SKILLED TRADES' WORK AND APPRENTICE TRAINING IN THE MANUFACTURING INDUSTRY WITH A PRIMARY FOCUS ON THE MILLWRIGHT TRADE: AN INTER-GENERATIONAL STUDY

By

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ABSTRACT

Technology has enabled management to utilize automation in the methods of production, and as such promoted a reduction in the use of traditional skills for traditional skilled trades' workers while narrower task specific apprenticeship training programmes promote the loss of trade knowledge traditionally passed from a trades' person to an apprentice in the manufacturing industry. The purpose of this intergenerational study is to trace the changing skill requirements affected by developing technologies in the manufacturing process focusing on the traditional skills of millwright trade, and associated skilled trades. To place in context the origins of the skilled trades' I have included brief histories of five skilled trades, to represent a selection of skilled trades' often closely connected through their work in the manufacturing industry; the millwright, electrician, welder, toolmaker and machinist. In an effort to also report the possible effects of technology on skilled trade labour from a tradesperson's perspective I have utilised my own experiences and incorporated anecdotal evidence from interviews with certified millwrights and apprentices that are either presently working in the trade, or have retired from the trade in Canada. Interviews with three generations of millwrights assisted in making comparisons of training and expectations of millwright work, together with changes in the control millwrights' exercise over the jobs they

perform. The focus of the thesis is the possible effects of technological progress on the required skill sets of three generations skilled trades' with a primary focus on millwright skilled trades'. Restructuring and the utilization of new technologies has facilitated a reduction in the overall number of skilled trades' workers that were previously required when traditional skilled trades' personnel were utilised. Therefore, utilization of technology to lower production costs by modern industry is affecting social structure, in that, traditional opportunities for members of the working class, without the benefit of a university education, are restricted in their ability to obtain well paid jobs as skilled trades' personnel in the manufacturing industry.

Thesis

Technology has enabled automation to be utilized by management in the methods of production, and as such promoted a reduction in discretion and control in the use of traditional skills for traditional skilled trades' workers while narrower task specific apprenticeship training programmes promote the loss of trade knowledge traditionally passed from a trades' person to an apprentice in the manufacturing industry.

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LIST of ABBREVIATIONS & ACRONYMS

AEU	=	Amalgamated Engineering Union
AFL	=	American Federation of Labor
BTSTC	=	Bruce Technology Training Centre
C of A	=	Certificate of Apprenticeship
CAF	=	Canadian Apprenticeship Forum
CAW	=	Canadian Auto Workers Union
CIO	=	Congress of Industrial Organizations
CNC	=	Computer Numerical Control
C of Q	=	Certificate of Qualification
DNC	=	Direct Numerical Control
EDM	=	Electronic Discharge Machine
ICT	=	Information and Communication Technology
ILGWU	=	International Ladies Garment Workers' Union
IMF	=	International Monetary Fund
MASW	=	Machinists and Aerospace Union
MES	=	Manufacturing Execution System
NC	=	Numerical Control
OECD	=	Organisation for Economic Cooperation & Development
OHSA	=	Ontario Health and Safety Association
OPSEU	=	Ontario Public Service Employees Union
PLC	=	Programmable Logic Controller

PWU	=	Power Workers Union
SCADA	=	Supervisory Control and Data Acquisition
SMAW	=	Shielded Metal Arc Welding
T&GWU	=	Transport and General Workers Union
TNC	=	Transnational Corporations
UAW	=	United Auto Workers Union
WHMIS	=	Workplace Hazardous Materials Information Systems
WTO	=	World Trade Organization

CHAPTER 1: Introduction

Introduction

The focus of this study is to assess the changes in technology on the skilled trades in manufacturing. Advances in industrial technology have spawned extensive and intense debate among researchers about which theory is best suited for research on organizational change and the world of work. There are two sides, or camps, in the technological debate. On one side, a group believe that technology is driven, unchangeable, and technological advances determine organizational change. This group believes that external technological developments force companies to adapt the strategies and their operation. The ultimate end of this would be technocracy, where experts in science and technology would rule the social system. Conversely, the other the side of the debate believes that social choice controls technology; the organization determines which course to take, and the technology chosen to suit the organizational structure (Thomas, 1994)

Regardless of which side of the economic Globalization debate is favoured, Transnational Corporations (TNC) the World Trade Organization (WTO) and the International Monetary Fund (IMF) is a union that virtually controls democratic governance and are among the chief users of technology in all spheres of the economy. Teeple defines globalization as, "The arrival of self generating capital at the global level: that is, capital as capital, capital in the form of the transnational corporation, increasingly free of national loyalties, controls and interests" (Teeple, 2006, p.14). As the name implies a TNC is a corporation that operates across many nations without any specific allegiance to workers or consumers, and makes decisions based on the global market and not on national considerations apart from those that will be of financial benefit to the corporation. In addition, companies are increasingly favouring marketing over production, and no longer have an interest in owning the production process (Klein, 2006, p.152). Thus, manufacturing jobs are rapidly disappearing in the west and unions weakened by technology displacement, together with plants that are owned by offshore contractors. Notwithstanding, *Free Trade* agreements that facilitated increased mobility for companies that sought offshore locations with lower wage rates to reduce their labour costs. A primary example, there is virtually no longer any textile industry left in Ontario, Canada.

The effect of economic globalization is having an equivalent effect on workers, as did mechanization facilitated by the industrial revolution. Today, increasingly work is being broken down into simplified tasks to facilitate the individual tasks for incorporation into computerized manufacturing systems. Fifty-one years ago, Fortune magazine reported that corporations in America were eliminating two million jobs annually but the new jobs created are low-paying, temporary positions (Leaver & Brown, 1946). Although unemployment figures have improved slightly in Canada, part-time and temporary employment continues to increase (Statistics Canada, 2007). Effects of technological advancement have the potential to affect all workers.

For most industries in North America, the cost of labour is a significant percentage in the cost of production. In an effort to reduce production cost and to remain competitive in the global market place, manufacturing industries are implementing various strategies in attempts to reduce production costs. Industries have been aggressive in the use of technology to create flexible manufacturing systems that will meet the changing demands of the market. Downsizing has been the most common strategy used by companies in both USA and Canada in attempts to become more competitive. According to Krahn et al., job cuts and restructuring have occurred in almost half of Canadian firms with 100 or more employees and one third expect more downsizing to come (Krahn, Lowe & Hughes, 2006, p. 256.). Companies reducing their labour costs in attempts to increase production levels with fewer workers, or to reduce the bottom line, have experienced extensive reductions of the workforce in North America. In the USA "Fortune 500 companies have on average 15 times over the past 15 years reduced their workforce, eliminating 2.5 million workers from their payrolls" (Krahn & Lowe, 2002, p. 249).

However, it is not only unskilled and semi-skilled jobs; it is the labour force in its entirety, including skilled trades' labour together with reductions in management personnel, themselves affected by management strategies, are all workers caught in the net of downsizing. Technology is enabling sophisticated methods of production to replace the 'Good Job' of the traditional skilled tradesperson in numerous production processes that traditionally required skilled trade labour. It is not just a direct affect of the changes in required skills but also a side bar of computerized manufacturing. In so far that when Business Week in March 1983 projected 50,000 jobs will be eliminated in the auto industry (as cited in Noble, 1984, p. 348) the job losses will include a percentage of skilled trades labour in the auto industry. Technological advancement in the methods of production has historically necessitated changes in the skills sets of skilled trades' workers. An historical example of this is the printing trade. A trade with a long union history of successful collective bargaining, and arguably a trade that exercised more control over the job process than any other skilled trade is, now almost non-existent. The printer's union with a long and successful history of aggressive bargaining could not counteract management strategies that utilized computerized production methods that eventually resulted in the demise of the printing trade (Zimbalist, 1979). If a complicated task that requires decisions to be made by the worker is replaced by several simpler tasks that do not require meta cognitive ability[1], the task can then be more easily incorporated into a computerized manufacturing system and this leads to the elimination of skilled trade jobs. For example, Computer Numerical Control (CNC) metal cutting machines have affected toolmakers and machinists as computerized vibration analysis equipment have affected millwrights.

Increasing production and raising the profit: But who pays in the end?

In medieval times, the merchant guilds gradually eroded the strength of the craft guilds that resulted in the merchants gaining control of production from the artisans and craft guilds. The next epoch was the industrial revolution that enabled the replacement of craftsmen who could not compete with the new machinery. For example, skilled wool combers, calico printers, hand loom weavers, wool shearers' were workers replaced by machines and semiskilled machine operators, who for the most part were women and children, poorly paid, and worked in appalling conditions. Thus, pure technique is not a concern, "but rather the marriage of technique with the special needs of capital" (Braverman, 1974, p. 52).

An early advocate for the division of labour in using the strategy of breaking down tasks into simple elements was the philosopher and economist Adam Smith in the late seventeen hundreds. His goal was to increase production and, by restricting one man to perform one, or two operations in the manufacture of a pin, production increased by having one worker perform one operation instead of making the entire pin (Hodson & Sullivan, 2002). Therefore, it would make economic sense to pay several workers to perform one task in the production of one pin. Smith thus rationalised that by doing so would significantly increase the number of pins produced in a day, and at the same time reduce the cost of labour.

Going one step further the nineteenth century philosopher Andrew Ure interpreted Smith's philosophy and captured the spirit of automation when he wrote,

> "By the infirmity of human nature it happens, that the more skilled the workman, the more self-willed and intractable he is apt to become, and, of course, the less fit a component of a mechanical system, in which, by occasional irregularities, he may do great damage to the whole. The grand object therefore of the modern manufacture is, through the union of capital and science, to reduce the task of his work-people to the exercise and vigilance and dexterity" (Ure, 1835, p. 18).

Ure wrote his philosophy approximately one hundred and seventy years ago referring to the industrial revolution. He also prophesied, "On the automatic plan, skilled labour gets progressively superseded, and will eventually be replaced by mere overlookers of machines" (Ure, 1835). Ure's prophesy would seem to be coming true. Smith's observations and Ure's prophesy laid both philosophical and operational principles for deskilling, increasing production, and reducing labour cost that are operational today. Taylor (1911) built upon this premise promoting his vision of Scientific Management for organizing work based upon the principle of efficiency, and went beyond Smith's aim to increase production. Taylor's goal was to gain power by removing the necessity of workers making decisions thus increasing management's control over the production process. As he states,

> "All possible brain work should be removed from the shop and centered in the planning or laying-out department the work of every workman is fully planned out by management at least one day in advance, and each man receives in most cases complete written instructions, describing in detail the task he is to accomplish, as well as the means to be used in doing the work. This task specifies not only what is to be done, but how it is to be done and the exact time allowed for doing it. Scientific management consists very largely in preparing for and carrying out these tasks" (Taylor, 1911, p. 39).

Thus, as acknowledged by Taylor, knowledge is power, and traditionally workers who possess specialized high-level knowledge and skills traditionally had greater power and hence commanded higher remuneration for their work than lesser skilled workers command. Nevertheless, as technology advances, and particularly the development of worker robots, the need for *traditional trade skills* decrease with unskilled and semi-skilled workers performing production tasks, enabling employers to increase control over production, undermining worker power which leads to lowering worker's wages, resulting an increasing proportion of "Bad Jobs"[2]. Therefore, it is in the interest of companies and management to invest in technology to increase production quotas, thus requiring lower skill levels for the production process that facilitates a decrease in labour costs over the long term, thus an increase in profits. Thus, industry leadership views the industrial automation of production as essential to increasing profits.

However, technology is also a very convenient means for management to increase their control over the work process. Quoting several instances in history economic historian Steven Marglin offers a very compelling argument against management reasoning, that utilizing technology is the only way for companies to remain competitive. Marglin contends, "Neither of the two decisive steps in depriving workers of control over the product and process. 1) The development of the minute division of labour that characterized the putting-out system, and 2) the development of the centralized organization that characterizes the factory system" was not to gain technical superiority but to gain more output for the same input (Marglin, 1974, p. 61). Similarly, Noble identifies many instances where management used technology to increase control over the work process. (Noble, 1984, p.52).

A grounding of the industrial skilled trades'

A skilled tradesperson is not an ordinary jobholder. These occupations signify achievement, skill, status, and belonging to a culture that is rooted before the industrial revolution. The skilled trades' person also gains entry to prestigious limited groups who undertake skilled work. Skilled trades in manufacturing are many and varied, and regarded as being at the top in the class hierarchy of industrial manual workers. Traditionally, skilled trades' workers, due to their extensive trades' training and knowledge of their trade, have more discretion and control over work than production workers do. Examples of traditional skilled trades' in manufacturing are; toolmakers, millwrights, electricians, and welder fitters. The focus of the study is on the millwright trade.

Two main disciplines divide the millwright trade into industrial, and construction millwrights. Industrial millwrights repair and maintain machinery and equipment in manufacturing and processing environments, whereas the construction millwright, as the name implies, perform work in the construction industry and the installation of machinery and equipment. The origins of the millwright trade is traced back to the Feudal System in the Middle Ages peasants performed labour for the Lord of the manor for two or three days of the week to construct and maintain the estate's roads, walls, buildings, and equipment, together with making clothes for the community that populated the manor. The peasants were formerly serfs who either purchased their freedom from a Lord, or had escaped serfdom by some other means (Tausky, 1996). Wind and water powered the mills used to grind grain, crush ore, drive saws, polish armour, and other tasks performed by machines. Wind and waterpower transferred to the grinding stone by a series of wheels, shafts, and gears. Unlike the design engineer of today who designs the unit, but is not required to be involved in the *hands on* creation of parts, the medieval millwright manufactured the parts and equipment, doing most of the work himself that would require various skill sets. For example, a millwright would be skilled in carpentry, construction and blacksmithing, etc. As an artisan, he would be a member of a Craft Guild. A primary objective of the Guild was to provide stable work for the membership and artisans from the various craft disciplines who organized it. Examples of the craft disciplines would include shoemakers, carpenters, tailors, bakers, brewers, blacksmiths, etc. The guilds also created and operated a formal system of quality control to maintain the standard of workmanship, materials, and pricing of the work and products produced by the artisans. Their mandate also included the training of artisans to protect the reputation of the membership and status of the guild (Hodson & Sullivan, 2002, p. 16). Membership of the craft guilds would consist of employers (master[3]) and employees (journeymen and apprentices).

The state initially played an indirect, but important role in the local governance of apprenticeships in England through the 1349 Statute of Labourers that regulated apprentices. However, the introduction of the Statute of Artificers in 1562/3 increased Government intervention when the local law transformed into national law. The laws were an attempt to safeguard working conditions of apprentices and to prevent abuse by their masters/employers (Clarke, 1998, p.30). The Industrial Revolution caused a further breaking down of the *traditional* trades' and the creation of new trades that required lesser skill sets than the original *traditional* skilled trades'. Management control increased exponentially with advances in technology. Similarly, the introduction of the NC machine in the 1950s was the forerunner of today's technological advances in most computerized manufacturing methods, enabling increased control over production. Governments throughout the OECD continue to dictate apprenticeship training and working conditions for apprentices.

Technology in the workplace

Industrial manufacturing industries entered a technological era with the advent of the Numerical Control (NC) machine that was an epoch in the history of the skilled trades'. NCs were the introduction of computerized manufacturing technology in the workplace. The technology was introduced in part to eliminate the cost and inflexibility of jigs and fixtures, and equally important, to take skill and control off the shop floor" (Noble, 1979, p. 80).

Technology enabled companies to increase their control over the production process and to make choices that were previously unavailable to them. The extensive use of Programmable Logic Controllers (PLC's), Robotics and Computer Numerical Control (CNC) programming in the manufacturing industries has facilitated increased management control over the production process (Wolfe, 1990, p. 96). However, technology has not only affected blue-collar workers. For example, the advent of the Information and Communication Technology (ICT) era has facilitated simplification of clerical tasks that previously required extensive training in those specialities in clerical work. Glenn and Feldberg state that, clerical work has been "simplified beyond recognition" virtually eliminating stenographers (Glenn & Feldberg, 1979). The computerized office has had a dramatic effect on the clerical work and has facilitated extensive reductions in clerical job opportunities. Administration divided many tasks that clerical workers performed into small, individual tasks to facilitate the computerization and simplification of clerical work (Hodson & Sullivan, 2002). As personal computers have enabled increased production, it has been my experience that companies increasingly require many of the front line staff to perform their own administrative work, and tasks previously been carried out by office secretaries and typists. Furthermore, computer technology has enhanced management control with sophisticated electronic surveillance systems of the work place, together with telecommuting that has enabled companies to use "offshore" offices where non-unionised cheap labour is readily available, thus further reducing opportunities of employment in Canada and the US.

As prophesied by the two Canadians, J. J. Brown and E. W. Leaver in their 1946 article "Machines Without Men", published in the November issue of Fortune, computerized manufacturing methods have effected skill requirements of the manufacturing industry, and in some sectors abolished the necessity of skilled trades' labour in manufacturing processes (Noble, 1984). For example, many welding and paint spraying tasks in the automotive manufacturing industry are now performed by worker robots, tasks that were previously performed by certified human welders and paint sprayers. Before computerized manufacturing systems, auto body parts were spot-welded together manually and car body parts were paint sprayed manually. The cost of increased efficiency and higher levels of production have unfortunately been born by the workers replaced by worker robots.

Most economists regard the use of manufacturing technology as essential to stay competitive in the global market. Consequently, technology is utilised for lowering the required skill, and knowledge levels of skilled trades' workers, or as in the case of the production welders in the auto industry, almost eliminating the necessity of particular trades. The aim of manufacturing and processing plants is the creation of a multi-skilled specialized workforce consisting of technicians who will possess individual skill sets tailored to the department, or section, in which they work. Thus, many of the specialized or tailored skill sets are not transferable, unlike those of traditional skilled trades' workers. Originally, it was not a technical necessity that dictated the path of development, and it is not the technology that will reduce the income of those displaced by technology. Noble states in *Forces of Production*; "NC machines were developed at great expense, not to the companies who were instrumental in the development of the machines, but to the taxpayer" (Noble, 1984 p. 11). Government guided military contracts for the research and development of NC machines toward companies favoured by the military. For example, institutions like the elite universities, Bell laboratories, General Motors etc., (Noble, 1984). The reason primarily for the development of NC machines was not as much to reduce production costs, but to gain advantage in the ongoing struggle to wrest control of the shop floor from the machinists. However, it seems the majority of modern management is caught up in the ethos that to remain competitive it is essential to invest in the latest manufacturing technology, disregarding the potential of utilising existing skilled trades personnel that could maximize the potential of new technological advances. I concur with Feenburg, it is not technological determinism that is causing the erosion of available positions for skilled trades' workers; it is modern management that has replaced the traditional congeniality of the guilds with the new forms of technical control (Feenburg, p18. 1995). However, continual technological development is integral to the capitalist mode of production, and the owner-workers struggle over labour control of the labour process is endemic to both the production process itself and attempts at technological change by both owners and workers. However, the rate of technological change at the time of the craft guilds was a gradual process when compared to the technological advances of the industrial revolution that facilitated methods for the frenetic pace of capitalist production.

Skilled trades' training

The Mechanics Institute founded in 1823 provided informal vocational education for craftsmen and apprentices and considered a forerunner of community colleges. However, formal, in-class theoretical training for apprentices was not available in North America until the beginning of the twentieth century (Strauss, 1968, p. 213). Canada did not fully develop an indigenous apprenticeship system and historically depended on importing skilled trades' labour from Europe through immigration. In the UK, and later in North America, governments made a significant investment in the post war era (1950s - 60s) for secondary education to facilitate the expansion of universities and the creation of community colleges to promote workplace-training programmes: for example, classes for in-class theory for trades' apprentices. However, many apprentices in Canada had difficulty in finding suitable classes within commuting distance of their homes. In less populated areas, apprentices could not attend the required in-class theory classes without moving to area where the community college was located. By comparison, in recent times distance education and the utilization of computers facilitates the delivery of the theoretical instruction in skilled trades training to replace in-class training for apprenticeship training in several provinces across Canada. The aim is to facilitate apprentices in areas of the country where distance between colleges create a significant obstacle to apprentices who must complete the mandatory theory or in-class training that is a requirement of the present apprenticeship programmes. Nonetheless, this still does not solve the problem of the practical or hands-on training that is required for fluid power, power transmission, machining etc. Considering the diversity of reports in the literature, it is necessary to verify that proposed reforms of apprenticeship training programmes will provide a level of training that will equip an apprentice with the skills necessary to become a trades-person capable of meeting the challenges of the technological requirements of modern industry.

Significant changes to apprenticeship training programmes introduced in Ontario, Canada with amendments to the *Apprenticeship and Qualifications Act* in 2000 created heated discussion among skilled trades' unions criticising the changes introduced by the Provincial Government. A highly controversial amendment being that it is no longer mandatory that only a certified skilled trades' person may train and instruct apprentices. The Act now permits a non-certified person deemed to be proficient in the performance of the task to train an apprentice. A further amendment changed the fundamental structure of apprenticeship with the abolition of time served apprenticeships, and the introduction of task-orientated apprenticeship training system. In which the apprentice is required to have practical tasks signed off when each set of tasks are completed. The apprenticeship deemed complete when the sponsor, together with the successful completion of practical, and theoretical in-class components of the apprenticeship signs off all stipulated tasks for the apprenticeship-training programme. However, my experience is that many members of bargaining units and management, in the manufacturing industry are questioning the possible effects of the radical changes introduced into the apprenticeship training programmes in Ontario. Concern is mostly about, the quality of training received by apprentice, sponsoring apprentices, and the potential abuse of signing off training modules. It has been my experience in industry as a skilled tradesman, and as a member of faculty teaching pre-apprenticeship, and apprenticeship training programmes at a community college in Ontario, that an apprentice should receive the necessary skills training, and also be able to learn the 'Trade Knowledge' of the pertinent trade. Trade knowledge, or tricks of the trade, is both an understanding of the relevance of the process of knowing not only how, but also why. Further discussion on 'Trade Knowledge' is in chapter 2.

While it has been necessary for the workforce in general to acquire new skills to operate computerized equipment and for people to think more on the job, there are other several important issues to consider relevant to workers. For example, technology has enabled companies to restructure and downsize their workforce, and still achieve the same, if not higher production levels. From my experience in industry, the initial assertions made by the proponents for computerized manufacturing that technology would require the acquisition of new skills are false. In that, the new skills could eventually counteract the potential deskilling process created by computerized manufacturing. Computerized manufacturing methods are eroding traditional trades' skills manufacturing industry, but rather than incorporating existing skilled trades workers' in the developing technology, management for the most part has significantly reduced the requirement for skilled trades' workers. CNC machines have significantly affected the availability of some trades. Skilled trades' most affected so far, are toolmakers, machinists, and welders (Hodson & Sullivan, 2002). Nonetheless, as a millwright in the early eighties I was unemployed for the first time in my life and unable to obtain work as a skilled tradesman. Therefore, I agree with Krahn and Lowe that enskilling[4] was in fact probably short lived in that the enskilling trend may well have slowed down considerably or even stopped in the 1980s in a climate of high unemployment rates caused by substantial industrial restructuring and organizational downsizing, enabled by the widespread introduction of automated technologies (Krahn & Lowe, 2002).

In an effort to reduce labour costs, employers have introduced various techniques designed to reduce skilled trades' labour costs. For example, multi-skilling, multi tasking. It is therefore necessary to define the difference between the three techniques. Multi-tasking adds to the workload, but does not necessarily requiring a higher level of thinking. Multi-skilling/multi-crafting is a training system that teaches parts of a trade and requires a skilled trades' person to perform functions or tasks of other trades. Multi-skilling/multi-crafting connects to a similar practice in which a company creates "designer trades", generally known as multi-crafting, that are subsets of established trades'. It satisfies the company's specific needs but does not require a certified trades' person. All these practices contribute to a *watering down* of the traditional skilled trades'. Company practices that limit an employee's ability to obtain employment in an established regular trade facilitate the elimination of skilled trades' jobs from the production process. Thus, technology has enabled sophisticated automation methods of production and has promoted a lowering of the required skill levels of operators and skilled trades' personnel (Krahn & Lowe, 2002, p. 294).

Heated debate over skilling, multiskilling, and deskilling of the skilled trades' and apprenticeship training seems to be similar to the description of globalization by Jameson & Miyoshi:

> "The modern or post-modern, version of the proverbial elephant is described by its *blind observers* in so many diverse ways. Yet one can still posit the existence of the elephant in the absence of a single persuasive and dominant theory; nor are blinded questions the most unsatisfactory way to explore this multileveled phenomenon" (Jameson and Miyoshi, 1998, p. 222).

CNC machines have significantly reduced the number of machinists required in the manufacturing industry in that, one machinist can now operate several CNC machines whereas previously a machinist would operate one machine at a time. This applies equally to toolmakers in that many operations previously performed by tool and die makers who utilized traditional methods for making toolage and dies. For example, turning, milling, grinding, and bench fitting now performed in many industries with Electric Discharge Machine (EDM), CNC machines, or the developing technology of rapid prototyping. Welders have suffered a similar fate in the manufacturing industry with the introduction of computerised welding machines and worker robots. An increasing number of companies are sub-contracting work previously performed by millwrights employed within the company. For example, equipment alignment performed with the traditional equipment; straight edges, feeler gauges, dial indicators and associate hardware was a task performed by millwrights. However, since the introduction of laser alignment[5] it is common for companies to sub-contract out alignment work. Similarly, it is also common for companies to "contract out" vibration analysis[6] tasks.

It is unacceptable in the present era of rapid technological advancement in the methods of production and social change, the evolution of technology is the only viable way to remain competitive, but decisions made regarding the adoption of new technologies, based on the interests of both owners and workers (Feenburg, 2002). My research will build on the existing knowledge concerned with technological change and the skill requirements necessary to perform maintenance tasks in computerized manufacturing environments, together with apprenticeship training relative to industry's present skills training requirements.

Statement of the Problem

As suggested in the introduction, technological change and advances in computerized manufacturing processes are facilitating deskilling of millwrights and skilled trades' workers in general. often resulting in a good job' being replaced with a 'bad job', or in some cases the complete elimination of the job previously held by skilled trades' worker. The consequence is the elimination of a livelihood that provides for a good quality of life for working class people and a reduction of their status in the workplace, which can affect their self-esteem and well-being.

Purpose and Objectives

The purpose of this study was to evaluate the perceived consequences of technological change in the manufacturing process on labour practices, the required skill status of millwrights. This includes retired millwrights, currently employed millwrights, and apprentice millwrights from a millwright's perspective

The specific research objectives were:

I. To assess and document the extent of deskilling of the millwright trade, from a millwright's perspective while also being alert to any counter trends.

II. To assess changes in the basic skills of the millwright trade from a millwright's perspective.

III. To assess changes in the power relationship between management and millwrights as a consequence of current technological advancements in the production process.

The Significance of the Study

Skilled trades' have traditionally been recognised as a 'Good Job' that was (a) obtainable without the benefit of a university education, (b) a working class job that pays well, and (c) because of the extensive knowledge required by a skilled trades' person the position was respected and carried status in the workplace. Technological development and computerized manufacturing processes are facilitating the steady erosion of the skills formally required, not withstanding new skills learnt in the operation of computerized equipment. Thus, it may be that computerized manufacturing processes, and associated equipment are assisting in the devaluation of the skilled trades' as an occupation. That would create a situation that has the potential to fuel the power struggle between employers and trade unions. Particularly in regard to management's endeavour to bridge the gap between the philosophies of Ure and Babbage to replace skilled trades' personnel with lower paid semi-skilled labour, and the Tayorist vision of developing methods of organising labour. For example, a reclassification of semi-skilled workers for a diminished version of the present skilled trades' workers who would possess a lesser skill set than those skilled trades' workers who are presently working in automotive manufacturing and associated industries.

"Bad work holds no vision of work as an activity that concerns itself with the long term welfare of other human beings or of subsequent generations" (Kincheloe, 1999).

Methodology

In an effort to report the effects of technology on skilled trade labour, from a millwrights' perspective, I have incorporated anecdotal evidence from millwrights currently employed in the millwright trade. As an *insider* in the manufacturing industry, I have utilised my own experiences as a skilled tradesman. To acquire cross-generational data, face-to-face interviews conducted with participants that represented experiences in three common stages that span the career of a skilled trades' person. The *initial learning stage* as an apprentice, the stage employed as a *qualified trades'* person, and that of a *retired trades'* person. The three groups consisted of; millwright apprentices enrolled in millwright apprentice-training programmes, millwrights who had served an apprenticeship and possessed a Certificate of Apprenticeship (C of A), and Certificate of Qualification (C of Q) and currently employed as millwrights. Retired millwrights who had either, served an apprenticeship, or been grandfathered into the trade. The term Grandfathered, relative to skilled trades' in Ontario, refers to a person granted a Certificate of Qualification by the Provincial government after providing satisfactory evidence to verify having sufficient previous experience of working in the trade, but not has graduated from a relevant apprenticeship-training programme.

The study is limited in that data gathered is from a limited sample, and an *insider's* perspective of people working as millwrights or apprentices in the millwright trade, nor does it contain a management perspective.

CHAPTER 2: Literature review

Introduction

The breaking down of required skill sets faced by skilled trades' workers today is similar to those faced by skilled trades' workers for the last five hundred years.

In the history of the skilled trades, there have been three epochs. First, the gradual change in the relationship between the owners and the craftsmen who ceased to be self employed and became employees of the owners signalling the end of the feudal system. Secondly, the invention of the steam engine in the mid 18^{th} century together with the creation of new trades and the deskilling of many existing skilled trades'. Third, the use of computerization in the manufacturing process that enabled, among other things, the creation of CNC machines that no longer required a 'hands on' operator to create the profile of a machined part. The CNC programme having been written, and checked for errors, human beings are no longer necessary to the actual machining process. Prior to CNCs machines, apart from some gradual improvements in lathe design, the machining process had remained relatively unchanged for the previous two hundred years.

This literature review will trace the skill requirements dictated by developing technologies in the manufacturing industry, focusing on the traditional skills of the millwright trade and the associated skilled trades, and as such, the chapter is both analytical and descriptive. As previously stated, to place in context the origins of the selected skilled trades, effects of technological development, and gradual dilution of the trades I have included brief histories of the millwright, welder, machinist, toolmaker, and electrician. Thomson (1983) refers to technology and the labour process utilising Marx's analogy of the bee and the architect. However, the same example could also be describing the traditional skilled tradesperson in the labour process:

> The bee works in a complex and productive way, and the architect consciously constructs the operation. Hence, man not only effect change of form in materials of nature; he also realizes his own purpose in those materials (1983, p. 39).

For the skilled trades' labour, the opportunity Marx refers to is rapidly disappearing as technology and management choices continue to reduce the control of the labour process from workers. This is accomplished by dividing work originally performed by humans into smaller tasks enables the substitution of human workers with sophisticated machinery and worker robots in the production process. The scope of work originally performed by traditional skilled trades labour is therefore, eroded with the combination of deskilling skilled trades, together with the utilisation of readily available production technology.

This has enabled management to restructure their workforce and lessen reliance on skilled trades' workers and more readily utilise less skilled labour in ever-increasing numbers that will result in a further decline of skilled trade labour in the production process. For example, the unprecedented rapid decline in requirement for tool and diemakers. Most research on the labour process and the skilled trades has focused on member countries of the OECD, particularly UK, Germany, and the USA, which are, according to Fuller and Unwin (2003), a reasonable representation of the western industrialised society.

Prior to the Industrial Revolution owners and management utilized techniques that broke down complicated tasks into several simple component tasks that less skilled workers performed, thus reducing the cost of labour in the production process. Simplification with the aid of successive new technological developments has enabled the introduction of increasingly sophisticated production methods that have facilitated significant reductions of the workforce in the manufacturing industry. Those remaining workers who operate, or oversee, the new technologies have been required to learn new skills. However, the new skills are usually specific to the technologies used in the production process of that particular plant, and are possibly not transferable to other companies or employers. Traditional skilled trades' labourers have broad based transferable skills enabling them to gain similar employment elsewhere. An example of skilled trades in the manufacturing industry would be machinists, tool and die makers, electricians, millwrights etc., (Hodson & Sullivan, 2002, p. 27).

Today as the acquisition of robotic technologies is becoming more achievable for small companies; increasing numbers of worker robots are replacing human workers who previously performed the unskilled, and semiskilled repetitive manufacturing tasks of production. However, technological change has also contributed to the reduction, or elimination, of many skill requirements formally associated with various sectors of skilled trades' labour. The most glaring example in recent times was the decimation of the printers, typesetters, and associate trades with the introduction of computerized printing processes. As Marx states:

> "The development of the means of labour into machinery is not an accidental moment of capital, but is rather the historical reshaping of the traditional, inherited means of labour into a form of adequate capital. The accumulation of knowledge and of skill, of the general productive forces of the social brain, is thus absorbed into capital, as opposed to labour, and hence appears as an attribute of capital, as opposed…. In machinery, knowledge appears as alien, external to him (the worker); and living labour as subsumed under self-activating objectified labour" (Marx, 1973, pp. 492; 639).

In this chapter, I will *attempt* to clarify the frequent misunderstanding of the differences between a certified skilled trade workers, uncertified skilled workers, and semi-skilled workers in the manufacturing industry. The remainder of the chapter will include a brief explanation of the traditional role of selected skilled trades' workers in the manufacturing industry, together with a description of the origins of the skilled trades and the gradual reduction in the breadth of required skill sets over time. Thus, attention paid to de-skilling, enskilling, and multi-skilling, together with an exploration into the dilution of the traditional skilled trades'. In addition, there is a brief investigation into apprenticeship training and company attitudes toward apprenticeship training, and the origins, and role of unions in, apprenticeship training.

Misinterpretation: Defining Skilled Trades

As previously stated, from a skilled trades perspective deskilling, enskilling, (learning new skills), and multiskilling (learning portions of other trades) often seems to be confused by academic authors who research industry and participate in skilled trades' debate. The majority have not served a skilled trade apprenticeship, or have not worked in industry for enough time to understand the nuances of the skilled trades. Understandably, some are guilty of *blurring* the demarcation lines between skilled trades' workers who have successfully completed apprenticeship-training programmes for their trade before qualifying as a skilled trades' person, and a person who may possess certain skills required for their work, and indeed, who may be very skilful in the tasks they perform. For an example of *blurring,* Penn in his book *Class Power and Technology* (1990, p. 28) criticizes Braverman's work while nonetheless acknowledging that Braverman's *Labour and Monopoly Capital* (1974) is a lynchpin for further debate. Penn however appears to lump all skilled labour together, seemingly without differentiating between skilled trades' labour and workers who possess a high level of education and the skills necessary to operate increasingly sophisticated technological equipment. Skilled trades' personnel differ in that they have received continuous training during an apprenticeship in a designated skilled trade, during which they learn the theory relative to the pertinent trade. For example, trade math that would include gear train calculations and corresponding speeds of input and output gears in gear trains, machining feeds and speeds calculations, physics, metallurgy, electrical theory. A millwright apprentice would learn the theories of fluid power, power transmission, and machine technology and so on; together with the practical training necessary. Therefore, the apprentice thus gains the necessary knowledge of the different facets of the production process that are relevant to their trade. This is not just knowledge and skills for individual pieces of equipment in a particular plant. An insistence on calling traditional skilled trades' people *craft labour* does not acknowledge that the craftsperson / skilled trades' person, regardless of the era, must keep up with current technology in order to perform the tasks required of them in order to retain the jobs they are employed to do (Penn, 1990).

To exemplify this point, Braverman (1974), who served an apprenticeship as a coppersmith and was himself a qualified tradesman, wrote:

> I was always conscious of the inexorable march of science based technological change; moreover, in my reflections upon this subject and in many discussions among craftsmen debating the old and the new in which we took part, I was always a modernizer. I believed then and I believe now, that the transformation of labor processes from their basis in tradition to their basis in science is not only inevitable but necessary for the progress of the human race and for its emancipation from hunger and other forms of need. (Braverman, 1974, p. 5)

Skilled trades' people often discuss the subject of industrial change and the effects on the skilled trades, but unless one is or has been a working member of the skilled trades' *community,* it is unlikely that an *outside*r will be privy to such closed discussions. Being a 'time served' tradesman, and having taken part in similar discussions, I agree with Harry Braverman, and it is unfortunate that his detractors do not seem to grasp what Braverman meant from a skilled trades' perspective. Braverman's point was that as the owners and managers of industry have utilized increasingly sophisticated technology in the methods of production, the number of 'good jobs' that would be available would be reduced accordingly, as would the required number of skilled trades' personnel. In Braverman's description of NC machines, he concludes:

> "The unity of this process in the hands of the skilled machinists is perfectly feasible, and indeed has much to recommend it, since the knowledge of metal-cutting practices which is required for programming is already mastered by the machinist. Thus there is no question from a practical standpoint there is nothing to prevent the machining process under numerical control from remaining the province of the total craftsman. That this almost never happens is due, of course, to the opportunities the process offers for the destruction of craft and cheapening of resulting pieces of labor into which it is broken" (Braverman, 1974, p. 137).

Thirty years later Braverman's forecast about large reductions in the numbers of workers displaced by restructuring, and downsizing that was made possible by several factors. One of them is the use of computerized manufacturing processes, seems to have been true. A minimum of approximately 250,000 jobs in the manufacturing sector in Canada have been lost in the last five years. Statistics Canada estimates that workers displaced by firm closures and layoffs who find other jobs suffer an average decline of 25% in annual earnings, a loss of approximately $10,000 in annual earnings (Weir, 2007). As previously stated, his forecast for commerce has also been realised with significant numbers of clerical workers displaced, and worldwide adoption of the computerized office environment. Those who retained their jobs during computerization and restructuring of clerical work did need to acquire a proficiency in new skills. Once the procedure is mastered one data entry person can perform a significant amount more work than previously possible in the pre-computer era, nonetheless the acquisition of new skills were in addition to skills they already possessed. For example, management does not classify data entry as requiring a high level of computer literacy. Nonetheless, according to Hodson & Sullivan more efficiencies in data entry work are being created during which individual workstations will be eliminated, information accounting system will become fully automated, and data entry jobs will metamorphose to be more programming and machine maintenance, rather than clerical (Hodson & Sullivan, 2002, p. 238). Braverman was also correct in forecasting machines would do increasing amounts of skilled trades' work, and that semi-skilled labour would require higher levels of formal education and accreditation. However, many jobs advertised requiring specific accreditation do not actually need the level of education requested by the potential employer (Livingstone, 1999, p. 216). It should not be assumed, that because computer-integrated manufacturing has broadened the task scope of some blue-collar work by increasing the range of tasks performed by some blue-collar workers that the increased range demands greater skill or increased cognitive complexity (National Research Council, 1999).

Nonetheless I do appreciate it must be difficult to understand a tradesperson's perspective of what is required from skilled trades' personnel without the benefit of work experience as a skilled trades' person. Unless the author, or researcher, received training, together with several years experience in the trades, and subsequently gained '*Trade Knowledge'* (as previously stated, see endnote 19), their understanding at best, is based on assumptions gained as second hand information. The manufacturing industry, and most processing environments can be hard environments in which to work, and many manufacturing processes can be dangerous for the people working in them. For example, foundries, and metal cutting trades and press shops can have the potential of being especially dangerous. The *'Steel men'* who work in the metal foundries are proud of their tough hard-man image gained from working in a dangerous environment and in order to survive many workers create a veneer, or an attitude, in the workplace that enables them to survive in a tough environment.

History of the Skilled Trades

Before mechanisation and scientific management, craft workers had significant control over the work process. However, during the first part of the twentieth century jobs were broken down, facilitating the dispensation of skilled labour (Thompson, 1981, p. 285). Gradual deskilling in the manufacturing industry has enabled, in part, the substitution of skilled tradespersons with lower paid semi-skilled or unskilled personnel that has subsequently lowered the cost of production. This is exemplified in the works of people such as Adam Smith (*An Inquiry into the Nature and Causes of the Wealth of Nations, 1776),* Charles Babbage (*On the Economy of Machinery and Manufactu*re, 1832), and Fredrick Taylor (*The Principles of Scientific Managemen*t, 1911). Taylor is probably the person who had the most significant direct impact on modern production. In Cooley's opinion, "Seventy years of scientific management have seen the fragmentation of work grind through the spectrum of workshop activity engulfing even the most creative and satisfying work" (Thompson, 1981, p. 89).

As the use of computerized manufacturing techniques and the utilisation of computerized maintenance equipment increases, it is inevitable that some trades have, and will continue to disappear, replaced by the creation of hybrid trades. Increasingly computerized manufacturing techniques are rapidly expanding the simplification of tasks previously requiring skilled personnel. Therefore, if the de-skilling trend becomes even more widespread and one person possesses the knowledge and skills of two or more different trades, then it follows that computerization is successfully increasing production while decreasing the skilled trades' labour force. For example, an industrial millwright who traditionally maintained the mechanical maintenance of machinery and equipment in an industrial environment is increasingly required to possess a deeper knowledge of work previously the domain of the electrician. For example, when management introduced Programmable Logic Controllers (PLCs) in the 1970s to control machines in the production process, the maintenance and adjustments were strictly an electrician's work. Today many plants including automotive manufacturing plants (renowned as active union shops) require millwrights to perform first level troubleshooting of PLC systems as a part of their job description. The introduction of multi-skilling is changing the role of the single disciplined trades' person. As other skilled trades in the manufacturing industry are subjected to deskilling and are thus in decline, increasingly millwrights with a good knowledge of electrical work are rapidly becoming one of the most sought after trades in industry. Therefore, contrary to the current practice of increased specialization and in the pursuance of reducing, or eliminating, the majority of traditional skilled trades' workers, it is feasible that either the electrician or the millwright will no longer be required, being replaced by one multi-skilled technician.

Master craftsmen and the training of craft apprentices have played an important role in society since ancient times. In Greek mythology, Hephaestus the god of fire was a blacksmith and patron to all craftsmen. However, the first record of a London (UK) apprentice is in 1265 A.D. (Akroyd, 2000). European guilds date back to the middle ages when craft guilds and merchant guilds controlled commercial activities in medieval Europe. In the fifteenth century, the craft guild's power and influence began to decline and craftsmen increasingly worked for the merchant guilds. Thus, Merchant Capitalism gained control of commerce in the late Middle Ages and early modern period 14^{th} to 18^{th} century (Tausky, p.19-20). The merchants' control in the industrial society had a significant effect on the independence of the artisans. Merchants gradually gained control of production by gathering workers and equipment in their own workshops, together with a monopoly over the raw materials. Thus, forcing local craftsmen to work through the merchants to pursue their craft. Increased competition, created in part by merchants utilising the *putting-out system t*hat further weakening the guild's influence over production, together with rising costs eventually made it extremely difficult for artisans to open their own shops (Hodson & Sullivan, 2002).

Traditional apprenticeship as we understand it today is traceable to medieval times, but the most significant changes to the crafts and apprenticeship began in the 17th and 18th centuries. The development of the steam engine and the commencement of the industrial revolution in the 18th century caused a proliferation of new crafts, or trades, and the dilution of others, notably the millwright and blacksmith. As the traditional crafts were broken down so the extent of the skill sets diminished, and a perfect example of this was the millwright. The original millwright was as much a design engineer as he was a craftsman. He designed and manufactured *every* part of the mill structure, together with the necessary equipment. Nevertheless, his job was not completed. He then assembled the mill and performed any maintenance necessary to keep the mill running efficiently. Skilled trades' categories have gradually diminished since then (See Appendix I). For example, very few shoemakers, or cobblers still ply their trade, and the printer's trade reduced to the point of near extinction by the use of computerization in publishing industry. A continuation of the trend is still in effect today. For example, the traditional welder's trade is a dilution of the blacksmith trade, is divided into three different trades; (1) Welder (2) Welder B (3) Welder C. Different classifications/certifications denote various levels of skill and complexity. For example, welder fitter, pressure vessel, and pipe welder, all position welder (a person who can weld metal that is in the vertical, horizontal and overhead positions), and others who may be qualified to weld in only one or two different position (flat, horizontal, vertical). Although not included in manufacturing trades in the strictest sense of the word, originally a skilled auto-mechanic who was required to maintain and repair an entire vehicle except the repair of the coach/body work (vehicle / car panels)[7]. In management's pursuit of efficiency, and profit, methods engineering has been utilised by the automotive manufacturers to breakdown the auto mechanic's work into closely timed modularized tasks[8]. Government cooperation facilitated the division of the original work performed by the skilled auto mechanic into several modules. Thus, creating new diluted trades and the auto mechanic trade transformed into work requiring a limited skill sets performed by technicians who specialize in certain tasks. For example, Automotive Glass Technician, Automotive Steering, Suspension and Brakes Technician, Frame Straightening Technician, and so the list goes on, modularizing one original trade to twelve separate trades. Modularization continues to reduce the number of well paid jobs available as an auto mechanic, while depleting the skills formally required by the traditional automotive mechanic, However, some original auto trades on the list have since been revoked (Alignment, and Brakes Mechanic, Transmission Mechanic), or combined into other technician classifications. Nonetheless, the original trades of auto mechanic and body repairperson remains diluted (Ontario Ministry of Education Ministry of Training, Colleges, and Universities, 2006).

The problems pertaining to skilled labour shortages, the demands of industry, and the ebb and flow of skilled trades training continue to be as mercurial today as they have been for most of the last four hundred years. Members of the ancient Guilds possessed specialized skills and knowledge that enabled a partial transfer of power from the owners to the tradesmen. As previously stated the European skilled trades' apprenticeships date back to medieval times and fostered by the old Guilds as a protectionist measure. In Western Europe if a person wished to work in the skilled trades it was first necessary to serve an apprenticeship. This system enabled the guilds to ensure skilled tradesmen performed the work, and prevent unskilled workers, who would claim to be skilled, from obtaining work as a skilled tradesman. Boys (and their guardians) signed contracts to serve as indentured apprentices under the supervision of a master craftsman to learn the skills of their particular trade. The apprenticeship was legally binding for both the master and the apprentice. The master owned the apprentice's labour for the entire period of apprenticeship (Wright, 1908). On completion of their apprenticeship, the indentures were presented to the new journeyman that asserted that he had successfully completed his training, and was capable of performing as a craftsman. During that period, it was common for apprentices not to receive any remuneration during the first years of their apprenticeship, and only received very low wages after that, until they became a journeyman when they would either start their own company, or work for someone else if they could not obtain the capital necessary to open their own business.

Prior to Merchant Capitalism and the industrial revolution, most master craftsmen operated their own business employing journeymen and apprentices, but with ever increasing dilution of the *traditional* skilled trades together with the creation of new skilled trades categories that required a lesser range of knowledge and skills. For example, a blacksmith would normally work in an agricultural environment producing and repairing pots and kettles, farming tools and equipment, shoe horses etc. (Hazen, 1999). In the post industrial revolution era, welder fitters and vehicle builders are examples of the new trades that evolved from the blacksmith trade. New trades evolving in the post industrial revolution from the Turner, a tradesman who was skilled in the use of woodturning lathes were the trades of fitter and turner and the general machinist (see Appendix I). Thus with the dilution of the traditional trades and creation of new trades that required reduced range of skills the prevailing conditions further reduced the opportunity for master craftsmen to be self-employed. The changes in the modes of production enabled by the new technology caused reductions in status, control, and the relative earning ability that a master craftsman would have experienced in the medieval period. Another major shift was restrictions imposed on the skilled trades' person regarding the extent of freedom to design, and the creativity afforded to the tradition craftsmen in how to perform the work.

In the latter part of the 18th century, the industrial revolution, the introduction of labour saving machinery, and the subdivision of labour began the decline of the ancient apprenticeship system (Brown, 1908). This transitional period heralded an increasing knowledge of science and technology together with a decline of the belief in the divine right of kings, and that political hierarchy was not a continuation of *God's Will.* A decline exemplified by eventual acceptance of Darwin's theories of evolution by the Church. Originally rejected in 1859 by the religious establishment, but accepted in that the Church allowed his burial in West Minster Abbey next to Isaac Newton (Fancher, 1990, p. 205). According to Brown & Harrison, the industrial revolution created a complete break with all of human history, and it implied that all past accumulated common sense of human experience redundant (Brown & Harrison, 1978). However; Burawoy (1979) rationalizes that changes in the relationship between craftsmen and owners really began at the end of the feudal system, and the industrial revolution sped up the transformation from a situation where a skilled tradesman was usually self-employed to a situation where the tradesman sold his labour and became an employee in a firm owned by a capitalist. In a diluted form, the power struggle has continued to the present day and employers continually seek ways to limit the necessity of skilled labour in the production process and continue to replace skilled trades' personnel with semi-skilled, or unskilled labour who will be paid at a lower rate and so reduce the cost of production. The industrial revolution marked the end of putting–out, so called because merchants put-out the raw materials to homes of several different peasants for preparation of suitable yarn to be collected later and redistributed to other peasants for weaving the finished products that would be collected later (Tausky, 1996, p. 21). This enabled the merchants to avoid the rules and regulations imposed by the Guilds that controlled the purchase price, quality of the product, and working conditions of the craftsmen that produced the work. The system also allowed non-guild workers into the production cycle. This was achieved by *putting-out* simple tasks that be performed by less skilled workers who would be paid less than a craftsman. For example, preparing and softening leather and carding wool[9]. The *putting-out* system was the earliest form of wage labour that is still utilized as a means of cheap labour for industrial production today. For Example, *Homeworkers* in Canada's garment industry work in unregulated, home-based sewing facilities is a modern example of companies putting-*out* work for workers to perform at the worker's home where regulation and control of working conditions does not apply. Whereas, manufacturing facilities are regulated under the jurisdiction of the Ontario Health and Safety regulations, and the Workplace Hazardous Information System (WHMIS). The Toronto District Council of International Ladies Garment Workers Union (ILGWU) estimates that there are approximately 6000 Homeworkers in Toronto, the majority being immigrant women of colour. (The Homeworkers market, 2004).

As previously stated, since the industrial revolution companies have utilized technology in an attempt to reduce the size of the labour force. As technology has developed and become more sophisticated, many tasks formerly performed by skilled trades' are increasingly performed by robotic labour and employers are eager to employ semi-skilled workers that are capable of performing specific tasks, but possess neither a trade certification nor particular *trade knowledge.*

The Manufacturing Skilled Trades

In general, there is a poor understanding of the skilled trades' in manufacturing by the majority of people, both on the inside and outside of the manufacturing industry. The majority of people when asking me about what I do for a living, even if they may have heard of a millwright, usually do not know what work a millwright actually performs. An even lesser number of people are aware of how far back in history skilled trades' reach. For example, the bow lathe can be traced to the Egyptians in 300 B.C., and blacksmithing to the Ancient Greeks. The skills required for the trades have been dynamic, and necessity dictated the craftsmen and craftswomen adapt to the constant changing requirements of new technologies and the changes in the mode of production. It is widely accepted that by far the greatest effects to craftsmen and women was the period of the first industrial revolution. Wool combers, calico printers, and handloom weavers suffered competition from machines and the rising population. Weaver numbered 400,000 in the late 1700s earned an average of twenty-three shillings a week. The number reduced to approximately 200,000 in the 1830s, and a reduction of their earnings to an average of five shillings a week. However, for those craftsmen and women whose skills were in demand, and not forced to compete with machines, benefited from industrial expansion (Heyk, 2002). To assist in a better understanding of the transitions I have included a brief history of five trades and apprenticeship training most pertinent to the manufacturing industry; millwrights, toolmakers, machinists, welders, and electricians.

Welders

Technology and changing requirements of industry caused the demise of the Blacksmith's trade[10] and transformed the blacksmith into the welder's of today. Estimations of the earliest examples of pressure welding lap joints[11] date from the Bronze Age, more than 2000 years ago. The ability to create furnaces that could reach the melting point of metal was achieved by approximately 1000 BC, and by 500 BC iron technology had spread throughout the classical world (Bealer, 1976).

The high point of the blacksmiths' craft was in the Middle Ages when blacksmiths respected for their skills, were celebrated members of their society, and by necessity known by everyone living in the area. The blacksmiths produced virtually everything made of iron from cooking pots and utensils, to ornate hinges for hanging the church doors. A skilled blacksmith earned the respect of their communities because they made a significant contribution to community life. Blacksmiths produced articles to facilitate the very existence of everyday life in the countryside. Other craftsmen relied on him for many of their tools, for example, hammers, axes, augers, plane bits, files, and chisels, etc. The blacksmith produced farm equipment i.e., scythes, sickles, plough shears etc., and was essential to transportation in the repair and maintenance of horse drawn vehicles (Bealer, 1976).

The most highly skilled blacksmiths produced the weapons of war on the blacksmith's anvil, from the ancient spear maker producing primitive spears to an expert armourer who, skilled in the blacksmith craft, manufactured chain mail, swords, and shields. The armourer utilising his skills in the craft produced canons in the early thirteen hundreds and gradually metamorphosed into the gunsmith with the advent of small arms, flintlocks, and shotguns (Ferris, 1852). A ship's blacksmiths made necessary repairs on the ships metal fittings, grappling hooks, harpoons, and guns thus enabling ships to remain at sea for extended periods.

The blacksmith learnt an important part of the basic trade skills, and *trade knowledge* during the blacksmith's apprenticeship. Hammering[12] (Nonfusion welding) was a method to weld many iron items during the Middle Ages, so an extensive knowledge of how to use the tools and material was an essential prerequisite to be a successful blacksmith. The apprentice learnt how to use all the tools and equipment of the trade, together with knowledge of metallurgy. During the apprenticeship, the apprentice became well versed in the use of tools and when to use various methods of heat treatments applied to the metal. The size of the fire and the fuel used affected the success of the work done at the forge. It was therefore essential for the apprentice to learn the type of fuel required to create the fire, the amount of heat required, and what type of fire to make for the size of the work. For example, charcoal was the original forge fuel until somewhere between the 15th and 18th centuries when blacksmiths gradually began to change to coal as their primary source of forge fuel. However, not all coals were suitable for forge fuels, and the lack of access to a source of good coal slowed the adoption of coal as the primary fuel for blacksmiths (Bealer, 1976). However, the art of blacksmithing remained relatively unchanged until the nineteenth century until Edmund Davy's discovery of acetylene in the early eighteen hundreds. By the late 1800s, gas welding and cutting were developed and the introduction of the welding torch in 1887 sped the development of the welding process facilitating an increased speed of production (Cary, 2004). By the turn of the century gas, welding and cutting had developed, together with methods of mass production, and although workers learnt new skills, the new processes reduced the number of workers necessary for the production process. The new methods of production adding momentum to a series of events that eventually caused the demise of the blacksmith's craft, and their role in community and industry. It is a primary example of the erosion of traditional trade skills, together with the reduction in the level of control skilled workers had in the production process.

As the blacksmith's forge disappeared and the continuing research into welding resulted in the development of carbon arc and metal arc welding, resistance welding[13] became a practical joining process. Welding, as we know today began in the late eighteen hundreds and early nineteen hundreds with the development of spot welding, seam welding and flash butt welding[14] and facilitated the methods for mass production. As progressively sophisticated welding equipment is developed, the necessary original skill set required for joining metals, together with an extensive knowledge of tools and materials has gradually diminished. This has resulted in less demanding work that requires fewer tools, and less trade knowledge. In North America, the modern *welder fitter* trade is the trade that most closely resembles the traditional welders' trade. Over the last three decades the necessity of skilled labour to perform welding has been systematically eroded way. For example; an essential skill in welding was possessing the knowledge of how to keep the *puddle* of molten metal under control, if this is not accomplished it will result in unsatisfactory welds that may lack strength, be uneven or have excess slag. However, it is no longer necessary to possess the previous level of knowledge and skill in order to obtain a satisfactory weld bead.

Technological development has resulted in a reduction of the skill requirement necessary for Shielded Metal Arc Welding (SMAW). This facilitated by the development of arc welding machines containing a computer that performs the calculations necessary to control the current in order to melt the electrode, or welding rod, and computing the distance of the rod from the work piece being welded. Thus, the machine automatically compensates the amount of current to create the correct heat generation in order to maintain the optimum heat required for a perfect weld. Thus, a traditional skill eradicated.

I have used one of these machines; it is astounding how far the electrode can be moved away from the work piece, and still accomplish a satisfactory weld. The final stage of course is the complete removal of the human operator from the welding process by the substitution of robot welders; sometimes know as *steel collar workers*. One of the many tasks robots are admirably suited for is welding. Almost every major vehicle manufacturer in the world now uses welding robots to spot weld cars and trucks. Welding robots have proved successful in most production processes in both small, and medium sized plants in North America. The advantages to the company are consistency and improved weld quality, together with the inevitable reduction in the number of welders required in the production process thus, resulting in a better product for consumers.

Computerized welding technology has facilitated the welding processes utilized in the manufacturing industry in that welding is no longer recognised by some *'old timers'(o*lder welders having served a traditional welding apprenticeship in Europe) as a trade in the traditional sense of the word, but more of another production tool that an assembly operator must learn how to use. However, 'Head-hunters', or employment agencies are reporting that although they can recruit technicians that are able to programme the welding robots they are unable to recruit personnel who possess sufficient *traditional* welding knowledge to be able to troubleshoot the actual welding problems. Computerization of the welding process has reduced the overall number of welders required in the workplace, but to a lesser extent, the knowledge of the traditional skilled trades' welder seems necessary when the welding robots malfunction. However, in the automotive manufacturing industries, often a millwright initially troubleshoots the problems on the line. Consequently, in contrast to the high profile position a blacksmith had in medieval times, together with recognition as an important member of the community, the modern welder employed in a production industry is relatively unknown by people outside of the manufacturing industry. It is doubtful if the average citizen would know what a welder's work entailed. To the average citizen a welder's job is as much of a mystery as a millwright's is. Furthermore, I was recently discussing the effects of technological advances to the welding process with an extremely experienced welder who ended our discussion with the statement, "welding is not a trade anymore, it is just a tool".

Industrial Millwrights

Most skilled trades' personnel would agree that to be successful in the skilled trades a person (apprentice) must have an affinity for detail because attention to detail creates mastery in the trades. I served a comprehensive five year *indentured* apprenticeship during which I was taught to use most types of metal cutting machines, hand and power tools, in the process learnt that working within specified tolerances was of paramount importance when operating machines and when bench fitting. I recall in my apprenticeship that one bench fitting exercise required an accuracy of one thousandth of an inch for the entire project. The project entailed making a metal block 3.5 x 3.5 inches square x 1/8" thick. In the centre of the square, a hexagonal hole removed. A male hexagon then made from another piece of material to fit the hole with an accuracy of - 0015" + .000 on each mating side. The point of this introduction to *Industrial Millwrights* is that the students I meet in pre-apprenticeship and apprenticeship programmes are at first reluctant to perform bench work, and even more reluctant use a hand tools unless they are powered. In my experience there are very few people, if any, who can operate a hand-held power tool with an accuracy of one thousandth of an inch. It is usually necessary to explain to students in pre-apprenticeship programs that it is often impossible, when repairing equipment and machinery, to remove major units in order to machine the part that to be repaired. The work performed with hand tools to avoid major disassembly of the machine that would result in extensive down time and excessive losses in production. I referred previously to a certain attitude, or state of mind that is necessary to be successful in the skilled trades, I mention this purely to exemplify the dramatic changes I have found in the attitudes of the majority students and apprentices that I have met during the course of my career. I believe the change in attitude of these potential tradespersons can be attributed in part to society witnessing, and in some cases experiencing, the replacement of the original traditional skilled trades' person with their extensive repertoire of skills, by workers who have been trained with a limited, and specialized skill set to facilitate the particular requirements of specific companies. However, they have not usually received sufficient training that would satisfy the skill requirements of a particular skilled trade.

As previously stated, my apprenticeship was comprehensive, but I would not claim my apprenticeship was as comprehensive as those served by the original millwrights. They designed and supervised the construction of an entire mill, including the millpond, dam, water powered wheel and necessary machinery for grinding corn and grains. The origins of the millwright trade are in ancient history. Records in the Doomsday book show that there were water mills on the river Trent at Winshall, England in 1086 (Burton-upon-Trent: The Economic History). At that time, there were approximately 6000 working water mills[15] in existence. The building of the mill relied solely on human strength and ingenuity as no machinery or standardized parts were available. Millwrights were equally skilled in the use of carpentry and blacksmithing[16]. The millwright possessed knowledge of woods used for various parts of the mill, and the lubrication required to facilitate the smooth running of the wheel. For example, white oak was the most suitable wood for the water wheel shaft and the water wheel, gears, and bearings were made of stone or wood depending on availability. Tallow used to lubricate the wooden bearings, and stone bearings lubricated with either water or tallow (Hazen, 1999, p. 12). The millwrights also undertook major repairs to the mill's equipment. It was extremely difficult to persuade millwrights to come to North America in the 1600s. Thus, settlers would order a complete windmill in kit form from England, necessitating a complete mill be disassembled, and the parts shipped in kit form to North America. However, eventually the craft of milling and millwrights crossed the Atlantic and millwrights were forefront in the design and construction of the water mills supplying the power required for development in the early days of North America (Hazen, p11, 1999).

John Rennie may exemplify the extent of a millwright's knowledge in the eighteenth century. In 1783, James Watt employed John Rennie, a trained millwright, to complete a contract for a flourmill in London. Rennie, while employed by Watts, learned to work in metal and subsequently developed machinery suitable for steam engines built in the Boulton & Watts plant. John Rennie went on to become, what is now classified, a civil and mechanical engineer, designing canals, bridges, docks, and harbours[17] (BBC, 2004). Nonetheless, the introduction of the steam engine was the beginning-of-the-end as far as the original millwright profession was concerned. The advent of the steam engine in the mid-18th century accelerated the division of skilled labour with new trades created in the form of turners, fitters, machine makers. In the same period, mechanical engineering received formal recognition in America completing a transfer of the planning and design of machinery and equipment from the millwright to become the domain of mechanical engineers. By the end of the nineteenth century, the task of the millwright was broken down into smaller units and the role of the millwright became one who executed the plans produced by civil and/or mechanical engineers. However, millwrights still required a well-rounded technical education that included the ability to calculate strengths of materials and resultants of forces, together with machining, welding; reading technical drawings, and possess an understanding of electricity (Hazen, 1999). Sadly, the changes subsequently diminished the status of the original millwright and the recognition of their work as a profession. The millwright trade eventually became one trade among the other skilled trades that created in that era.

Machinists and the Toolmakers

To facilitate further understanding of the nuances of machinists and toolmakers as skilled trades it is necessary to define the skilled trade of a machinist. A semi-skilled machine operator should not be confused with a skilled machinist who has completed an apprenticeship. The public, and many people inside the manufacturing industry do not, or can not, differentiate between a semi-skilled machine operator who is competent at operating a particular kind of machine and a skilled machinist. A traditional skilled machinist graduated from a formal apprenticeship-training programme after receiving training for most types of metal cutting machinery accordingly having amassed a vast knowledge relevant to the metal cutting industry. It is necessary for a machinist to be knowledgeable about metallurgy, metal cutting technology, cutting speeds and feeds, mathematics, cutting tool geometry, grinding, and that is only a part of what a machinist is required to know. To put this into perspective, the extensive knowledge a machinist must either possess, or at least be aware of, is contained in a 2500 page text, the *Machinists Handbook.* Many refer to the *Machinist Handbook* as the machinist's bible in that it contains most of the theory that a machinist needs to know. In addition, a machinist must have excellent hand and eye coordination and be skilled in the use of lathes, machining centres, milling machines, various types of grinders. For example, a surface grinder, cylindrical grinder, internal grinder, and external grinder, together with drilling machines, boring machines, planer machines, are a sample of the machines machinists are expected to use. To facilitate an understanding of the changes in the skills a machinist has required during the development of the lathe, I have included a brief history of the lathe.

The lathe is a machine referred to as "the engine of civilization" and it is the only machine capable of replicating itself (Ancient Lathes). The word lathe comes from the word lath, which is a piece of split wood or timber in the form of a thin strip used as a power source for early lathes. An Egyptian stone carving circa 300 B.C. is an early reference to a lathe. A helper pulling a cord in a reciprocating motion supplied power for the lathe. Although there are references to Bow Lathe[18] by the Ancient Greeks and Romans and speculation about the use of Pole lathes[19] in 200 B.C., there is little further reference to the development of the lathe until Leonardo Da Vinci's descriptive sketch, circa 1480, of a treadle wheel lathe that operated by the turner's foot and gave continuous rotation. The flywheel and continuous rotation was probably the biggest technological advancement in the lathe for over two hundred years (King, 2004).

The evolution of the modern lathe accelerated rapidly in the later part of the 1700s. The developments included, replacement of the wooden bed with iron bearers and the mounting of a carriage on the bearers that enabled the bearer to maintain a true relation with lathe axis, which served as a platform for a movable carriage connected to the spindle through a gear train (Harris, 2004). Up to the eighteenth century, lathes used for turning wood, clay etc., it was not until approximately the turn of the 19th century metal-cutting lathes were developed. Maudslay, an English machine builder, manufactured a metal-cutting lathe that set the standard from which most machine builders of the industrial revolution in Britain can be traced (Harris, 2004). Evolution of the lathe advanced rapidly during the nineteenth century and the addition of a sliding tool carriage geared to a spindle, together with the refinement of micrometers[20] for accurate measuring enabled turners to produce a product with consistent accuracy on a lathe making standardized parts and mass production a reality.

Advances in lathe technology simplified the machining operation, enabling less skilled operators to run the machine after a skilled machinist had *set up*[21] the machine. This eventually led to new classifications and a further breakdown of the machinist trade. In the early eighteen hundreds introduction of mass production techniques, that included the use of jigs and fixtures, had advanced sufficiently by the end of the century that the machinists who made the tools, jigs, and fixtures became a specialized trade. The specialist machinists who made the tools jigs and fixtures separated from the general machinists, so creating the new category of a toolmaker. During this period, new categories were created within the machinist trade and the manufacturing industry in general. For example, (a) machinist/setter originally set up jigs and fixtures and later the stops on turret lathes used for mass production. A machine operator could operate a lathe but would not possess an extensive knowledge of a master craftsman. The person, who prior to mass production, would have been an assistant turner, employed to supply power for the lathe, and to clean castings. As previously stated, simplification of lathe work and the creation of mass production created major changes in the machinist trade and with each new development so the machinist job gradually became easier, systematically eroding the extent of craft skills previously required.

The quick-change gearbox developed in the 1920s & 30s is a relatively more recent development, one that simplified the procedure for changing feeds and speeds on a machine. A development alleviating the calculations necessary for a machinist to make in order to calculate the number of teeth on a gear required in a gear train. For example, in order to obtain the correct revolutions to cut a thread, or change the cutting speeds and feeds on a lathe. Development of *Tracer* technology in the 1930s and 40s enabled partial automation. Accomplished by, copying a master profile traced with the use of electrical and hydraulic equipment, then relayed to a cutting tool that in turn reproduced the profile of the master profile. Development continued to gain momentum until the creation of the first Numerical Control (NC) machine for the US Air Force in approximately 1949. However, the manufacturing industry did not drive the initial development of the NC machine; the US Air Force spent an estimated $62 million on the research and the creation of a market for the NC machine (Noble, 1984, p201).

I remember the first Numerical Control (NC) machine purchased in the early 1960s by the company where I worked. I well recall the reaction of the workforce; it was a mixture of awe and fear, and as a senior apprentice I immediately recognised the impact this new technology would have on the industry, and on my future in the industry. The first NC machines were crude by today's standards, and were a nightmare for the programmers and those machinists working with them. The levels of stress were unbelievable, as it would take days to write, and troubleshoot, a workable programme for the machine. Among the craftsmen cynicism ran high when we learned of the purchase of these so-called miracle machines that were credited with an almost mythical capability. Nonetheless, it was soon realised that the machines were far less than perfect, and some wit would point out he could have produced more parts in less time than it took to get the NC machine running properly.

First, the technology was unlike anything most of us had seen before, and the concept of a machine controlling the cutting operations without input from a machinist touching the machine was difficult for the machinists and toolmakers to accept. Nevertheless, they visualized the potential these machines had in the production process and to their future employment. However, I think few realised in those early days of NC machines the impact the new technology would ultimately have on the reduction of the labour force and future consequences for the metal cutting trades. Although apprehensive, many wished to learn how to programme and operate the new machining technology. As with the separation and deskilling of the original millwright skills, management deemed the programming of the new CNC machines a separate discipline from machining. Management policy therefore excluded machinists from writing the CNC programmes. Engineers and management, with the vast majority having no machining experience whatsoever, badly underestimated the high level of skill that was required to be a successful machinist who could efficiently make a part on a machine. I clearly remember the immense amount of time required to produce a part, and the pressure on the programmers trying to get the programmes to run, without crashing the machine, and to produce a part within specified tolerances.

Unfortunately, common sense did not prevail, and very few machinists from the shop floor had the opportunity to receive the training that would enable them to write NC programmes. Some of us wondered why management separated machining from programming when an experienced machinist with an extensive knowledge of machining would be in a much stronger position in which to write a NC machine programme, than would a person without any experience of machining. It seemed illogical to ask a person without sufficient knowledge of machining to write a CNC programme that controlled the tool path of a metal cutting machine. The programmes would often contain cutting paths that would damage the machine toolage, sometimes with disastrous consequences. Considering the number of times the machine crashed, and the consequent loss of time and money associated with the crashes, I think perhaps we were partially correct in our logic, and appraisal of the situation. However, most of us were too naive to realise that it was not just an attempt to increase production, but also an opportunity for management to increase their control of the production process.

Perhaps it was a misperception of the management that a tradesman could not possibly understand the nuances of NC programming and the new technology, or as Noble reports in *Forces of Production,* the industrial engineers did not want the machinists to programme the machines (Noble, 1984). Perhaps the engineers had not heard of the cynical, but popular, saying among the skilled trades' personnel, "An engineer designs it, but it takes a tradesman to make it work." In the early days of NC machines, this became apparent to management in that many adjustments to the program and tooling were required in the creation of a successful program for the machine to make a production run. Adjustments to the programme and tooling invariably required cooperation between the programmer, and the person operating the machine. At that stage of development, the input of a skilled machinist was still a necessity. Refinements made to the early CNC (or NC) machines, which were only capable of *point-to-point positioning,* or moving in a straight line, later developed into CNC machines that were capable of moving on a *continuous-path,* or *contouring machining.* Continuous path contouring is the ability to control the motions of two or more machine axes simultaneously, and proved to be the most significant development in machine tool history for moving control from the skilled trade machinists into the hands of management. The operations of the original chucking centers (CNC lathes) were a computerized form of a *turret lathe*, or *capstan lathe,* a machine that had a turret, or capstan, in the place of a tailstock that would be the normal attachment on a standard engine lathe. The tailstock on an engine lathe can only hold one tool at a time, whereas a turret lathe or capstans have the capability of holding several different tools at the same time. On the turret/capstan lathe, to determine the saddle movement along the bed of machine stops are set at suitable positions along a spindle fitted on the bed of the lathe, above or below, the lead and feed screws. On Chucking Center or CNC lathe, the tool travel is determined by programming suitable codes into the machine's computer, to enable the CNC machine to cut the profile of the required part. A traditional engine lathe is an efficient way to produce round parts but is unable to compete with a CNC lathe's ability to maintain consistently high levels of accuracy of four tenths of a thousandth of an inch (.0004") at high rates of production. As the reliability of CNC machines improved, the machines required significantly less monitoring, and once the CNC programme is entered into the machine the machinist is no longer in control and management succeeds in regaining control of the production process. As computerized machines became more reliable, manufacturing processes required fewer machinists. Thus, reducing the size of the machinist workforce and causing a decline in union membership. Thus, weakening the negotiating position of the unions, and strengthening management negotiating position to reclassify skilled trade machinists as CNC machine operators. David Noble's (1979 p 42) prophecy of skilled trade labour replaced with lower paid semi-skilled operators has fast become a reality in the manufacturing industry.

Software now generates CNC code from a blueprint drawing and eliminates the necessity of a CNC programmer. CNCs and computerization have now virtually removed the necessity of a skilled machinist and programmers from the machining process. As previously mentioned, in many instances computerization has enabled worker robots to replace human welders and paint sprayers in the manufacturing process. As Computer Numerical Control (CNC) machines have become commonplace in the industry a steady erosion of traditional trade skills have been facilitated by the introduction of technology in the production process until machinists and toolmakers are now little more than CNC machine minders. This largely accomplished in the toolmaker and the mould maker trades by introduction of increasingly sophisticated software and CNC machines. CNCs now are used for almost any operation in the metal cutting industry including plasma and laser cutting, electro discharge machines (EDM), routers etc. It is possible to programme a CNC machine to complete almost any project, or task that a machinist or toolmaker previously did, excepting, that the CNC machine can complete the job faster and can consistently maintain closer tolerances than any human being is capable of doing. The machinist category is still in existence but in the industry recognition of a machinist as a skilled trade is disappearing, and at best, diluted by new classifications replaced by new categories of CNC machine operators. I have previously defined a machine operator classification as not being the same as a skilled trade machinist. However, government seems to still insists on funding machinist-training programmes in their return to work programmes. Computerization and CNC machines are doing to the metal cutting trades what computerization did to printer's trade in virtually eliminating the necessity of human labour in the printing industry (Zimbalist, 1979, p. 122).

In a declining US economy, attempts by major companies to reduce tooling costs, together with an increase in companies utilising tool-making shops in China have led the National Tooling and Machining Association to claim that 30 % of toolmaker shops in the USA have closed down between 2000 and 2003. Many more are having difficulty in keeping their businesses open. In Michigan alone, this has resulted in the disappearance of 34,000 tooling jobs (McCracken, 2003, p.1). Tool and die makers are traditionally among the highest paid skilled trades' workers in the plant by virtue of the knowledge and skill involved that their work requires. Therefore, from an owner's perspective, it makes sense to significantly reduce the number of toolmakers or eliminate the need completely if technology can replace the manual skills and knowledge of the toolmaker. Some regard Rapid Prototyping (RP) as the biggest threat so far to the tool making trade. Recently a toolmaker expressed to me that it was his belief that RP will bring to an end the mould makers and toolmaker's trade. "Why would you need toolmakers like me when all you need is a computer, software and a prototype printer?" He served a five year tool and die-makers' apprenticeship in the UK and has at least thirty years experience in the trade. He has experienced many changes in the manufacturing industry on both sides of the Atlantic and is convinced that in the span of fifteen to twenty years rapid advances being made in production technology will virtually eliminate the need for traditional trades in the manufacturing process.

The following are a sample of the technological advances that are available, and are being utilised in the metal industry. Rapid Prototyping followed CAD/CAM in the technological advancements achieved by developers in the machine tool industry. Rapid prototyping used as an instant manufacturing tool to process a wide array of applications. For example, automotive, dental, biomedical, motor sports, consumer electronics and military aerospace applications. Solid Imaging is an innovation designed to reduce manufacturing errors together with producing products faster and at a lower cost. Recent advancements in Selective Laser Sintering (SLS)[22] and Stereolithography (SL) technology are now an alternative to some conventional manufacturing methods (Krar, Gill & Smidt, 2005, p 791). Savings obtained by the elimination of tooling, and savings on low production runs. The part created by utilising CAD/CAM software and related computer applications using Laser energy melting, and fusing the materials in the formation of successive layers of the material until the part is formed. Unlike the traditional methods of production, toolage is no longer required in this production process, and it therefore follows machinists and toolmakers are no longer required in this production process either.

Computerization of the manufacturing process now incorporates various levels of computerized control systems. For example, Direct Numerical Control (DNC), a system that transfers files between PC and CNCs, Manufacturing Execution Systems (MES), that measure and control critical production activities in the management of real-time aspects of production, and Supervisory Control and Data Acquisition (SCADA) is a computerized system for gathering and analyzing real-time data used on top of a real-time control system. The utilization of control systems that facilitates Computer Numerical Control (CNC) to be a node on a corporate network enabling managers ability to monitor and control the manufacturing process worldwide via the Internet (Krar, Gill & Smidt, 2005, p. 816).

Industrial Electrician

Most people do not differentiate between different electrical trades but nonetheless there are several categories and specializations within the electrical skilled trade. For example, the categories include; residential, industrial, construction (residential and rural[23]), automotive, shipyard electrician, seagoing electricians, and so on. The electricians themselves and their unions have always closely guarded electrician's work; in so far that I have heard some electricians admit it was sometimes to their own detriment. However, in spite of protective practices, deskilling has happened in the electrical trades as it has to the other skilled trades. When wiring panels and creating electrical harnesses, electricians would solder and fabricate the connection, create a harness without the use of jigs, and build electrical panels from scratch etc. Semi-skilled personnel without a skilled tradesperson present now often perform conduit installations. Mike, a person who is a skilled trade electrician, and has a Bachelors degree in electrical engineering, explained to me that in his opinion deskilling has been exacerbated by modularized work initiated by the auto industry where each department is a self contained unit: body shop, paint shop, chassis, etc. Each department has a permanent team of skilled tradespersons attached to it, but they do have the opportunity of rotating between departments in order to learn other applications of the trade. However, few take advantage of the opportunity and most personnel stay within the department. Mike also told me developers and contractors are taking advantage of the readily available pre-wired panels and switch gear etc., and a construction electrician now allowed only eight hrs in which to wire the average house. Before the advent of modularisation, wiring a house would take a least a week if not more. This is a clear example of both deskilling and a reduction of labour required for the job.

Prior to the mid 1800s, electricity remained primarily the domain of inventors and scientists. Compared to the other trades mentioned in this paper, the electrician's trade is a relatively recent innovation. However, the origins of electricity had been know as a *force* 2500 years ago when Thales, a Greek philosopher, in 500 B.C., realised that when amber was rubbed with other materials it became charged with a *force* that would attract other objects[24]. Nothing of any significance happened until 2000 years after that when in 1600 William Gilbert discovered that it was possible to charge other materials besides amber. He named materials that could be charged electriks, and materials that could not be charged nonelectriks. It was more than two hundred years after Gilbert's discovery before a practical application found for the *Force,* and Michael Faraday demonstrated the mechanical production of electricity in 1831, but it was not until the development of a dynamo in 1873, capable of prolonged operation that enabled electricity to become an industrial commodity. However, through most of the nineteenth century the use of electric power was limited by small productive capacity, short transmission lines, and at high cost. It was not until 1883 the Parliament Buildings in Ottawa were lit by electricity powered by a steam-driven plant on the Ottawa River. In the same year, Hamilton installed Canada's first incandescent streetlights (Saskpower, 2005). In the closing decade of the 19^{th} century, unsafe working conditions in the growing electrical industry prompted electrical workers to organize and form the National Brotherhood of Electrical Workers (Green, 2001).

The progress of electrical generation since the beginning of the twentieth century has facilitated significant technological progress in electrical control systems used in the manufacturing and processing industries. The work of industrial electricians started to change dramatically with the advent of microelectronics and digital controls. Introduction of PLCs in the late 1960s significantly reduced the costs of changing over production lines for different products and the recognition of most tasks associated with PLCs as electricians' work. In my experience, that remained so for more than twenty five years until gradually the trade demarcation lines set by the unions softened somewhat, and millwrights were allowed to initially troubleshoot robots and associate PLC controls on production lines etc., in manufacturing and processing industries. PLCs have developed from quirky and somewhat unreliable beginnings to a component utilised to control the operation of advanced flexible manufacturing systems, car washes and domestic heating systems. However, although millwrights are expected to have a limited knowledge of electricity and electronics, the repair of PLCs and associated circuitry remains mostly the domain of electricians.

Apprenticeship Training

Traditional and Post-Modern Apprenticeship

There is general agreement that the origins of the modern apprenticeship system in the United States began approximately between 1860 and 1872. Not only craftsmen, but also employers were complaining about the general decline of mechanical skill and the flooding of skilled trades with semi-skilled labour. Many of the states in the USA eventually introduced and passed legislation to oversee, and control apprenticeship training (Wright, 1908).

This is apparently an interminable problem, it is exactly what the trade Guilds of the sixteen hundreds in England had tried to prevent. In the twenty first century, over four hundred years after the medieval craftsmen, similar concerns, and attitudes seem to prevail, and de-skilling remains high on union priority lists. Then, as now, there were various views and beliefs held by management as to what were the most satisfactory method of training to meet the labour requirements of the time. Some employers considered that the standard of trade skills be maintained while others preferred the introduction of semi-skilled labour into various trades thus reducing the cost of labour. As previously stated, traditionally semi-skilled workers were regarded as proficient in single operations, but lacking the extensive knowledge and skills of a skilled craftsman. It therefore required less training time, and companies could employ boys who would be much cheaper to employ than a journeyman would.

Apprenticeship: Short-term loss, long-term gain.

I am probably among the last of a generation of skilled tradesmen that served a traditional indentured apprenticeship. The company required a deposit of five pounds sterling (approximately equal $10 - $11 CAD) from my parent as a guarantee for my satisfactory completion of the apprenticeship, or the five pounds would be forfeited. Apprentices in Europe traditionally received a low wage in part payment for the training they received during their apprenticeship. My weekly wage as a first year apprentice was seventy-five shillings and two pence, or £3 15s 2d. A fifth year apprentice at that time earned £6 13s 9d (approximately $14 – $15 CAD). I finished my apprenticeship five years later, and the tradesman's weekly wage in the plant was approximately £21(approximately $44 - $46), a wage that seemed like a fortune to me after five years of earning less than all my peers who had not served apprenticeships. Alan Locket in his biography (Lockett, 1995, p 15) recalled that his starting wage as an indentured apprentice in the Barrow ship yards in the UK was 17s 6d for a 47 hr week in 1944 and the same £5 deposit was required from his parents. However, his wages were approximately four times less than mine were as a first year apprentice 15 years later. Although wages had risen, the required deposit had remained the same. In contrast, a decade later in the 1970s a deposit for apprenticeship training was no longer required and indentured apprenticeship had ceased to exist. This indicated a change of attitude held by employers toward apprenticeship in the UK and other industrialised countries where apprenticeship is a part of the culture. Companies were becoming unwilling to make the necessary investment in long-term vocational education required for apprenticeship training programmes. Increasingly, as computerized manufacturing became more sophisticated, and therefore more adaptable, management preferred to rely on training less qualified workers/operators who would accept lower rates of pay.

In a traditional apprenticeship, the apprentice learnt the trade skills and secrets by working with different tradesmen throughout the term of their apprenticeship. During the five years of my indentured apprenticeship, I worked with tradesmen in every section, and shop in the manufacturing plant. I received instruction in every facet of the production process including, electrical shops, tool room, gauge room, research and development, heat treatment and so on and so forth. I would not claim to be expert in all the machine practices that I have previously mentioned, but in the company where I trained as an apprentice, regardless of the trade, all apprentices would eventually learn to operate most machine tools i.e., machinist, toolmaker, fitter and turner, machine fitter electrician, millwright. Lockett, a shipwright who served his apprenticeship, and then continued working at the Barrow-in-Furness shipyards, UK, until he retired, worked in a very different industry from mine. Nonetheless, he spent his apprenticeship working in the majority of departments in the Barrow shipyards, which ensured he gained extensive training for his chosen trade as a shipwright (Lockett, 1995).

I spent the first year of my apprenticeship, in the *Boys Shop* learning skills machining and tool making under the guidance and supervision of a toolmaker called George. He was responsible for training first year apprentices and his high standards at first seemed unattainable to us as sixteen-year-old boys entering the industry. However, in that first year most of us made a complete set of machinist tools that included; a toolmakers' precision vice, a sprung scribing block, machinist screw jacks, protractor, ball peen hammer, external and internal callipers, toolmakers clamps etc. The hardware required for the assembly of the tools necessitated making each part by hand. The task included making every spring, screw, nut, and washer, from steel bar, rod, or spring steel etc. However, my particular favourite, was a 'four-start, square screw thread, and nut' that I made it at the request of the research and development department, and for that special project, I received the princely payment of one packet of twenty John Player cigarettes. It was a sense of achievement knowing that as a first year apprentice I had successfully completed a difficult project for the research department which expected extremely high standards. I will be forever grateful to George in that he managed to instil into most of us apprentices a pride in our trade, and an understanding of the requirement of excellence that tradesperson must have to be successful in their chosen trade.

Philosophy toward apprentice training in the 60s was very different from the philosophy regarding apprenticeship training in the second millennium. The emphasis in the 60s focused more on the training of the apprentices, than the output of production by the apprentice. Companies I knew of in the UK that were committed to apprenticeship training viewed apprentices as company assets and apprentices were valued as the next generation of skilled labour. By talking to apprentices from other companies, I understood this to be the same in most of the larger companies i.e., Fords, British Rail, Leyland, and AEC etc. Apprentice wages were low and I knew that people my age employed in unskilled positions were earning far more than I was, but as a first year apprentice, I was not expected to contribute anything to production, and very little in the second year either. It was not until the third year of the apprenticeship that apprentices make a reasonable contribution to production. Company philosophy was that training was the priority for apprentices, not their contribution to production. I personally did not know of any apprentice in the company who viewed himself as a source of cheap labour. However, I later realised, there were some companies that did regard their apprentices as a source of cheap labour.

In hindsight, I think of myself as very fortunate to be an apprentice at that time, compared to apprentices today who work in companies that must compete in the global market where time is the most valuable product, and the pressures of production inflicted even on first year apprentices. In a cooperative effort by union and management to ensure emphasis on training over production, apprentices were unable to join the Amalgamated Engineering Union (AEU) until the second or third year of their apprenticeship. However, the AEU still monitored the ratio of one apprentice per craftsman, and ensured strict adherence to the rule. Following a tradition that trade skills are passed to an apprentice only by a skilled craftsmen, and only a skilled tradesmen trained apprentices. It was not just to ensure the quality of apprentice training but also as a protectionist measure to dissuade companies from employing excessive numbers of apprentices for the purpose of cheap labour. In the traditional system of apprenticeship training, training did not necessarily end at the completion of the apprenticeship. In some companies if apprentices did well academically during their apprenticeship, the company provided opportunity to apply for university and enrol in an engineering degree programme. However, by the mid-sixties, toward the end of my apprenticeship, in reality there was little opportunity for an apprentice to continue on to a university education. Nonetheless, it has been my experience, and it is generally agreed by most skilled trades' personnel I have consulted, that if someone is going to be successful in their particular trade it is essential for them to posses certain attributes. For example, a) enjoy what they do b) have pride in whatever trade they pursue, and c) possess a sense of belonging to their trade community that has been gained by working with established trades people during their apprenticeship. During their training, apprentices should also acquire the aforementioned, *trade knowledge* and an understanding of the relevance within the process. It is not only necessary to know how, it is also necessary to know why. However, in contrast to the traditional 5-year apprenticeship I served in the sixties, most current millwright apprentices, unless apprenticed within a metal cutting trade i.e., toolmaker or machine shops, do not receive any machinist training at their place of employment. A millwright apprentice in Ontario receives approximately 100 hrs of machinist training in community college during the course of their apprenticeship. Prior to publication in Ontario, the 1992 edition of the Industrial Mechanic (Millwright) Apprenticeship Training Standards (number 4604 Set Up and Use Machine tools), machine shop training was not listed in detail. Nonetheless, the training was specified as, set up and operation of various machines for example, shears, lathes, grinders, milling machines, shapers, etc., (Ministry of Colleges and Universities, Ontario Regulation 685/79). However, each province and territory in Canada governs their own training and certification policy, currently making 13 different apprenticeship systems in Canada. Nevertheless, federal government contributed funding to the provinces, and territories for apprenticeship in-school training until 1999 when government made the decision to withdraw the funding from the provinces and territories.

After the Federal Government's announcement to withdraw their contribution of apprenticeship in-school training after 1999, a discussion paper on *Apprenticeship Reform* was issued by John Snobelen, then Minister of Education and Training, in December, 1996. The goal of the Minister was to discover the views of stakeholders in the apprenticeship training system and informing them, they had "the greatest stake in the apprenticeship system" (Snobelen, December 1996, p. 1) so they may help in reshaping apprenticeship training in Ontario.

Objectives of the reform were to investigate or *look at* some of which are: a new legislative framework to facilitate the expansion of apprenticeship to new trades, be more flexible, and establish an administrative infrastructure to promote accountability, quality control etc., to make apprenticeship funding more cost-effective, and sustainable.

Therefore, the extent of machine shop training received by the apprentice before the amendments to Bill 55, *The Apprenticeship, and Qualification Act, 1998* introducing task specific training was at the discretion of the employer and the tradesperson. The trades' person training the apprentice would advise the employer of the progress made by the apprentice and would recommend the amount of training the apprentice required on each machining process. The apprentice invariably cultivated extensive tacit knowledge, and learnt the tricks of the trade from the close working relationship between the apprentice and tradesperson, skills that do not appear in textbooks. The possession of the trade skills together with trade knowledge are essential in becoming a well-rounded skilled trades-person that can perform efficiently in the workplace. Therefore, government changes in Ontario, Canada, to apprenticeship training programmes made in Bill 55, *The Apprenticeship and Qualification, Act, 1998* requires evaluation to provide evidence for making decisions on future program reforms that will be necessary to meet the demands created by constant technological change. The difficulty however, is to make pertinent changes in the apprenticeship training programmes quickly enough to keep up with the dynamic technological demands of industry yet retain the integrity of the apprenticeship programmes. However, since the amendments to Bill 55, it is no longer mandatory that a skilled trades' person be required to train an apprentice. In Ontario, anyone can train an apprentice who is proficient in the particular task for which the apprentice requires training. Thus, if the trainer is only proficient in a particular task, the tacit knowledge gained by the apprentice pertaining to the skilled trade must, therefore be limited in every sphere of the training the apprentice may receive from trainers who are only proficient in specific tasks. I, together with many other skilled trades' people, believe this will exacerbate the dilution of the skilled trades'

Technology is enabling sophisticated methods of production to replace the traditional skilled tradesperson in numerous production processes, and the somewhat dubious corporate sense of ethical responsibility, if it ever existed, has become diluted further still. Approximately three years after the introduction of the modern apprenticeship system in the UK (1993), the Ontario Government started to circulate proposed amendments to *The Apprenticeship and Qualifications Act*. In a summary of the discussion paper for apprenticeship reform the mid nineties (1996) Government claimed that proposed reform of the apprenticeship training system would abolish the fixed duration, or time served apprenticeship. Traditional apprenticeship training would be replaced with modularized, task-specific training based on where a series of competency checklists. The modules signed off when the apprentice had received the training and had attained competency. The system still allows continuation of the age-old practice of unscrupulous managers and employers abusing apprenticeship-training systems.

Apprentices I have known through my work as a community college professor have told me of instances where they, or other apprentices they knew, had work competency sheets signed off as completed when they had not received the required training and their subject knowledge was at best, limited. From my discussions with apprentices, I believe this to be common practice especially in the midsize and smaller companies. This practice is unfair to the apprentices by reducing the training they are entitled to receive and reduces their potential skill level. An illegal act breaking a legal contract between the apprentice and their sponsor company. The fast track task-specific training system itself prevents an apprentice from achieving *trade knowledge*[25]. Nonetheless, the Ontario Government proclaimed the new legislation on Jan 1, 2001. Government in the *Fact Sheet* claims *among* other things to have doubled the amount of people entering apprenticeships in Ontario. However, many of the new apprenticeships are in services industries not previously classified as skilled trades. In many instances, only limited training time was previously required thus classifying them as semi-skilled occupations, together with the breaking down some of the existing trades that did previously require apprenticeship, into areas of specialisation. For example, Horse Groom (formerly a part of the work of an apprentice jockey). Grooming is also a task previously learnt of necessity when owning a horse. Further examples are Food and Beverage Server (waiter, server, bartender, or counter staff) Educational Assistant (previously volunteer parents), Childhood Educator, Florist, Motion Picture and Theatre Script Supervisor. One of the later additions to the inflation of skilled trades is a four-year apprenticeship for an *Information Technology Support Analyst – Help Desk.* The listing advises, "Training for this trade is for Ontario only." However, as all traditional skilled trades' *are* recognised across Canada it would therefore be reasonable to assume a lack of recognition for the trade of *Information Technology Support Analyst – Help Desk* in the other Provinces and Territories in Canada (Ontario Ministry of Education/Ministry of Training, Colleges and Universities, 2003).

The inflation of the skilled trades and slackening of the previous rigorous selection process are important issues, and have apparently had a negative impact on the drop out rates from youth apprenticeship training programmes. The highest attrition rates are in the new non-traditional trade apprenticeships. I, and many others I have spoken to, believe the system to be a thinly masked attempt to reduce the potential skill levels for future generations and so restrict the opportunities of the working class youth that have traditionally been willing to extend themselves by making a commitment to learn a skilled trade. Current apprenticeship is at best restrictive in its approach, and open to extensive abuse by companies that have no interest in extensive training of their personnel. Nonetheless, they are interested in the cash incentives offered by governments that will finance apprenticeship training. Abusive companies have no interest in the traditional approach to apprenticeship training, but the company adopts a guise of apprenticeship within the guidelines in order to obtain financial benefit for the training required for people they have hired for positions as process operators (Fuller & Unwin, 2003). This practice limits the range of skills obtainable by the apprentice.

Historically the 'Trades' apprenticeships have been one of the few ways a young person without the benefit of a university education could eventually earn a reasonable wage and maintain stable employment. Previously, employers were willing to train a youth as an apprentice without previous industrial experience. However, employers now usually require an applicant to have graduated from a relevant college pre-apprenticeship programme before they are willing to hire an apprentice. Obviously, employers are no longer willing to teach basic fitting or machining skills but expect the prospective apprentice to possess a basic set of trade skills. Presumably, this is because skilled trades' personnel by virtue of their extensive training are a minority in the workforce, are therefore higher paid and difficult to replace, thus employers consider basic trade skills training as a waste of company resources.

As previously stated, Amendments to Bill 55, *Apprenticeship and Qualifications Act,* 1998 introduced by the Ontario, Provincial government, under the leadership of Mike Harris made significant changes with the of the present apprenticeship system. The Act allows any person considered proficient of performing the particular task to train an apprentice. Previously, in the traditional system of apprenticeship the only people permitted to train apprentices were certified skilled trades' personnel.

In the apprenticeship contract, a company must agree to grant apprentices time off work so the apprentice may attend in-class instruction for trade theory at community college. However, as professor in the Community College system there have been many apprentices complain to me that even to get unpaid leave in order to attend the mandatory in-class instruction[26] it is sometimes problematic for them. This company attitude in itself is another major problem for apprenticeship training programmes[27]. It is common knowledge that within the industry there is manipulation of the apprenticeship training system by certain companies. For example, there are companies that state they do not have sufficient work for the apprentices, and the company claims that circumstances forced them to lay off[28] third and 4th year apprentices. However, when the company supposedly does have sufficient work they do not opt to hire back the senior apprentices, but hire 1st or 2nd year apprentices who would will be paid lower wages than the more senior apprentices that were previously laid off. To me, this reflects a basic lack of commitment to apprenticeship training and more of a definite commitment to the use of cheap labour. In an environment of volatile markets and an uncertain future, it cannot be easy for young people who make the commitment to enter the skilled trades as a career.

Decreasing apprenticeship completion rates

Authors contradicting Braverman often quote *increasing* numbers of skilled tradespersons over the last several decades, however they often omit to clarify that the overall numbers of apprenticeship completion rates compared to the percentage of apprenticeship starts and registrations have decreased (Sharpe, 1999). It should also be noted that the number of completions in 1997 (16,383) was below that of 1977 (17,429) *despite* the 40% increase in the size of the labour force and 40.2% increase in total apprenticeship registrations over the period. In 1977, 14.18% completions of total registrations had dropped to 9.51% completions of total registrations by 1997 (Sharpe, 1999, p.6). Furthermore there was a further decrease in completions rates from 1997 to 2004 to 7.4% (Statistic Canada, 2006). The two axes graph below exemplifies a significant drop in the level of completion rates compared to the increasing registration rates in Canada. The graph was compiled from data obtained from Sharpe (1999, pp. 245-246) and Statistics Canada (Statistic Canada, 2006).

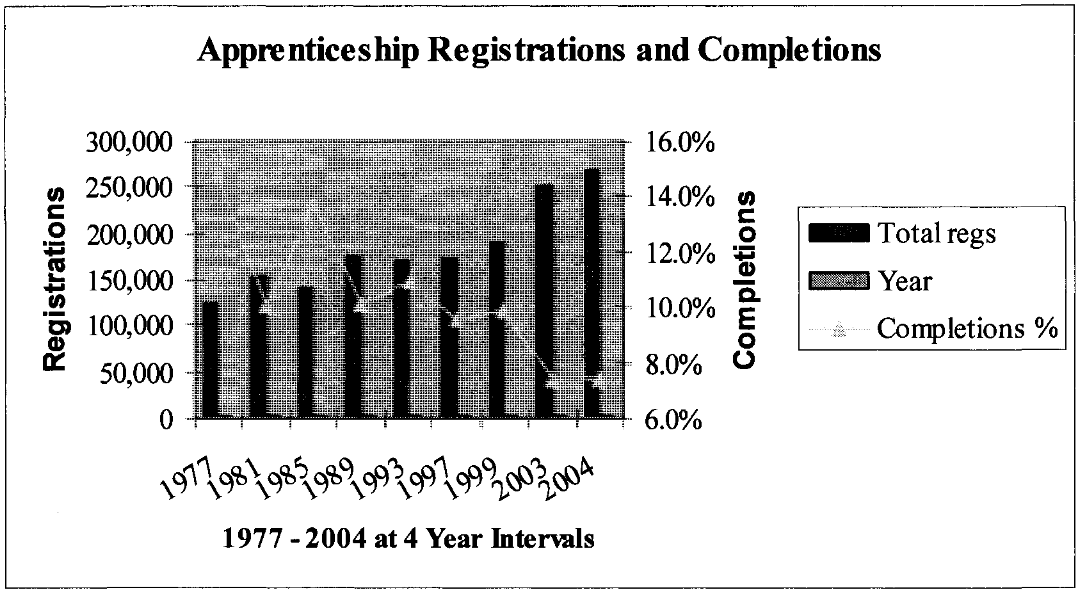

Figure 1. Apprenticeship Registrations and Completion Rates 1977-2004

According to Sharpe (2003), there several reasons to explain the significant drop in the apprenticeship completion rates in Canada. Over several decades; fluctuations in demand by employers due to changes in the macroeconomic climate, decline in the quality of entrants in an apprenticeship programme, the growing relative unimportance of completion of apprenticeship programmes for employment in certain apprenticeable trades (Sharpe, 2003, p.254).

Social Organization

Trade unions and the skilled trades

Modern trade unions originate from the medieval guilds, and from the Compagnonnage in France. The Compagnonnage welcomed workers from the various trades endeavouring to record their travels and negotiate for workers in all trades (Ridley, 1999, p.6). The craft guilds governed apprenticeship training, but prevented apprentices from becoming members of the guilds until the apprentices had successfully completed their apprenticeships and became master craftsmen. It was an attempt to prevent companies using apprentices used as cheap labour, to protect their employment opportunities, and wage rates.

Many trade unionists believed that skilled trades' should not, be taught in schools. Originally, trade unions opposed trade schools and were suspicious of their capability to teach trade skills. However, they did not oppose broad general industrial education in night, or continuing education schools (Wright, 1908). Competitive markets in the global economy, rapid advances in computerized manufacturing, and changes in company strategies have created significant changes in the manufacturing workplace. Thus, with a gradual decline in union membership, and subsequent weakening of their bargaining power since the late seventies unions have been forced to adopt different methods of operation in order to retain their influence in the workplace. The emphasis on labour education has traditionally been *Tools* courses, preparing union activists for positions within the representation and bargaining system. Canadian unions did not cultivate partnerships with universities, but preferred to educate their own staff (Spencer, 2006). However, unions are becoming increasingly involved in community and sociological issues in general. The Ontario Federation of Labour (OFL) website lists the various current union interests. For example: environment, human rights, and privatization, health care, housing, and gender issues. Attitudes have been slow to change in North America, it was not until 1996 that organized labour, and higher education discussed their common interests in the welfare of workers (Kincheloe, 1999, p.323). Traditionally unions generally believe that apprenticeship training is more effective if performed in the workplace. In my experience, companies are favouring applicants for apprenticeship training programmes who have successfully completed a relevant pre-apprenticeship programme. Ironically, some unions are now financing apprenticeship-training facilities to fast track apprenticeship training, claiming the projects will assist in the training of apprentices to help meet the forecast shortages in skilled trade labour markets over the next decade. The Power Workers Union (PWU) and Bruce Power in Ontario agreed through collective bargaining that there should be an apprenticeship-training programme at Bruce Power and tradespersons registered with the Ministry of Trades, Colleges, and Universities. Bruce Technology Skills Training Centre (BTSTC) is a company owned operated and managed by the PWU that provides training facilities to Bruce Power at the Bruce Energy Centre complex (www.btstc.ca). The BSTSC has contracted Fanshawe College in London Ontario and Lambton College, in Sarnia, Ontario, to deliver training for the apprenticeship programmes. The colleges at campuses in London and Sarnia will deliver the in-class training. It remains to be seen if the training will be narrower in scope and specific to the power generation industry or will be applicable to the millwright trade in general and as such allow apprenticeship graduates the freedom to seek employment elsewhere if they so wish. However, considering the size of the investment by the union, it would seem the future expectations of the union is to supply apprentice training on a much wider scale that can be applied to the millwright trade as a whole. Other instances of partnership with Ontario colleges have also received generous funding. For example, The Ford Training Centre of Excellence in Manufacturing at St Clair College that focuses primarily on the requirements of the auto manufacturing industry. A large auto parts manufacturer boasts of its apprenticeship program, but unfortunately the training seems to be specific to the company's needs instead of training for transferable skills that would enable the graduate apprentice to work as a millwright elsewhere and in other types of industry.

Another examples of community cooperation is equipment donated by manufacturers, including CNC machinery that is unfortunately utilised to manufacture parts for companies in the area and thus to some extent restricts the use of the machine.

Unions represent bargaining units that may consist of either skilled or unskilled labour, or a combination of both. In order to avoid confusion in discussions concerning unions there is a difference between a trade union for unskilled and semi-skilled workers, and skilled trades' workers. For example, the Transport and General Workers Union represented semi-skilled and unskilled workers, and the Amalgamated Engineering Union whose membership consisted of skilled trades' workers. A craft union's goal obviously is to improve the working conditions of the membership, but they are also concerned about the legislation and rules governing apprenticeship, protecting the quality of instruction apprentices receive, and protecting the superior status of their members. While unions are not usually antagonistic to each other in the workplace, as their common bond is their seemingly continuous confrontation with management, there are clear lines of demarcation between skilled craft unions and semi-skilled unions. The following story exemplifies the extent of protectionism, told to me by a person who had served his apprenticeship in a shipyard in the UK, and on the surface, the incident seems utterly pointless. It is a story of a wildcat strike that shut down a shipyard because a person who was not a member of the electrician's union removed a temporary electricity cable (industrial extension lead) that was lying across walkway. The person removed the cable because it was causing an obstruction and preventing the transportation of a piece of heavy equipment through that section of the shipyard. Evidently, the intention was to replace the cable after the equipment had passed through the section. This and other seemingly petty disputes came at a time when shipyards in the UK were struggling to survive against offshore competition and extensive reductions in the ship building industry. In the first instance, the action appears to be ridiculous, but in hindsight, their protectionist measures were not very different from any other trade unionists that have sought to protect their jobs and livelihoods.

I have been a member of both the Amalgamated Engineering Union (AEU), and the Transport and General Workers Union-Salaried Staff (T& GWU) in England. I have also been member of the Machinist and Aerospace Workers (MASW), and Ontario Public Service Employees Union (OPSEU) in Canada. My experience gained from membership in those unions, is that there is a difference clearly delineated between skilled trades' workers and the remainder of the work force in European industry, far more so than in their North American counterparts. In the MASW, bargaining unit there was no recognition of skilled trades as a separate body of the membership. Because the skilled trades labour was a minority group, very little attention was paid to the concerns, or requirements, of the skilled trades' contingent within the membership, and in my opinion skilled trades labour in the plant were poorly represented. Nonetheless, there were skilled trades' workers on the works committee.

Similarly, the printers' unions did little to protect their trade until 1840. Paradoxically, printer's unions in the United States did nothing to limit the number of apprentices allowed into the trade. This is surprising considering the trade unions at that time were a continuation of the medieval Trade Guilds who jealously guarded their trades. This was in stark contrast to attitudes of unions in Europe in the 19th century. On one hand, the unions were deeply concerned with apprenticeship and the conditions and legislation regarding apprenticeship training, but on the other they would not allow apprentices to enlist in the union until they had served four or five years of their apprenticeships. As Liepmann

(1960) explains, it was a paradox in that apprentices were the next generation of craftsmen on whose future the union depended, but the union perceived apprentices as a threat to the craftsmen's right to do the job, and to their bargaining power in wage negotiations. They were cheap labour during their apprenticeship, and the apprentices were a potential cause of overstocking the trade when they became craftsmen. Today many professional associations still endeavour to limit intake to protect the validity and status of their membership. The practice in not limited to professional associations but has carried over into several other sectors. For example, contractors, realtors, auto manufacturers, together with business corporations are creating their own training programmes thus, restricting entry into technical jobs (Collins, 1979 pp. 191-204). By limiting the number of people trained in a trade, the graduates are therefore a more valuable commodity in the market place.

Nonetheless, American labour unions have more than made up for any possible lack of activity in the 1800s. The major contributing factor to the sudden escalation in union militancy and general labour unrest during the Second World War was abuse of the labour force prior to and during the Second World War. Noble (1984) reported that it was the opinion of Government and company management that industrial labour confrontation endangered the American war effort. Union membership increased between 1940 and 1945 by six million members. There were several reasons for this phenomenon. For example, (a) a significant change in the composition of the work force caused by a vast increase in the number of women and black Americans, who were not resigned to the discipline and exacting conditions of industrial work (b) wages (c) de-skilling or downgraded jobs (d) and working conditions i.e., high production levels, long hours, and a hazardous environment. Industrial accidents between 1940 and 1945 caused the death of eighty-eight thousand workers and over eleven million injured in industrial accidents. Eleven times the total U.S. casualties in combat. The vast increase in membership allowed organized labour to gain new levels of power and political influence.

The Trades Union Act in Canada resulted from resistance by craft union action, the Toronto printers strike in 1872. American based international craft unions affiliated with the American Federation of Labours (AFL) were prominent and controlled the Canadian craft labour market. Non-craft workers, who were without union representation, attempted to create *industrial unions* that would represent all workers who did not qualify to join a craft union. However, during the period from its inception in 1875, until *industrial unionism* established itself in Canada, it met strong political opposition from within its own ranks, and from outsiders. For example, employers, governments, and craft unions realized it would be unwise to affiliate with unskilled workers who would weaken their power base. Craft labour unions dominated most labour action until the 1940s when the United Auto Workers (UAW) were victorious in their dispute with General Motors establishing *industrial unionism* in Canada (Krahn, Lowe, & Hughes, 2007 p. 351). The vehicle that the unions used to influence American society and so make gains for the unionized labour force was the Congress of Industrial Organizations (CIO); its influence reached north across the border and also affected Canadian labour relations. In 1944, workers at Stelco Steel, Ontario gained certification for Local 1005 of the Steelworkers of America. However, it took another two years and an 81-day strike before the union became firmly established (Sanger, 1988).

De-skilling and automation increased dramatically in the post war years and out of necessity, unions adopted a more defensive role than previously held. The main aim of the union was to save jobs, which in hindsight is analogous to trying to stop a tidal wave with a sandbag. Noble states that "between 1948 and 1960 the number of blue-collar workers in the United States declined by 500,000, by 1956 white collar workers outnumbered blue-collar worker counterparts." In 1983, the US Congressional Budget Office estimated that by 1990 a combination of automation and cutbacks would eliminate three million manufacturing jobs (Noble, 1984 p. 348). However, de-skilling and mass automation soon created serious problems of skilled labour shortages. Management had not rated apprenticeship programmes as a priority since the onset of automation. Consequently, companies trained insufficient numbers of apprentices to keep up with demands of increased production levels. The existing skilled labour force was shrinking because of a combination of retirement, and a reduction in numbers of skilled immigrates. The US Department of Defence in its concern about the availability of skilled machinists decided to increase automation and downgrade state-subsidized vocational training programmes (Noble, 1984, p. 339). This trend was not unique to North America. For example, traditional apprenticeships experienced a rapid decline in Britain from 1964 -1995, as apprenticeships in manufacturing fell from 250,000 to 47,000. Reasons given by the Institute of Personnel Development were structural changes that have reduced the size of apprentice-friendly industries, high levels of unemployment, rise in pay for unskilled young workers making apprenticeship less attractive, and the growth of government training schemes i.e., Youth Training Scheme (Institute of Personnel Development, 1999).

As de-skilling continues, seemingly unabated, and increasing numbers of less skilled workers participate in jobs that were previously the exclusive domain of skilled labour, and with the slow, but steady decline of union memberships, unions have adopted/forced into a significantly more co-operative role since the 1980s. Contributing factors have been company restructuring, increased unemployment levels, decreasing memberships, together with the previous amalgamation of many craft unions with other larger general workers unions'. Traditional protectionism of skilled trades' work has become a somewhat lesser issue for unions than retaining the power of the unions themselves. Union coverage in the manufacturing industry dropped from 45.5% in 1988 to 32.6% in 2003, a 12.9% reduction in 5 years (Jackson, 2005, p. 170).

Summary

Skilled trades have been in a continual state of flux since their inception, affected by such measures as government overruling protectionist measures practised by the Guilds and flooding of the trades with semi-skilled labour[29]. Technological changes enabling the breaking down and simplifying the work performed by skilled tradespersons and unions rarely able to bring any effective pressure on management to prevent it. The traditional approach in attempting to reduce the power and control of skilled labour over the work process has been to divide a skilled trades' work into several simpler tasks allowing less skilled, lower-paid workers to perform the work. An example of the reduction of workers and wages were the handloom weavers. The number of weavers were halved and their average wage dropped by 22% from the late 1700s to the 1830s. The industrial revolution did not initiate women and child labour for they had always been an active part in the production of goods, but in cooperation at home, not in a highly controlled factory setting where their lives were controlled by factory owners (Heyck, 2002).

The division of skilled jobs facilitates the use of technology that has further assisted management to increase levels of production, and reduce the cost of labour.

Both components considered essential in a technological society if a company is to remain competitive in a global marketplace. This despite the potential social ramifications caused by increased levels of unemployment in the manufacturing industry, and general underemployment in the workforce that promotes the acceptance of 'bad jobs'. Continually changing social relationships in the workplace has furthered change in the balance of power in favour of management. While acknowledging competitiveness is an important goal, so are employment security and the quality of working life (Rosenburg, 1989). If tasks that formally required the knowledge of a skilled tradesperson are no longer required, for example, skilled labour replaced by utilising technology, then the tradesperson's position is made redundant and can be replaced by labour that is either semi-skilled, unskilled, or replaced by worker robots, so reducing the cost of production. Labour theorists describe this organization of labour as deskilling and a destruction of autonomous craft labour (Feenburg, 2002).

Automation technology has become extremely efficient over the last twenty years, and extensive investments made by large companies in upgrading their equipment have enabled them to make significant increases in production. However, there have been equally significant reductions in the labour force required to produce their product (Rifkin 1995). Extensive reductions of the unionized labour force in the last decade have left unions in an extremely weakened position. Thus, unions are reluctant to make demands previously regarded as normal bargaining tactics in the protection of their respective trades. Traditionally management has been reluctant to include unions in the formation of company training policies. Too often employee training becomes a bargaining tool in union contract negotiations. Unions in their present weakened position, of a reduced membership, there is little likelihood that unions will be included in policy planning in the near future. Especially, as companies increasingly move their operations to areas where there are no unions, together with an abundance of cheap labour. In their continual pursuit of cheaper labour, some companies are moving production from China, which has been the traditional source of cheap labour, and are now locating their plants in other Asian countries where the cost of labour is lower than in China (The Economist Newspaper, 2007).

A growing concern among the membership of the skilled trade unions is the number of company specific or designer trades that are increasing rapidly within the industries. The concern is raised by the Ontario Federation of Labour in a paper responding to the amendments made by the Ontario Ministry of Education - Ministry of Training, Colleges and Universities, to The Apprenticeship and Certification Act (OFL, 2001). The Act introduces the creation of new trades that in some instances are dilutions of existent trades. Ontario claims the amendments would strengthen apprentices training and increase accessibility to skilled trades'. However, Company Specific, or Designer trades require a lower overall skill level, are non-regulated, and derived from other existing trades. Resulting in unskilled personnel trained in a shorter time with fewer government restrictions than the traditional apprenticeship training programmes. Governing bodies in the union movement are understandably concerned about these practices and view them as attempts by companies to reduce the skill levels in the trades and erode even further the remaining power of the unions.

It seems that technology and consequent changes in the workplace will continue to reduce the availability of relatively well paid skilled trade jobs in the manufacturing industries. Sophisticated technology is rapidly removing the necessity of traditional skilled trade labour in the production process to the point where the only skilled trades that remain will be a limited number of those who maintain the equipment used in the production process. For example, CNC machines have enabled a reduction in workers' knowledge. Metal cutting machines were predominately the domain of skilled trades' labour, but now companies employ semi-skilled operators to run CNC machines and do work that previously required tool and die makers, and skilled machinists. Likewise, when GM automated and restructured their Linden, New Jersey plant in 1985, 25 percent less production workers were required (Krahn et al, 2007, p.p. 301).

Computerized manufacturing requires workers to acquire new skills. Nonetheless, once workers learn the new skills, fewer workers achieve increased levels of production. The introduction of Computer Assisted Drafting (CAD) practically eliminated the need for skilled engineering drafters with the introduction of the computer software like AutoCAD. However, the enskilling and deskilling debate is unlikely to be resolved as management argue shortage of skilled workers as one of the reasons for introducing computerized manufacturing while creating extensive unemployment.

CHAPTER THREE: Methodology

Research Approach

A comparative case study method utilised to assess the effects and extent of technology on how millwright trade skills have changed over time in the manufacturing industry. The case study method facilitated a rich description of the particular situation, from a millwrights' perspective. It was important to gain rapport with the participants as an *insider,* to enable the collection of experiential data to which an *outsider* would not have been privileged. The use of semi-structured interviews facilitated a deeper understanding of the effects of technology on changes to the skill sets, and millwright training, rather than using questionnaires. To assess the extent of change over time in the skill sets of millwrights, and levels of apprenticeship training it was necessary to formulate open-ended questions for the interviews.

To assess the effects of technology on how millwright trades skills and training has changed over time, the cohort consisted of four current apprentices, four experienced, currently active millwrights, and four retired millwrights: a purposive sample of twelve respondents. Qualitative data then systematically gathered from the three groups of industrial millwrights utilising face to face, one-on-one interviews in a cross-generational study. The data entered using qualitative analysis software, creating role-ordered displays to assess skill levels achieved through apprenticeship training programmes, extent of deskilling and counter trends.

Interviews conducted at the convenience of the interviewee, and conducted on site, in person, or utilizing telephone interviews depending on the subject's preference.

The interviews were approximately 30 to 45 minutes in length. As previously stated, there is limited availability of previous research material on cross-generational sub-groups focused on the mechanical trades, so virtually no access to archival data. Although a larger cohort may have been preferable, it was impractical at the time to recruit, and interview, a larger cohort owing to limited resources, and availability of suitable participants.

Data Collection

Individual interviews enabled the collection of data from millwright apprentices, millwrights currently working in the trade, and retired millwrights. It was necessary to collect experiential data, as there were not any reliable listings of generational subgroups pertaining to the millwright trade. Therefore, it was necessary to consider what information would be required in order to facilitate an understanding of the changes in skill sets over the three generations of industrial millwrights.

Participants

To facilitate a cross-generational study and to better assess the effects, and extent of the changes in millwright work, and apprenticeship training programmes over a period of 55 years it was necessary to select the participants from three generations of millwrights. Therefore, three separate groups of participants represent three main stages of a millwright's career in the study. (1) second year apprentice millwrights (2) millwrights who were presently employed, and having approximately fifteen to twenty years experience working in the millwright trade (3) people who had been employed as a millwright for the majority of their working career, and had since retired. The participants were skilled trades' personnel from large, medium, and small manufacturing plants in Ontario. Participants worked in various types of manufacturing and processing facilities during their careers that provided a rich description of the situation studied, and highlighting the varying standards of training received by apprentices in the three generations of millwrights from the mid 1950s to the present. A small purposive group of twelve participants recruited randomly from prospects gained by general enquiry with contacts in the manufacturing industry, technical training facilities, and millwright unions.

Four apprentices participating in the study came from diverse industrial applications. For example, industrial manufacturing, animal feed processing, and the printing industry. Four millwright participants had a wealth of experience gained from a wide range of industrial industries. Their trade experience gained working as maintenance millwrights in companies ranging from automotive and automotive parts manufacturers, food processing, brewery, and millwright unions, etc. Four retired millwright participants had worked in several types of industry during their respective careers and gained their training in diverse types of industry. For example, an apprentice machinist mechanic, an apprentice engineering mechanic in the Canadian navy etc. All the retired participants have received their training before trade certification for millwrights existed in Ontario[30].

Research Data

It was important to formulate questions that would make possible an assessment of stakeholder's perceptions of changes in the millwright trade with reference:

- To assess skill changes required for millwrights in relation to technological changes.

- To assess changes in the millwright's discretion and control over the work they perform.
- To assess the level of skills achieved in their respective apprenticeships.
- To assess changes in the quality of apprenticeship training programmes.

After pre-testing the interviews with people who were in the millwright trade, but who would not be participating in the study, it was necessary to generate an interview schedule. Interviews conducted in a sequence appropriate to the career progression of a millwright. The sequence of the interviews were somewhat arbitrary, but to facilitate time restraints regarding apprentices the first sets of interviews were held with apprentices, millwrights were the second set, and retired millwrights scheduled third. Interviews held at neutral locations remote from their workplaces and at locations convenient to the participants at sites chosen by them. Interview sites included participant's homes, coffee shops, and public buildings. A semi-structured, open-ended interview with each participant consisted of a core of 12 open-ended questions. Interview schedules for the three generations are in appendix; VI, VII, VIII.

Individual interviews

Millwright apprentices interviews

In additional to the four core questions, listed above, under Research Data, relevant to the three generations of millwrights, it was necessary to design specific questions to assess:

- The skill levels achieved through modularized apprenticeship training programmes, assess the extent of deskilling and counter trends.
- Skill levels achieved through the apprenticeship training programmes.
- Subsequent and relevant perceptions not related to the first two themes.

Apprentice's questions focussed on modularized apprenticeship training programmes and their individual training experiences. See appendix for detailed questions. The interviews, digitally recorded, transcribed, and saved on computer discs for future analysis.

Industrial millwright interviews and retired millwright interviews

Additional questions focused on the participants perceptions of how technology had affected the required skill sets of the maintenance millwright. Questions focused on the participant's perceptions of the differences between the modern, or traditional, apprenticeship training programmes and the current modularized apprenticeship training programmes in Ontario, Canada. Participant anonymity maintained by conducting interviews away from any site connected to their respective workplaces.

To facilitate rapport with the participants I explained to the participants about my work history as a skilled trades' person so that they would be aware that I was an *insider* and knew the *trade,* and had several years experience in industrial maintenance. This did promote an *insiders* atmosphere enabling data to be collected that may otherwise not have been possible to obtain. Additional interview questions asked of the millwrights and retired millwrights that would assess their experience, training, and qualifications as a skilled trades' person working in the maintenance field. Stakeholders had different perspectives and opinions, but all participants shared a common desire to maintain apprenticeship training at a level that would meet the changing requirements for maintaining equipment and machinery in a computerized manufacturing environment.

Data Analysis

As stated previously, the core research objectives were to assess the changes and extent of current technology on the required skill sets of skilled trades' personnel in the millwright trade.

A preliminary step in organisation of the data was to create; a start list of codes with the qualitative data analysis software, and the creation of primary *Tree Nodes.* The software then created codes identifying each stakeholder or *Node*. Thus, the first two numbers identified the stakeholder group classification thus each set of codes identified as pertaining to particular group stakeholders:

- Apprentices were designated (1.1)
- Millwrights (1.10)
- Retired millwrights (1.11)

The remainder of the code contained between two and six numbers that designated various attributes and skills of the stakeholders and their trainers/mentors: training, ability, required skills and sub-contracting of skilled trades' work by the company. For example, nodes for the following apprentice categories were; trainers (1.11) if the trainer was skilled (1.111) and if a skilled trainer possessed a C of A (1.1111) or possessed a C of Q (1.1112). The Start List consisted of three different codes with respective codes created that were relevant for each of the stakeholder groups interviewed. An example of the generated codes in Appendix X. Interviews questions for each group had the same core questions.

The method to assess the data to create matrices that displayed the role of the stakeholders and the cross-generational changes to the skill sets of the stakeholders. To assess the training the participants received through apprenticeship programmes, or specific training programmes for new technologies. Each group entered into a Role Ordered Matrix required the creation of six matrices for each group of participants. Individual participants entered in each of the six matrixes to establish if the participant had received training that enabled them to acquire the various skills. For example, to learn skills necessary for scraping bearing housings, skills necessary that would enable the participant to operate metal cutting machinery, skills to use vibration analysis, and laser alignment equipment, and so on. Column headings on the matrix to best describe the types of equipment and skills for which participants may have received company sponsored training. Either obtained through apprenticeship training programmes, or upgrading necessary to enable the use of new equipment. For example, the implementation of training programmes that would enable the participants to become proficient in the use of PLCs, laser alignment, and computerized vibration analysis equipment together with other technological advances in plant maintenance equipment. Column headings were included in the matrix to assess the extent of sub-contracting work that had potential to eliminate the necessity for a company to train their employees in new technologies. To assess training received by participants on relevant technological advances regarding industrial maintenance equipment, column headings, derived from data collected from the interviews, were then collapsed into main headings for the matrices, *Programmable Logic Controllers, Vibration Analysis, Thermal Testing, Robotics, and Laser Alignment.* To assess training received in the use of hand tools requiring a high level of skill *Pouring and scraping of Babbits,* and *Machining* to assess opportunities received for on-the-job machining experience, in addition to the compulsory in-school training. *Sub-contracting,* to assess extent of companies participating in the practice of sub-contracting out work that could be performed by skilled trades' workers employed by the company.

Comparisons then made among the types of training opportunities received by the participants. The role ordered matrix facilitated comparison of data to assess generational differences in training and skill sets regarding deskilling and counter trends in the millwright trade. To display cross-generational changes recorded in the data a further matrix created that included the three generation of millwrights.

CHAPTER FOUR: Findings and discussion

Introduction

The purpose of the discussion is to examine the stakeholder's perceptions of how the millwright trade is changing together with the extent of deskilling and their experience of counter-trends. The implications of the findings describing the areas of common interest to the stakeholders conclude the chapter. For quotations in this chapter, participants assigned arbitrary generic codes. For example, Apprentice = A.1, A.2…, Millwright = M.1, M.2…, and Retired Millwright = RM.1, RM.2… . Furthermore, all quotes in the findings are verbatim as recorded in the interviews. No changes were made to make them correct.

Apprentices

As previously stated, companies willing to make the necessary financial commitment to train apprentices are relatively difficult to find in Canada, and North America in general. The methods of delivering apprenticeship training has changed significantly over the last two hundred years, but unfortunately the practice of using apprentices as cheap labour does not seem to have been eradicated. The lack of government monitoring for the training apprentices receive after the apprentices initially *sign up* with a company, is a concern for many skilled trades' workers. As previously stated there has been a significant change in the method of training apprentices. For example, Government did not stipulate in the Act a required period to complete the apprenticeship training. Apprenticeship training is now modularized, in that, the apprenticeship considered finished when all the required modules are signed off as completed, and it is no longer a requirement in Ontario for an apprentice to be trained by a certified tradesperson. A person other than a skilled trades' person who has experience in the particular task and deemed to be proficient by the company in the performance of the particular task can now train an apprentice in that task. Moreover, compared to training received by previous generations of millwright apprentices' data collected from interviews with apprentices, reflect a very slack attitude by employers regarding the training of their apprentices. Either indicating the apprentice trainers are failing in their task, and rigorous monitoring has ceased to exist or the management condones weak training practices.

Company training ethic

Among the changes introduced by Bill 55 was the introduction of *signing off book* or *training record,* which requires a signature from a responsible person to sign off a training task when the apprentice completes the necessary training required for the task. However, data collected from some apprentices participating in the study appear to cast doubt on the actual *signing off* training as satisfactory. It is also a stark comparison to previous practices and standards associated with traditional apprenticeship training.

> We haven't done much of signing off of the book so far, so they are not real good at following the actual curriculum. I kind of, do by trial and error learning so I do actually get some knowledge, and guys will say "Oh well this is how you're supposed to do it," so you take it with a grain of salt, or whatever, and you pick up from him, and him, and him but to actually get detail, you know the actual schooling, that is *definitely* appreciated because it gives you some of the things you can do. A.1

In some instances satisfactory training seemed to be suspect in some companies. For example, some apprentices felt their training had not been sufficient and they reported shift assignments to shifts, usually at night, where they were the only maintenance person in the plant. Placing any worker with insufficient training and lacking experience into such situations is a very bad practice. One response in particular I found quite disturbing, in that it was normal practice in the plant for a *second year* apprentice to be responsible for maintenance on the night shift, and without any other maintenance personnel on duty in the plant. In my opinion that has the potential of being a very dangerous situation in most manufacturing environments.

> The other apprentice and I get sent off to wherever we are needed. I actually got to work with another feller for like three months before they put me on shift by myself, so now three quarters of the time on shift by myself. A.1

Departmentalization of plant maintenance in one company seems to affect the level of training received by the apprentices in that company. One apprentice interviewed stated that to receive training on vibration analysis for the ventilation fans it is necessary for him to request the relevant training. Balancing fans and rectifying vibration problems are tasks that are normally performed by millwrights, and should therefore be a part of the apprentice training programme in that company.

Unless the long-term strategy of a company is to maintain, or increase sub-contract work it seems strange that companies do not appear to be investing in human capital by training their apprentices in the new techniques of production and plant maintenance. For example, companies do not seem to be training apprentices in the use of vibration analysis equipment, thermal testing equipment, laser alignment equipment, or the repair and use of

PLCs. None of the participant apprentices had received training on robotics, or vibration analysis equipment. However, one apprentice received training on PLCs, and another had received training on laser alignment equipment. Nonetheless, neither apprentice seemed well versed in the respective subjects. A second year apprentice who had not received training for PLCs reported that if there was a problem he could not solve he called the leadhand, who sent a millwright into the plant. Nonetheless, instead of the apprentice staying with the millwright and receiving instruction while the millwright repaired the equipment, the task for the apprentice was to try to keep the system running manually. From the company's perspective, it appears to be a short-term gain and a long-term loss with the apprentice losing all the way round.

> We do not have electricians there are just millwrights. When I am there on shift at night, and something quits working I have to try and figure out what the problem is. I don't like doing it particularly but what else can I do? A.1

In some instances the standard of maintenance practiced in plants, reported by apprentices, appeared to be very poor. After the initial installation, machinery and pumps were not monitored for misalignment, often remaining out of alignment for long periods, causing flexible couplings to fail prematurely. Predictive maintenance not practiced, and equipment repaired only when it ceased to function. In some instances data reflected that some apprentices appeared not to be receiving adequate training. Information gained from the data indicates the quality of training and expectations for some junior apprentices, yet again, bare no comparison to the previous rigorous levels of traditional trades' on-the-job-training previously delivered to apprentices. For example, every participant in the groups of retired millwrights, and millwrights midway through their career reported satisfaction with their apprenticeship training. Notwithstanding, the required skill changes, apprentices should be trained in the existing skills, together with skills appropriate to relevant developing technologies. It cannot be overemphasized, the importance of well-rounded training to enable the apprentice to become a proficient skilled trades' person.

> There isn't a lot of instruction. We just have new machinery and sometimes we have problems figuring out what is going wrong. I feel myself, I don't get trained the way I should, seeing I am in an apprenticeship I should be there helping him and learning on the job and a lot of times he is out doing the job and I am inside doing something else. We do have problems on the other machines; the couplings just fall apart after about a week. The rubber parts falls apart, or it is the jaws. One seems to be sliding out all the time. I had a problem and I phoned, and told him and he said "You better get out there and retaining all this information." Well that's fine, but when I go out and do something its only once in six months, and then he wants me to go out and do it. Well he has been doing it for fifteen, sixteen years. He knows most times, but that doe not help me learn and I don't think that is a good way to train somebody...
>
> We don't really do much alignment. We have pumps, but they are just set in, and bolted down. Actually they just slide in the recess. We do have couplings but they are the grid type and some are the interacting rubber type. The settings are already there and it is just a matter of putting the pump in. So we don't align the motor with the pump. But we do have problems; the coupling just falls apart after about a week. The rubber parts falls apart or it is the jaws. One seems to be sliding out all the time. A.3

However, other apprentices had received limited instruction on PLC and the opportunity to practice limited troubleshooting utilising the system control boards, which entails *touch screens* to ascertain if a particular generator is not working, and if thermocouples are recording data. In actuality, the PLC system troubleshoots itself and identifies defective units. The human worker is then only required to replace the defective units. In some plants where millwrights and electricians were on staff both mechanical and electrical maintenance work were being sub-contracted and the company maintenance personnel were doing what the apprentice described as the *rough work.* The apprentices stated their disappointment at missing the opportunity to receive training in those areas, namely because of company policy to sub-contract work that could provide many learning opportunities.

All the apprentices gave similar responses to questions about training they had received on new computerized equipment except for one who worked in a unionized plant where only electricians could work on PLCs, and related electrical equipment. Again, data revealed a sharp contrast in the methods of training compared to the traditional skilled trades' training regimen. Unions enforce strict adherence to trade demarcation and millwrights did not work on electrical equipment. However, many companies now expect millwrights to possess at least limited knowledge of digital and analog electrical systems, including PLCs. Therefore, it seems short sighted that companies training apprentices would not facilitate at least minimal on-the-job electrical training that would enhance their in-class training received at community colleges. In traditional trades training programmes, it was a common practice for those responsible for training the apprentice to attempt alignment of relevant on-the-job training with in-class training whenever possible. However, from the interview data it appears that attempted alignment of practical to theory is no longer the practice.

> They preach safety (and training) that we have our safety meetings every month and that but? In a way you do learn it, but it would be better if you had someone that knew it. I get on the phone a lot of times and call somebody. Usually I'll call the lead hand and if he can't figure it out somebody will come in because you are busy running around trying to keep the systems running somehow right? Sometimes it is necessary to operated it manually. A.1

> PLC training is more like on the job training, we go through everything at once, we can't grasp it, but over time I understand it. There are times I'm kind of lost and I'll call my boss. I get called in I ask him, now how do I turn this thing back on? They are all different to turn back on. PLC programs monitor the generators and thermocouple to take the readings. But it is not often we have anything to do with the PLCs at all. A.2

We do not do much of work on any PLCs, nobody does much on that. I think it's mostly electricians. No we bring people in (sub-contracting). There is a lot of that. We have sub-contracting millwrights that come in as well. It is very disappointing because not only do we not get the training we lose pay that way. We pretty much do the rough work. A.3

From the data displayed in table one, most of the companies do not appear to be training apprentices for computerized equipment, and as can been seen from table two it seems to be that sub-contracting is becoming a normal strategy.

Table 1. 1 Apprenticeship Training

	PLCs	Laser Alignment	Vibration analysis
Apprentice 1	Yes	No	No
Apprentice 2	No	No	No
Apprentice 3	No	No	No
Apprentice 4	No	No	No

Apprenticeship training for computerized equipment

Table 2. 1 Sub-Contracting

	PLCs	Laser Alignment	Vibration analysis
Apprentice 1	Yes	No	Yes
Apprentice 2	Yes	NA	Yes
Apprentice 3	No	No	Yes
Apprentice 4	No	NA	Yes

Sub-Contracting Maintenance Tasks

The apprentices in general expressed anxiety over the level of training they had received; neither did the majority feel confident about being the only maintenance person on a shift who was responsible for maintenance. The data indicated that trainers in some instances seemed reluctant to train the apprentices. This is vastly different from my experiences as an apprentice. I did not ever have the misfortune of receiving training by someone who seemed reluctant to teach me the trade. The attitude of tradesmen was one of enthusiasm for their trade, and pride in training an apprentice. In the fifth and final year of an apprenticeship, there were always other skilled trades' people on the shift. Apprentices would always have a skilled trades' person to refer to if necessary. Notwithstanding, capital intensification, and the number of skilled trades' workers per shift may have been reduced, however leaving an inexperienced apprentice responsible for maintenances on a night shift is not only irresponsible, it appears to be a company using an apprenticeship as a guise for cheap labour.

All the apprentices worked for companies that sub-contracted out maintenance work, and every apprentice felt they were missing an opportunity for training. The apprentices believed they should at least have had the option of receiving training. One apprentice commented that he learned more in-depth training at the college than he did on the job. This is the opposite to what should be happening as an apprentice spends only three, eight week blocks of in-class tuition in the duration of the apprenticeship. The programme requires the majority of the trade training delivered in the work place. Only one apprentice had received even limited training for PLCs.

Millwrights

This group of participants received their respective apprenticeship training, lasting between four and five years in length, between the early 1960s to the early eighties. All the participants possessed a C of A, and a C of Q. Skilled trades' personnel who had completed an apprenticeship and possessed a C of A trained all the millwrights. Each participant considered that their respective trainers possessed extensive knowledge of the trade and relevant production processes. Participants portrayed a sense of pride in responding to questions about the trade knowledge

The current apprentices were very critical of their respective training programmes. For example, how the lack of tuition, and training could impinge on their future careers. In contrast, all the millwrights currently working in the trade together with the retired millwrights participating in the study respected the skill of the tradesmen who trained them, and praised the extent of how much they learnt and the skills they were taught. They spoke warmly of their respective apprenticeship experiences regarding the quality of training they had received and the expectations of them as apprentices. Data represented in the section for retired millwrights, reflects a more stringent level of training, and controls administered over the conditions that governed their training than did the current generation of millwrights. This maybe explained by a stronger influence of the European apprenticeship system, a more stringent level of discipline that existed at that time, and the retired millwright participants were still in their early to mid-teens at the time they were receiving apprenticeship training. However, they all believed that the attitude or way of thinking they developed during their apprenticeship training was a fundamental part of becoming a capable skilled tradesperson. They acquired *Trade Knowledge* by getting to know the trades' person they were working with, and told what tasks to do, including cleaning the tools at the end of the day and sweeping the floor. As the relationship developed so the tradesperson would teach the apprentice, as one millwright put it "*all the small stuff and tricks of the trade*".

> Every one of them was a skilled tradesman. They worked in separate areas, but they could work the whole of the plant. I served my apprenticeship in the construction union. I am a construction millwright by trade and you are not allowed in the union unless you have your trade papers. A lot of them were from Europe, a lot were from the UK. Their attitudes were traditional and it was, you sweep the floors, you do this, you do that, but he (the tradesman) was good, and you learned a lot. They told you all the small stuff, the tricks of the trade that you would never forget. You got to know the tradesmen you were working with, you clean the tools at the end of the day and he taught you the little things. M.1
>
> There is a style of thinking you develop in the trade that's peculiar to the trades' person, and I have said this at work. I will give you an example; when my production line goes down and two production people open up the gate, put their lock on, and they walk over to the robot, they look at this, and that, trying to see what if the weld wire is stuck and what they say is, "What is going on"? Now they are holding up the line, and wasting their time. A trained tradesperson will come to the door and while he is opening the door and putting his lock on, he is looking at the robot and wondering if this process or that process up there is causing the problem. He is analysing the situation before he is even in the gate. Where the person who is not trained, is totally mystified, and does not know the possible causes of what has happened. A good trades' person does that without even knowing he is doing it. M.2

Knowledge is power?

Reponses from questions put to the millwrights regarding discretion and control over the work they performed did not evoke any strong response. Levels of discretion and control varied depending on the company. However, in automotive plants and related parts manufacturers, standardization may have facilitated a decrease in the level of discretion and control that skilled trades' previously possessed, thus creating an increase in management control, possibly more so than in other industries.

Interview data displayed that in one plant that operated under the traditional forms of discretion and control for skilled trades, personnel changed dramatically after an industrial dispute in the early eighties. Prior to the dispute, the millwright ran the lines (maintained, repaired and overhauled the equipment and machinery), created his own schedules and preventative maintenance programmes. The company provided the necessary budget for the maintenance programme. However, after the industrial dispute the participant reported that everything changed, and the company management closely controlled maintenance of the plant. Management strategy was then closer to the level of control exercised by the majority of management in manufacturing. The dispute may have motivated management to plan for future technical change in the methods of production to shift the center of control back to management.

> I started at the company in the mid eighties but they closed that in the early nineties and I got transferred to the plant I am in now. Only two out of fifteen millwrights got hired back when they closed the first plant. Two of us got transferred and kept our seniority. Ever since I came to here I have worked on the same lines. When I started I did not receive any training, I did them on my own and no one told me what to do. I make up my own schedules, maintain them, and overhaul them. They asked me what budget I needed to do the job and I ran it all. Now it is starting to change; maintenance used to have total control of the plant before the union dispute and the lockout. Everything changed after that when we came back the company took control of the plant. Things went downhill quite a bit and it's now starting to come back up a little and the form has changed quite a bit since then, and we now have new guys in management who do not know anything about the plant so they have to rely on the millwrights and electricians. M.1

The following data suggests that there may have been a basic change in attitude by skilled trade workers regarding the work they perform. This also may explain a reduction in the discretion and control afforded to the skilled trades by management.

> It really depends on who you have, they basically let me go without supervision if they need something they know I will go down and do it, but we have a few guys who are a little hard headed so they keep a little more grip on them. I am very much against it but some guys do things that will create overtime. There is no need to do those things because we are already on

> unlimited overtime. As a result the company is always looking for technology in order to automate the process and replace operators where possible the aim in the plant is to replace as many people as possible with automation. They still need the skilled trades but we are 4 full guys down (millwrights), but the company is contracting the work out. They can't do that with everything, there are some jobs and key operations that need an in-depth knowledge to work on and set up, so they do not let outsiders touch that because they have found it does not work. The subcontract work is restricted to conveyers and things like that. They do not let them a touch the technical equipment. M.1

Since the dispute seven years ago, management and supervisors have rotated, and the company has moderated its' position and are now beginning to rely a little more on the skilled trades' maintenance personnel. However, the company management is modifying the methods of production utilising computer-manufacturing systems, and is presently content to run the maintenance department with four full-time skilled trades' personnel under strength. The company has reduced its skilled trades' staff by 15 millwrights alone since the early eighties. Nonetheless, production has steadily increased. The company explored the limits of sub-contracting and for now, the practice is to sub-contract out conveyor alignment tasks that would previously been performed by the company millwrights, together with increased utilization of machine operators in the maintenance of the machines.

> If I am in charge of the revolving machine I basically let the guy go say, I need to change a bearing but it is the type of machine that you have to know how it works, on the inside of carrier, it all works on balance and if you take some carriers out you will have problems with the main carrier chain which is a 4 inch pitch chain, it is pretty heavy and the sprockets are eighteen tooth but they are wide, two and a half feet in diameter. If something cuts loose someone is going to get hurt. But I usually prepare the machine before I let him (the operator) take it off and do it. The helper/operator does not know anything about the workings of the machine. On some work they (the operator) will say what needs to changing and we will let them go and do it. If they (the operators) have a problem then we show them what to do and how to get over the problem. In overhaul there are four mechanics and for work staff. Work staff are production guys since we don't have the line running instead of sending them home they put them on the line as a helper. There is one Mechanic and a helper that work together in the overhaul. They don't know how to tear it apart, so I explain to them how it works and comes apart with special powers, (hydraulic pullers) and equipment. Normally maintenance work is done by two mechanics. It is only when it is in an overhaul period that millwrights work with a helper/operator. There are a lot of jobs for in a plant where you can get away with one guy and he may need a little bit of help. M.1

However, company personnel continue to maintain the technical equipment. It is a modern day example of the philosophies of Smith and Taylor in that management pays a little more money to the operator, but still less money than would be paid for skilled trades' labour, thus lowering the cost of production. Going one-step further are companies that build their manufacturing plants offshore and use a minimal amount of skilled trades' workers. For example, the New York Times reported[31] GM/DELPHI downsizing and GM closing plants in US and Canada. Since 1978 GM have built 50 parts factories in Mexico, reported to employ 72,000 workers (Dillon, 1998, p.1). Thus, from the interview data a pessimist could speculate that some auto parts manufacturers could be one-step away from taking similar measures. For example,

> They could easily take somebody and train them. They could take someone from the floor (a production worker) and set up a whole new classification and pay them say seven dollars an hour less than what I am making, and still pay them three dollars an hour more than what a production worker makes, they could call them whatever kind of technician. A technician properly trained could do my job easily without any of my millwright training. They will still require a certain core of competent skilled trades' people but not as many. But I don't think it will happen as much in the heavier industries. M.2

Money is a great motivator to remain in a job when a person has responsibilities and has adjusted to the level of a higher income bracket. I have spoken with several people who dislike their job, but enjoy the benefits that come with the employment, so they stay. I know a line worker with a university degree who claims that he shuts his brain down on the line, and switches it back on when the shift is over. I believe the participant quoted above is not the only millwright who uses just a fraction of the trade skills in his possession. Large companies who pay high wages are an attractive proposition for many people. The work may not be challenging but it pays well. Therefore, eventually I think the new *classifications* the participant referred to will be the norm.

Traditional tools: scraping the bottom of the bearing

From my discussions with millwrights in Ontario there appears to be very little agreement between them about the necessity of blueing and scraping of plain bearings in the twenty first century. However, it clearly states in the Industrial Mechanic (Millwright) Apprenticeship In-School a requirement for the apprentice to learn the necessary knowledge pertaining to plain bearings. Some maintain it is a redundant skill while others quote there are still certain industries (pulp and paper) that still use Babbitt bearings in machinery and it is therefore a necessary skill for apprentices to learn. All the millwrights agreed however that the skill is seldom required in industry today. The millwrights in the study had all learned how to blue and scrape bearings, but all stated they had not poured Babbits, or scraped bearings for many years. The reason being that in most industries have replaced Babbitt bearings with frictionless bearings (Ball or Roller bearings), and the vast majority of friction bearings that do exist are fitted with pre-machine shells that do not require scraping. However, blueing and scraping bearings was stock-in-trade for many of the skilled trades'. Many skilled trades' workers made their own scrapers from suitable high carbon content steel suitable for hardening, often old discarded files, and tailored the scraper by grinding the steel to a suitable shape suitable for job at hand, and apprentices usually made themselves a set of hand scrapers. It was unacceptable to purchase a scraper from a tool store. Conversely, most apprentices today do not learn how to blue and scrape bearings, and millwrights rarely have scrapers in their toolbox, and to the best of my knowledge some do not even own a scraper.

> The only place you would have a scraper in your box is in the crusher's area where there are Babbitt bearings. The journals are about 12 inches thick and the shafts on them are about 4 inches where they crush the some of the ingredient. There are a series of rollers and they have to scrape the bearings. The new machines coming in have roller bearings. They are using are using new technology in that area for that process and they have roller bearings in them. When I first started in the trade I poured Babbitt bearings. We had to blue the bearings, put the shaft back in and then take out for the shafts and scrape the journals and then put the shafts back in to find the high spots, try it and then scrape the journals again until they were perfect. M.1

In many companies, standardization and computerized manufacturing has affected the variety of tools and skills that millwrights use most often. Responding to questions about hand tools, interviewees agreed that within automakers and associated suppliers they used mostly small hand tools and were limited in the scope of tasks they performed.

> In my opinion the type of maintenance work I do today does not relate not to the millwright trade I was trained for. It is just one of the things, you know, you have companies going out there hiring millwrights, and wasting the talent of the millwright by having them do other things because they (the company) are told they require millwrights. In the plant I work in now I could probably carry a pouch with a set of standard Allen Keys, a set of metric Allen Keys, a 3/8 drive ratchet and a couple of sockets, a couple of flat head screwdrivers, and some wire pliers and get by perfectly fine. Very occasionally there will be a job that will require me to open my toolbox and get into some heavier tools. Today it's a production driven environment, keep the line going at *all costs*. M.2

It has been my experience that the *quick fix* practice is becoming increasingly common in other types of manufacturing. A *quick fix* is sufficient repair work to keep the machine or equipment running, but not necessarily sufficient to repair the machine or equipment so it does not break down over the long term. The consequence of the *quick fix* is often unscheduled downtime resulting in an increased loss of production.

> In the company that I work for I have see a large shift toward production power, it used to be your maintenance department, your production departments, and never the twain shall meet philosophy or meet somewhere in the middle and try and try to get along with each other. Maintenance had the philosophy was to shut down this line and fix it and production wanted to run the line regardless, so you have two opposing philosophies, and that's' fine. Well now where I work we don't even have a maintenance department anymore so I work in a production department and my department head is not a skilled tradesman. So I'm on the line trying to utilise my skills as a maintenance technician within the parameters and rules that are as a production person tells me. Now of course the things that I want to do, I can't do because they say will it run and I say well yes but I ought to fix it not run it. Its frustrating when you can't make someone from the production side understand that it is in the best interest to stop the machine now, and they cannot see it is the long term interest because they look at how it is going to effect how many parts they are going to make for the next day and one of the bosses are going to come down here and complain that I didn't make enough parts, and they can't see beyond that. It's a production driven environment. In the long term it is going to be a bad thing for the industry. We seem to be drifting away from the identity and the culture of the trades. We are highly encouraged to identify with production people on the lines you are working on. Even if you don't fit in and even if your mentality is totally different from their mentality this is what you are supposed to do. M.2

In an age of global competition and rapid turn-around times, this appears to be a somewhat strange strategy. However, it is unusual today to make replacement parts for equipment and machinery in the plant. Notwithstanding, spare parts in the plant are kept to an absolute minimum. It is more economical to minimize levels of spare parts, than to maintain an extensive stores inventory in the plant providing that spares are quickly available from a supplier. Reducing the reliance on skilled trades' workers for the production of spare parts achieves additional economies. Previously it was common practice for companies to have alternative machines to use as replacements if a machine or a piece of equipment in the manufacturing process malfunctioned. Thus, facilitating the removal of the defective machine, or equipment from production, and repaired it to a level where it would run for months, or even years without problem. The *quick fix* approach to maintenance has therefore drastically reduced the discretion and resulting control of the millwright over the production process.

All the millwrights had extensive experience in other types of manufacturing, power plant, and mining industries, and seemed somewhat nostalgic about the exhilaration and danger that was sometimes associated with the variety of their work in other industries. They termed such work as *real millwrighting*, compared to the type of work they were presently performing. They resented the changes of management strategy that had resulted in reducing their discretion and control as skilled trades' workers and the lessening reliance on their skills.

One millwright was exuberant in his response to a question about fitting bearings and the amount of skill was required to balance ventilation fans.

> We used enormous exhaust fans in the mining industry and they were journal type bearings. The shafts as I remember were 14 inch diameter and the fan would rotate at 900 rpm and the paddle wheel would be approximately 12 ft across the paddle wheel. It was interesting stuff because we had to balance these fans if one those fans threw a weight off. I didn't see one, but I saw pictures of one that had sheared a 14 inch shaft off completely, at the bearings on both sides. It came out through the housing just like if you opened up a piano and disintegrated as it was going. It went up three or four floors, incredible interesting. When they (the fans) got out of balance we shut them down opened the access doors and rotated them slowly, and hammered them, because the dust and dirt would build up on the paddles and throw them out of balance. before you brought over any of balancing equipment. It was a different balancing system that it is today, you were using strobe lights, charts and graphs and doing vectors. Two guys, one guy on each side holding the strobe on the bearing and another guy holding a strobe light with the charts set up around the shaft, and marking the shaft. The other guy over here doing calculations figuring out how many grams was going to be put on the fan and where you are going to put them. M.2

In his words, "that is what a real millwright should be able to do". He further explained that although in the plant where he now worked had extraction and ventilating fans, they were small in comparison. He reported that the company sub-contracted the work for balancing the fans, as it was economically viable for the company to keep him on the line.

> Fan balancing is contracted out where I work now. Today it is a totally different thing, the contractor comes in with a small computer sets up the little probe and the vibration analysis equipment. The company wants their maximum bang for the buck. It is the same as having me out there keeping that piece of machinery, the line, running. Anything extraneous to the line a contractor is brought in to deal with it. M.2

However, he also expressed plainly how he felt about the situation.

> It makes me a whore, that's what I tell the guys. I mean just about thirty years in the trade and I am line whore. I have gone from being a millwright and a tradesman to being a line whore. They pay me to walk the line, and keep the line going, and I take the money and say thank you very much. I'll keep your line going for yer. But your pride really goes down the tubes. M.2

Machining Skills

In the Ministry of Skills Development, *Regulations Pertaining To Industrial Mechanic (Millwright)* apprentices should receive machine shop training for the skills required in Schedule 2 – Workshop Experience. According to the Act, the employer is required to provide the opportunity for the apprentice to receive the necessary training. However, in my experience millwright apprentices in Ontario did not receive their machine shop training from most companies, but trained for the most part in community colleges. Most apprentices are unlikely to have an opportunity to further their machine shop training they receive in college to gain practical experience of machining in their respective companies. Therefore, millwrights do not often perform many machining tasks, unless it is the practice in the particular company. Data gathered from the interviews suggest that the automotive and automotive parts manufacturers do not require millwrights to perform machining operations, but have tool rooms or machine shops to perform machining operations.

One participant employed in an unrelated industry reported that although the millwrights still did their own machining operations it was less than was previously required. The company had not kept machinery in good repair and the participant stated that it was not possible to achieve the close tolerances required for some of the work.

> We did all our own machining and we used to machine all the shafts up to 12 ft in length. I used it to machine all my own, but, the machinery is worn so now we can't get the tolerances close enough. We still do the small stuff for that usually have a we get to a local machine shop to do most of the machining now. Though we still do make split bushings the company would prefer the machining to be subcontracted out. We have a couple of guys in the shop on machines who by trade not millwrights, they were taken on before the rules were changed, but now you have to be a certified millwrights to work in the maintenance department for company. They were machinists and they came from the old country. It is good now because if I have a problem on the lathe I ask them, how do I am I going to do this? And they always have a solution to the problem. There is very little machining training in the millwrights program and I have really told myself a lot of the machining I do now. M.1

The policy has been not to replace machinists as they retired, but rather the company adopted a strategy to sub-contract the work rather than hire machinists and replace the worn machinery. Thus, management is lessening the reliance on skilled trades' workers in the transition to computerized manufacturing.

In contrast one participant millwright who had worked extensively in the resource industry had also completed an apprenticeship as a machinist and possessed a C of Q as a machinist.

> I was the millwright on the crew that was the machinist. Especially on the field work when they wanted a part made. It was a distinct advantage on the job, and also getting employment as a millwright machinist. You are seeing more and more in the resource related industries, and which I believe will dominate calendar for the next 200 years. Manufacturing is on its way out where millwrights will not require a machinist's license. It was not common for millwrights to have a machinist's license. I have encouraged my son to obtain a machinists license as well as a millwright license as I believe that machining skills will remain a dual opener to jobs. A large power company in Alberta stipulates that millwrights must have machinists' skills. Millwrights with a machinist license will be given preference. M.3

Table 3. 1 Machining Tasks

	Perform machining tasks	Sub-contracting
Millwright 1	Yes	Yes
Millwright 2	No	No
Millwright 3	No	No
Millwright 4	No	Yes

Performing In-House Machining Task sand Sub-Contracting

Maintenance and the new technologies

As previously stated, the introduction of Programmable Logic Controllers (PLCs) in the 1970s transformed the methods of production and the skilled trades' associated with industrial manufacturing. PLCs exacerbated the *restructuring* or *downsizing* that began with the automation of the production process enabled by NC machines in the 50s and 60s.

When first introduced PLCs were the sole domain of the electricians, and fiercely protected by the electrician's unions. In some unionized industries that still prevails, but millwrights are increasingly becoming more involved with the repair and programming of robotics and PLCs, together with the repair of CNC machines. This may of course have been associated with the lack of union representation in some of those plants. Data collected from interviews with millwrights working in union and non-union plants/facilities differ considerably. One millwright did receive PLC training, but not allowed to work on PLCs because of union demarcation.

> We are not allowed to touch them. The electricians do that, it is a very traditional setup electricians are electricians and millwrights are millwrights. If you want to change a motor an electrician comes down and wires it, and a millwright changes the motor. When the motor is fitted an electrician wires it back up. The electricians (union) are the problem in our plant they will not allow us to go out for training on the PLCs or anything electrical. When they closed the other plant all the mechanics in there had extensive PLC training delivered in the plant by Alan Bradley (PLC and electrical component manufacturer). I don't know of anyone who was transferred to other plants being allowed to use their PLC training. If you are not allowed to use it you forget it all. I can go down and change very basic machines but if an electrician caught me doing that for doing that they would raise all hell. M.1

However, the three of the four participant millwrights received very little formal training on PLCs, and they considered the minimal training they received as inadequate. The remainder reported not receiving any training on PLCs. Attitudes of the various companies seemed that because they employed electricians who worked together with the millwrights in the plant, it was therefore unnecessary to train the millwrights on PLC equipment. Nonetheless, the company still required the millwrights to work on PLCs, robots, etc., without the benefit of formal training.

> I have not received any formal training on PLCs. They need to upgrade the millwrights and send us out for training, but they (the company) said to we can learn it as we go and we have got electricians to do that work as and we all work together. I think it has been a big handicap, the cost it does to that line between old generation and new generation, but I do notice in industry that when the pressure is on they call the old guys who calm the situation down and troubleshoot the situation, and difference between the generations is distinct. I really see that we are short skilling the younger tradesman in that they can run anything computerized, and that is good, because they need to know that. But when it comes time for them to actually fit something perfectly and to make it work, or to break something (take it apart) and pull it out and be safe, they have very little skills in that area. M.3

The millwright participants believed that while it was a good thing for the apprentices, and a new generation of tradespersons to receive training in computerized manufacturing methods, the apprentices lacked the necessary skills to troubleshoot machinery without the aid of computerized equipment. They were not receiving sufficient training in how to perform the basic tasks required in the trade. For example, skilled fitting of parts, the safe and efficient removal of units from machinery, make the necessary repairs and to put the machine back into production in a timely fashion. This exemplified by a response from a millwright who had many years experience in the trade and was working in a computerized manufacturing environment.

> You know what; it (the technology) has taken over the troubleshooting skills. Now I can go to a machine and it tells me (what is wrong) I don't have to look at it. You know I think I made that statement before because I know the troubleshooting skills. When the technology tells you that, the job comes down to just replacing parts. Technology does remove those in essential skills. That reminds me when years ago we traveled around doing (working on) rotating equipment. Back then the TI59 calculator coming on board as the state of the art and we had these little programs that we could put in it. We would punch in the in formation and it would give us the readout for the alignment moves. But we were going through the Airport one day and going through the metal detectors wiped out all the programs, so when we went to use the calculator to speed things up there was nothing there. We laughed about it and we thought now we have to get our graphs out. But now, there are a lot of people using laser alignment equipment who do not know how to do it any other way. All they are doing is taking the measurements from the laser alignment equipment and if they do not have any other way and their power cord gets cut and they don't understand how to do alignment without the laser equipment they don't have any other way to do the alignment. M.3

<u>Sub-contracting versus training:</u>

Information gained from the interview data indicates most companies are not willing to make the financial commitment required to train millwrights for technological advances in maintenance equipment. If the company provides training at all, it was mostly of short duration. Millwrights often reported that their employers do not allow them to use the new equipment that would have enabled them to gain practical experience with the new equipment. For example, laser alignment equipment, or digital vibration analysis equipment etc. Machine alignment entails aligning machine shafts on vertical and horizontal plane to reduce machine vibration to a minimum thus increasing the working life of the machinery. Vibration analysis is a method to detect potentially destructive vibration that can ultimately destroy the machine, by monitoring waveforms with computerized equipment. Many companies preferred not to train their millwrights or apprentices, choosing to sub-contract out maintenance tasks to maintenance companies. However, it was also usual for companies to expect millwrights to perform tasks on computerized equipment for which they have not received training. It is true the millwright gained the new skills essential to retain his job, but they were self-taught. A situation that raised stress levels for the worker to a state that affected his quality of life for several months.

> I have to say you are thrown to the wolves because you are hired as a skilled trades' person and you are put on a three month probation period, and this is exactly how it happens; you are put out there on the floor, you are given a line (a production line to maintain and keep running) and it is sink or swim. You learn the process, and if you don't learn the process you are not going to make it through your probation period, so you fake it till you make it. Now in all my years there I have had three days of training on robots and that is spread out over six years. That's how it is I have seen trades' people be hired, they come in, and gone in three weeks. Before I started here in Ontario I had not seen a robot. I had to learn how to operate it, teach it, (*lead by the nose* technology to show the robot the work path and positions. The computer then retains it in memory), program it, and learn how to troubleshoot and fix it. That became one of the big things in my trade, dealing with robots and dealing with the welding system attached to the robot. That is a large part of my trade today troubleshooting the problems with the welding operation that includes the robot. M.2

From data gathered from interviews with the participants in this study, and from my own experience within the industry, skilled trades' workers in many industries are being restricted in the scope of work they perform. Relative to their training and potential ability, many skilled workers now seem to be employed as semi-skilled workers. Increasingly companies are sub-contracting tasks that were previously the responsibility of millwrights employed within the company. It has now become common practice in a wide range of diverse industries to sub-contract tasks. For example, the alignment of conveyors, roller mills and similar equipment, together with the balancing of rotating equipment, vibration analysis and thermal testing. Thus, a millwright who traditionally performed alignment tasks with dial indicators, plumb lines, and levels are often no longer are required to perform alignment tasks.

> We have just got a laser alignment tool in the plant. We have done a little vibration analysis that we do not use a lot of it. We have not received any training on it. We are basically on a 'if it breaks down fix it' situation we are firefighting and we do not have enough guys. We have three lines running and (production) it runs around the clock so it is hard to keep up. M.1

> They get less training for the robots; enough so they can manipulate the robots but the PLC are only worked on by electricians. Our people are trained on vibration analysis but laser alignment is sub-contracted out. M.4

Companies have changed strategies, and rather than train their millwrights to become competent in using the new technology, the company prefers to sub-contract out the maintenance work in the plant. However, though there were some examples of enskilling, the two millwrights who had received training on laser alignment equipment were not required to use the new skill. Previously the millwright performed alignment of cut-to-length lines[32], but with the introduction of laser alignment equipment, the company sub-contracted out the work. Millwrights interviewed agreed the tasks referred to above have been made easier and therefore, faster to perform with the aid of computerized equipment. A millwright gave me the following example, "Basically that with a laser (alignment equipment) you could install equipment in line with each other at a distance of 250 to 300 feet because the beam does not sag". As such, technological advancements in maintenance equipment make it financially viable for the formation of companies that specialize in performing certain maintenance tasks and obtain contracts for maintenance work from companies that would have previously hired their own millwrights, or more probably, hiring lower paid semi-skilled workers, trained only on laser alignment equipment. Data in Table 3 may indicate that it is common for companies to sub-contact laser alignment and vibration analysis, etc. However, wages paid to workers hired by subcontractors are usually at a lower wage rate than millwrights hired by major manufacturing companies, except for union locals that perform contract maintenance work.

Interview data indicated that a certified millwright, hired as a millwright in an auto-parts manufacturing company, was classified by the company as a maintenance technician. His sole responsibility was to maintain a production line in order to minimize downtime. It seems therefore, that the company had made a conscious decision to restrict the responsibilities, and work the company maintenance personnel performed, to designated sections within the plant. Millwrights technically had the option of transferring to other departments, but according to the millwright interviewed, it rarely happened.

*Table 4. 1*Vibration Analysis

Vibration Analysis	Training	Sub-contracting
Millwright 1	Yes	Yes
Millwright 2	No	No
Millwright 3	No	No
Millwright 4	No	Yes

Vibration Analysis and Sub-Contracting

Table 5. 1 Laser

Laser Alignment	Training	Sub-contracting
Millwright 1	No	Yes
Millwright 2	No	Yes
Millwright 3	No	No
Millwright 4	No	No

Laser Alignment and Sub-Contracting

Millwrights reported reductions in the number of maintenance staff hired by companies and a general reduction in the size of maintenance departments over the last twenty to thirty years. Contributing factors that influence company policy are a combination of changes in company strategies regarding maintenance techniques, and technological advances in maintenance equipment. In modern industry, it is common not to repair defective small units, but simply replace them with new units. For example, previous practice when the vanes or an impeller in a pump wore down, the pump millwrights would repair the pump and put it back into service. However, this is no longer the practiced, smaller pumps are scrapped and replaced with a new pumps. Small to medium sized pneumatic cylinders are usually manufactured as sealed units that are designed not be repaired and must be replaced. This practice, facilitated by the economies of computerized manufacturing, and the availability of lower cost units manufactured in *offshore* plants where labour costs are substantially less than in established industrialized countries. The replacement of whole units assists companies to reduce maintenance labour costs, and downtime in the production process.

The data indicate, albeit from a small sample, that the discretion or control millwrights have over their work has eroded over time. Previously, a millwright would determine what work was required to repair equipment, and control how to perform the work. It seems that in some industries management who are not certified as skilled trades' frequently assign millwrights what to repair, and in some instances tell them how to do it. There are several reasons that may explain this phenomenon. For example, (a) an indication that management is gaining more control over skilled trade workers in the workplace, and therefore dictating how maintenance work is performed, (b) it may reflect the participant millwrights were correct in their perception that apprenticeship training standards are dropping, and that the present generation of millwrights did receive inadequate training in their apprenticeships. This is supportive of the general thesis.

Millwrights expressed concern over the lack of training they had received for the new maintenance equipment. Those millwrights who did receive training were resentful that the companies did not allow them to use the training. All millwrights resented companies sub-contracting work that they believed company maintenance personnel should and could perform. For example, machining, vibration analysis, laser alignment, and thermal testing were all tasks previously performed by company millwrights.

Retired Millwrights

Work experience, in the field of industrial maintenance, for most of the participants was between 38 and 50 years beginning in the 1950s. The Certificate of Qualification (C of Q) did not exist when any of the now retired millwrights received their initial training or employed elsewhere as millwright apprentices in the 1950s. Then, the required certification for the trades' was a Certification of Apprenticeship (C of A). In 1980 when Ontario introduced millwright certification, some older millwrights, having spent many years working in industrial maintenance, evoked the *grandfather clause* to gain entry into the trade as a skilled trades' person, often with the assistance of local union halls. From information gained in discussions with millwrights from all over Ontario, industrial management in general seems to prefer C of A certification as it verifies graduation from an apprenticeship-training programme whereas a person with a C of Q maybe grandfathered in to the trade. Some of the retired millwrights expressed concern about people *grandfathered* into the trade in that it was common for a person *grandfathered in* to receive limited training in specific areas of the trade. Those grandfathered in had not received, or acquired the full range of millwright skills that would be acquired through an apprenticeship, and therefore not have transferable skills necessary for working in different types of manufacturing environments and companies. In some ways, analogous to the medieval stonemasons forming craft lodges to prevent unskilled workers who claimed to be skilled obtain work as stonemasons.

The first retired millwright interviewed, was instrumental in the introduction of millwright apprenticeship training in Ontario. Before the introduction of apprenticeship and the Certification of Qualification (C of Q) for the millwright trade, Machinist Mechanics performed maintenance and repair work in the manufacturing industry. Consequently, some of the participants were *grandfathered in* and received a C of Q from the certifying authority, but did not possess a Certificate of Apprenticeship (C of A). All participants who possessed a C of A reported that the training during their apprenticeships was thorough and all received their training from skilled tradesmen who were dedicated to the trade and had immense pride in being a skilled tradesperson. Until the mid 60s, in Europe indentured apprenticeships were legally binding, and carried a financial penalty to any parties that did not keep the contract. Furthermore, the apprentices could not legally participate in a labour dispute or strike, nor take time off from work without first gaining permission from the employer. Either an apprentice could defer military National service until the end of the apprenticeship, or the time taken for military service during the apprenticeship added to the five-year contract. All the retired millwrights participating in the study had pride in their apprenticeship and the apprenticeship system regardless of where they received their training.

As previously stated, in Ontario the introduction of apprenticeship for *industrial* millwrights was in the late 70s. However, apprenticeships for construction millwrights were already established, so industrial millwrights coming from Europe would sit the exam for construction millwrights.

> I sat the C of Q here. You must remember that when I came here there were only construction millwrights, so I sat it. I was out in fifteen or twenty minutes. RM.1

As previously stated, Machinist Mechanics in Ontario, prior to 1980 performed machine maintenance and repair, but according to available data, after the introduction of the millwright apprenticeship programme in Ontario there was a minimal training requirement for machining skills in the apprentice-training programme. In my experience, the majority of companies do not require millwrights to perform extensive or complicated machining operations. As with any skill, the lack of practice promotes a reduction in the skill level. This supported by a response by a retired millwright who had been an *apprenticed* as a machinist mechanic.

> I have a certificate of apprenticeship which is an equivalent to a Certificate of Qualifications.[33] In those days they did not have a certificate of qualification. They started apprenticeships just after the war, and the number on my certificate was 234 or something like that. I got my certificates and in about 1955, from the department of labor that became involved about that time, just after the war. My apprenticeship was for a machinist but I was recognized by the company as a Mechanic. When they introduced the millwright's certification I had to provide verification from the company about the millwright work I had done and wrote the C of Q exam. RM.3

Data gained from the interviews with retired millwrights in the quotations below, indicate there has been a change in the discretion, and the level of control millwrights have over jobs they are required to perform. However, the amount of discretion afforded to millwrights now varies according to company policy.

> Different plants have different systems. One company for example is governed by a specification. Every job has its own specification regarding how equipment is welded and aligned. How everything is supposed to work. At another you had to have a set of blue prints, or if there was some custom fittings to do they would bring in some brackets or hangers that had been modified because they are not carrying the engine quite parallel and the engine would not slide in to some place it was supposed to. The Engineers favourite expression was 'Make it work'. It doesn't matter how, as long as it works the way they want it to. But it had to be idiot proof. RM.4

The retired millwrights reported definite changes in the levels of discretion they had experienced during their careers. A contributing factor for this may be the introduction of *grandfathering* in tradespersons. Skilled tradespersons who have served a tradition apprenticeship (C of A) usually possess a wider range of skills, and are more knowledgeable about the trade overall than a tradesperson who has been grandfathered in and is possession of a C of Q.

> When I first started to I had a lot of discretion. Supervisors' methods change in different plants but over the years I have had a favourite expression and that was "You can tell me what you want me to do, don't tell me how to do it." I always told supervisors it's your job to tell me what you want done. Don't tell me how to do it. It has changed. Probably because people are trying to protect themselves and it is probably the reason that even straightforward jobs are done to specification. The engineers are trying to cover their asses. But it has taken a lot of way from the job. You have to remember to tear up (separate) qualified tradesman (C of Q) and certified tradesman (C of A), they are not the same. There can be a difference, and you get a foreman who has ten people with him. He knows he has one person who he can send on his way with full discretion, and that he could not send some other guys. He knows that because the other guy is possibly going to make a screw up, and he is stuck with him, but that guy is not going to have any discretion. RM.4

Another possibility raised in the data, that of cultural differences in apprenticeship training and the resulting effects on the apprentice after they became qualified skilled trades' workers. Data gathered from retired millwrights indicate a general change in the level of discretion and control afforded to millwrights over the several decades of their respective careers. Many of the retired millwrights were trained by tradesmen' who themselves had been trained in Europe where the attitude of society to skilled trades' workers and apprenticeship was very different from a North American perspective.

> There was the Plant Engineer, and then there was a maintenance supervisor, he was a machinist, and he never tried to tell you how to do a job, unless you got into trouble (had difficulties). He would say "so and so is down see what the problem is, let me know if you need any help." RM.1

> In those days it was pretty straightforward there was a job to do, and you did it. You decided how it was done and what was to be done. Today it's not like that. The factories I worked in they would say we need you in on Saturday, and then they would give me a job and I would go in and do it...
> I suppose I did have a boss but they did not tell me how to do the job, just to get on with it. I would get a couple of guys to work with me and just get the job done. I worked in Southern Ontario for thirteen years and I had the whole division from the Windsor to Niagara Falls. It was heavy maintenance work and often using construction equipment. My boss was in Detroit and I hardly ever saw him. His main order to me was, "just keep her going". RM.2

In the following data, there is an indication of subtle changes gradually occurring in the workplace regarding the discretion and control afford to the skilled trades' workers. The participant referred to supervisors although initially there were no direct instructions, but the first data set reflects the *master mechanic/supervisor* was present at the job site. Past practice was to let skilled trades' workers use their own discretion to perform the tasks they were required to perform.

> I worked as a millwright in BC for a year in a shop there where they repaired tug boat engines. Our job was to take the engine out and bring it to the shop and the marine mechanics would work on the engine then we would install it back in the tug. The marine mechanic would come and run-in the engine to check it was running properly. Then we would check everything was installed correctly. I found there was no supervisor as such. There was a supervisor but he was more an administrator looking after the paper work. He wasn't out there telling how to put the engine in the tug boat. He was what they called a master mechanic, an expression I had not heard for many, many years. BC has the longest history of millwright mechanics it goes back to before the First World War. RM.1

In the following instance, the data reflect further changes in direct supervision, in that the supervisor would let some trusted skilled trades' workers use their discretion but others required permission to shut machines, or entire lines. The second and third data sets reflect situations that are now common in the manufacturing industry where there is direct supervision of skilled trades' workers, and often by supervisors who are not qualified in any of the skilled trades'.

> If there was a potential problem I could shut the machine down and the supervisor in the department would not bother me. He knew that I would not shut it down without reason. They would tell me and there was a problem on a machine and to go and find the problem, and fix it. I would order the parts but if it was a rush order that's where the machining skills came in, and then you would have to manufacture a substitute quickly to get them through that particular order. RM.3

> In my 15 years experience as a supervisor the majority of Canadian millwrights required direction. I do not mean any bias there. I found the majority of European millwrights, especially the Germans and Brits, were very good. They did not require very much direction but the Canadian guys, whether it was because they felt insecure in themselves or because they had not gone through a credited apprenticeship. It may have been in the training where they were expected to ask every step of the way. I had one guy who used to come back to me after he had been gone on a breakdown and I would ask "well what did you find wrong"? "Haven't a clue" he replied. He had been up there for an hour, and he hadn't a clue. If I had have said that as a millwright I would have been looking for a new job. I found as a maintenance supervisor eventually millwrights would not make a decision that had to be made. There was one guy told me one day, he said "that is your job to make decisions." RM.1

> They are trying to decrease the supervision, but then in a couple of plants I was in when they did that within six months they were back up again. RM.2

Every retired millwright participant believed their level of discretion, and therefore control over the jobs they performed, had been gradually eroded during the years they had worked in the trade. During the interviews all the participants gave me the distinct impression that their trade was very important to them, and it had been far more than just a job during their working life. They were proud of their trade skills, of their trade knowledge, and of the quality of work, they could perform. The interview data exemplified significant changes in the level of discretion and control over the time span covering the careers of the retired millwrights.

<u>Deskilling, enskilling, or multi-skilling?</u>

An example of a traditional skill is the practice of *Blueing* and scraping bearings, and tapers, to remove any high spots and create a smooth bearing surface.[34] The purpose is to maximize the working life of a plain or tapered bearing, and is a task that requires dexterity and skill. It was formally a required skill for many skilled trades' personnel. For example, millwrights, machine fitters, toolmakers etc., who fitted and *mated* bearing surfaces, before the widespread introduction of technological advances in metal cutting machinery. For example, in the late 1970s CNC machines could achieve consistent accuracy within tolerances of one or four ten thousandth of an inch (.0001 - .0004). Thus, in the second millennium, it is very seldom manual skills are required in manufacturing. Plain bearing are usually preformed shells can be easily replaced requiring only relatively low skill levels that. Scraping of plain bearings is a skill is gradually disappearing, except for the fitting of Babbitt bearings. Table 6 is an example of the changing skill requirements in the manufacturing industry, and the lack of skills training given for the fitting of tapered bearings, pouring of Babbitt and the scraping of Babbitt bearings.

The majority of the millwrights and all retired millwrights had received training for hand scraping and fitting of bearings. However, none of the apprentices interviewed had received any training for that particular skill. In contrast retired millwrights responding to questions regarding Babbitt bearings, referred to their previous experiences of pouring and scraping of Babbitt bearings, and the skills necessary in building and repairing various types of machine bearings. Interview data gives an indication of the changes in maintenance equipment. The first example is a simple hand tool replaced by a hand held motorized scraper fitted with a carbide tool bit. The tool dramatically reduced the time necessary for scraping machine ways, beds, tables etc.

> There is a greater variety of tools today and they have become less expensive. We made our own scrapers out of files, especially the half moon scraper and flat scraper even the *Way* scraper for scraping the bed of the milling machines. They now have the carbide electric ones. We didn't have the carbide then. It did come, but not when I first started. R.M.1

Initially CNC machines were only cost effective if large batch runs were machined, but as CNC machines became more user friendly it became reasonably economical to programme even '*one off*' jobs. Thus, almost obliterating the requirement for skills necessary to hand fit friction and frictionless bearings, and for millwrights to machine bearing housings.

> We scraped in bearings and whatever was required. We did a lot of fitting; we made everything from start to finish. We made the castings and machined them, and then we fitted everything which is something you don't see today. It was a very interesting job then. A lot of those skills are gone. That type of work really disappeared with the introduction of CNC machines. When computerized machines came in, that all but disappeared. There are exceptional circumstances where fitting is still required, but not generally in the trade

> anymore. It is not really necessary anymore because then you could machine to a scribed line, but computerized machines will retain consistent accuracy at 2/10th of thou (.0002") which was unheard of in the old days and that is why you used to do the scraping and bluing to obtain the accuracy. RM.3

> We poured our own Babbitt bearings and turned them to size ourselves, cut the twelve grooves especially on the turbines, back in the sixties Timken used to make brass fully floating bearings the used to last for ever. You could take them apart and there would be hardly any marks on them. RM.4

The participants relating their experiences reflect changes that have occurred in the field of industrial maintenance during their careers. By comparison to the 1960s and 70s there are very few applications now where hand poured Babbitt is used for friction bearing material.

> I did quite a bit of pouring babit; we used to pour babit bearing on the four column hydraulic presses. In the platen that goes up and down in those days most of the bearings carrying the platen up and down were Babbitt bearings. They are made with fibre now but from what I hear they are not very good and don't last very long. RM.1

> I did pour Babbitt but I have not done so for many years. A lot have been replaced by nonfiction bearings and lubricant impregnated friction bearings, sintered bronze etc. and now when I was in the navy we had all steam engines and we spent hours scraping Babbitt bearings. RM.2

An indication of the change occurring in the skill requirements for millwrights across generations is illustrated by data in Table 6 below.

Table 6. 1 Disappearing Skills

Disappearing Skills: Pouring and Scraping of Babbitt Bearings

Apprentices	Training	Scraping Bearings	Pouring Babbitt
App 1	No	No	No
App 2	No	No	No
App 3	No	No	No
App 4	No	No	No
Millwrights	Training	Scraping Bearings	Pouring Babbitt
Millwright 1	Yes	Yes	Yes
Millwright 2	Yes	Yes	Yes
Millwright 3	Yes	Yes	Yes
Millwright 4	Yes	No	No
Retired Millwrights	Training	Scraping Bearings	Pouring Babbitt
Ret Millwright 1	Yes	Yes	Yes
Ret Millwright 2	Yes	Yes	Yes
Ret Millwright 3	Yes	Yes	Yes
Ret Millwright 4	Yes	Yes	Yes

In contrast, most of the retired millwrights had very limited, if any, experience working with the new skills required for computerized manufacturing techniques. Nonetheless, several were still working in the trade when the companies they worked for started the transition to the new method of production. However, millwrights at that time did not work on PLCs etc., consequently did not receive any training on the new systems. Initially PLCs were the sole domain of electricians. However, gradually millwrights were required to work on them, and this according to one's perspective, is either the start of multi-skilling, or enskilling. Nonetheless, considering the previous very distinct demarcation drawn lines between the trades' shown in the data, multi-skilling may be the more appropriate label. Retired millwrights when given the option by management not to participate in training, due to their upcoming retirement, the retired millwright participants either denied the opportunity to receive training on PLC etc., or choose not to participate in work that involved PLCs, robotics, or vibration analysis etc., highlighted in some quotations and following text below.

> In the last ten or fifteen years they started to get computerization equipment, but I suggested to the supervisors that they encourage the younger people to get the training as it would be more beneficial for the company. I did a little of it that, but I did not get very involved because of my age. The electricians did all the work on PLCs at first and then in the last few years they were getting the millwrights to do that work. The industries are all the same they do not want to pay two men when they can pay one to do the job on the second and third shift so they trained to millwrights to work on the PLCs. When I first started, there were 26 categories. It seems that as categories have disappeared many have been absorbed into the millwrights' trade. I have found for that because of all the demands out there fellers go on to get an electrical license. Some actually have several licenses.[35] RM.3

> I did not get into it, and really the closest I got was to work once with an electrician on one PLC. RM2

I worked with the traditional troubleshooting equipment, first a thorough understanding of the machine, a stethoscope, and a metal rod (on the bearing housing) in combination of a good sense of touch and observing the equipment in the plant. It is difficult to explain but usually you just knew when something was going to go wrong. Today it seems it can't be done without a computer. RM.3

I did some maintenance work on them, but 90% of it was electrical and the company I worked in trained electricians and millwrights on them and to the company it was a package deal. They bought the machine from a big company in the States. In Holland, Michigan and we were sent down there, three or four at a time, for a week. We spent a week down there learning all about these robots. How to programme it, how to troubleshoot it with the TV screen and 9 times out of 10 the trouble when it went wrong it was electrical. RM.1

One retired millwright considered a major change in the types of equipment used by millwrights today was the introduction of laser alignment equipment used for the alignment of drive shafts and machine levelling. Before the advent of laser alignment equipment the most common tools used for alignment were dial indicators, straight edges, feeler gauges, and callipers, and to a lesser extent electric alignment. In some applications, it was necessary to align the machine cold and then perform further alignment checks after the machine had reached normal operating temperature.

I think it is the alignment equipment. I think the feeler gauge and straight edge were the only tools we had for coupling and shaft alignment. Today they have laser alignment, we had nothing like that and we had to align some delicate stuff the same as they do today. But you had to do it with *'touch'*. It's not the equivalent, so the *touch* had to be there. This is where I say the basics come in, the expansion of the metal with heat, it may only be a couple of tenths of a thou, but especially with something like hot water pumps it could put them out of alignment. So you had to align it and then after it had run for a while and after it had heated up you would have to check the alignment and then bring it up to running alignment. They don't have to do that today. I amazed when I found that some shafts had been installed by the contractors 25 thou out of alignment! So they (the company) put a new shaft in every two years. The millwrights are laughing at them, it economically sound to the company, but there are a lot of but to us trades' people who are wondering, "why don't you check the damn thing"? But it was originally put in that way by the contractors. RM.1

With the introduction of laser alignment equipment, it is common practice for equipment manufacturers to supply alignment specifications for thermal growth[36]. That is the alignment of the machine at the machine's normal running temperatures. However, another retired millwright did not consider laser alignment useful on small installations and considered laser equipment not very much different from electronic alignment except that whereas the wire in electronic alignment equipment could move, a laser beam will not. Nonetheless, laser alignment equipment is much faster to set up than electrical alignment, and traditional alignment equipment, and with less chance of human error. All calculations are performed by the computer, together with the quantity of shims that should be added, or removed from the beneath the machine supports/feet displayed on the equipment readout.

Generational changes in apprenticeship training

A major concern of several retired millwrights was that they had witnessed a lowering in the quality of training given to apprentices over the years they had been working in the trade. Other concerns were that without adequate training millwrights could not effectively perform effective troubleshooting which is a major requirement of the millwright trade. Originally, the Canadian apprenticeship training system was modelled on the British system of apprenticeship training. A retired millwright in response to a question about apprentice training made the following observations on the changing standard of apprenticeship training and the inconsistencies in the delivery of the training apprentices receive.

I was instrumental in getting the apprenticeship program recognised in Ontario. we got the certification brought in. We did convince the company to hire an apprentice toolmaker and an apprentice millwright. They got a young guy from one of the High schools. He stayed on days and worked between the three millwrights (for training). RM.1

I have spent a lifetime promoting skilled trades and I have seen a lowering in the quality of the training. They are not learning the basic skills and without them it lowers the person's ability to troubleshoot. By relying more and more on the technology they forget, and gradually loose their fundamental skills of how the process works. This weakens their trade knowledge. The companies are requiring multiskilled people with mechanical and electrical skills. But first I think high schools should make math and science compulsory subjects. It is essential in order to help the young people entering the workforce cope with the new technology. RM.1

The apprentices were trained in all the skills and would go to different tradesmen for training. If a job was being done that required a specific set of skills the apprentice would be put with the tradesmen doing the job so the apprentice could be trained and get experience on that work. When it was finished the apprentice would then resume his normal training programme. That company was very good at training apprentices, but there are companies out there who will just keep an apprentice on a cut off saw for six months. Although there are ministry representatives for apprenticeship training who travel around the Province visiting companies that are training apprentices there is only so much one person can do. Most of the apprentices only see a ministry representative once during their apprenticeship. RM.3

In North America the attitudes of companies are not favourable for apprentice training. I have advocated for apprenticeship training for decades but I do not think the culture will be easy to change, if it is even possible. Unions say they promote apprenticeships but there are many instances where they are obstructive to apprenticeship training programmes. I think there will be a return to the Master Craftsman or the original concept of the millwright trade in a highly technical form. One who will be highly trained in cross trades (multi-skilled). The millwright mechanics will do the grunt work, i.e., machine and equipment installations, and the electricians will be wiring the installations and pulling wire etc. RM.1

The retired millwrights all commented about the simplification of maintenance work, and traditional skills required for repairing defective units are not being utilised in that mostly defective parts are no longer repaired, but replaced with new units. Thus, causing a gradual reduction in the number of skilled trades' workers employed in manufacturing.

> When I started at the Canadian Timken there were thirteen to sixteen machine repairmen working there now there are only nine or ten. I can see nowadays there are new ideas and, as much as new technology. On pumps for instance and it is not know a case of changing the vanes, now they change for the whole Pump. Now they just take a pump off the shelf and install it. RM.4
>
> I don't think apprentices are given the opportunity to make it a trade. Most factories don't want tradesmen anymore and they are not interested in apprenticeship training. RM.2

Discussion

Apprentices

Assessment of the findings indicates the level of *on the job* apprentice training may not always be satisfactory. Apprentices in the study often did not have the opportunity to use many of the traditional millwright skills on the job, and often not trained in the new skills either. Technological advances in maintenance equipment have created new skill requirements for millwrights. For example, laser alignment equipment that determines the amount of misalignment, identifies *soft foot* (a situation where one or more feet of the machine is not in contact with the ground), and gives the amount of shimming necessary to align the machine. The new equipment eliminates the skills previously required, and affords the millwright less discretion than that with traditional skills. Interview data reflects the apprentices in the study were not satisfied with the on-the-job training they were receiving. From the data, it appeared that often the apprentices did not receive on-the-job training in many of the traditional skills. For example, fitting and scraping of bearings or in the new technologies. Therefore, not only were they were not receiving the mandatory training designated by the Government; they were not given the opportunity to learn about technological advances of new production methods either. This would indicate a lowering in the standards of apprenticeship training over the generational period covered in the study.

There is controversy over reforms introduced to apprenticeship training throughout the OECD as to whether the necessary levels of skill possessed by skilled trades' personnel have been maintained, increased, or decreased. The introduction in 1994, of Modern Apprenticeship programmes introduced in the UK, Fuller, and Unwin argued that, "Government is more concerned with social inclusion than with developing a high quality based work route" (Fuller & Unwin, 2003, p1). In Ontario, Canada, as previously stated, The Apprenticeship Certification Act, 1998, sparked controversy about the adequacy of reforms to Ontario apprenticeship training programmes, and if the traditional skill levels maintained when apprentices received training from semi-skilled personnel. It is widely acknowledged by experts in the field that apprenticeship entails more than training (to do something through instruction), but more to educate and understand. As Noble so aptly states;

> Training thus typically entails a radical divorce between knowledge and the self. Here knowledge is usually defined as a set of skills or a body of information designed to be put to use, to become operational, only in a context determined by someone other than the trained person; in this context the assertion of self is not only counterproductive, it is subversive to the enterprise.
> Education is the exact opposite of training in that it entails not the disassociation but the utter integration of knowledge and the self, in a word, self-knowledge. Here knowledge is defined by and, in turn, helps to define, the self. Knowledge and the knowledgeable person are basically inseparable. (Noble, 2002, p.2)

Apprentice training programmes require much closer monitoring to ensure that apprentices receive quality training, and not used as cheap labour, as is so often the case in many industries. A frequent criticism is there are too few government officials employed, for adequate monitoring of the number of apprentices in Ontario. However, for a government representative to obtain accurate information is difficult at best. Firstly, the apprentice may be reluctant to complain for fear of jeopardising his employment as an apprentice. Second, management may be unwilling to spend time for an ongoing investigation and monitoring of their apprenticeship-training programme. Increased monitoring of apprenticeship would require a strong commitment by both government and industry in order to motivate, and educate company managements who claim to require skilled trades' personnel, but who appear to be reluctant to invest sufficient funding to create a workable solution.

According to a major survey conducted in 2003 on behalf of the Canadian Apprenticeship Forum (CAF), an organisation that has a mandate to promote apprenticeship training in Canada, there are significant barriers to apprenticeship training in Canada. Therefore, if the CAF, a major supporting body of apprenticeship training, recognises the obstacles and barriers to apprenticeship training programmes in Canada, will there ever be sufficient commitment by the industry and both levels of Government to sustain future apprenticeship training in Canada? Furthermore, industry has no qualms about hiring willing students who have completed only one year of a two-year training programme. They, the students, have gained little knowledge, but sufficient for companies who are willing to hire them at lower rates of pay that a graduate of the programme could expect. It is common for students to take jobs in industry and not return for the 2nd year of the programme. For example, in pre-apprenticeship toolmaker programmes Community Colleges are becoming unwilling, or unable, to offer government sponsored cooperative pre-apprenticeship programmes. The present funding structure makes it unaffordable for the college to sustain financial viability with insufficient students enrolled in the second year of a two-year programme because students have gained employment and decided not to complete the 2nd

year of the programme. Unfortunately, the student often finds themselves eventually *layed off* from the company and lacking sufficient qualification to gain employment elsewhere.

As previously stated, employers have traditionally been unwilling to invest in human capital formation. Companies in Canada and the USA have traditionally relied on skilled immigrant labour from Europe who would not require training, and would initially accept lower wages than local skilled trades' workers would. Nonetheless, *why would* companies want to invest their capital in supporting apprenticeship-training programmes that will eventually produce high paid workers in the form of skilled trades' personnel, when technology is enabling machinery to perform many of the tasks that were formerly the work of skilled trades' labour? Data gained from interviews with the millwrights substantiated a move toward deskilling, it that, it seems the auto manufacturers and auto parts manufacturers are leading the gradual transformation from skilled trades' labour to the creation and development of teams comprising of *technicians* that work in one area of the plant.

Millwrights

As previously stated, technological advancement in the methods of production has historically necessitated changes in the skills sets of skilled trades' workers. However, computerized manufacturing required *significant* changes to the skill sets of skilled trades' workers. Maintenance personnel employed in union shops, who did receive training to operate computerized equipment, were either restricted or not allowed to utilize the training they had received on the new technologies. The findings also indicate that there is a significant increase in the practice of sub-contracting, or *contracting out,* of industrial maintenance work previously performed by millwrights employed within the company. In

North America, skilled trades' unions that did exist, have for the most part been absorbed into general worker unions, where the skilled trades' workers constitute a small minority of the membership. As a minority, skilled trades' work is not relevant to the majority of the union membership in the work force. Therefore, according to data received from a skilled trades' worker and highly placed union officials, there seems to be little union resistance against companies who wish to sub-contract skilled trades' work. For example, in *non-union* companies that sub-contract tasks of laser alignment and vibration analysis are not concerned if the worker performing the task is skilled trades' qualified, or semi-skilled providing the alignment analysis or vibration analysis are performed adequately. Nonetheless, in my experience, unions in *closed shops* often require sub-contract workers also to be members of a union before granting their permission for sub-contractors to work in the plant. However, in recent discussions with the owner of a company that performs laser alignment and vibration analysis etc., on a sub-contract basis, the workers are not certified skilled trades' workers. Nonetheless, unions often require skilled trades' workers to accompany sub-contract workers performing the work. For example, making necessary adjustments to the equipment stipulated by the sub-contractor. This is a further example of the division of labour, and potential deskilling.

Interview data reflected that management seemed not to be willing to maintain previous levels of staffing for maintenance departments, preferring instead to include operators in maintenance work and hire less maintenance workers, who work unlimited amounts of overtime. Previously this would have been unacceptable in unionized shops. It suggests another example of the weakened position of organized labour. Nonetheless, for several years now there has been the disturbing pattern, from a skilled trades' worker's perspective that millwrights are unanimous in their concern over the loss of discretion, and control over the work they perform, since they started working in the industry.

Retired millwrights

The majority of retired millwright participants expressed more concern than currently employed millwrights did, on several issues. They were especially concerned over what they perceived to be a significant lowering in the standards of apprenticeship training programmes and the delivery of on-the-job training in the workplace during the last ten to twenty years. Retired millwrights were also more concerned about the inadequate monitoring of the' workplace training by government bodies. This also raised an issue of the attitude of skilled trades' workers toward the training of apprentices. Retired millwrights reported that during their apprenticeships, only the best tradesmen trained apprentices. Tradesmen who had delivered their training were pleased to do so, and were proud of the acknowledgement of their trade skills and of having the opportunity to pass on the skills of *their* trade to the apprentices. However, most of the retired millwrights had observed unwillingness on the part of younger millwrights to train apprentices. This may be associated with a seemingly increased reluctance of most companies to participate in apprenticeship training programmes, and extensive restructuring within the manufacturing industry.

There was consensus among the retired millwrights there had been a general increase in the management practice of sub-contracting out maintenance work. All participants believed the millwrights employed in the companies should perform the sub-contracted work. The retired millwrights were also resentful, again more so than the millwrights, that in the industry overall they had observed a significant loss of control and discretion afforded to millwrights over the work millwrights performed in the manufacturing industry. However, millwrights may be partially to blame for their loss of control. According to one of the participants, some millwrights are reluctant to make decisions, and consider decision making not a part of their job. If this *way of thinking* is common among millwrights presently employed in manufacturing it reflects a momentous shift in the mindset and attitudes of the present generation of skilled trades' workers, compared to the previous generation of skilled trades' workers/millwrights.

Changelings

Qualified millwrights working for the sub-contractors often perform sub-contracted alignment and vibration analysis work. However, as maintenance equipment becomes more sophisticated, the operator now reads the necessary information for adjusting equipment from the screen of the computerized equipment. Thus, if the rapid advances made by the manufacturers in simplifying the operations of computerized maintenance equipment are considered, it can only be a matter of time before the person who performs the sub-contracted maintenance work will be someone trained specifically in the use of laser alignment or vibration analysis. Comparing interview data from all participants (apprentices, millwrights, and retired millwrights) indicates that company managements are increasingly likely to sub-contract out certain tasks involving new technologies rather than investing in human capital by training their own millwrights to perform the work. Therefore, it seems doubtful that it will be a skilled trades' millwright, with a wide range of trade skills, who the company will hire to perform the work. Analogous to the millwright's position is the current rapid replacement of skilled machinists, toolmakers, and welders by worker robots, CNC, and EDM machines in manufacturing industries.

When there are unemployed toolmakers, a skilled trade previously considered the most secure trade in manufacturing, it follows that employment in the remainder of the skilled trades is equally insecure. Student enrolments in established courses for toolmakers have dropped so substantially that some colleges have replaced toolmakers courses with CNC operator courses. Despite statements, to the contrary, there has been a substantial reduction of work opportunities for toolmakers and machinists in the last five to ten years as companies have increasingly adopted computerized manufacturing methods that replace many skilled trades' workers. According to the Canadian Labour Congress (CLC) report, figures acquired from Statistics Canada *247,300 manufacturing jobs* have been lost in Canada from November 2002 – February 2007 (Weir, 2007), and the number is still increasing.

Workers lose skills if they do not have the opportunity to use them regularly. It is therefore a reasonable assumption that eventually the certified millwright, referred to previously, may not be able to perform the skill set that originally qualified him as a millwright. Similarly, maintenance millwright/technicians who maintain compressors, and are restricted to perform work that is closely associated with compressed air systems will also be in danger of loosing their original range of skills. However, it is essential for skilled trades' workers to retain their full range of skills if they are going to retain their independence and be able to continue working where they choose in their trade. Management strategy of specialization therefore restricts the certified millwright's ability to obtain work elsewhere in the future, except in other industries closely associated with auto manufacturing lines with similar production processes. A skilled trades' person is traditionally a versatile worker who can adapt their trade skills to suit the requirements of any industry. Therefore, company strategies of worker specialization will erode the necessity of traditional skilled trades' labour.

The creation of a new class of maintenance technicians that specialize in particular fields would be financially viable and an acceptable alternative for management. A technician trained as a specialist in a compartmentalized manufacturing environment, and who has not received training in a traditional form of apprenticeship will not have acquired the overall trade knowledge that traditional apprenticeship training provided. The practice therefore is true to the Taylor tradition of hiring people as untrained replacements trained to do specific work the company requires. The new employee receives higher wages than they would for semi-skilled work, but less that of the skilled trades' worker, they had replaced. Over the long term, the utilization of such personnel will facilitate a reduction in the wage rate for maintenance personnel.

Paid labour are usually considered one of the highest costs of the production process, and the loaded labour rate, the true cost of employing workers, is a major consideration for companies when investing in computerized manufacturing methods that facilitate increased efficiencies of production. The new manufacturing methods enable a reduction in the number of higher paid traditional skilled trades' workers. Creating a restructured method of production requiring fewer workers who would be either semi-skilled or multi-skilled technicians, who would receive fewer wages. Automobile manufactures, astute leaders in the art of restructuring, recognise it is economically more advantageous to invest in technology that will facilitate reductions in their work force. Furthermore, to maximize profit the company strategy would be to manufacture products incorporating maximum technological advantage, further reducing the level of discretion, and control of remaining skilled trades' workers. Thus, facilitating a further decrease in the requirement for skilled trades' labour required in the production process. This would enable products to be manufactured utilising computerized manufacturing methods, while employing a minimal amount of low cost human labour that is readily available offshore. Would companies then want to invest in apprenticeship training? I think the answer is they would not.

Conclusions

There are several indicators arising from the study that do not bode well for the survival of traditional skilled trades in the manufacturing industry. An increase in the number of skilled trades would not previously qualify as skilled trades. For example, the *restructuring* of the following trades; the auto mechanic split into approximately seven different classes, the welder, and the groom has received similar restructuring. The very notion of skilled trades' is undermined as previously stated, by the methods utilised to train apprentices, and the policy of broadening the definition of the skilled trades. In Ontario, the introduction in the late 70s, of apprenticeship training programmes for *industrial* millwrights and the introduction of a millwright C of Q in early 1980s are relatively recent beginnings for millwrights as skilled trades in Ontario, compared to other jurisdictions some established for decades, and in other instances for centuries. This together with changes in company philosophy regarding apprenticeship training may explain the attitude of some companies toward millwright apprenticeship training, and their unwillingness to participate in apprenticeship training programmes.

However, in reference to the recent changes in apprenticeship training programmes, it could be argued, rather than promote watered-down versions of apprenticeship training programmes and train apprentices with semi-skilled labour, it may be more advisable to revert to requiring certified skilled trades' workers to train apprentices. In addition, increase government onsite monitoring of the delivery of apprenticeship on-the-job training. This could, ensure that government standards are adhered to as well as ensuring a future supply of highly skilled trades' personnel in Canada. If industry is to remain a democratic competitive force in the global marketplace, it is necessary to create apprenticeship-training programmes that effectively meet the changing demands of industry and will sustain the pool of skilled trade labour, ensuring skilled trades' personnel are an economically, viable alternative for modern management.

Many companies are unwilling to train their millwrights in the use of new computerized maintenance equipment. As one participant reported, although the millwrights need training on the new equipment, the company maintained that because the millwrights work as a team with the electricians, they could *learn as they go*. Moreover, those that do train the millwrights apparently often do not allow them to use the new equipment but, according to the interview data, prefer to sub-contract the work to outside companies. This reflects a lack of recognition and status in industry for traditional skilled trades' personnel in Canada, compared to their European counterparts. It has always been necessary, and considered a part of the job for skilled trades' workers to *figure out* the work. However, considering the changes in the skill sets necessary for working with computerized manufacturing systems, the level of informal learning expected of skilled trades' personnel by some companies, exceeds normal expectations. Nonetheless, from a practical standpoint, with training there is nothing to prevent the new processes from remaining the province of the skilled trades'. While the short sighted attitude of using training as a bargaining chip prevails in contract negotiations, nothing will change. Likewise, the enskilling and deskilling debate is unlikely to be resolved as management argue shortage of skilled workers as one of the reasons for introducing computerized manufacturing while creating extensive unemployment. For example, the increasing numbers of unemployed toolmakers, machinists and so on.

Industrial management increasingly require machine operators to become more involved in the equipment maintenance, this together with increased *quick fix* maintenance practices, reduce the levels of discretion and control of skilled trades' workers. Thus, causing an erosion of the traditional skills, and subsequent deskilling of the traditional millwright trade, eventually reducing the required number of skilled trades' workers required by the industry. Interview data indicate changes in the work culture that are symptomatic of the steady reduction of control and discretion allowed to skilled trades' workers. Information gained from the data, reflects changing attitudes of some skilled trades' workers. Their perceptions regarding the level of their discretion and control over their work have changed, in that they do not expect to have the control or discretion to make the decisions afforded to previous generations of millwrights.

A continuation of this trend would indicate that eventually millwrights may not be involved in basic machine maintenance, and companies will expect operators to possess higher levels of technical knowledge. Especially in non-union shops, or where the union representation is weak. Management attitudes are increasingly drifting away from apprentice training and companies are loosing opportunities where skilled trades' workers could with their knowledge, probably be the greatest asset to any company introducing computerized manufacturing processes. Of course, several other factors that are beyond the scope of this study, also affect a company decision not to adopt apprentice-training programmes.

Accepting restructuring and the utilization of new technologies has facilitated a reduction in the overall number of employees that were previously required for any level of production, thus fewer skilled trades' workers are required. Social structure is therefore affected. In that, traditional opportunities for members of the working class without the benefit of a university education are restricted in obtaining well-paid jobs as skilled trades' personnel in the manufacturing industry.

The data indicates, albeit from a small sample, that the discretion or control millwrights have over their work has eroded over time, so weakening the skilled trades' culture. Most of the millwrights received either inadequate training or none at all, on the new technologies. However, companies endeavour to promote a team spirit, and encourage workers to identify with each other, in order to facilitate a fusion between two groups of workers who have very different attitudes toward the work they perform. In a steadily changing work culture, as a participant so aptly put it, "We seem to be drifting away from the identity and the culture of the trades." It is unlikely that the enskilling and deskilling debate will be resolved as management continue to argue that the shortage of skilled workers is one of the main reasons for introducing computerized manufacturing, while creating extensive unemployment. For example, the increasing numbers of unemployed toolmakers, and the continual difficulties faced by people seeking entry to apprenticeship training programmes. However, this together with steadily increasing levels of computerized manufacturing, I believe it is very possible that the majority of traditional skilled trades' labour will all but disappear in Canada and the USA within the next two or three decades. Advanced sophisticated manufacturing methods, maintained by limited numbers of multi-skilled technicians will steadily replace skilled trades' labour, in the manufacturing process. Traditional skilled trades were never meant to be enshrined and preserved as wistful memories of days gone by, but used a foundation for the expansion of new skills that are required for computerized manufacturing, and beyond. Therefore, I hope that this study may encourage future exploration of broader based comparative studies on the skilled trades'. The scope of which expanded to a comparative study of the manufacturing process that included all relevant OECD member countries.

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APPENDIX I Effects of technology on the skilled trades

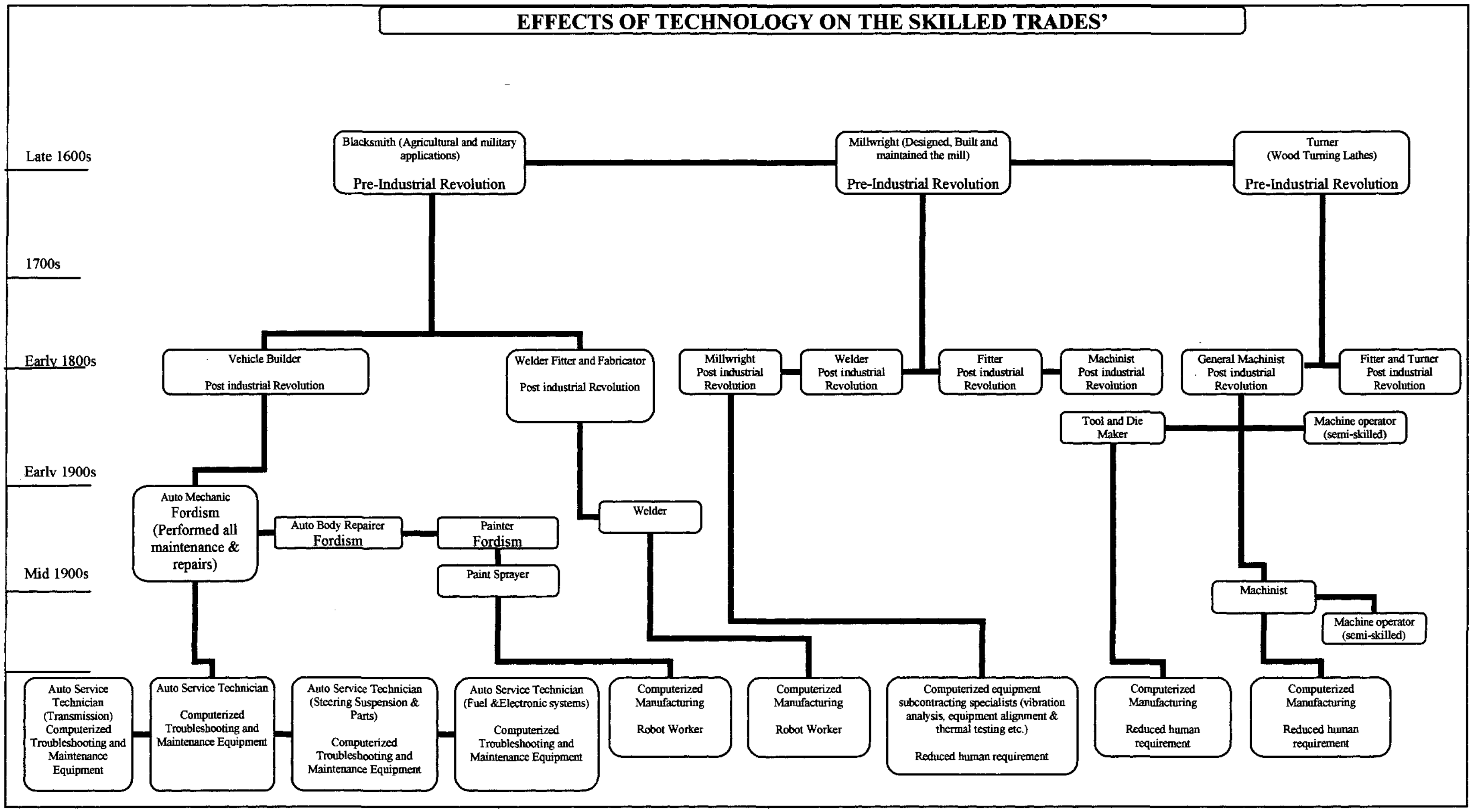


Figure 2 The effects of technology on the structure of skilled trades' over time

APPENDIX II: Origins of the lathe

Origins of the Lathe

- The sketch is based on stone carving circa 300 B.C. but artifacts dated circa 7th B.C. have been found which have marks consistent with having been turned.

Figure 3 Sketch of Egyptian Stone Carving

From MacGregor Historic Games http://historic games.com/lathes/treadle.html Date accessed: June 2005

APPENDIX III: Origins of the lathe

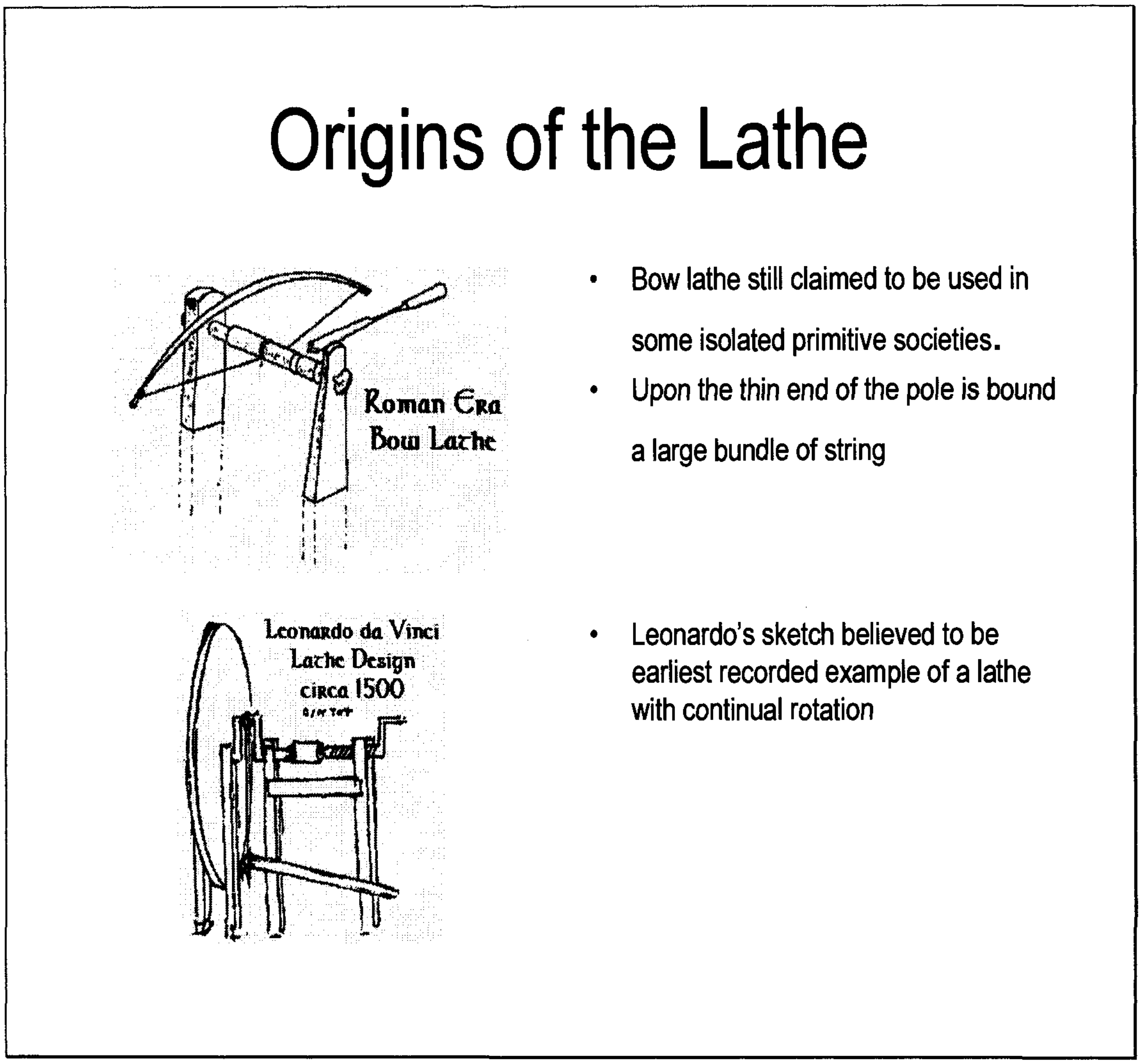
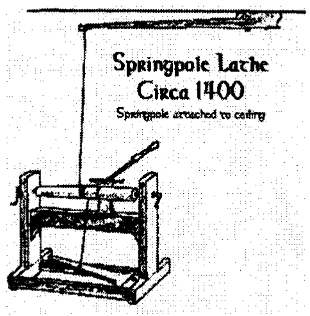


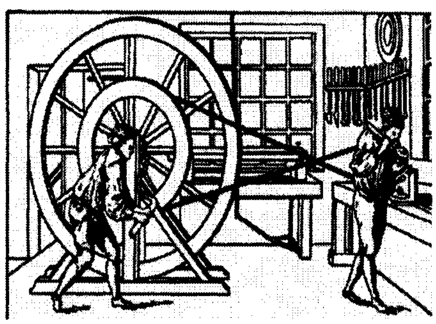
Figure 4 Roman Bow Lathe and Leonardo Sketch of a wheel lathe

From MacGregor Historic Games http://historic games.com/lathes/treadle.html Date accessed: June 2005

APPENDIX IV: Origins of the lathe

Origins of the Lathe





- The thick end of the pole was nailed to a timber in the ceiling of the room and the amount and diameter of the string varied to suit strength of the turner and the type of work being done i.e., light or heavy work (Moxon, 1703)
- *Mechanick Exercises or Doctrine of Handy-Works* in 1703
- The Great Wheel lathe was the next important refinement in lathe development. A large flywheel separate from the spindle of the lathe maintained a uniform speed and enabled the lathe to rotate in the same direction replacing the former lathes and a reciprocating motion (Moxon, 1703)

Figure 5 Springpole Lathe and The Great Wheel

From MacGregor Historic Games http://historic games.com/lathes/treadle.html
Date accessed: June 2005.

APPENDIX V: Apprentice interview questions

Interviews: Series of open-ended questions.

Interviewees: A cohort of skilled trades' personnel employed, and retired, from large, medium, and small manufacturing companies.

- Apprentices, preferably 2nd year
- Sample drawn from millwrights preferably with 15 - 25 years experience in their trade.
- Retired millwrights.

Apprentice:

1. How did you learn about the skilled trades?
    - 1.1.1. Was your decision to become a millwright influenced by careers' information from high school, or government information programmes for instance?
    - 1.1.2. Do the people who train you to do the respective tasks possess a C of A and/or a C of Q?
    - 1.1.3. How extensive do you consider their knowledge of the production process was?
    - 1.2. What hand tools do you use in the repair of machinery besides the basic hand tools like wrenches, screwdrivers and hammers etc., for example have you ever been shown how to blue and scrape in bearings, or the use of scrapers for the fitting of tapers, and bearing housings etc?
        - 1.2.1. Have you poured babits, or are plain bearing shells already preformed to fit without any adjustment being necessary?
    - 1.3. How often are you required to use your machining skills in order to make, or repair a part for a machine or piece of equipment?
    - 1.4. What equipment do you use for the levelling and alignment of machinery and equipment?
    - 1.5. How extensive are computerized production methods utilized for the production process in the plant?
        - 1.5.1. What computerized maintenance equipment have you been trained on, for example; maintenance management software, vibration analysis, laser alignment, thermal testing equipment etc?
        - 1.5.2. Have you received training and been given the opportunity to work on any PLCs, robots, CNCs or computerized maintenance management software?
    - 1.6. What do you think the prospects are for millwright trade and apprenticeship training in the future?

APPENDIX VI: Millwright interview questions

Millwright

2. How did you learn about the skilled trades, and what made you decide to become a millwright?
    - 2.1.1. Was your decision to become a millwright influenced by careers' information from high school, or government information programmes for instance?
    - 2.1.2. How long have you been in the trade?
  - 2.2. Do you have a C of A and a C of Q?
    - 2.2.1. Were the people who taught you the 'trade skills certified skilled trades' people?
    - 2.2.2. How extensive do you consider their knowledge of the production process was?
  - 2.3. How much discretion do you have, as a tradesman, over how the job is done regarding the tasks you are required to do?
    - 2.3.1. Has your control or discretion in making those decisions changed over the time you have been employed as a millwright?
    - 2.3.2. What are your responsibilities as a skilled trades' person when you supervise other people involved in the work process?
  - 2.4. What hand tools do you use in the repair of machinery besides the basic hand tools like wrenches, screwdrivers and hammers etc., for example the use of scrapers for the fitting of tapers, and scraping in bearings and bearing housings etc.?
    - 2.4.1. Have you poured babits, or are plain bearing shells already preformed to fit without any adjustment being necessary?
  - 2.5. How often are you required to use your machining skills in order to make, or repair a part for a machine or piece of equipment?
  - 2.6. Were you and other tradesmen asked, or expected to train apprentices?
  - 2.7. How extensive are computerized production methods utilized in the plant?
    - 2.7.1. Have you received training and been given the opportunity to work on any PLCs, robots or CNCs?
    - 2.7.2. Do you perform maintenance work on them, or are they the responsibility of specialized departments?
    - 2.7.3. What computerized maintenance equipment have you been trained on, for example; vibration analysis, laser alignment, thermal testing equipment, maintenance management software etc?
  - 2.8. How do you think technology has affected the work that a millwright is required to do now, compared to when you first became a tradesman?
    - 2.8.1. What do you think the prospects are for millwright trade and apprenticeship training in the future?

APPENDIX VII: Retired millwright interview questions

Retired millwright

3. How did you learn about the skilled trades and what made you decide to become a millwright?
    - 3.1.1. Was your decision to become a millwright influenced by careers' information from high school, or government information programmes for instance?
    - 3.1.2. How long were you in the trade?
  - 3.2. Do you have a C of A and a C of Q?
    - 3.2.1. Were the people who taught you the 'trade skills certified skilled trades' people?
    - 3.2.2. How extensive do you consider their knowledge of the production process was?
  - 3.3. How much discretion did you have, as a tradesman, over how the job is done regarding the tasks you were required to do?
    - 3.3.1. Did your control or discretion in making those decisions change over the time you were employed as a millwright?
    - 3.3.2. What were your responsibilities as a skilled trades' person when you supervised other people involved in the work process?
  - 3.4. What hand tools did you use in the repair of machinery besides the basic hand tools like wrenches, screwdrivers and hammers etc., for example the use of scrapers for the fitting of tapers, and scraping in bearings and bearing housings etc.?
    - 3.4.1. Did you pour babits, or was the plain bearing shells pre-formed to fit without any adjustment being necessary?
  - 3.5. Were you required to use machining skills in order to make, or repair parts for a machine or piece of equipment?
  - 3.6. Were you and other tradesmen asked or expected to train apprentices?
  - 3.7. How extensive were computerized production methods utilized in the plant?
    - 3.7.1. Did you receive training and given the opportunity to work on any PLCs, robots or CNCs?
    - 3.7.2. Did you perform maintenance work on them, or were they the responsibility of specialized departments?
    - 3.7.3. What computerized maintenance equipment have you been trained on, for example; vibration analysis, laser alignment, thermal testing equipment, maintenance management software, etc?
  - 3.8. How do you think technology has affected the work that a millwright is required to do now, compared to when you first became a tradesman?
    - 3.8.1. What do you think the prospects are for millwright trade and apprenticeship training in the future?

ENDNOTES

[1] The knowledge people have about the way they know their world (Davison & Neale, 1990, p. 15).

[2] The short term goals and the absence of ethical vision: Bad work holds no vision of work as an activity that concerns itself with long-term welfare of other human beings or all subsequent generations. Little effort is made in the workplace to cultivate the notion of the community war of human beings past, present, and future. That concept would negate tendencies such as Dynamic obsolescence, which serves as a symbol of bad work's alienation from human need. Management often labels concerns with long-term human and environmental questions as frivolous and unscientific; such concerns have no place in the company's quarterly of plans. Labor and teaching as well as ethical fragmented; workers see little connection between their work lives and the needs and concerns over the human community. Work is further separated from life (Kincheloe, J, 1999, p.72).

[3] An apprentice after completing several years of training would become a journeyman and qualified artisan who would produce what was judged a masterpiece and would be admitted to full membership of the guild as a master craftsman (Tausky, 1996, pp. 16-17).

[4] A worker learning new skills in addition to those already possessed to enable the worker to perform new tasks associated with the demands of technological development. For example, a millwright may learn how troubleshoot manufacturing production system with the use of PLCs where formerly a methodical inspection of each separate piece of equipment in the system would be required.

[5] Laser alignment devices operate utilising a laser beam directed to a 90° prism reflector that is directed back to a sending unit where a receiving transducer accepts the signal and converts it into an impulse for the calculator. The beam sensor detects up and down movement reading and measuring the offset angles when the beam is detected at one position (12:00) and then at a different position (6:00). The calculator determines offsets and angularity. An advantage of laser alignment equipment is that the operator is not required to read and record measurements, or perform the calculations thus eliminating the risk of human error. Corrective values for shimming the machine feet are displayed automatically in a computer display.

[6] Monitoring the vibration characteristics of an individual component in order the condition of the component to facilitate analysis for example, damaged gears, bearing, shafts, and fan blades etc.

[7] Today the coach maker's trade is virtually non-existent.

[8] Until the early 1900s, the majority of the production workers were skilled craftsmen.

[9] The process of preparing cotton and wool for spinning

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[10]The Blacksmith's trade is among the most ancient of the trades. In Greek mythology Hephaestus the god of fire, especially the blacksmith's fire, was the patron of all craftsmen.

[11] To join (metals) by applying heat, sometimes with pressure and sometimes with an intermediate or filler metal having a high melting point

[12] The earliest method of joining metals involved heating two pieces of metal until soft and pliable. When the pieces were hammered together, the metals were not melted but were joined by the pressure of the hammering.

[13] Resistance welding uses heat and pressure to join metal parts

[14] A technique for joining segments of metal rail or pipe in which segment aligned end to end are electronically charged, producing an electric arc that melts and welds the ends of the segments together (also called flash welding).

[15] Water was the only natural power source and wooden mil wheels were constructed to generate power for the mill

[16] The modern attempts at multi-skilling should not be compared to the high level of trade skills possessed by the original millwrights. In my experience, few tradespersons are highly skilled in skills that are not normally associated with their own trade.

[17] http://www.bbc.co.uk/history/historic_figures_john.shtml

[18] A bowstring wrapped round the spindle and operated in a reciprocal movement by an assistant supplied the power to turn the spindle.

[19] A Pole lathe was more powerful than a bow lathe and operated by a treadle mechanism allowing the operator to use both hands for the turning operation. There is speculation Pole lathes were used by the Iron Age Celts in England.

[20] James Watt is said to have made the first micrometer. However it was Ciceri Smith who patented the first digital micrometer in 1893 to make a micrometer that was easier for his employees to read (Rolt, 1929).

[21] To *setup* a machine is the positioning of stops to restrict the travel of the cutting tool to ensure the correct dimension of the profile will cut within tolerance. i.e., + or – n thousandths of an inch. The tool post is fixed to the saddle which is traversed along the bed of the lathe by the carriage driven by the leadscrew.

[22] Selective Laser Sintering (SLS) systems use heat from a laser to melt and fuse powdered materials into solid cross sections, layer by layer, until the desired parts are complete. (Krar, Gill & Smidt 2005 p.793)

[23] Rural electricians do not require the same length of training and are not qualified to do residential work.

[24] The Greeks called amber *electron* from which the word *electric* was derived.

[25] *Trade Knowledge* is gained from the apprentice working for extended periods of time within a community of qualified skilled trades' personnel. *Trade knowledge* is passed onto the apprentice when the apprentice becomes what Fuller and Unwin (1999) describe as a 'legitimate participant' and earns the confidence of the trade community.

[26] In-class instruction consists of three separate sessions of eight weeks in length that is required to complete the apprenticeship.

[27] I have heard of plants in the recent past where personnel do not complete their apprenticeship because of not being able to attend the mandatory in-class training.

[28] An employee temporararilly discharge from employment, due to the shortage of work.

[29] Cromwell in Britain allowed demobilized soldiers into protected trades without apprenticeship. "National legislation in 1647 and 1654 exempted from apprenticeship requirements those who had served the parliamentary cause" From: 'Early modern Chester 1550-1762: The civil war and interregnum, 1642-60', A History of the County of Chester: Volume 5 (I): The City of Chester: General History and Topography (2003), pp. 115-25. URL: http://www.british-history.ac.uk/report.asp?compid=19198. Date accessed: 23 August 2005.

[30] The Certificate of Qualification (C of Q) for millwrights did not exist when any of the retired millwright participants received their initial training, or were employed as millwright apprentices in the 1950s. Then the required certification was a Certification of Apprenticeship (C of A). Consequently, some of the older millwrights were *grandfathered in* to the trade. C of Q for the millwright trade was introduced in 1982 in Ontario.

[31] GM Delphi produces many of the parts and components previously made at plants in Flint and Saginaw in its "Componentes Mechnicos" plant in Matamoras. Delphi Automotive Services, in 1998 was Mexico's largest private employer.

[32] A Cut-to-length line, takes flat rolled steel or coiled steel, unrolls it, levels and cuts it to desired length sheet. Metal used for making the vehicle body panels.

[33] The Certificate of Apprenticeship certifies satisfactory completion of an apprenticeship programme. A Certificate of Qualification certifies satisfactory mark achieved in a Provincial Government, Ministry trade examination.

[34] After pouring Babbitt when making Babbitt bearings it is necessary to scrape the bearing surfaces smooth to conform to the matching journal.

[35] A person holding several trade licences have usually been grandfathered in to the particular trade rather than having served several separate apprenticeships. Another alternative is for a person to obtain testimony from an employer, or present sworn testimony that they have previous experience in the work. The experience was then awarded as time toward the relevant apprenticeship. In my experience, many believe this system is very open to abuse. Especially when companies that are owned or managed by family members or friends who provide testimony. This is the main reason that employers prefer a C of A plus a C of Q.

[36] Thermal growth is the change in the length of a particular metal resulting from the change in temperature of that metal. Typically, when a metal bar is heated, it will get longer. These changes can be very small (0.0005 in.) or they can be very large, depending on the length of the piece of metal and its coefficient of linear expansion.