chemistry, though both countries had significant achievements, nor to seek national traits and to blame the industries for being dependent. Neither dependent nor backward, both countries' chemical industries drove the formation of institutions, made links with other sectors, acquired personnel, and applied knowledge no matter what its source. The disappointments, if there were any, were those suffered by many countries in the forthcoming second industrial revolution. Canada and Australia entered the 1920s with settled chemical industries and strong communities of chemists supporting their recently formed Chemical Institutes. World War had alerted all governments to the strategic importance of their chemical industries and chemistry and

79 Sankey, *op. cit.* note 73, 48-49.

chemical engineers sensed the important role they would play in their countries' futures.

III.
Secondary Industry and Chemicals in Australia, 1920-1945

Between the end of the First World War and the end of the Second, the isolated seven million people of Australia became a fully industrialised nation, producing the goods and equipment expected of economic development. Historians have argued that high protective tariffs from 1920, by stimulating widespread import replacement and forcing overseas companies to set up in Australia. [80]

This theory is persuasive until we enquire into the wider economic factors that governed the history of colonial chemistry:

1. *Technology Transfer in Chemical Industry*

For most of the nineteenth century, the market for chemical manufactures in Australia did not allow Australian companies to compete efficiently with international companies, even in Australian domestic markets. International companies had their centres of innovation in the northern hemisphere, and even where knowledge of their operations was freely available, overseas innovators used techniques and materials not available in Australia. Typical examples are the high-pressure processes for the synthesis of ammonia and methanol, which were developed in Germany, and high-performance metal alloys for special purpose use. Moreover, international companies could make more efficient use of their new industrial techniques through massive production and consequent economies of scale, whereas Australian companies manufactured essentially for the Australian domestic market, which was too small to gain economies of sale.[81]

In the manufacturing sector, international companies could get round rather than over the tariff barrier by conducting limited assembly of imported subassemblies in Australia. Essentially, the product was imported, although it qualified as locally made. In the chemical industry this meant importation of primary products followed by modification, blending or formulation in Australia and marketing in direct competition with the Australian manufacturer.

80 See, for example C.B. Schedvin, *Australia and the Great Depression* (Sydney: Sydney University Press, 1970); Peter Cochrane, *Industrialisation and Dependence* (St Lucia: University of Queensland Press, 1980); A.G.L. Shaw, *The Economic Development of Australia* (Melbourne: Longmans, 1980); and W.A. Sinclair, *The Process of Economic Development in Australia* (Melbourne: Cheshire, 1976).

81 These factors are discussed more fully in A.T. Ross, 'Technology, 'Industry and War in Australia 1918-1945' (unpublished manuscript), chapter 1, 'Awaiting the Apocalypse: The Industrial Development and Defence of Australia, 1914-1918.'

Exceptions are typified by bulky or dangerous goods, such as superphosphate and sulphuric acid, by certain pharmaceuticals which were protected by government, and by paper produced from Australian eucalpyts. The resulting picture is one of uneven development. Sulphuric acid and superphosphate was produced in Australia, and foreign competition virtually eliminated, as early as the 1870s, but the industry was rationalised in the 1920s by a series of amalgamations and restructurings which enhanced its hegemony.[82]

In pharmaceuticals, aspirin was first produced by the Nicholas brothers during the First World War, when German imports were suspended; and the Nicholas position was maintained thereafter despite keen competition from Baeyer. [83]

Commercial interest in paper-making from eucalypts was awakened in 1925, when quite unrelated mining ventures invested some of their profits in the industry.[84]

The research of Boas and Benjamin was stimulated by French experiments a decade earlier, and further Australian development was a triumph of national ingenuity.[85]

Australian companies found they could not hide behind tariff barriers. Foreign companies could begin assembly from imported components and argue that the product was locally made, with jobs for Australians as a point in their favour. Since many Australian companies had to import components or raw materials, local assembly did not greatly disadvantage the foreign competitor. All too often, Australian companies struggled with unfamiliar industrial techniques and materials — which almost guaranteed that the overseas product was of better quality and cost less. These economic and technical realities produced disincentives for local businesses to begin production in Australia of valuable and advanced products. As a result, there was no basis for Australian industrialisation.

2. *Local Technology in Australian Industrialisation*

Products designed in Europe and North America reflected the requirements of the northern hemisphere, so one way for Australian companies to compete with internationals for the domestic market was to modify overseas developmental and manufacturing designs to reflect unique Australian requirements. This

82 Poynter, *op. cit.* note 10.

83 *Aspro: How a Family Business Grew Up* (Melbourne: Nicholas International, 1936).

84 W. J. Algar, 'Forest and Forest Products,' in J. Kolm (ed.), *Technology in Australia, 1788-1988* (Melbourne: Australian Academy of Technological Sciences and Engineering, 1988.), 193-252.

85 N. Rosenthal, 'Boas, Isaac Herbert (1878-1955),' *Australian Dictionary of Biography*, 7 (1979), 332-333.

trend could be reinforced if local companies modified manufacturing designs to make wider use of local materials and more familiar industrial techniques. Such materials were cheaper and supplies more dependable. So simple gains, such as reduced stockpiling, were available. The hardwood pulp industry became a case in point. Tariff protection in these circumstances widened the margin of economic competitiveness for Australian local industry, although by favouring current technology over new technology, it also sowed the seeds of future problems.

This 'local' strategy, although seemingly simple, was seldom so in practice because of subtle links between design stages.[86]

This problem is probably more easily appreciated with some examples. The unique problems posed by Australia's *Eucalypt* hardwoods have been mentioned. When the Broken Hill silver, lead and zinc mines were opened up in the last decades of the nineteenth century, it was found that the normal (European) ore separation technology (the manufacturing design) would not work efficiently on the complex Broken Hill sulphide ore. Large quantities of zinc, as well as silver and lead, were lost as slag, because the performance predicted by the developmental design could not be achieved. Only the richness of the ore deposits allowed the mines to remain profitable. Much effort was expended in generating a new developmental design which could handle the local ore, and then in deriving an efficient manufacturing design. What was needed was a scientific capability, particularly in materials reseach (including metallurgy), industrial chemistry and metrology. Did such capabilities exist in Australia during the 1920s and 1930s? They did, largely in the great mining companies and the state and federal government instrumentalities such as the railways, electricity and water authorities, the Postmaster General's Department and the Defence Department.

The great mining companies mostly grew out of Broken Hill where, as Geoffrey Blainey has pointed out, they had encountered particularly complex problems in ore separation.[87]

Being accustomed to using science and engineering in their mining operations, the companies which ran Broken Hill turned to science to solve the ore separation problem. They employed the largest number of scientists (some forty analytical and mineral chemists, metallurgists and chemical engineers) in Australia in the early 1900s and succeeded in developing the flotation separation process which subsequently was adopted around the world. This left the mining companies such as BHP and the Collins House group with a

86 See A.T. Ross, 'The Arming of Australia' (unpublished PhD dissertation, University of New South Wales, 1986), Annex A.

87 Geoffrey Blainey, *The Rush That Never Ended* (Melbourne: Melbourne University Press, 1963) and *The Rise of Broken Hill* (Melbourne: Macmillan, 1968).

developed technical and scientific infrastructure which they turned to new manufacturing problems linked with refining metals. The First World War provided particularly good opportunities.

All supply to Australia from Europe and North America ceased as the industrial energies of the Northern Hemisphere were drawn into the War. Anxious to prevent a collapse in living standards, and to help local employment, Australian governments encouraged the develpment of large scale steel manufacture and non-ferrous metal refining. The mining companies used their technical and scientific staff to solve the problems of using local materials and of modifying overseas technologies. By 1920, they had succeeded in moving into many areas of metal refining, including the complex process of producing 99.99% pure zinc.[88]

At the same time, Australian scientists were urging their government to take 'steps to see that so far as possible all new chemical works and plant should be erected with a view to ready adaptability to war work,' [89]but competition from overseas companies reappeared in Australia and brought difficult times for the fledgling Australian secondary industry. But BHP and the Collins House group continued to move into new industries such as steel fabrication, paints, simple chemicals and fertilizers, because of their ability to modify overseas developmental and manufacturing designs to make use of local materials and locally efficient industrial technologies. These two were the most powerful industrialising force in private industryb, but they alone would not have been sufficient to create the industrialisation of the early 1940s without the influence of state and federal government utilities.

State and federal government involvement in Australian economic development had always been more important than that of private enterprise. The reasons for this need not detain us,[90] but in the 1920s, state governments still ran huge public utilities covering railways, trams, electricity, water and gas, and electrical communications. These systems were all comparatively modern and employed the latest technologies from overseas, necessitating significant imports of overseas products. State and federal governments employed many engineers, technicians, chemists and metallurgists to keep such systems running efficiently. Such professionals formed a body able to provide powerful technical advice on all the technologiės comprising their systems. Under the active encouragement of state and federal governments in the 1920s to give wide margins of preference to budding local industries, the professionals took an active role in manufacturing. Organisations like the railways and electrical

88 Ernest Scott, *Australia During the War* (Sydney: Angus and Robertson, 1936) and C. Forster, *Industrial Development in Australia, 1920-1930* (Canberra: ANU Press, 1964).

89 *Report of the Australasian Association for the Advancement of Science,* 15 (Melbourne, 1921), xxix.

90 See N.G. Butlin *et al.* (ed.), *Government and Capitalism* (Sydney: Allen and Unwin, 1982).

authorities absorbed large quantities of supplies of all kinds, so they were in a position to offer strong inducements to local industry participation if the technical problems of modifying overseas manufacturing designs could be overcome. Technical staff were in a position to supply much, if not all, of the technical advice needed to solve such problems. This led to many new industries in steel fabrication, chemistry, electrical goods, wireless and cement products, to mention a few.[91]

Local firms were encouraged to accept orders and were steered through the technical problems of manufacturing design modification and production by the technical personnel of the great public utiliites.

The most important example of this technical process at work was the Munitions Supply Board [MSB] of the Department of Defence. The Australian government, responding to calls by scientists and engineers, charged the MSB in 1921 with helping to develop secondary industry in Australia so that in time of war, all munitions production would be self-contained within Australia, relying on no important components or materials which had to be imported from overseas.[92]

The MSB ran several groups of factories which collectively represented the most advanced and versatile manufacturing force in Australia. The Explosives and Filling group made the most advanced chemical products in Australia; the Ordnance Factory group was the best equipped engineering workshop in Australia and the centre of drop forging and heat treatment; the Small Arms Factory group was the centre of the precision engineering industry and of mass production of complicated interchangeable components; while the Ammunition Factory group was the centre of large scale mass production in Australia and of automatic quality assurance.

These organizations were a most important source of new technology to Australian private industry and it was made freely available because it helped to broaden the technical base of secondary industry, and therefore of self-containment as well. But the 'brain' of the MSB was the Munitions Supply Laboratories (MSL) which during the period 1920-1945 were the largest industrial research group in Australia. MSL provided the detailed scientific research support to the engineering and chemical activities of the factory groups. Together they extended wide support to secondary industry and other semi-government organizations such as universities, electricity authorities and the Council for Scientific and Industrial Research.[93]

91 Ann Moyal, *Clear Across Australia* (Melbourne: Nelson, 1984); Forster, *op. cit.* note 88.

92 Ross, *op. cit.* note 86.

93 See MSB, *Reports to Commonwealth Parliament, 1921-1939*, in Commonwealth Parliamentary Papers.

Sometimes this was to help local firms complete defence contracts, but often it was technical assistance which had no direct connection with defence except that it encouraged the technical and manufacturing capabilities of secondary industry.[94]

During the Depression, the MSB took an even more active role in the development of secondary industry. Australia's balance of payments crisis forced the government to impose import restrictions which in effect barred many goods from Australia. The MSB, along with many commercial firms, moved to supply the missing goods through local production. The MSB was careful to move into areas which were not likely to be attempted successfully by other organizations, and used its scientific and engineering capabilities to set up new industries. This included highly specialised lead free paints, aircraft dopes, enamels, varnishes and lacquers, cotton wool, nitrobenzene, acetone solvents, non-ferrous sheet and strip, copper electrodes, non-ferrous press and screw machine products, lipstick containers, machine tools, dies, gauges and motor car parts such as axles, universal joints, engine connecting rods, crank shafts and shock absorbers. As these projects became established and attracted larger markets, the MSB withdrew if a local commercial organization wished to take over, and handed over all the necessary technical information.[95]

3. *Australia's Chemical Industry by the mid-1930s*

Most of the fundamental elements of the chemical industry had been established in Australia by the mid-1930s. In paint and varnishes much of the research was done by big mining companies such as Collins House which were anxious to encourage more use of Australian lead amongst other things. They developed paints which were well adapted to the harsh conditions of Australia. They also did much research on nitro-cellulose paints which was impressive enough to convince the big internationals Du Pont and ICI that they should combine with Collins House to market Du Pont's new product Duco, rather than face effective competition within Australia.[96]

The MSB also contributed significantly to research in paint technology. Between 1918-1940, the paint and varnish industry moved from outweighing imports by 50% to a position where local production was six times the import figure.[97] Local production predominated over imports.

94 Ross, *op. cit.* note 86, especially chapters 2 and 3.

95 Ross, *op. cit.* note 85.

96 The resulting company, Dulux, has recently been fully integrated into ICI Australia. See also Forster, *op. cit.* note 88, 44-45.; Melbourne University Archives, Colin Fraser Papers, File 1/53/8.

97 Statistics are based on Australian Bureau of Census and Statistics data contained in the *Overseas Trade Bulletin* and the *Production Bulletin*.

In rubber and rubber products, the overseas manufacturing designs had often to be modified because Australian conditions were different; harsher sunlight for instance causing rubber to perish more quickly. These problems were solved so that local production, which was on a par with imports in 1918, surpassed them by 1927 and went on to fourfold dominance by 1940. The categories of soaps and candles, and inks and polishes were not affected greatly by environment, and were simple to make. The main challenge was to use local materials and through this gain an economic advantage over overseas companies exporting to Australia. By 1918-19, local producers had succeeded in this endeavour and were dominating imports, an advantage which was not lost throughout the 1920s and 1930s.

In the more complicated area of chemicals, drugs and medicines, the need to modify overseas manufacturing designs was less to accommodate environment than to use local materials and resources. The production on a large scale of basic chemicals such as sulphuric acid, was prompted by the production of sulphur dioxide as a byproduct of the smelting of non-ferrous metals. The Collins House group, as well as the big mining company Mount Lyell and long-established Cuming Smith, not only sold sulphuric acid commercially, but used it to make fertilizer.[98]

The production of drugs and medicines was influenced by several factors. Australia had a different profile of disease and bacteriological infection, and consequently could not expect overseas suppliers completely to satisfy Australian demands. This was the reason for the creation of the Commonwealth Serum Laboratories in 1916, which grew rapidly throughout the 1920s and 1930s.[99]

However, there were many areas of medication in which Australian requirements were exactly the same as for the northern hemisphere. Where the market was large enough, as for headache powders, there was an incentive for local firms to use local materials to try and make acceptable substitutes. A significant research effort was required, but a number of firms did succeed in this area, such as Nicholas with Aspro, and Felton Grimwade with several different types of products.[100]

For chemicals, drugs and medicines, local production matched imports by 1921-22; and by the early 1930s, exceeded imports by a margin of two to one.[101]

98 Geoffrey Blainey, *The Peaks of Lyell* (Melbourne: Melbourne University Press, 1978), 180-183; Blainey, *The Rise of Broken Hill, op. cit.* note 87, 80-83.

99 See *Science and Industry*, 2 (7), (July 1920), 419-427.

100 Poynter, *op cit.* note 10; Kohm (ed.), *op. cit.* note 84, 656-658.

101 These categories were combined by the Bureau of Census and Statistics, and it is impossible to separate them.

For the Census and Statistics category of oils, fats and waxes, imports continually outpaced local production by a wide margin. This somewhat surprising result is caused by combining petroleum oils with fats/waxes. The former was wholly imported, Australia having no indigenous oil fields at this time. No amount of chemistry could overcome this weakness although BHP and ICI tried with synthetic oil production from coal and shale oil. Neither process was economically viable even although they used local materials.[102]

For the whole chemical industry, local production was dominating imports by 1924/25, and by 1935/36 was twice the value of imports.

4. *The Role of International Companies*

Australian governments were not opposed to international companies if they set up full and proper production in Australia. Indeed, the international companies involved in the high technology industries of the age such as advanced chemicals, car manufacture, aircraft production and electrical goods were seen as potential catalysts for further local industry growth if they could be persuaded to set up full production and not just assembly of imported components.[103]

For example, the car industry drew on a vast range of lesser industries for its components and these could be supplied by new local industries. But it was not easy to persuade these internationals to set up proper production because they could make more money exporting to Australia. Full production in Australia led to high capital costs and small production runs for the small domestic market.

Thus local production was possible only if advanced technology could be established in Australia. A rival international company could do this by setting up full production in Australia, but most international companies in advanced industries had cartel agreements amongst themselves, which meant that they could not be played off against each other in this way by the Australian government. The technology had to come from Australian science and industry, and its successful development would enable local firms to resume the market shares of the internationals or, an alternative strategy, force the internationals into local production.

The MSB was Australia's major source of technological capability in chemical industry, and action ensued when it determined that the production of nitric acid in Australia should be self contained, because it was vital for military explosives production. In order to escape from importing nitrates, Australia

102 Kohlm, *op. cit.* note 100, 669-670.

103 See A.T. Ross, 'Australian Overseas Trade and National Development Policy, 1932-1939: A Story of Colonial Larrikins or Australian Statesmen?,' *The Australian Journal of Politics and History*, 36 (2), (1990), 184-204.

had to establish synthetic nitrate production. This was a very advanced chemical technique. The MSB had been conducting research into this area for some years, and in 1936 it told ICI that the time had arrived for ICI to begin local production. ICI was opposed to this because the capital equipment was expensive, and it had already over-equipped itself with capacity in Britain. But the MSB was not to be put off. When the head of ICI, Lord McGowan, visited Australia in early 1937, the Australian Government shocked ICI by threatening to create its own synthetic nitrate industry. Normally this would not have worried ICI or other big international companies, because small countries like Australia rarely had the technological credibility to make such a threat and the Australians could not call in another international company because ICI was protected by cartel agreements from all international competitors.[104]

However, in 1936, ICI had witnessed the creation of the Australian aircraft industry in which BHP, the Collins House Group and GMH had been invited by the government to combine to set up the industry and shut out the British who until then had only been interested in exporting to Australia. Although ICI knew that no international company could be used against it, it also realized that the big Australian companies would respond to an appeal to nationalism. Those companies in conjunction with the MSB collectively had the technical and financial resources to set up the industry and so ICI agreed in February 1937 to set up synthetic nitrate production in Australia. This was satisfactory to the Australian government because it gave an absolute guarantee of quick success and the promise of keeping in touch with the latest technical developments.

The MSB was not the only organization capable of this sort of 'technological threat'. The Collins House group and BHP proved in the case of the aircraft industry that they could establish this advance industry when their threats were ignored by the British aircraft industry.[105]

In the case of the alkali industry, ICI once again moved to pre-empt a local threat by establishing themselves as local producers and not simply importers. The Collins House group had warned ICI during the 1920s that it was thinking of establishing the alkali industry in Australia, so ICI offered the group special share options in ICIANZ to discourage this action. However, by the 1930s the technical capability of the Collins House group had grown so much that ICI felt it had to establish local alkali production before the group did. As well, the threat of competition was such, that ICI once again offered share options to buy off Collins House.

104 W.J. Reader, *Imperial Chemical Industries: A History* (London: Oxford University Press, 1975), vol. 1.

105 J. M. McCarthy, *Australia and Imperial Defence, 1918-1939* (St Lucia: University of Queensland Press, 1976).

In the electrical industry the Australian government controlled firm of AWA persistently pioneered local production of new electrical products through its laboratory and engineering staff. This forced the international companies such as Standard Telephone Company and Phillips to also set up full production in Australia.[106]

Australian governments also had considerable success in pushing the motor industry towards self contained production in the 1930s. The American firms which dominated the industry were forced to act, amongst other things, because of the technological threat of the MSB and Australian Consolidated Industries.

5. *Australia into War*

Australian secondary industry had reached an advanced stage by 1940, where locally based production dominated imports in every major area of manufacturing.[107]

This development placed Australia in a strong position to fight the Second World War, particularly against Japanese invasion. During the war years, Australian industry supplied all the most advanced equipments of war including modern aircraft, optical munitions, radars, guns, AFVs, warships, small arms, and radio.

This success took place in two stages. First, the war encouraged the modification of overseas manufacturing designs to reflect local requirements and to use local materials and skills. This process allowed local secondary industry to compete with overseas exporters, and laid a framework for such basic industries as steel production, non-ferrous refining, metal fabrication and simple chemicals. The technical assistance gained by private industry from the great public utilities, including the MSB, was vital in many areas for which there were no large scientifically oriented private companies like BHP and the Collins House group.

Next, the knowlege and infrastructure developed from this experience led to credible technical industries, which were forced to begin full production in Australia or to withdraw from the market. Without this sophisticated technical challenge, involving the capabilities of both private and public organizations, the high technology industries of the period would not have been established until well after the war, to the great detriment of the Australian war effort. That war effort was in fact sufficient to have thwarted a Japanese occupation of Australia because it was massive and largely self-contained.

106 Forster, *op. cit.* note 88.

107 Figures from the Australian Bureau of Census and Statistics are compiled as part of a detailed study of industry during the period 1918-1940. Ross, *op. cit.* note 86.

Conclusion

Australian secondary industry had reached an advanced stage by 1940 in which local production dominated imports in every major area of manufacturing. Over the period 1934/35 to 1938/39, the engineering and refining industries had expanded by 62% and maintained a sixfold domination over imports. The same pattern was shown by motor vehicle production, electrical goods and the clothing and textile industry. In the chemical industry, local production had expanded by 30% and although imports had increased by 60% they still amounted to only half the local figure. This development placed Australia in a strong position to fight in several theatres of the World War, especially in the Pacific where Japanese invasion threatened.

The rise of secondary industry in Australia was driven by the development of local science and technology which allowed Australian industry to compete with overseas exporters. In the areas of most interest to us here, the expertise residing in MSB, BHP and the Collins House group was put to use in the development of non-ferrous refining and the production simple chemicals. This new-found credibility forced the internationals to begin local production or to withdraw, leaving the field to Australian companies. Tariff protection, the customary way to encourage local industry by widening the margin of competitiveness, was not alone sufficient to bring about the change. Nor did governments resort to the nineteenth century device of rewards for specific ventures. Of course, tariffs did stimulate the use of local materials and encourage design for specifically Australian conditions, but the new and vital factor was the nurturing of a substantial group of skilled professional engineers and scientists.

We see this process as developing from traditions exemplified in these case studies. In its early stages, the chemical industry consisted of many small firms. Failure was endemic because these concerns had little in the way of scientific basis and even less capitalisation. Through amalgamations, takeovers and accumulation of capital the industry was rationalised and came to depend more upon the work of engineers and scientists. This change was accompanied and dependent upon the growth of professional associations and of institutions which provided technical training. Thus professional education replaced the philanthropy of the lectures of arts and science which characterised the middle years of the nineteenth century. The universities began to develop graduate schools and governments played their part through the establishment of research institutes and national science and industry organisations.

At the close of the last century, and for the first decades of the next, this consolidation of the chemical industry became an internationalisation, culminating in the cartel agreements between American, British and German conglomerates in the 1920s. The almost inevitable consequence was that Australia, like some other countries, faced the possibility that it would become solely an export market and that local innovation and control would be stifled. Fears for national identity were sharpened in the 1930s by the onset of a second international conflict and by the need for isolated countries to become more self-sufficient, for their own survival and for their obligatory part in the war.

The chemical industry thus became an instrument of national development, too important to be left to the whim or business dictate of an international company yet starved of local support and local expertise. The key role of government and a few nationally-based firms in the development of Australia is part of a larger story, but the chemical industry is typical of those which matured with great speed. Australian entrepeneurs and technicians combined the experience of overseas industry, knowledge of the literature, the encouragement of government, and local ingenuity. In the nineteenth century, this was enterprise in its simplest form, but a century later the equivalent step involved substantial financial and government backing, and collaboration between a great range of professional contributors.

The Canadian case offers striking differences as well as close similarities. By 1939 virtually all Canadians lived and worked as part of an advanced industrial economy. This was true even though the primary sector, including agriculture remained enormous as well as disproportionately important within the nation's political economy. Further, the next six years would see a new wave of industrialization. Although reluctant warriors, Canadians supported a war effort out of all proportion to their numbers and ended the conflict in the unaccustomed position of a 'middle power of the first rank.'

Industrial chemistry played an important part in these developments. This is especially true as applied to forest products and non-ferrous metals but also to a very wide range of other outputs. Canadian chemists had shown leadership in such fields as high sulphur content petroleum refining, the extraction of by-products from pulp mill waste and gold refining. Polymer chemistry would join the list in the post-war years along with uranium processing. The tariff had been the central issue of Canadian politics from the 1870s until the Great Depression. The rules of the game were changed not only by GATT. For forty years prior to the Second World War, Canadians had heard the message that science, especially industrial chemistry, could be used to replace tariffs. Somewhat to many Canadians' surprise, it had, at least to a degree. Canadian products had become competitive both domestically and in world markets and the range which were would continue to widen. The road to the 1988 Canada-U.S. Free Trade Agreement winds through the laboratory.

The story of industrial chemistry in Canada is not just the story of new or improved products and processes; it is also a story of professional evolution. The creation and growth of new institutions of industrial chemistry parallels that in Australia, slightly in advance chronologically. Canadian historiography has focussed too much on the role of the Federal government and, in particular, on the National Research Council. While the NRC made important contributions, so, too, did other Federal agencies as well as provincial science bodies.

To these must be added educational institutions, constitutionally creatures of the several provincial governments. In the private sector individual firms, trade associations and professional bodies, all had important roles to play.

In this broad picture, Australia and Canada are very similar. While the United States has been the dominant partner in both Australia and Canada, both dominions have found that their chemical industrial development has been mediated by unique cultural, political and geographic circumstances. Increasingly, the pressures of economic integration has been of vast significance to every aspect of this development, facilitated by flows of technical information, technical standards, specifications, memberships in technical bodies, dual patenting, and the movement of scientific and engineering personnel between the two countries. The two dominions, once apart, seem to be drawing closer together.