DOCUMENTS

"More News from Nowhere:"

Utopian Notes of a Hamilton Machinist

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SKILLED LABOUR IS subject to cyclical fluctuations in supply and demand like any other commodity. In Canada it has never been possible to match supply with demand. In fact, the two seem always to be completely out of phase with one another. When there is a shortage of skilled labour, there is also a critical demand for skilled labour, and the government caves in to pressure to import skilled workers from abroad. Thus, the immediate demand is satisfied and there is no incentive to develop training programmes. When the next cyclical shortage occurs, there are no training facilities and no trainees. Consequently, there are more imports of skilled labour and the cycle repeats itself.

In this article I hope to track the skilled labour market conundrum by means of an unorthodox approach. Rather thaa asking,"why can't Canada train its own skilled labour force, why must it import skilled labour?" let us assume that Canada can train skilled workers and need not import them. Then the question becomes, "why are Canadian workers unable to learn critical skills on the job?"

The answer to that question lies in the way in which jobs are designed and work is organized on the shopfloor to inhibit learning. I make the assumption that learning on the job is the *sine qua non* of trades training. The hostility to learning in our shops and factories is a kind of industrial pathology that is strangling our economy.

The arguments presented in this paper are based on three years of work in large, unionized machine shops in Hamilton, Ontario. I went to work in Hamilton in 1977, partly from choice and partly out of necessity. Previous experience in the trade made it possible for me to get a job, but my skills were limited. I hoped to learn enough on the job to generalize my command of machine shop

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technology and to become a journeyman. On the surface, this is a reasonable expectation and one shared by most working people in Canada, who expect to be able to learn and grow in their jobs and to acquire higher levels of competency if they so desire. The realization that this was an illusion caused me to look more closely at the reasons why people do not learn on the job.

I

EVEN THE SIMPLEST job can be difficult to analyze. As an example of a simple job, I propose to look at the manufacturing of fishplates at shop C. A fishplate is a flat piece of steel used to support rails and was a staple of this shop. My job was to mill one side flat on a large vertical milling machine. There was nothing conceptually difficult about making a fishplate: the problem was simply to devise methods that would fit into the time constraints imposed by the planning department.

Underlying the apparent mechanical simplicity of the fishplate was a complex historical evolution. Railway fishplates were usually forged, but cheaper methods were adopted for other applications. Hot rolled plate could be sawed to length, milled flat, and then drilled for bolt holes. This initial form of the "machined" fishplate was subject to a number of subsequent changes in process technology.

The development of powerful hydraulic slitters led to them being slitted rather than sawed. (A slitter uses a large knife edge rather like a paper cutter to cut the steel.) Sawing left the rolled steel plate relatively flat, but slitting bends the ends out of shape and makes them ragged and irregular. With the development of powerful hydraulic punches, punching was substituted for drilling the holes. This further warped the plates and had the added disadvantage of leaving them covered with thick grease that was used to lubricate the punch dies as they forced their way through the metal.

Although quite a bit of time was probably saved by making fishplates with these innovations, some negative trade offs were incurred. To begin with, there was the twisting and distortion of the plates caused by shearing and punching. This was acceptable, however, in terms of North American engineering philosophy, because only one flat side was needed. As long as the last operation was a milling operation, a flat surface was guaranteed.

This kind of reasoning demonstrates the positive content of scientific management. Everything not absolutely necessary is discarded to make the machine work. If only one flat surface is required, then only one is machined. If bending and twisting do not interfere appreciably with the functioning of the machine, and if they accelerate or cheapen the process of making the machine, then they are acceptable. Here the tradition of scientific management cuts across the tradition of the skilled craft workers, which requires that everything be flat and square. The conflict between the craft workers and the engineers focuses on Frederick Winslow Taylor's fourth general step in the development of a "law" of production: "eliminate all false movements, slow movements, and useless movements." In this case the "useless" movements of straightening and milling have been eliminated.

The grease left on the plates, however, represents an example of the negative content of scientific management. At the end of an eight-hour shift, the operator is covered with it, and it increases the danger of dropping a plate on the operator's hands or feet. It could be cleaned off, but that would constitute a "useless movement" under the canons of modern production engineering. The only way the cleaning operation could be made "useful" would be if operators complained enough to force the company to do the cleaning.

In fact, the planning department finally agreed to add an operation in which the grease was washed off the plates in chlorothene. This complicated the situation by adding a health hazard, because the residual chlorothene was later burned by the milling cutters, along with residual grease, potentially forming phosgene gas. The likelihood of this happening was debated at length between the company and the newly formed union health and safety committee until a machine operator was killed in another shop by phosgene gas generated in a similar way.

The company then conceded the point, and the planning department added another operation in which the plates were steam cleaned and all residual grease and chlorothene removed. Since this operation had only been added under protest, it then had to be policed by the union safety committee. In practice, the steaming was often done incorrectly or even skipped entirely. Negative trade offs tend to generate a backlash against technological innovations. Production engineers often fail to anticipate the negative consequences of planned changes and only discover them afterwards. This is one reason why they are reluctant to compensate for them unless they are forced to. The compensatory operations did cut into the savings made by the new process. But even with the losses incurred through the washing operations, shearing and punching were still much more efficient than milling and drilling.

Two operations had been taken away from the machine shop, and two cleaning operations had been added, which were also performed outside the machine shop. Finally, even the remaining machine shop operations were transformed. The original milling method was to hold the fishplates one at a time in a vise especially designed for holding rough metal parts called a clamp-down vise (in shop slang, a rat-trap vise). Planning had allowed the operator four minutes to mill a fishplate by this method, and it was a well known secret among the operators in the shop that the job could be done in at least one-third of the time. Various mechanisms exist in any shop, however, that bring such matters to the attention of the planning department. Even in the context of an incentive programme there are limits to what an operator is expected to make. The payroll department does not like to make out big cheques for machine operators; when they do, the planning department is notified. Although the days have passed when the time study people would sneak down the aisles spying on the operators and looking for jobs on which they might be able to cut the time, the foreman and the foreman's friends still keep a jealous eye on any operator who is making "too much money." The planning department has informal sources of information that keep it informed on the current state of shop floor technology. In due course it may decide to note officially a job which has been paying particularly well, as finally happened in the case of fishplates in shop C. The contract specified that planning could only change the time on a job if they introduced some sort of technological change, but almost any change in method counts as a technological change. All they had to do was substitute a device that holds three fishplates for the old clamp-down vice that only held one. They chose a magnetic table, a common production device that could be used on a vertical mill with little or no imagination, and could hold three fishplates at a time. This enabled them to divide the four-minute-per-piece production time of the old method by three and come up with a new production time of 1.35 minutes. One sometimes wonders whether this sort of bureaucratic buffoonery is deserving of the name "planning" at all.

The new time of 1.35 minutes was the result of a magician's trick; a piece of pure number magic. There is no mechanical reason why milling three pieces in a magnetic table should take almost exactly one-third of the time it takes to mill one piece in a vice. To prove this, simply make a list of the different operations that go together to make a milling sequence. The material has to be lifted off a pallet and put on the magnetic table. The rough edges have to be filed off each piece. They have to be removed, stacked in a box, and painted with an anti-rust compound. The time required for these operations remains the same whether they are milled three at a time or not. The actual cutting time is only a portion of the time required to do the job, and only that portion should have been divided by three. The planning department obviously did not know the actual time required to do the job by the new method. Perhaps it would be more accurate to say that they did not care what the actual times were. The setting of the new time really was a political process concealed under a veneer of technology.

If a job is to be analyzed as a learning situation, then the important thing about it is the kind of experiences it generates. Some of these are the obvious ones that the designers of the job intend to be there; others are not so obvious or are not intended; and still others are the opposite of what was intended. Moreover, processes are continually being changed, and the experience of the process is constantly being modified. One of the experiential dimensions of work is the periodic change of the work process. We are not talking about major historical changes like the invention of the steam engine, which have macrotechnological effects. Rather we are concerned with small variations in method, such as the use of different work-holding devices, different tools, and so on. Viewed from this microtechnological perspective, industrial work becomes peculiarly plastic and malleable. It is whatever the worker chooses to make it at the moment, depending upon the tools and materials available. The structural fixedness of work is a bureaucratic overlay which serves to mystify work in the eyes of the workers and to make work susceptible to bureaucratic planning. This contradiction between what work actually is, and what it is socially defined to be, is at the root of the answer to the question "why don't Canadian workers learn skilled trades on the job?" What is learned on the job is knowledge of work as it actually is, but what is necessary for entry into the skilled trades is knowledge of the job as it is socially defined to be.

To return to our example of a simple job, the single most important feature of this job, and of all other jobs, is the time that it takes to do it. In practice, this time seems to exist independently of any method, machine, or system of tooling. Even if a job has never actually been done in the time allotted for it, that time is still the time for that job. If two different operators do the same job by two different methods in two different times (something that happens with alarming frequency in the real world), the time for the job is still the time printed on the work order. In the real world, job times have a kind of absolute quality that keeps them external to the actual work process itself. Within the context of managerial ideology, these job times are empirically established scientific constants. It is assumed, under Taylorist premises, that the planning and methods departments have "collected into one series the quickest and best movements as well as the best implements." Related to this concept of industrial organization is the assumption that there is such a thing as the "one best method," and that the supervisory personnel know what this method is. Within the conceptual framework of managerialism, job times tend to be rationalized as the time it takes a good worker to do the job using the best method. This is only meaningful, however, if there is an existing best worker and best method. In practice, both are often absent, and supervisors are forced to resort to the example of a retired or deceased operator who allegedly could make the time. These deceased or mythical workers become the patron saints of the shop: reviled during their working lifetimes, they are revered in their absence.

Besides obscuring the actual time required to produce anything in a real working environment, the bureaucratic simplification of work glosses over the psychological components of the work process. Anyone who has worked in a shop knows that the time required to do a job varies greatly from individual to individual, and that this variance is due, in large part, to skill or experience. Of course one can compensate for lack of skill by working at a more frenzied pace, but there are limits to what can be accomplished by working harder rather than "smarter." "Smarter" is a very important factor in determining actual production times.

Conventional work measurement tends to ignore the role of competency in production, or it makes grossly unreasonable assumptions about the cognitive content of work. Generally it is assumed that the cognitive content is nil, that threshold levels of competency are quickly reached, and that further increases in competency have no significant effect upon output. But clearly if one is interested in analyzing a job as a learning process, cognition and competency must be taken into account. How can we do this?

Even a simple job like milling fishplates will reveal a complex fine structure when properly analyzed. When I began working at shop C, I was immediately impressed with the complexity of the information used by the operators in that shop. After a while, it dawned on me that this information could be organized into Kuhnian paradigms. In effect there was no significant difference between scientific knowledge and working knowledge except in the wide degree of freedom allowed to scientists to play with their system versus the narrow restrictions placed upon workers while working.

II

MY FIRST DAY at shop C was terrifying. I had been hired as a vertical milling machine operator, and I had really never operated one of these machines before. I had steeled myself to bluff my way through it, but I felt nervous and jumpy. The foreman showed me around the shop. I was given a perfunctory lecture on safety, the purpose of which was to enable the company to weasel out of its responsibilities if I should ever be injured. Then I was introduced to Bill who was to be responsible for breaking me in on the verticals. For once, luck was with me. Bill was the kind of machinist who keeps a company going in spite of itself. Intelligent, critical, and conscientious, he was also a gifted teacher who knew how to make an on-the-spot assessment of your difficulties and how to provide the missing concepts or pieces of information. He was also very patient and stood up well under my endless barrage of questions.

Shop C depended upon the time honoured system of "old hands teach new." They were using this system even though the union was supporting an informal policy of refusing to train unless a training allowance was paid. This made sense from the point of view of business unionism, the kind most commonly practised in Hamilton, but made no sense from any other point of view. For one thing, it tended to turn the newer workers against the older. Imagine being brought into the shop by the foreman, and introduced to the person who is responsible for teaching you your new job. You shake hands, everyone smiles, the foreman leaves, and your teacher turns around and tells you that you aren't going to be shown anything. Who is the victim? The company?

The entrance to a skilled trade bristles with barriers, and the passage appears virtually impossible. Most people drop out somewhere along the way. The cumulative effect of these dropouts is a critical shortage of skilled labourers. At least I managed to make it over the first hurdle. There were others who were not so fortunate. The company hired a number of women graduates from a Mohawk College machine shop course shortly after they hired me. Of these, two were lucky enough to get teachers who were willing to teach them. The third was assigned to a numerically controlled mill/drill, and the men working there refused to train her on the grounds that: 1) the union would not let them;

2) women should not work in machine shops anyway; and 3) the company was trying to replace men with low-paid women workers.

This situation rapidly evolved into a perverse comedy. The company was able to demonstrate its eager compliance with the new human rights legislation while shifting the blame for its failure to integrate women into the shop onto the union. The union, caught with its pants down, was not even aware of the fact, and continued to mouth the most vulgar chauvinist arguments in defence of an indefensible position. The victim of the process, remarkably, sided with the union and told the company that she refused to be trained. The shop was treated to the spectacle of a deadlock in which a trainee spent the whole day wandering around cultivating an active social life for eight hours a day. It later appeared that the company had only managed to win training for one of the other women by promising a steady day shift to her trainer. This was an illegal agreement — it meant, in effect, that the company had agreed that the trainee would work steady afternoons, a violation of the contract — which later exploded.

The moral of the story was that any attempt at training in shop C touched off the acquisitive instincts of everyone concerned. Training was a commodity to be withheld from the market until the price was right. This incident alone should have warned me that there were many irrational forces operating in the shop.

I was prepared for the possibility that the people I would be working with might refuse to train me. I had already run up against such a refusal in shop A, before I had been able to formulate my research clearly. That company had an explicit policy of not training anyone, especially if they were Canadian. This policy was applied with an irrational consistency that probably had something to do with the plant manager, who was manifestly crazy. One day, the main crane in the transfer bay at shop A broke down and was being repaired by some maintenance electricians. They were under a lot of pressure, because 30 or 40 fitters were standing around waiting for them to finish. In the midst of this chaos, someone wandered up to the electricians and asked them to fix an extension cord. Naturally, they refused, and in a few minutes they were called into the office of the plant manager.

"Why didn't you honour my signature?" he screamed, waving the work order for the extension cord in their faces. "You must learn to honour my signature."

The electricians immediately tackled the problem of the extension cord. Predictably, the extension cord proved to be a very complex and difficult task and it was some time before they were able to get back to work on the crane.

On another occasion, this same plant manager was walking down an aisle when a young slinger dropped a bundle of scaffolding at his feet from a height of ten or twelve feet. He immediately began to scream at the slinger, telling him he was suspended for three days. Of course, he was badly frightened. All plant managers probably harbour dark fantasies of being assassinated by their employees. All the noise and commotion brought the shop steward over on the double and he explained that the man could not be suspended because it was the responsibility of the company to train the man properly and they had obviously not done so. This was in the days before the new Ontario health and safety legislation had become law, and shop A was in the top ten on the accident charts. The manager was temporarily at a loss for words, but he quickly recovered, turned to the slinger and said, "You are still suspended for three days, with pay."

Thus craziness starts at the top and works its way down, subtly diffusing itself throughout the entire organization. While working at shop A, I made friends with Gord, a Scottish machinist who had served his time on the Clyde and had come over to Hamilton in the early 1970s. Gord had worked all over England and Scotland and in most of the major shops in Hamilton. He takes his trade seriously and is proud of his skill. But even Gord does not know everything. Gord had started working at shop A just before I had left. At that time there was a Scottish foreman in the machine shop that was almost as crazy as the plant manager. He assigned Gord to work on a lathe which had a tracer attachment that Gord had never seen before. Gord told the foreman that he would need some time to familiarize himself with the attachment and asked if there was anyone in the shop who could show him how it worked. He was promptly told that this would be a violation of the company policy against training anyone. Gord would long ago have been a foreman himself were it not for his inability to suffer fools gladly. He began to hurl verbal abuse at the foreman who retreated into the manager's office and emerged some time later to announce that the rules would be suspended in Gord's case and that he would be given fifteen minutes' training time. As far as I know, Gord was the only person ever to crack the training policy at shop A, and that was due in part to his education in the British labour movement where he had served as a shop steward.

My own experience with the no-training policy at shop A was very painful. While I was working on the fitting floor I was attracted to an enormous planer mill in the adjoining machine shop. I think it was love at first sight. This machine was so large that the operator stood on the table and rode back and forth on it as it worked. It was easily the largest machine tool that I had ever seen, and it was old. It dated back to World War I at least. This appealed to me as a historian. It was the only machine for me, but what was I to do? I did not know how to run a planer, and the company would not train. I kept my eye on it for a while, and I learned that the company was having a difficult time finding operators for it. For a while I toyed with the idea of approaching them on the question of training and offering to develop a training programme for them that would enable them to move untrained people onto the machine with a minimum of anguish. I later discarded this idea as unlikely to succeed, but it did set me to thinking seriously about on-the-job training methods. For the first time I began to think about the specific skills that enable an inexperienced person to move into a new job without disrupting production, and I also began to get a dim vision of how the lack of these skills acts as a barrier to the mobility of labour. There was nothing theoretical about this: I was personally confronted with barriers.

It occurred to me at this time that it would be possible to devise small-scale training modules to break down the barriers to a specific work centre. The method employed would be participant-observation — a kind of combination of industrial ethnography and oral history. I also began to wonder whether or not the historical method might actually have some practical application in this case. An investigator, myself naturally, could be employed at the work centre in a training capacity and would learn as much about the run of work in that centre as he could in six months or so. After that he could sit down with the methods department and work out a short training manual for the run of jobs on that particular machine. A second person would be hired and the investigator would then act as instructor. The idea would be to design a training system that would fit into the standard "old teaches new" methods that are used almost everywhere. The manual and training methods would enable each subsequent operator to become an instructor when necessary.

One of the problems with designing modules for the use of a worker/instructor is that it may conflict with the collective agreement. Training functions are not usually part of the job description of manual workers, however skilled, though they are often called upon to do it. There is a growing resistance to this on the part of skilled workers who want to be paid for training, and they are right to resist. Formally transferring training functions to the labour force also makes a tiny dent in the managements' rights clause of the average collective agreement, and this is always resisted by management, as is anything that involves a transfer of functions across boundaries. It is easier to import a skilled operator from Europe.

This method of constructing a training model was particularly intriguing to me because it entailed retrieving information from an informant using methods similar to those used in oral history. Gradually, as I toyed with this hypothetical training method during working hours, it became clear to me that the labour force in shop A constituted an important reservoir of technical information vital to the running of the shop — especially because there were many craft workers who had served their apprenticeships there and worked there all their lives — and that the methods of historical analysis would be a useful way to collect and to organize this information.

While thinking about the old planer mill in shop A, I had a first, dim vision of what industrial sociologists were beginning to define as a working knowledge paradigm — a body of ideas existing in the heads of the labour force that governs the outcome of work. But I saw it only through a glass darkly. I had many things to learn.

I decided to talk my way onto the planer by lying about my qualifications. The next time the job was posted, I put in an application claiming that I had prior experience operating a planer and managed to convince the foreman to move me to the machine shop. Right away I found myself in trouble. The current operator, a very skilled Scottish immigrant, told me that he would not teach me anything but I was welcome to watch and learn what I could. At first this seemed reasonable to me in my innocence, and it enabled my partner to masquerade as a human being when in fact he was a first class bastard. The problem was that the machine was so archaic that it did not follow any mechanical principles recognizable to my generation. My partner had the advantage of having been trained on obsolete equipment in the United Kingdom. The feeds and speeds on the machine were changed by opening a gear box, taking out one gear and putting in another. Sometimes a combination of several gears had to be changed, and a pin had to be moved from one shaft to another. All this gearing has been superseded by modern hydraulic feeding mechanisms, but this machine was very old. Hardly anyone in the shop knew how to run it other than my partner, who was a planer specialist, and he refused to tell me anything. There was no one I could ask. The company could probably have persuaded him to show me how it worked, but they had a no-training policy. To make matters worse, we were put on two shifts, days and nights. Even when I know what I am doing, night shift has never been my best. One night, I was planing the top of a large steel weldment, when I noticed that the machine had stopped feeding. The tool simply went back and forth over the same spot instead of moving over a little and cutting off some more metal. I stopped the machine and opened the gear box. By watching the gears I could see that, for some reason, the shaft that moved the cutter was not turning, but I could not figure out why not. I took it apart and put it back together several times, to no avail. I began to panic. I had to have some work done by morning or they would realize that I did not know how to run the machine. I began to panic. I began to feed it across by hand, using the crank to jog the tool over another fraction of an inch after each cut. Suddenly there was a loud metallic crunch. The piece that I was machining, which weighed several tons, moved several inches down the table. I pushed the red panic button. The machine died and came to a complete halt, while I stood there shaking with fear and shame.

After surveying the damage, I realized that I had somehow snapped a two-inch tool holder in half and moved the piece out of its set-up. I reset the job, took out the broken tool holder, and replaced it with a new one. The next morning I told the foreman that I could not run the planer. I expected to be fired, but he took it relatively calmly. After turning red in the face and gesturing to the divine creator of the universe for moral strength, he asked me if I could run a horizontal milling machine. I lied and said that I could, and he moved me onto a Cincinnati horizontal milling machine. Once again, the person responsible for breaking me in told me that he would not teach me anything. I cannot remember ever having encountered a run of bastards like those I found at shop A.

They were as thick as blueberries. Unlike the company, this person had a very good reason for his own personal no-training policy. He wanted to be paid a lead-hand rate. The company had refused to give it to him and so he was refusing to train anyone. I could only grope my way into milling blindfolded. All of my previous experiences had been on lathes and grinders. I managed to make much better progress on the horizontal mill than I had on the planer. I managed to figure out some set-ups and thread my way through the basic tooling, but eventually I ran into trouble doing the simplest job. I was given some rough blocks of steel that had been flame cut out of solid plate and I was supposed to make them square. Like most operations this one is simple once you know the "trick," but I did not know it. This problem is written up in most standard textbooks on machining, but I blush to admit that I did not even bother to look it up. The result was another ignominious defeat.

This time, however, I was more tactically subtle. I had come to realize that it was impossible for the foreman of the machine shop to admit that he had made a mistake by taking me on: something he would have to do if he wanted to get rid of me. This gave me bargaining strength if I was willing to brazen it out, and I was. The foreman took me aside one day and pointed out to me, gesturing to the divine creator again, that I had produced about 80 hours worth of scrap. I agreed with him. He asked me how it happened. I explained that no one was willing to show me anything. He pointed out that I was already supposed to know how to run the machine. I explained that I did, sort of, but that there were some jobs that were beyond me. *In fact, almost all the jobs were beyond me.* After a prolonged period of negotiations, I was put on a large drill press and remained there for the rest of my time at shop A.

Every shop bristles with barriers to learning. Newer workers are not instructed, or are deliberately misinstructed, or pick up bad habits because of the chaotic, unplanned, and constipated systems of training. Any system of production generates further reciprocal barriers that make change difficlt. The labour force throws up barriers to new technology. New technologies create barriers that limit the movement of labour into certain types of productive activity.

The need to readjust one's perceptions is a barrier that requires some sort of training programme to overcome. It is perhaps the most important of all barriers. Because of it, no one can come directly from the world of ordinary experience and begin to do machining without an adjustment period.

Everything in the process of machining constitutes a barrier to the entry of unskilled labour. The visual storage of information in blueprints requires some training before the information can be accurately retrieved. The specialized measuring instruments require training before they can be used accurately. The machines themselves create barriers. The controls are not always intuitively obvious and differ from one make to another of the same type of machine. There is no such thing as standardization of controls in machine tools, although the use of the console format for controls may go a long way towards solving this problem. Consoles reduce machine operations to button-pushing operations. Consoles can help workers make links with common cultural devices like typewriter keyboards and push-button telephones, and could make it easier to incorporate non-specialized categories of labour like office workers into non-traditional careers.

Some of these barriers can be overcome in the classroom environment of a community college. Shop math and blueprint reading can be taught. Some of the initial shyness attendant upon first operating a machine tool can be overcome operating an engine lathe or a milling machine in a college shop. But the full significance of these things can never be understood until the students begin to understand what it is that they do not know. Only then can the restructuring of perceptions and the painful mastering of a myriad of specific details begin.

Not all barriers relate to the individual trying to learn the trade. Some barriers are created by other workers in the shop. As I have explained, machinists frequently refuse to teach a new person anything. They hide tools and fixtures. They set booby traps on the machine so that the new person will make a mistake and scrap the job or wreck the machine. All this is part of the initiation that most new machinists experience in this country, where they do not have the benefit of formal on-the-job training programmes. Usually a new person only survives if lucky enough to find an ally in the shop, usually an older machinist who is willing to act as a teacher. Failing this, the prospects are pretty grim.

When I began to work in shop C, I was painfully aware of some of the barriers to learning a trade on the job, although I did not yet realize the full extent to which industrial behaviour has become pathological. I was therefore greatly relieved when I found out that Bill was willing to train me, and I had at least a few hours of vertical milling under my belt. My first job was a simple one. I was given a casting, and I had to mill some flat spots on it. There was a fixture that made it even simpler. This was the first shop that I had ever worked in that had so many jigs and fixtures. A fixture is simply a device for holding a particular part of a particular machine while it is being machined. Many parts have odd shapes and are difficult to hold down tightly. Much of the skill of the late nineteenth-century machinist was invested in knowing how to hold an odd shape so that it could be safely machined. Fixtures and jigs were obvious ways of bypassing that particular skill component. Thus the problem that had so often baffled me on the milling machines in shop A was now resolved by the engineering at shop C. A technical barrier to my entry into the shop had been removed.

But as so often happens, when technological changes are introduced, one problem is removed and others replace it. Old skill components were removed, but new ones were required. The introduction of jigs and fixtures into shop C had greatly accelerated the pace of the work, as intended. Working at this increased pace produced its own problems, as I discovered as I moved on to my next job.

I was given 100 large steel plates to clamp in a vice and mill flat on one side. The pieces were flame cut, and the edges were ragged, and it took me a while to learn how to hold them securely in the vise. Once I had solved that problem, I began to speed the machine up in order to make time on the job, but then I began to lose my finish. One of the technical specifications governing the work of a machinist is the finish, or the kind of surface left after machining. A numerical scale has been devised for designating different types of finish and is always specified on machining drawings when it is important. There is a direct relationship between the quality of the finish and the speed at which a part can be made. Tighter tolerances mean slower speed of work and vice versa. As the machinist increases the feed of the machine, the finish becomes progressively coarser. Milling machine operators are especially plagued by this.

As I began to cut the plates at full speed, I found that I could get the required finish by speeding up the RPM of the cutter, but that in doing this I also burned out the inserts in the cutter after only a few passes and it took about a half an hour to change all the inserts. I was back to square one. Finally Bill showed me the way out of this dilemma. The trick was to make a couple of cuts with the spindle running at high speeds and then slow it way down to about 250 RPM. The problem was that the cutters were so old, so worn, and so banged up that the inserts did not all sit at the same level. A difference of a few thousandths of an inch in the height of one insert could leave a groove that would ruin the finish. By making a few cuts at high RPMs, the high inserts were worn down to the level of the rest of the cutters, and the result was a smooth finish. This was an ingenious non-textbook solution to the problem and it was also time-efficient, because it is a laborious process to set all inserts so that they are running true.

Here was an example of an informal method. It was not in the standard literature. It was not known to the supervision, or to the methods or engineering departments, and yet it was an essential step in getting the work done within the time limits provided. There was a history to this problem that I managed to unravel while I worked at shop C. Originally there had been a specialist that had maintained the cutters and fitted the inserts so that they would cut evenly. This was good scientific management. The operator was not required to know how to change inserts and repair cutters. Another job was designed to take care of these functions.

All the operator had to do was to go to the tool room, turn in the old cutter, and get a new one. But systems of internal accounting were refined. The machine shop was required to demonstrate that it generated a profit. In other words, it was required to keep books that would show whether or not outputs exceed inputs. Of course, the definition of input and output is somewhat arbitrary. Maintaining cutters was defined as an input, that is, as a cost to the machine shop. A job that had been defined by the methods of scientific management to be a technically valid specialty, had now been redefined by scientific accounting as an economic drain on the shop. Gradually and surreptitiously, it was shunted aside. The layout worker was given the additional task of maintaining the cutters. When it became apparent that this involved more work than one worker could comfortably do, the maintenance was simply stopped. The job became a task that existed on paper but was not performed in practice. If an operator wanted a cutter, the wait became longer and longer. Shop C was a piece work shop and the last thing the operators wanted to do was wait. Operators began to devise ways of getting around the cutter maintenance task. These bypass techniques became part of the informal technology of the shop. This may seem like a rational solution to the problem, but note the cost of maintaining the cutters is still there. It now appears as excessive use of inserts worth about $10.00 each. Every time I brought back a handful of worn out inserts, the layout worker (who was responsible for cutter maintenance) would put on a little act. "What are you doing to these things, don't you know they cost ten dollars apiece?" "Oh," I answered. He knew perfectly well what was going on, but he felt constrained to keep up appearances. A lot of social energy in a shop goes into maintaining the appearance of rationality.

The real rationality was derived from the logic of various subgroups. It was rational for the operators to use this expensive bypass technology because it enable them to make bonus. It was rational for shop supervision to countenance it because it made their internal accounts look good. Occasionally they would get complaints about excessive consumption of inserts, but this was not considered as bad as hiring an extra person to maintain the cutters. The usual response was to cut back on the supply of inserts, and then go back to normal after the heat was off.

The purpose of a cost-accounting system is to provide a detailed quantitative account of all transactions between departments. The effect of informal work methods is to bury some of these transactions. At shop C informal methods were often used to bury transactions that could not stand scrutiny by the accounting and production departments. This was particularly ironic because the company had just invested in an expensive computerized data-processing system to enable it to rationalize its managerial accounting.

When I later came to understand these phenomena in greater detail, it became apparent that much of the informal technology in the shop was of this type. That is, it was intended to bypass irrationalities in the formal design of the work system. The operators did not think it possible or useful to explain the problem to management. They simply devised ad hoc solutions which they kept to themselves. Supervisors, vaguely aware of these methods, refer to them as "tricks of the trade." Such a managerial view amounts to saying that these solutions are not really knowledge, but some sort of cunning response on the part of semi-rational machine operators. The only problem is that the shop fails without these "tricks."

Foremen know things too, especially foremen who have worked at the trade. But their knowledge is of a different order unless they have actually done that specific job on that specific machine. The probability of this occurring is very low.

Not much thought, therefore, is given to the general principles governing the contribution made to work by workers. Changes in technique introduced by labour are "small" changes. Workers function as a subgroup in a large, hierarchically structured corporation. Each subgroup has its own set of production techniques and these are hierarchically ordered.

Some kinds of knowledge are considered "higher" or more important than others. At the top of the heap is the so-called pure science. On the next level lies the information pertaining to engineering. Below this is the knowledge supposed to be in the possession of the journied worker. This consists of the standard shop practice of the textbooks and the generic skills set out in the occupational analyses of the trades published by Canada Employment and Immigration. There is a lower level of technical skill however, namely, specialist skills. These are the skills pertaining to the use of specialized tools and machines that are often encountered in the average run of work. At the bottom lies the residuum of working knowledge that pertains to specific jobs on specific machines in specific shops. Only the top two layers of this hierarchy are described in the technical literature. The lower two remain almost totally undocumented.

Let us consider a specific example from each category. The engineering technology that lies near the top of the pyramid is mostly embodied in tooling (which includes jigs and fixtures) and machinery. In the example that we have been discussing, the engineering component would be the vise, the cutter, the inserts, the machine, and so on. The engineering components that are most specific to this job of milling plates, however, are embodied in the clamp-down vise. Tooling engineers operate within the framework of a trade off between equipment costs and labour costs. Every tool has to justify its existence by a reduction in labour inputs greater than the cost of the tool. In the case of a vise, the savings are realized in terms of reduced set-up and clamping time, and increased safety during cutting. This means that the vise can be mounted more rapidly than another set-up devise, that the piece can be clamped more rapidly, and cut at higher feeds and speeds. All of these conditions rest upon the assumption that the operator knows how to use the vise efficiently.

Any hierarchy must be integrated in order to function. Unless there are links between the top and the bottom, the ideas flowing from the top will not be put into practice. This often happens in modern industry. If a vise is used by someone who does not understand the ideas embodied in its design, it will not have an effect on work methods and will not reduce cost. Modern society's view of industrial production is very strongly focused on the top of the hierarchy of technical knowledge. As a consequence, the bottom tends to slip out of focus. In practice, no one really knows how a particular task is performed except the person who performs it. There is no control exerted on methods, and the methodology of the shop as a whole experiences a kind of random drift.

Returning to our discussion of the clamp-down vise as an example of embodied engineering technology, the next question to be asked is whether or not there is a discussion of this device in the engineering literature. The answer is no. It is too specialized a device to deserve mention even in a standard text on tool design. The only sources of information are manufacturers' catalogues and instruction booklets, and these sources of information are seldom found on the shopfloor.

Neither the engineering literature, nor the shop literature intended for the training of journied workers contain sufficient information to enable a person to use the clamp-down vice intelligently. Where then does this information come from? It comes from the shopfloor where it is stored and passed on to new workers. It is part of the working knowledge of the shop, but is of a sufficiently general nature that it might be shared by more than one shop.

The function of working knowledge is to solve problems that crop up on the job. It usually takes the form of statements like, "if this happens, then do this. . . ." Working knowledge can be thought of as a large set of instructions in the form of if-then statements. Some of these statements are more general than others, and there is a longstanding trend in Canadian society to order them hierarchically, and make them the specific property of different occupational groups, called "professions," when they are found towards the top. We have even given names to some parts of this hierarchy of knowledge; science and engineering are names applied to the upper parts of the hierarchy; not much thought has been given to the lower parts of the hierarchy and, consequently, we have no names for the different parts of it. American industrial sociologist Ken Kusterer has proposed the term "working knowledge" for the lower levels of this hierarchy.

At the bottom of the hierarchy of knowledge lies the information that is limited in scope to a few runs of jobs that are performed by a single machine. This information has been traditionally entrusted to the machine operators because there is too much of it, and it is too unwieldy to be handled by traditional methods of information processing — punchcards, shop manuals, work orders, and so on. Modern word processing and data processing technologies raise the question of whether it is now possible to organize all these specialized and specific bits of information into a centrally controlled system. If the answer is yes, then we can readily predict the demise of the industrial worker as a cognitive agent. The old programme of scientific management would at last become an accomplished fact rather than a crude approximation. This is why the use of robots, process computers, and numerically controlled machines is so potentially explosive.

The actual potential of the new cyberneticized factory has yet to be assessed. What are its social effects? Can human labourers be reduced to robot accessories? Can the old dream of labour as the passive, compliant agent of capital be realized by this means? Clearly the real power of the new technology lies in its capacity to give management greater control over the cognitive content of work. It promises to enable the manager to determine, by means of a tape or a disc, a detailed sequence of minute operations under exactly measured conditions, thereby eliminating any residual decision-making powers accruing to labour. Whether or not this will be successful remains to be seen.

Some idea of the potential of the cyberneticized factory can be gained from a study of the impact of older techniques of scientific management upon working knowledge, and especially upon the bottom levels of working knowledge. This in turn, will enable us to understand the historical evolution of on-the-job learning (as opposed to on-the-job training) and shed light upon the current obstacles to expanding labour force skills.

III

AS AN EXAMPLE of the bottom level of shopfloor knowledge I would like to look at the way in which Bill, a fellow machine operator, taught me how to wear in cutter inserts in order to get a proper finish.

This technique is shop-scientific because it is a response to systems breakdown in shop C. The worker's solution to the breakdown was to develop a technical alternative. The foremen in the shop had responded within the paradigm of scientific management, by dropping the finish specification. I learned this when, after working at shop C for several months, I approached one of the foremen and asked to use the large sixteen-inch cutter to do the fishplates. I wanted to do this because the job had been timed with this cutter and I wanted to see what kind of savings in time would result from using a larger cutter. The foreman did not want me to do this because it would require putting 40 $10.00 inserts into an empty cutter. In other words, it would cost him $400.00 on his internal accounts. We argued. I pointed out that I could get more done with the bigger cutter. He was not impressed. Finally I pointed out that the smaller cutter was ruining the finish, because the back edge dragged across the piece and left a series of circular gouges. (I neglected to point out that I had a method for overcoming this.) "Don't worry about the finish," he said, "just get them flat," thereby cancelling the finish requirement on the drawing. Of course, he would never do this formally, but it is the informal practice that always prevails in a shop.

In fact, there was not only a fragmented hierarchy of knowledge operating in shop C, there was also a set of antagonistic paradigms operating at the lowest levels of the hierarchy. This antagonism was most sharply focused around the interplay between methods, quality control, and production times. This is the traditional battlefield where the different segments of a bureaucratized, industrial corporation struggle for hegemony, and the struggle reinforces mutually opposed knowledge paradigms. There is, to begin with, the engineering/planning paradigm that assumes the existence of a body of standardized methods with standardized times and a tightly organized top-down chain of command. People functioning in this paradigm assume that the jobs are planned and described at the top and executed at the bottom. No antagonisms exist, or, if they do, they are "irrational" or symptomatic of temporary breakdowns in the system. The engineering/planning paradigm is mediated by the supervisory paradigm which is a repository of many vestigial concepts of the old scientific management ideology. It is obsessed with the importance of the mythical "one best method," constantly searching for "unnecessary" operations and eliminating them and guarding with paranoid diligence against the "soldiering" of the labour force. But the supervisory paradigm is mediated in turn by the working knowledge paradigm. In this cognitive limbo, the other paradigms are assumed to be idealistic and unworkable, science is in disrepute and a great emphasis is placed on common sense. The management system is perceived to be irrational and in a permanent state of chaos.

As we have seen, hierarchical knowledge systems tend to place the most general forms of knowledge at the top. One could conceive of other systems that might order knowledge differently. In a factory, general technical knowledge occupies the top of the formal knowledge hierarchy and this allows management to exercise centralized control over the process of production. The corporation becomes a kind of crude social computer in which hierarchical relations are part of the "grammar" of organizational behaviour and determine the order in which operations are performed — that is, planning takes place before work, and so on.

In our hypothetical, cyberneticized factory, all these hierarchies would be strictly integrated. The worker would tend the machine, the supervisor would supervise (that is, make sure the worker did not spend too much time in the cafeteria), the planners would plan, payroll would make out cheques, and so on. The problem of the cutter inserts would not arise. The instructions would be given directly to the machine, there would be no possibility of their being lost while while being passed across contradictions from one paradigm to another, or would there? A closer look at the interactions between hierarchies, paradigms, and subgroups in the old scientifically-managed production shops may help to answer this question.

In a production shop, workers and machines tend to operate at their limits, and problems are resolved pragmatically and informally, often overriding the determinations of the hierarchy. The pace at which work proceeds is subject to a formal system of calculations. A fishplate had to be milled in less than 1.35 minutes before any bonus could be made. This meant feeding the table past the cutter at about twenty feet per minute. But in order to make any significant amount of bonus, the job had to be run much faster. In addition to bonus, there was also fool-around time to be figured into the equation — time to attend to one's bodily functions, to get coffee and drink it, to go and talk to one's friends, or just to sit and think. These breaks are important to the proper functioning of the human organism, but in an incentive shop they have to be earned. Everything must be running smoothly and you must be well ahead or you cannot even afford to take a piss.

I found out through experience that one generally had to be able to produce at twice the rate set formally by the methods department in order to make out comfortably. The incredible speed at which one had to operate posed technical problems in its own right, and naturally these problems had only informal solutions because, formally, we were not supposed to be working at these rates. I gradually worked the feed on my table up to 42 feet per minute, more than twice the rate specified by methods. But I ran into problems. The most disconcerting one was that the cutters would occasionally gouge into a plate and throw it out of the magnetic table. This also bothered my friend Bill whose work station was potentially in the path of the flying fishplates. But Bill was not willing to help me solve this problem because my production was getting too high. He did not sympathize with my desire to bank time in order to walk around and talk. He belonged to the old school that thought that workers should fake being busy by slowing down and pretending to work even when they were not. Besides, like most older, experienced machinists, he had a fear that younger workers would come into the plant, learn the job, and then kill it by turning in too many pieces. Consequently, speed skills are taught even less often than are the more basic skills. After a period of observation, I learned that the plates had been twisted by slitting and punching until they had a concave and a convex side, and that they tended to fly off the table if the convex side were put down. Thereafter I was very careful always to put them on the table concave side down; it was a simple solution to a problem that was made difficult only by the fact that it was not formally recognized as existing. Eventually I also collected a set of small steel bars that I used to wedge the plates in along the edge of the table. This Rube Goldberg arrangement held them securely and I was able to cut them with impunity at incredible speed. I had become a fishplate specialist.

The specialists in modern North American industry are the counterparts to the European skilled trades workers. By definition, the specialist is adapted to a particular, well defined niche in the process of production. If removed from that niche, or if the process is changed, the specialist is no longer functional. The trades worker, being a generalist, is more useful in fluid, partially defined conditions. We shall see later that the relative importance of trades workers and specialists depends in large measure on where in time they are located on a product cycle. But before broaching this question, I would like to argue that once industry initiates the use of specialists, it unintentionally generates systems of social interactions that automatically preclude the development of generalist work patterns. The behaviour patterns built into any technical process are so poorly understood that I will try to illustrate some of them in detail.

Being a specialist in a job means being locked into the job. In an incentive shop like shop C, it also means making bonus. As the operator refines a specialty, full bonus begins to be made, and this helps the worker to internalize and identify with the specialty, which is simultaneously becoming a prison. But making full bonus arouses the jealousy of other workers who have been gradually socialized by the incentive system to relate to an extra 50¢ an hour like a starved piranha to a piece of meat. Incentive systems bring out the absolute worst in people. The problem is exacerbated by the fact that there are floaters in the shop — people who do not yet have a permanent machine or a specialty, and who therefore have a hard time making bonus. These floaters function as a kind of reserve army from which newer operators can be drawn and assigned to work with an established incentive worker. There are two reasons why established incentive workers do not like to have other workers put on their machines with them: first, it means that they have to work shifts; and second, it means that they have to share the gravy with their partners, or "mates" as they are called by immigrants from the United Kingdom. The gravy consists of the jobs that are so badly timed that an operator can actually make some bonus from them. Most operators run off the gravy jobs as fast as they can, bank the time, and then use it to cover the time they lose on jobs that have times that are impossible to make. Most jobs are impossible, but floor supervision usually manages to save a few from the ravages of the time study people, and parcel these out so that each machine routinely gets one or two of them in a month. The informal expectation is that the operators will squeeze the last ounce of gravy out of these jobs and use it to cover all the garbage that they are given. A simple arithmetical calculation will convince the reader that putting two people on a machine cuts the supply of gravy per person in half. Never have I known a foreman to put more gravy jobs on a machine because he has added a second shift to it. He does not have to, because formally speaking, there is no problem. The problems only exist informally.

Gerry, a recent Polish immigrant, had been floating around the milling section of the machine shop since long before I had arrived. The story was that he was hired to work in the gear-hobbing section, which is a nice job because you get to sit down and read a book all day, but that the work had fallen off there for some unknown reason and the machine shop supervisor had talked Gerry into moving. This meant that Gerry had to take a cut in pay — regrettable consequence of the collective agreement which assigned a lower wage rate to incentive workers than non-incentive workers. Gerry extracted a promise from the supervisor which amounted to guaranteeing that he would always be able to make up the difference in wages through bonus. How, you may ask, could the supervisor make such a promise? Before answering the question, it should be pointed out that this particular supervisor was known for promising almost anything to the workers provided that they would agree to do what he wanted them to; it was also well known that his memory in these matters was somewhat flawed. In this case however, with the benefit of some judicious prodding by Gerry, it was not difficult for him to keep his promise. The supervisor had only to tell Fred, the man responsible for assigning jobs to the different machines, to make sure that Gerry got his daily allotment of gravy. Fred, who knew all the jobs by heart, had only to check in the morning to see which machine Gerry was to work that day, select a nice little tidbit from his stack of cards (a technique known in the shops as shuffling the deck) and put it in the board for Gerry's machine.

Gerry was getting tired of his itinerant life and longed to settle down on one machine with a nice run of gravy jobs. In pursuit of this ambition he began to take a serious look at my machine. He noticed the long runs of 2,000 fishplates that we did, and upon inquiring found that they were considered to be a gravy job. But the clincher was another job, milling teeth in large sprockets, that gave the operator a chance to sit down for half an hour or so while the machine ran on automatic and made bonus. Gerry began to talk to me to learn more details about the jobs. I tried to warn him, but he naturally assumed that I was lying.

Gerry cashed in his marker with the department supervisor and got himself assigned to my machine. The next step in his plan was to get me moved off. This was possible because the foremen did shuffle the workers around periodically, and he could probably convince them to move me if he could outproduce me; and this he proceeded to try to do. It quickly resolved itself into a contest to see who could produce the most fishplates. I personally find this kind of competition revolting, and I tried to persuade Gerry to cooperate with me in some kind of bonus banking operation that would benefit both of us, but he was too cynical about human nature and too involved in the problems of immediate cash flow, so I was forced back upon a more defensive strategy. We always left a record of how many pieces we did each day, so it was easy to peg my production at a level just a little under his. This drove him mad and he worked himself into a frenzy trying to widen the gap between us. But as he increased his production, I stayed just a little behind him. At the same time I always told him that I thought he was a good machinist, and that I was impressed with how many pieces he made, and asked him for tips on how to run the job faster. This was all the exact opposite of standard procedure in the shop. Operators were supposed to conceal information and not to share it, and they were supposed to criticize each other and backbite. By breaking the rules, I created a kind of neurotic tension that could only resolve itself by one of us being destroyed. Gerry became wildly machiavellian, and I became so doggedly principled that I made myself sick. At one point I even left a note to Gerry telling him about a mistake that I had made during my shift. He naturally showed it to our foreman. The next day I got a long lecture about not making mistakes, but what I really learned was not to write notes.

Faster and faster we worked. The foremen rubbed their hands with glee; it had been a long time since they had gotten that kind of production out of that machine. Each fishplate weighed three or four pounds. We picked them up three at a time. We were slinging twelve pounds of metal onto the table of the milling machine, loading it into the magnetic fixture, taking it out, stacking it in boxes, picking up more, and so on. We were not machining — we were slinging steel and we should have been paid by the ton. Finally Gerry threw his back out when he slipped off the platform while he was lifting some plates at breakneck speed, and that ended the race.

Most of these contests end in injury — psychological or physical. This one, however, resolved itself on a more positive note when Gerry applied for compensation, the company contested it, and I offered to be a character witness on his behalf. After that we were friends. His big dream at that time was to save enough money to be able to go back to Poland and open up a small business.

The contest with Gerry involved sophisticated and expensive equipment. We had to finetune our operations and cut our times to a minimum. The spinoff from this game was higher productivity for the company, but that was not its purpose. Game behaviour is an important but little-understood part of work. Almost all incentive programmes depend upon a game response from their participants. The game can be played between production workers and management, or various other combinations might be possible. Incentive programmes turn a factory into a game board and its technology into pieces on the board.

This game playing will always appear to be irrational to any monolithically integrated hierarchy, even though it is an inevitable byproduct of these hierarchies. The irrationality of this kind of behaviour is due to the fact that it is not reducible to the terms of any kind of bureaucratized (rationalized) system. It is larger and more basic than bureaucracy. Game behaviour militates against the development of generalized knowledge in the labour force. General knowledge is "trumped" by specialist knowledge at a whole series of specific points in the process, and therefore it seems to be useless except for its status value.

Donald Roy was the first person that I know of to realize that incentive workers do not simply work in such a way as to maximize their income, although the ideology used to sell incentive programmes is very much "the worker as partner in the business." The working-class response is unlike the rational economic response of the business owner. Roy, an American sociologist, left graduate school in the early 1940s and went to work in a production shop in Peoria, Illinois. He intended to study "goldbricking" on the job, using the methods of participant-observation. He wanted to understand why workers withheld production even when they could make more money by working at full capacity. This was the classical problem of the paranoid paradigm of scientific management — the goldbricking worker fouling up production schedules. It took Roy six months or so to realize that making full bonus was only one possible strategy in the incentive game, and he soon found himself employing the non-economic strategies used by his fellow workers. Parameters other than money were operating in the shop. Business owners, after all, go through a complex process of conditioning that enables them to focus on the question of money to the exclusion of everything else. Production workers do not benefit from this same kind of conditioning, and if they did, it is doubtful whether industry would function at all.

Roy found that an important parameter for the production worker was the fairness of the time on a job. "Fairness" was determined by a kind of collective sense of how much work should be done in order to make a given amount of money. A gravy job was one which had a better than fair price on it. The usual strategy on a gravy job was, and still is, to run it as fast as possible and bank the time. Banking, in this context, means only turning in a portion of the work done on the day it is actually done and saving the rest to be turned in later. By banking, an incentive production worker can cover up the time lost on a job that does not have a fair time on it. In Roy's day, a lot of energy was spent in trying to keep the workers from banking. At shop C, the supervisors were pretty lax about it, probably because they had a more sophisticated understanding of the incentive game.

Banking was only challenged once at shop C while I was working there. My friend Butch was a lathe operator who was very proud of his high incentive earnings. He always turned in at least 150 per cent, sometimes more. But then, for some unexplained reason, one of the foremen decided to get him. Perhaps it was because Butch had ideas about becoming a foreman himself. They hired a young Quebecois lathe hand from Noranda, named Val. Butch automatically became Val's mortal enemy. This always seemed strange to me because Val did not have an ounce of malice in him. But with another man on his machine, it naturally became more and more difficult for Butch to make his 150 per cent per day. Then, as if to add insult to injury, the methods department decided to redesign his biggest gravy job, and cut the time.

Butch's tactics depended upon the fact that methods had planned a job in two different operations, with two different set-ups, which he could do in one operation and one set-up. Butch's working knowledge was superior to that of the planners. He had inherited some special tools from the man who had preceded him on the machine and these enabled him to combine the operations. This informal tooling, and the methodology to employ it, was the property of the labour force. Planning, however, had engaged in some industrial espionage and had determined, by watching Butch, that it was possible to eliminate an operation and a set-up. Accordingly, they decided to design a fixture that would combine the operations. Their solution was more expensive and less effective than the informal one developed by the operators themselves, but nonetheless they set out to impose it on the operators and to cut the times — the real purpose of the whole exercise.

By this time, Butch was frothing at the mouth. It was the beginning of the end for him. In a desperate effort to maintain his 150 per cent, he began to resort to the tactics associated with the checkout system. There is a certain surface reality to incentive systems that is vital for its acceptance. No one will participate in something that is obviously crazy. The checkout system is a prop that helps maintain the illusion of rationality. Everyone knows that incentive times are based on ideal conditions; the jigs and fixtures are all immediately accessible, the machine is running properly, threads are all clean so that nuts and bolts spin off and on without any problems, tools are where they belong and can be found without delay, cranes are available and functioning properly, etc. But everyone also knows that these conditions are never obtained in actual production. Thus there is a kind of "double think" involved in work measurement. The measured times are scientifically accurate, but they do not apply to the work being done in any particular shop. At the bottom line, nobody expects science to say anything meaningful about reality. That would be asking too much. Still it is annoying to have to work to standards that do not apply to the work you are actually doing. After many decades of bickering, management finally invented a device to defuse the situation. They instituted a number of categories that constitute exceptions to the "normal" (ideal) working conditions. When operators ran into "exceptional problems" (chronic systems breakdown), they could enter the time it cost them in their work records as checkouts: in other words, it was as though they had gone off incentive work, and were working at their base rates during the time that they were experiencing difficulties.

It was difficult and expensive for the supervisors to monitor checkouts, but they did try from time to time. Given the nature of the game, checkouts became an important device for covering lost time at shop C. Even if a job was timed down to the bone, it was still possible to make bonus on it by using checkouts, provided you were not being monitored too closely by supervision. Unfortunately, when Burch switched into the checkout mode which, as far as he was concerned, was a kind of engineering hyperspace, he was being monitored. He could not elude his enemy. He was being tracked, and they had him in their sights. Every morning the foreman would come to Butch's machine and question him about every checkout he had punched in the previous day. And always, Butch's 150 per cent was cut back to 100 or 110 per cent. His bank account began to dwindle as he used it to cover his losses. Butch was a very unhappy man. When he finally decided to quit, he did it with style. He walked into the shop in the morning, got himself a cup of undrinkable coffee from the coffee machine, sat down and drank it until 9:00. The shift began at 7:00. Then he took his coffee break which lasted until 12:00. At noon he punched his entire bank of about 2,000 minutes into the computer, picked up his tool box and quit.

Butch was a good worker who had got his fingers pinched in the machinery of administration. He reacted in an abrasive manner and was labeled "beyond salvage" by an ignorant and frightened group of supervisors. When he left, he took with him an important piece of the working knowledge paradigm of the shop that was never replaced, because Butch had never taught it to anyone else.

The company bureaucracy reacted with characteristic ham-handedness. The most immediate problem was the 2,000 minutes that Butch had punched in. This meant that either the payroll department had to give him more than 30 hours' pay for five hours' work — 600 per cent bonus — and the methods department had to admit that it had mistimed a job in such a way that this was possible, or the machine shop supervisors had to admit that banking was being practised in their shop. Butch was told that he would not be paid his 600 per cent bonus. He tried to file a grievance, but the union refused to take it. He then filed a complaint with the labour board.

Game behaviour is an important determinant in the actual day-to-day application of technology. This is especially obvious in the case of incentive systems, but also operates in shops that do not use incentive systems. The modern incentive system was one of the great dynamic achievements of management in the 1940s and 1950s. While it did not overcome the deep divisions between labour and management, it did integrate the worker into production in an entirely new way, and it harnessed the decision-making and problem-solving abilities of the workers without their being aware of it. Every management system has historical specificity and cannot be expected to function smoothly outside of its own time frame. The working-class response to this system was not the one that was anticipated, but it was a useful response nonetheless, because at least one of the parameters in the game generated by the incentive programme was to increase output. But, as Donald Roy had already made clear by 1952, it was not the only parameter. The game was played at the lowest levels of the hierarchy of technical knowledge. The centre squares were controlled by management through the medium of production engineering which constantly changed the contours of the board. An entirely new paradigm of working knowledge sprang up in response to this strategy that was concerned with the invention and concealment of bypasses to the formal technology generated by the production engineers. The production engineers, on the other hand, maintained a surveillance over the informal technology, and systematically robbed it of its best ideas. An incredibly fluid and dynamic system was created, but it was also a system that created much hostility and resentment. Moreover it was wasteful and tended to encourage the production of scrap and badly made parts.

The term "scrap" refers to parts that are finished, or partially finished, and then have to be thrown away because they are made to the wrong dimensions or specifications. Scrap is extremely expensive; it represents a pure waste of labour and material. Incentive systems inadvertently generate rewards for producing scrap and for concealing its production. It is always easier to make mistakes than to do things right. The high speeds at which modern labour functions increase the probability of errors. Boredom, fatigue, and hostility magnify the problem. When one adds to this the possibility of being paid for defective parts by slipping them past the inspector, one arrives at a maximum disposition towards disutility.

Michael Burawoy, who studied an incentive machine shop in Peoria, Illinois in 1974, related the increased propensity to produce scrap to what he called the "monomania for output." There is a tendency in modern management systems to disconnect output statistics from quality control statistics. Little scrap is actually reported, and this inflates output figures. Production managers and line supervisors find themselves colluding with the operators in covering up the real incidence of scrap and, of course, this can only further accelerate the rate of scrap production. The concealment of scrap becomes a tactic in what is known as the numbers game, or the game of producing output figures that look good on paper in order to pacify the plant manager. In this game there is often collusion between line supervision and the labour force as an entire shop becomes involved in an intricate cover-up operation.

Covering up scrap was embodied in a legend at shop C. A story was told that once upon a time, ten stainless steel panels had been ordered for a special customer, and they were to be engraved with a special design. Somehow, in writing out the order, ten got changed to 100, and 100 of these unique panels were engraved. Ninety of them were scrap. That weekend, the 90 scrap panels disappeared from the shop. For all intents and purposes they had never existed. To admit that they had existed would have threatened too many careers.

Game behaviour created strong interference patterns in the work at shop C. On paper, the shop was well tooled and the work was highly rationalized. But in practice, formal procedures were often overridden by informal ones. The same management design that was intended to rationalize work also divided the work force into subgroups with interests that were frequently in conflict with the interests of the corporation as a profit-making body. The interplay of subgroup logics led to outcomes other than these predicted by the formal structure. The maximization of production figures became the most important goal of the floor management subgroup. The labour force, in turn, learned to manufacture good statistics rather than good parts. In particular, the younger members of the labour force developed the cult of the conspicuous consumption of leisure. This was exhibited by three different groups in shop C during my stay there: the coffee club, the country club, and the Maple Leafs' fan club.

The coffee club was founded by Butch and his friend Tom long before I began to work at shop C. Everyday at 9:00, members of the club who were secure in the knowledge that they could make bonus that day, met at Butch's machine for coffee and doughnuts. Butch had a collection of chairs that he had scrounged from various places, and when there was an overflow crowd, boards were wedged into the machinery and cushions propped up to provide additional seating capacity. A salon atmosphere was quickly established, and the conversation ranged from fishing and sport to current events and politics. The unspoken rule was that no one would participate unless they were in a position to make bonus that day. As the meeting of the club progressed, people would excuse themselves, saying that they had to get back to work because they were a little bit behind that day. Finally, the meeting would break up in response to some silent consensus.

In spite of the fact that the coffee club required that its members be productive, it was persecuted. From time to time, it would be told not to congregate around Butch's machine, after which it usually resorted to the passive-aggressive tactic of moving the venue of the meeting. It would meet upstairs in the cafeteria for a few days, until it was chased out. Then it would pick someone else's machine as a meeting place. The whole shop would be treated to the spectacle of a group of five or six operators carrying chairs to some corner of the shop and sitting down to coffee and doughnuts. Eventually, the pressure would be taken off and the club would return to its traditional meeting place.

The country club was a little less formal and a little less visible. Its activities consisted in going to a nearby tavern and drinking as much beer as it was possible to do in a twenty-minute lunch. But once again, participation in the club's activities were limited to those who "already had their day in." This meant that only high producers and ace con men could join, because it was hard to get your day in by noon. The afternoon was spent sitting in front of the machine in a drunken stupor, pretending to work, and trying to avoid being hurt. Sometimes the country club members would sneak out of the plant before the 12:00 bell had rung. They had devised secret routes that got them past the guards without being caught.

Both the country club and the coffee club recruited from incentive production workers who were interested in investing some of their bonus time in on-the-job leisure activity. The Maple Leafs' fan club was based primarily on the workers who operated the automatic and numerically controlled machine tools. They all worked shifts in teams and were close to each other. Their day-to-day activities consisted of ordering in lunch from nearby take-out restaurants and sneaking beer into the shop to drink with their meals. In addition, they functioned as a kind of service club by marshalling support for popular lost causes. They actively campaigned for the Leafs during the winter, the Argos during the summer, and the NDP during elections. In a celebrated act of defiance, the leader of the Leafs fan club once brought a colour TV set into the shop in order to watch a game. The night foreman found him sitting in front of the TV set with his shoes off and his feet propped up on his work bench watching the hockey game. He was given a two-day disciplinary suspension.

Underlying all this game activity was the working-class ideal that an intelligent worker ought to be able to get on top of his work and should not have to work too hard — that it is better to work "smart" than to work hard. These men were flaunting their skill and intelligence.

Parallel to the hierarchy of skill and knowledge, there is a hierarchy of preferred social behaviour in which working on isolated individual tasks figures rather low. Most of the workers' time on the job is spent at the lowest levels of both hierarchies, but, whereas average workers do not feel motivated to move up the hierarchy of knowledge — in fact, they are discouraged from doing so — they are highly motivated to move up the hierarchy of social activity and do so at every opportunity. Incentive systems applicable to production hierarchies enable them to do this in bizarre and unexpected ways. The hierarchies of knowledge and social activity seem to be perpendicular to one another in the shop. The higher up one goes on one axis, the lower one goes on the other. Money provides a third axis at 90 degrees to the other two. High technique and high incentive earnings do not necessarily go together, just as high earnings and a high level of social activity are not necessarily positively correlated. In practice, people in the shop tended to orient themselves along one of these axes to the exclusion of the other two. Those who were technically ambitious quickly learned that the incentive system put a low value on the continuing development of individual skill, and they left the shop to seek work elsewhere. Those who were socially oriented developed their competence to the threshold levels that permitted them to participate in the social life of the shop, and then began to focus their energies in that direction. The high bonus incentive workers formed a group unto themselves.

The incentive system creates layers inside the working class. It separates the incentive workers from the non-incentive workers, and within the body of the incentive workers it generates a layer of full bonus earners whose consciousness is warped by their mode of existence. The full bonus workers are constantly forced to defend the substantial difference between their wages and those of their co-workers. With overtime (ten hours a day and six or seven hours on Saturday), a top bonus earner might make $27,000 to $30,000 a year, while the average wage in the shop is in the $12,000 to $15,000 range. The *incentive system thus creates a subgroup of producers inside the shop* whose material interests are directly linked to the maintenance of the incentive system. Even though this group may only constitute 10 to 15 per cent of the incentive workers, it plays an important role. It displays the possibility of making big money in a conspicuous way, and thereby validates the incentive system. Just as the club members display the potential for acquiring leisure time, the full bonus earners, who are usually not club joiners, display the potential for earning what passes for megabucks on the shopfloor.

The full bonus subgroup has other social functions. Making full bonus depends upon the support of the foremen; it is therefore more politically than technically determined. Full bonus earners are forced into the position of having to collaborate with supervision in order to maintain their position. This they do in the first instance by maintaining close communication with the foremen, and by separating themselves from the members of the opposing subgroup that avoids all contact with foremen. This constitutes the first level of collaboration *and it is especially significant in a large machine shop*, because the possibility of working independently always exists, and if everyone did, the foremen would have no handle upon the work whatsoever.

A second level of collaboration consists in banking. By overproducing on the jobs with gravy times and banking the time, the full bonus earners further validate the incentive system and help to conceal its irrationalities which, of course, they are materially constrained not to see. The irrationality in question here is that the measured times do not reflect actual production times in a large number of cases. Collusion between line supervision and full bonus workers conceals the irregularities in the system from higher levels of management and helps to protect the planning and methods department. None of this is conscious. In fact, full bonus earners often think of themselves as hardened anti-company workers, and can, under certain conditions, become militant trade unionists. They also think of themselves as winners and the others as losers, and they develop an entrepreneurial attitude towards their skills. They have, in effect, invested ten or twenty years of their lives in learning a small run of jobs on a particular machine, and the logic of their subgroup demands that that investment be made to pay. All the competitive rules of small business apply for them. They feel compelled to advertise themselves to the company by making the other operators look bad. They conceal information in order to create a monopoly on techniques which they can use to blackmail the company. They refuse to train new operators because this would endanger their private monopolies, and lessen the minute personal control over the process of production which they have managed to acquire by years of unstinting and unscrupulous effort.

This long digression into the sociology of shop C illustrates the way in which technical processes influence social behaviour and structure the evolution of subgroups. The incentive system per se is not a purely technical device, but it has an attendant technology related to the discipline of industrial engineering. The purpose of this technology is to reduce learning times, permit the entry of semiskilled labour, and make production times measurable and predictable. It has a built-in social dimension, and embodies an "intent" on the part of its designers. But the intent of the design has run afoul of the activities of the various subgroups operating in the technical field generated by the technology. The design has proved to be particularly vulnerable to game behaviour on the part of participating individuals. Game behaviour often overrules the intent of the design. Cultural discontinuities in the shop, essentially related to social classes, foster the evolution of informal subgroups that pursue their own logic. The possibilities for game behaviour and the dynamic potential of various subgroups are therefore at least partially determined in an unintentional way by the design of the technology being used, but engineers and managers seldom take these factors into consideration when designing systems.

IV

THE RELATION BETWEEN technology and social behaviour may be turned around, and investigated as the relation between social behaviour and technology. In this case, the lines of causality move in the opposite direction. The social relations in the production machine shop have influenced formal technology by pushing it in the direction of "user-friendly" machine design. There has been a complex interaction between social and technical factors that has operated over a long period of time to produce the modern "user-friendly" hardware found in production machine shops. Hamilton has been the chief Canadian centre for the development of these systems. A number of books and articles have been published on the Hamilton experience. Briefly told, the story is that a shortage of skilled craft labour combined with an increase in unskilled immigrant labour and young proletarianized rural Ontario labourers led Hamilton manufacturers to attempt to bypass the craft workers, and employ larger numbers of semiskilled workers. They refined the division of labour and simplified tasks so that they could be more quickly learned and easily performed. In this they were simply following an international trend that was operating in Britain, the United States, and Germany. Their efforts were not immediately crowned with success. There were almost insurmountable problems of discipline, and in the end, the old-line craft workers retained the whip hand because they were the only ones who could operate the machinery at maximum efficiency. Semiskilled workers were often reduced to little more than a goad to urge on the skilled craft workers to greater efforts. As one crotchety old Canadian iron master once put it:

> If I have just the number of hands for the work, every one of them will know that I cannot do without everyone of them, therefore every one of them will be my master, anxiety and trouble will be the consequence; and if I keep more hands than are necessary, so as I have it in my power to turn those away who will not do right, this is expensive.

Under the old nineteenth-century system of craft-operated machine production, the semiskilled worker was often regarded as an expense justifiable only when used to discipline the craft worker, and useful only for performing the simplest and most repetitive tasks or the work fit for the "ox-type" of worker, as Frederick Winslow Taylor once put it.

Gradually, it became apparent to engineers in the United States and Germany, that by making some basic changes in the design of machine tools they could make more efficient use of semiskilled labour. That semiskilled labour could, in fact, be made productive as craft labour; a liability, in other words, could be turned into an asset, and a cheap and abundant source of labour could be tapped. Between 1890 and 1900, new lathes were designed in which speeds and feeds could be changed by means of a gear box. Older methods had involved changing gears by hand — that is, literally taking out one gear and putting in another as was the case on the big planer mill at shop A — or sliding a belt up and down a conical drum or some other such crude device. Modern operators are so dependent upon transmission gear boxes that they would hardly be able to use these old pre-gear box machines without a lot of special training. Obtaining the proper feeds and speeds on the pre-gear box machines took a long time to learn and was a major skill component that separated the craft workers from the despised semiskilled operators. Vertical boring mills, perfected in the United States in big machine shops like those of General Electric, also contained an important element of deskilling. Large machine parts were difficult to set up on a conventional lathe where they had to be hung from the chuck and supported by the tail stock. When using a vertical boring mill, the operator could simply set the piece down on a flat table, bolt it, and machine it.

The deskilling machine par excellence was the turret lathe. The turret lathe was an American device. Initially constructed in New England in the 1850s, the aim was to avoid the time lost in setting a lot of different tools in a lathe by setting them all at once in a turret and then turning the turret around to gain access to the tools needed for a particular operation. Tool setting remains one of the most arcane parts of the machinists' art. During the deskilling drive at the turn of the century, the turret lathe came into its own. Gisholt and other companies manufactured big production turret lathes by 1893, and World War II-vintage Gisholts were still in operation in shop C when I worked there, though by this time they were somewhat the worse for wear.

Another important technological feature of the turn-of-the-century deskilling drive was the development of high-speed tool steel. Tradition tool steels were scarcely harder than the material that they cut, and they quickly lost their temper when overheated. Machinists learned to take slow cuts and to use lots of coolant. High-speed steel did what its name implied: it cut at high speeds without burning out. Craft workers had a mixed reaction to this new substance. On the one hand they appreciated its greater longevity but they regarded the possibility of higher cutting speeds as an abomination in the eyes of the divine creator. Conflict between labour and management over running speeds soon became a feature of every machine shop in North America, and the machinists were able to win a surprisingly large number of battles during the early years of conflict.

High-speed steel was the source of yet another labour-management conflect. The older, high carbon steels needed to be constantly sharpened in order to keep a good cutting edge. High-speed steel would hold its edge for a much longer time. With careful grinding and operating, a tool might last an entire shift without having to be taken out and reground. Under these conditions the geometry of the tool became much more important. Since the days of stone tools, the toolmaker has been aware of the importance of the angles that define the cutting edge and of the angle at which the tool is held. A complex body of craft lore had grown up around this subject in the nineteenth century. During the deskilling drive at the end of the century, the early proponents of scientific management transformed tool design into a science. The science of tool design came into conflict with the art of tool design. All the craft workers thought their own personal methods of tool grinding were the best, and went to great lengths to subvert the efforts of company engineers eager to try out new methods and to obtain standard results. The new paradigm had to forcibly displace the old. This was done in part by establishing a new craft specialty called tool-and-die making. Tool-and-die makers were machinists who specialized in making cutting edges and were specially trained in the machining of geometrically precise forms.

The decades between 1890 and 1910 saw the birth of the engineering paradigm that now dominates the hierarchies of knowledge in all our shops and factories. It began as a vision of the application of the exact sciences to problems of industrial production. Once this vision acquired sufficient theoretical detail, it had to be made operational. It could not be operationalized within the socio-technical framework that then existed in industry. The paradigm of the early nineteenth century provided the first line of resistance to the engineering paradigm. Their status, their social definition, their very existence, was invested in the continuity of the old paradigm. They would not give up without a fight.

At this point something must be said about conjuncture. Certain changes can only occur at certain points in time and not at others. Managers and owners could not alter their systems of production at will. They had to wait for them to run down. Thus the change to a new system of production could only occur at a social and economic crisis point, when it had become obvious that the old system no longer worked. The change in hardware automatically entailed a conflict with that portion of the labour force whose survival was invested in the use of the old hardware. There was no possibility of a peaceful transition. As we shall see, the victims of these changes, the skilled trades workers in this case, put forward a counter-programme of technological changes — worker's control — and devised new forms of organization to implement it. But they failed.

Every major technological transformation is simultaneously a massive social conflict. As we have already seen, every technical system entails complex social behaviour that eventually dominates the technology. These behaviour patterns resist change. One could argue that the dominance of a technology by its attendant social relations marks the beginning of the period of decline and obsolescence. In any case, once an industrial system is viewed as obsolete and the crisis generated by this obsolescence is sufficiently severe, something usually triggers off a struggle to change it.

At the end of the nineteenth century, the signal for the battle to begin was the outbreak of World War I. With the basic elements of their new technology in place, the engineers and informed managers with whom they collaborated were waiting for the opportunity to implement a social programme that could realize its productive potential. Labour shortages and sharply increased demand for war materials provided the rationale for the introduction of semiskilled, unskilled, and women workers into the machine shops of the belligerent nations. The labour response was fast in coming, and the machinists in the Clydeside machine shops were at the centre. The Clydeside engineers' union locals had already created a new type of union official known as "shop steward" to combat new technology and job redesign in the shop. The modern union shop steward was an immediate byproduct of the great deskilling drive, and was intended to be a device for working-class control over technological change.

The Clydeside militants of the Amalgamated Society of Engineers (ASE) were deeply influenced by the workers' control theories that had evolved out of the Industrial Workers of the World (IWW), and its affiliated unions such as the Western Federation of Miners. It was no accident that the idea of a new technology based on self-management should have been born in the resource-based industries of the western United States and Canada. In these regions a *modern, highly capital-intensive technology was already in place and was* being operated by a labour force that had been largely trained from scratch to work at high levels of skill and productivity. Craft workers were as scarce as engineers and shift bosses and supervisors were held in contempt as tools of the bosses with far less technical competence than the people whom they supervised.

The British social environment was different and the idea of self-management was potentially much more explosive. The ASE was quick to label the introduction of unskilled workers into the shops as "dilution," and this word has come to denote the practice of reducing the skill level in a work force by introducing unskilled workers and not training them to be fully qualified in their trade. The British government cooperated with the companies in this programme by calling up the skilled workers for service in the armed forces and leaving the dilutees at work. As the war progressed, more and more skilled workers were conscripted and replaced with unskilled workers, and the practice of dilution spread to non-defence industries. In winter 1915-6, the Clyde Worker's Committee asked the government to nationalize the shipbuilding industry and operate it through a board jointly controlled by the state and the trade unions. In May 1917, the Leeds Convention went out on strike in defiance of the wartime restriction on strikes. More than 250,000 engineers were on picket lines and all the big engineering shops were shut down.

In Britain, the workers' control movement was contained through the use of legal violence during the war. After the war, unemployment and lockouts were used to break all residual resistance, but the neanderthal leaders of the British business community proved singularly unable to make good use of the advantages they had gained through the application of social violence. Having cleared the way for the kind of technological changes that were rapidly transforming North American industry, they failed to implement them. They preferred to keep wages low and continue to produce with old methods and old equipment. Some sectors were more backward than others. The British coal mining industry had to be nationalized before it could be technologically transformed.

In Canada, the course of events was somewhat different. Mechanical engineers began to drift into Ontario in significant numbers after 1900, and the spread of American scientific management was facilitated by the spread of the American branch-plant system. Hamilton became an epicentre for the development of a Canadian efficiency movement, and the Canadian steel industry was heavily influenced by American ideas. Along with new management system and new technology came piecework systems modeled after Taylor's "scientific" piecerates. While the craft workers of Hamilton protested these changes, and sometimes even went on strike, at no time did they espouse the ideas of workers' control or form shop stewards' bodies or any other form of factory committee. In practice, they were too often embroiled in a simple struggle for the existence of their unions. Dilution of the skilled labour force occurred during the war. Thousands of women learned to be machine operators, but they were driven out of the shops after the war. The dramatic defeat of labour's militant response in 1919 led to the crushing of most trade union initiatives in the 1920s. Canada embarked upon a historical trajectory quite different from that taken by Great Britain.

The technological change accomplished during the war constituted a victory of hardware over people, but the situation was inherently unstable. A behavioural vacuum had been created that was quickly filled. Procedures were bypassed, short cuts devised, the possibilities implicit in new machinery and tooling were discovered and concealed. New alliances between subgroups were formed and new informal organizations were created until an equilibrium was reached.

In the 1920s, Ontario became a stage for the implementation of the full engineering paradigm as it had been envisaged by its designers 40 years earlier. There were no barriers to rapid socio-technical change in the province. Although we lack good studies on the history of the changes that took place in this period, we can confidently date the beginnings of the counter-paradigm, the new working knowledge paradigm, to this decade. Of course, whatever shopfloor counter-culture evolved in the 1920s must have suffered a serious reversal during the 1930s when so many people were permanently unemployed. The biggest impact of the engineering paradigm upon machine shop work practice during the 1920s and 1930s lay in the area of jigs, fixtures, and tool holders. Starting in the automobile industry, which was the industrial focus for the 1920s boom, a body of expertise grew up in the fields of quick-change tool holder design, specialized multipurpose production cutting tools, specialized machine tools, and jigs and fixtures designed to hold more than one part at a time. This knowledge further reduced production times, increased the pace of work, and accelerated a frenzied pursuit of speed in the workshop that did not come to a stop when the stock market crashed in 1929. If anything, the economic crisis intensified the measurement of time and the introduction of piece-rate systems.

By the time World War II broke over the desperate peoples of the world, the development of "user-friendly" machine tools and their associated hardware had created a virtual submode of production. The second period of wartime demand provided the opportunity to train a second generation of semiskilled workers in the use of this submode, and to displace and dilute further the skilled craft layer. World War II was the formative period for the type of factory system that predominates in industry today. The generation of machine operators that is now retiring from industry was trained during that period. Many of them were brought in to dilute the old skilled labour force, while others were fully trained in the numerous apprenticeship programmes that still existed. The shortfall of skilled labour that now threatens Canadian industry is a shortfall in people socialized in the World War II patterns of industrial behaviour.

But before we discuss the kinds of behaviour evolved by the wartime generation, it is worthwhile speculating on the nature of the counter-paradigm that was developed by the first generation of "diluted" machine operators. It would be interesting to know, in particular, what sort of games were played and how these influenced the further development of the engineering paradigm. We have only scraps of information on this process. Some of the best documented evidence comes from descriptions of the Ford plants in the 1920s where pace and discipline reached unsurpassed levels of intensity. The rules were so strict that they forced the workers to invent methods for bypassing them. Rule violation must therefore have been an important field for game behaviour in these early days of the engineering paradigm. One of the elements of the game was the famous "Ford whisper!" The idea was to talk with one's friends in a low, almost inaudible, voice while pretending to watch one's machine. In the tool-and-die room, craft workers would engage in small talk in low voices while pointing to machinery and parts in a random fashion or while standing over a blueprint and making random stabs at it with the index finger. Skilled craft workers like tool-and-die makers often had to collaborate in their work, and if they were accused of talking, they could always say that they were talking about the job. Some Ford workers became highly practiced ventriloquists, and learned to project their voice to one side without seeming to move their lips.

Another field of game behaviour was the well known grape vine. The workers at Ford had apparently devised a system of signals that gave them early warning about the activities of their supervisors, and foremen were already colluding with the workers by warning about "secret" visits to be made by Ford or his lieutenants. At shop C, I met Bill who claimed to have been an assistant foreman at one of Hamilton's steel works during the 1930s. He was hired because of his command of Slavic languages. The general foreman was an ex-British sergeant major, who could not talk to his labourers because they did not speak English. Bill was assigned to make regular tours of the plant, to make sure that everyone was working, to listen to what they were saying, and to report back to the general foreman. He always found, as he made his tours that the men were hard at work, and at first he could not understand why the general foreman seemed to think that the men were soldiering. As his perception of the mill became sharpened by hours of exposure he began to notice that certain peculiar bangings and thumpings always accompanied his movements from work station to work station. He eventually realized that the men had devised a signalling system that used the steel structure of the mill itself to transmit information about the movements of supervisors. It was therefore impossible to find out whether or not they were in fact always working. A sort of Heisenbergian indeterminancy principle overrode any attempts at work measurement. The general foreman never actually knew whether or not his men were soldiering, he simply assumed that they were on theoretical grounds. Eventually Bill gave up all efforts at supervision, and made a little informal bedroom for himself where he could catch up on his sleep. He learned to use the signals reverberating through the shop to keep tabs on the activities of the general foreman, and he was never caught sleeping. He finally realized that the movements of the general foreman followed a strict timetable and that all he had to do was to set an alarm clock to wake himself up. The game of grapevine must date back to the dilution drives during World War I. Prior to that it would not have been so important because craft workers could talk freely with one another and move about the shop as they chose.

While working at shop A, I discovered another old game that I called "counterespionage." The management methods specific to a diluted work force depended upon a more intensive use of company spies. Even when it was possible to talk to fellow workers, it was not safe to say what one really thought. The counter-espionage game consisted in learning to say the opposite of what one meant in such a way that one's conferee could follow the line of the argument without being able to prove that anything disloyal was being said. The most adept at counter-espionage at shop A was Ralph. One could walk by Ralph on the fitting floor and say, "How are you doing, Ralph." To which he would reply, "I don't have time to talk right now. I have to make money for the company." This actually meant that he was not doing anything in particular, was feeling bored, and would like it if you stopped and had a chat with him. The give away was the phrase, "I have to make money for the company." No one in their right mind would ever say that. On the other hand, he could hardly be called into the office and accused of wanting to make money for the company. Of course, this was archaic behaviour in the 1970s and Ralph did it more out of a sense of fun than because it was functional.

From what we know of internal games played in the 1920s and 1930s, we can guess that the stakes were psychological and emotional survival in the diluted shops in the face of an unprecedentedly ferocious labour discipline. The labour force that played these games was cowed into a stance of passive resistance. The resentments stored from this period bore fruit in the 1940s, when a new generation of workers embraced industrial unionism and demanded a different style of management. At the same time, the counter-paradigm of the worker became richer, more powerful, and more technical. When Donald Roy went to work in Peoria, Illinois in 1944, a rich counter-incentive paradigm was already in place but it does not seem to have been as evolved as the system at shop C in the late 1970s. The hardware, the key players, and the moves were all there, but the system did not work the same way in 1945 as it did in 1978 and the outcomes of the games were subtly different. The most noticeable difference is that the operators in modern day shop C have much more freedom of action than their counterparts in Donald Roy's 1945 study had. Roy's workers, for example, had to adhere to a strict work schedule. The jobs were assigned by a scheduling worker, and they had to be taken in sequence. Operators were given one card at a time. In shop C, the scheduler put out a bunch of cards on a board and operators could choose among them.

although they were expected to do jobs marked "hot" first. The scheduling man in Roy's shop was a powerful person. He doled out the job cards one at a time and could make or break an operator by giving or withholding gravy jobs. He did not seek out the operators. They sought him out.

What is involved here is the deskilling of the supervisory staff, or at least the attenuation of their authority. The modern schedulers have no real control over the operators; they have to bargain with them to get the jobs done in the order that is wanted. The schedulers have additional responsibilities; they must keep track of the movement of the work through the shop and they have various internal accounting functions. There is a noticeable tendency in the modern diluted shop for production jobs to become more specialized and more sharply defined while supervisory jobs become so general and so undefined as to be almost impossible to perform.

The foremen have been deskilled and generalized at the same time. In the nineteenth century, a foreman was something of a rarity. Craft workers often hired their own help and supervised them under the putting-out system, or they worked collegially or under the supervision of a master craft worker. In any case, it was normally assumed that supervisory responsibilities would be invested only in those who had greater technical competence than the people whom they were to supervise, and this remains an active assumption inside the working class. But there is an increasing tendency at the executive level to think of foremen as administrative specialists (as managers of people), and this specialty is thought to exist independently of any work-specific content. Thus, even though foremen are still formally responsible for training in their departments, they are practically incapable of doing so when any appreciable level of skill is involved. Many machine shop foremen are recruited from non-technical jobs. Some have been time-study evaluators. Quality control inspectors are made foremen and are expected to train and to supervise machinists. None of them, of course, would ever admit that they could not do it. In shop C, the general foreman was a tool-and-die maker expected to supervise machine operators working on an incentive system. Although it might have seemed that his tool-and-die experience would help him, in many cases it prevented his understanding the work in the shop, if for no other reason than that he consistently underestimated the difficulties of production work.

A story was told of him that illustrates this point. The general foreman of shop C had a friendly rivalry with a German-born machinist named Karl, who died of a heart attack at his machine while I was working there. Karl was socially ambitious in the way that skilled craft workers often are and was of the opinion that he was the one who should have been made general foreman. In fact, he always told his friends outside the shop that he was a foreman and concealed from them the fact that he was an operator. He always wore a sport-jacket when he came to work, and changed it for his grease-stained work clothes after he arrived. Karl was given the task of machining a part on his vertical boring mill that was very badly out of balance because of a large concentration of metal to one side. The piece was large and had to be cut at a high speed so that Karl was afraid that it would start to vibrate and come out of the set-up. He wanted a fixture made that would have a counterweight on it to counterbalance the part. The general foreman became involved, because he did not want fixture work charged to his department and because he took the attitude that every job was a rush job. He told Karl that it was only necessary to clamp a piece of lead onto the old fixture. Karl said that it would not work and the general foreman insisted that it would. The lead was produced and clamped to the fixture, but Karl was still reluctant to make a cut.

The foreman kept saying, "Go ahead, try it, try it," until Karl started the machine and began the cut. Of course the lead flew off, and almost hit the operator on the next machine, who was the one that later told me the story. In this case, the problem was that the foreman's tool-and-die experience was inadequate to permit him to understand the conditions that prevail under high-speed production conditions. By being made foreman of the machine shop, instead of the tool room, he had effectively been deskilled. In the modern diluted shop, then, supervision finds itself with greater responsibility for and less control over the work. Loss of control is a defining feature of the modern diluted shop. In the 1920s, supervision was clearly in control. In the 1980s, no one is in control.

Not only has the work of the supervisors been deskilled, it has also been mechanized. This is especially evident when one looks at the way in which paperwork is now performed. In the old days, the capacity to do paperwork was one of the things that set the supervisors apart from the labourers. It also rationalized their having a separate office away from the dirt and noise of the shop and wearing a clean shirt and tie. Today, while it is still true that operators in some cases may have less of an aptitude or inclination for paperwork, it is also true that the techniques of paperwork have been rationalized and mechanized to the extent that anyone can do it. Blueprints provide a good example of this. In the old days, blueprints were an expensive item. Many shops could not afford their own copying machines, and runners were employed to carry the master copies to a blueprint shop and bring back sets of copies. Masters had to be stored as full-size copies, and a staff was required to file, retrieve, and revise the masters which summarized the entire product technology of the shop. The shop prints were so valuable that they were stored in the tool crib in Roy's day and were issued just like tools and fixtures. Today, master copies of blueprints are stored on film strips and reproduced photographically. At shop C, a packet of paperwork is made up in the scheduling department for each job. A clerk, usually a woman, first gets a schedule of jobs, either from a VDT or a printout, then using a word processor and card punch she calls up a stock order and a set of work-order sheets, and finally she prints out a set of time cards — one for each operation. Then, going to a photocopier she reproduces whatever blueprints are called for on the work order. The paperwork is all stuffed into a jacket which accompanies the job on its odyssey through the shop. Thus there is no longer any direct link between supervision and paperwork. Gone are the days when a supervisor would sit down with a machinist and talk over the blueprint. The only real control link between the paperwork and the operator is the central computer.

Control in the shop has shifted away from the supervisory group and has been concentrated in higher levels of corporate management, on the one hand, and in the work force on the other hand. Loss of control entails informal workers' control, in accordance with some unenunciated law of the conservation of administrative energy. As control relations are shifted around in the effort to mechanize administration, some factors of control inevitably "leak" out and are absorbed by the work force. This eventually produces a demand for skilled labour to offset the technical failings of a mechanized management system. But the skilled labour is not there, because the last 80 years have been spent trying to eliminate it. The alternative to the greater use of skilled labour is to intensify the cybernetic control of unskilled labour through the use of numerically controlled machines and process computers. It remains to be seen which method will be the most productive.

V

I WOULD LIKE TO SPEND some time illustrating how the labour force picks up some of the elements of control that fall from the foreman's table and incorporates them into its working knowledge paradigm. Some control elements are picked up through game behaviour. The operators study the scheduling system because it is an important element in the game of "making out." In shop C, where the job cards were put out on boards at the beginning of the day, the operators quickly learned to shuffle the deck, that is, they took upon themselves the task of scheduling and grouping the work. This is a function that could be easily and efficiently handled by the work force in any case, but it is not. In the machine shop, the scheduling worker has devolved into a kind of "subforeman" who puts cards on the boards for each machine. In theory, the operators take the cards as they come to them, but in practice operators often "jump the board" and pass over jobs that they do not like or take a job that pays better. The scheduler, who is nominally in control of the sequence in which jobs are performed, is reduced in practice to a clerk who distributes job cards. The foremen, who depend to some extent upon the schedulers, also suffer a corresponding loss of control. The operators, on the other hand, exercise a surprising amount of constructive control over job scheduling. The scheduler has little or no understanding of machining, and often makes the mistake of putting a job on the wrong machine. Jobs are put on vertical boring mills; this is often the result of following planning department instructions that are 20 or 30 years old. The scheduler has no way of judging the viability of printed instructions that may often owe their presence in the computer to bureaucratic inertia.

Effective scheduling requires a realistic assessment of the times involved in producing a given part, and the scheduler often falls victim to the "heroic fantasies" of the planning department that are chiefly intended to rob the operator of making bonus. The scheduling man at shop C once calculated the time needed to finish a large order of fish plates at 600 unit minutes per day, and decided that he could just squeeze them in ahead of an order of escalator sprockets that were desperately needed somewhere but were not quite ready yet. Had he succeeded, it would have nicely rounded out the departmental production figures for that week, but he did not know that Gerry and I seldom produced more than 400 to 500 unit minutes per day on that job, although he would have known it if he had ever paid any attention to actual production figures rather than ideal production figures. The plates were simply too heavy to make a faster pace attractive. As a consequence, the time allotted for the job was about 20 per cent short, and the sprockets wound up collecting dust and grease in front of our machine. The scheduling man complained to us, and then became quite belligerent when we both indicated to him that we were not willing to go any faster.

"But you can't make any bonus if you only turn 400 minutes a day," he said; to which we replied with a sly look that let him know that we had our ways of making bonus with or without the necessary unit minutes. Having failed in his appeal to our greed, he tried to appeal to our sense of moral obligation to our employers, and this found even less of a sympathetic resonance. He was a devout, born-again capitalist and simply could not understand the way in which we viewed the work process and our place in it. The gulf was too wide.

The basic problem was that the planning function was not informed of actual production times. There was a sharp discontinuity between the planning paradigm and the working knowledge paradigm. The planning department had won the battle of the paper times, but it had lost the battle for the real production times. The operators had been silenced, but they walked away like Galileo, muttering under their breath, "nevertheless, the earth revolves about the sun." A rational readjustment of the two times was blocked by the gaming behaviour that overlay the knowledge paradigms. Measured time was an important card in the game of "making it." The planning department always tries to stack the deck in its favour by keeping measured times to a minimum, but in practice this amounts to nothing more than a bluffing tactic. Real control over production times remains in the hands of the operators, and they can and do withhold production when they feel that the times are unfair. In reality, planning can only succeed by convincing the operators that it is being fair, but most time-study evaluators are not astute enough to realize this. The "going in the hole" strategy of the operator is used to counter the "deflated price" strategy of the time-study evaluation. The consequence is that the planners and schedulers find that they are consistently behind their schedules, even though they should be well ahead according to the paper times. They have no power to change anything, all power having been taken away from them and concentrated in a corporate office somewhere in New Jersey, and so they rationalize the problem by saying that the operators are not working hard enough or do not know what they are doing — all variations of the old "you can't get good help anymore" argument.

The operators, on the other hand, cannot understand why the planners and schedulers are so stupid. Why do they not pay attention to what is really going on? The operators often intervene constructively in order to reschedule the work in an intelligent way. Of course this rescheduling is always done according to the dictates of enlightened self-interest. Experienced operators will group their own work. They will study the board carefully every day. I often saw Bill, the man who broke me in on the vertical mill, standing in front of the job board staring out into space. Under the shop discipline of the pre-war period he would never have been permitted to do this. In fact, he was doing the work of the planning department in his head without the aid of so much as a scrap of paper, let alone a computer. He would scan the cards; he knew all the jobs by heart. He would take a handful of cards off the board and start to order them in terms of the kinds of set-ups they would require. All the jobs requiring a standard vise were put together, followed by a job that required a vise and a fixture, and so on. Perhaps two jobs using the same tool would be grouped together. In this way he was able to make significant savings on set-up and tool changing times. This "grouping" operation was something that no planner or scheduler had the ability to do. Sophisticated computerized grouping methods have been developed in the Soviet Union, but they are hardly used anywhere in North America.

While operators often smooth out inconsistencies in scheduling when they can, there are many situations in which they are unable to intervene. Jobs are assigned to the wrong machine on the assumption that all machines of the same class are interchangeable. My good friend Lawry worked on a small engine lathe in shop C. He was given a job that required putting six inches of thread on a stainless steel rod using a threading device called a "chaser," because it pulls itself down the rod in much the same way a hand thread-cutting die moves down the work as it is turned. The chaser attachment is held by the tailstock which can be moved in as the thread is being cut, but the tailstock on his machine had only five inches of travel, something that the scheduler did not know when he called for six inches of thread to cut on it. Lawry did not feel like arguing about the scheduling, so he reverted to a "going in the hole strategy." He simply did the job the best way he knew how, knowing that he would not be able to make the time. He let the tailstock feed out to its full five inches, after which the pressure on the chasers caused them to disengage automatically. Then he loosened the tailstock, slid it forward, and finished the thread. This method was exorbitantly expensive, but there seemed to be no alternatives. The fault lay in the scheduling, though it would appear on paper to be owing to a lack of skill on the part of the operator.

Going in the hole means that the operator has a lot of time to visit and talk with friends. Lawry discussed the problem with his friend Tom, who was also a lathe operator. Both Lawry and Tom were members of the coffee club, and the club often discussed on-the-job problems. Tom finally announced the solubion to the assembled members of his club. It was simple yet elegant. All Lawry had to do was to loosen the tailstock and let the chasers pull the entire tailstock along the way until they reached a pre-determined point marked by a grease pencil mark. Then he had only to tighten the bolts on the tailstock and the chasers would complete their cut and disengage automatically. A going-in-the-hole job was transformed into a gravy job, and Lawry had even managed to wrangle an extra "allowance" out of the foreman on the grounds that the job was impossible to do in the allotted time.

In this case, it proved to be impractical to change the scheduling of the job, but the combined ingenuity of the operators managed to bypass the technical barriers on the machine and bring the actual production time into line with the paper time. Of course, there was a charge to the company for this service. Thus the informal technology of the working knowledge paradigm is a vital aspect of production under a modern incentive system. Large areas of decision-making and planning are left to the operator and are inaccessible to people working outside the paradigm. When a certain critical number of control factors have been transferred to the work force, the working knowledge paradigm becomes de facto, the only operational paradigm in the shop. Errors and inconsistencies accumulate in the engineering and planning paradigms without being corrected, and informal bypass procedures are invented by the operators. The correction factors for the other two paradigms tend to collect in the working knowledge paradigm. Planning and engineering departments work with a model that is increasingly *anisomorphic* with the realities of shop practice. This leads to periodic shop crises marked in the automobile industry by massive recalls, and in engineering shops by penalties for late delivery, sudden surges in defective parts, and unexpected jumps in operating costs.

The way in which so many solutions to practical problems get deadended in informal technology can be illustrated by the behaviour of the inspectors in shop C. The inspectors had compiled their own workbooks which paralleled the planning department's records and contained step-by-step instructions for inspecting the part. They also kept notes on those parts which experience had taught them would tend to show consistent errors. These informal workbooks constituted a set of guidelines for the on-the-job training of new inspectors, as well as a reference manual for experienced inspectors. Note that this manual indicates a breakdown in the feedback loop between planning and production. In all the large shops in which I have worked, no such loop exists. Instead, an informal system of corrections is set up by the workers which does not feed back to planning. The main reason for this seems to be that management in Canada consistently rejects the information supplied by its workers. After a while, workers give up trying to communicate.

Like inspectors, operators also correct for planning errors. Once while working on some cast iron parts, I ran into some unexpected difficulties. The castings were extra hard — this was a chronic problem at shop C. The tool that was specified by the work order would not do the job. After burning out three high speed end mills in as many hours, I decided that I was doing something wrong. Some research was called for. I asked my mentor Bill about it, and he told me to borrow a special two-inch carbide insert cutter from the numerically controlled machine tool section.

"But," I protested, "the work order calls for a high speed end mill."

His face contorted into a sublime expression of contempt at the mention of the words "work order." Nothing more needed to be said. What had happened was that the operators had informally changed the tooling on the job by borrowing some of the newer tooling used by their friends on the numerically controlled machine tools. The company does not bother to update the tooling on the conventional machine tools, because it is planning to phase them out anyway. But in the meantime, the operators, who are highly sensitized to these questions, notice everything new that comes into the shop, and try it out at the first opportunity.

A new operator has to reproduce this informal system. Because there is no training, each individual has to proceed pragmatically. The training costs in this case were two worker days of below standard production time and three burned out end mills. Thus I was not only compensating for errors in the planning paradigm, but I was training myself how to do it at my own expense.

Operators sometimes take over the functions of tool attendant. At shop D, where I worked after I left shop C, the story was told of old Ned, a high bonus man in the days when shop D was an incentive shop. Old Ned took responsibility for organizing the packing, which was an important part of the informal technology on the run of jobs that were assigned to his machine. "Packing" is a word used by machine operators to refer to pieces of metal of different thicknesses that are used to keep a part level when it is clamped down in the set-up. The shop used a lot of packing of different dimensions, and old Ned had it all organized in a cabinet next to his machine. He took upon himself the job of nagging people to make sure that they always put it back. And he would get very angry when the packing was not taped together properly or not put back in its proper place. When someone went to borrow the packing without asking him first, he would slam the door shut in their faces with his foot — the battered and dented doors are still pointed to as evidence of the truth of this story — and shout, "What do you think you're doing in there?" Old Ned believed in working at full tilt, and used to encourage his neighbours on nearby machines to compete with him in production. When someone was working hard, other operators would say "you are getting to be like old Ned."

Informal technology and organization is an integral part of capitalist production, and this is doubly true in shops with incentive programmes. Large areas of decision-making are simply non-transferable to any other position in the knowledge hierarchy. These non-transferable decision-making functions constitute a field for the exercise of worker expertise. The field is only limited because the managers want to limit it. The problem-solving abilities of the work force thus become a wasted resource, and the inevitable result is a highly evolved irrationality. As I came to understand the working environment at shop C better, I became obsessed with the psychopathology of it. The one unifying feature of the shop seemed to be the craziness that permeated every activity: the crazy dissociation between what was said and what was done; between the written word and the deed; between the paper world and the real world; the inversion of computer output and fact; and the transubstantiation of objective experience into subjective impression. These things began to weigh more heavily upon me than the technical problems of learning my trade, and I was schooled in this vision of the world, as in other things, by the people with whom I worked.

Morris, who operated a vertical boring mill, called my attention to the transcendent importance of the paper world. If operators run into snags, they tell their foremen, and the foremen get on the phone and call up the paper world. (Notice that the foreman is reduced to a relay switch between the real world and the paper world here.) Eventually a being from the paper world, usually male engineer in a pastel shirt and tie will drift ethereally into the shop. The problem then becomes a move in the intra-bureaucratic games of the paper world, which are chiefly concerned with getting someone else to make the decision. The operator sits idly by while the paper world flutters and shuffles its way towards a decision. The probability of this period of idleness had caused the operator to report the problem in the first place.

When the decision is made, and the work proceeds, the engineer will then describe the process in the following terms: "I put this part on the machine. I used this tool, and this feed and speed and the metal came off like butter and then I took it off the machine . . . etc." The operator overhearing this description thinks that the engineer is crazy because it was the operator who did these things, but the operator forgets that the operator only did these things in the real world. The engineer is talking about what the engineer did in the paper world, where it counts. Two diametrically opposed visions of reality thus coexist in the same space/time point, like two alternative universes. But the most important is the paper universe.

The paper universe does not recognize the contribution of labour, except as cause of errors. The real world does not recognize the paper world except as a source of irrelevancies. The supervisory link between the two worlds is ignored by both sides. The manual workers are confronted with a million and one irrationalities in their working lives. Work, as it is now constituted, is a *"crazy-making" environment. Workers cope with irrationality by tuning out.*

They restrict their attention to those things that they can personally control, or they join clubs and cliques that provide some expanded scope to their game playing and socializing proclivities. They create a world in which management is largely invisible to them, except as an occasional intrusive annoyance.

Alex, one of the lift truck drivers in shop C, had managed to create his own world without supervision. He had appropriated a desk from somewhere and he spent most of his time there reading the paper and drinking coffee. When operators needed something moved, they went to Alex's desk. If Alex was not there, they left a note. Foremen were careful to avoid Alex, because of his sharp tongue, and they usually left notes. He explained his attitude towards foremen as follows, "I just pretend they're not there. They are like this brick wall. You don't talk to it. If it is in the way, you go around it."

The tension between conflicting perceived worlds can be somewhat relieved by a tacit agreement not to interact, but the manual worker cannot ignore the work. The peculiar nature of manual labour derives from the fact that it is the principal sphere of interaction with the material world. Manual work is therefore less malleable than work in the paper world where the eraser is the final arbiter. The manual worker is locked into the craziness of the workplace in a way that other workers are not.

VI

AS I REFLECTED UPON all this, it became apparent to me how little I was learning about my trade and how much of my energy was being taken up in learning the rules of an archaic and essentially crazy social order. I realize that there were implicit, but well defined, limits to learning at shop C. It was okay to learn one machine, but not two. Learning was encouraged up to the threshold where game playing could begin, but after that it was discouraged. The more competent a person became, the more they were perceived as a threat by management and labour alike. Thus there was no incentive to proceed beyond a certain low level of competence. Nearly all workers voluntarily truncate their acquisition of skills shortly after they begin. This is no incentive to be interested in general skills. Only specialized skills and speed skills are valued. Having drawn this depressing balance sheet on my workplace, I decided that I would make one more effort to change machines and acquire a little more skill before leaving.

One of the real gains of the union at shop C was a job-posting programme. The company was required to post all job vacancies before hiring from the outside. This meant that I would at least have a chance to bid on a job, although my chances of getting it would be rather slim because the general foreman did not like to move people around after they had learned a run of jobs. I decided to try and get transferred to a vertical boring mill, a machine that had always interested me. It would be a step up into the major leagues of machine operators, because not many people know how to operate them. There are no vertical boring mills in community college machine shops, but there are a lot of engine lathes, milling machines, and drill presses. Consequently when an opening on a vertical boring mill was posted, I applied.

Although I was not initially sanguine about my chances of getting the job, it soon appeared that there was some room to manoeuvre. The foremen decided not to deny me the position outright. They had more subtle tactics in mind — too subtle as it turned out. They approved the transfer and then began to work on the man who operated the machine I was being transferred to. This required only that they feed his paranoia about losing bonus, but they used other dirty tricks. They also played on the fact that he was a devout born-again Christian and I was a godless socialist. Having played Iago to a vulnerable Othello, they had only to wait, and the results were not long in coming. The day I was scheduled to begin training on my new machine I came to work feeling happy and excited. I thought that I had actually managed to break out of the rut that I was in. I stood around waiting for Ron (the other operator) or someone to say something to me. Finally one of the foremen came by and told me to get to work.

"Where?" I asked.

"Over there," he said, pointing to the vertical mill I had been operating for the last eight months. I was somewhat taken aback, but I went over to my old machine to mull things over. Then I talked to the union president. He said that as far as he knew I was being transferred to Ron's machine. I waited until lunch, prey to growing feelings of apprehension. Finally, I screwed up enough courage to ask the foreman what was going on.

"Oh," he said, "we can't put you on that machine. Ron has refused to train you. You know how it is." He looked at me as though he expected me to sympathize with him because of the difficult position he was in.

I did not feel very sympathetic. I was crushed. I went back to talk to the union president. "There is nothing we can do," he said. He always used the plural when he wanted to dilute responsibility. "We can't force one man to train another." In fact, he was caught in a bad spot. The union was tacitly condoning an informal policy of refusing to train that had been instituted by some of the operators. He did not know what to do when his own members were victimized by the policy. In theory, only the company was supposed to suffer.

I was angry about the way in which I had been treated. Apparently, the plan had been to make me feel foolish and force me to realize that I could only change machines when the supervisors wanted me to, contract language notwithstanding. I began a one-man, slowdown campaign. I underproduced on the jobs that I knew how to do, and I began to choose as many new jobs as possible so that I would always have the chance to learn a few new tricks. I began to follow a policy of never making bonus, and going *in the hole* at every possible opportunity. It is a famous piece of shopworn folklore that a foreman will never transfer a man that is doing well. I proposed to overcome this traditional resistance by doing poorly. It was a tactic that had stood me in good stead before.

A deadlock was thus created that lasted for about two months, and was only ended when the whole shop became embroiled in pre-strike conflict. An informal overtime ban was instituted, then an informal ban on making bonus.

Production declined, tension and conflict escalated, culminating in a half-day stoppage the day before we were officially on strike. Everyone was certain that the company would settle and that we would only be out a few days. We were out three months.

When we went back to work, I was officially posted as a vertical boring mill operator, but I was still working on milling machines. Ron was still refusing to train me. Then the company posted a job opening on a different vertical boring mill, operated by a member of the country club named Don. Don was a widower with two schoolage children and his big fear was that he would be forced to work shifts and would not be able to be home with his children during the evening. I could not work permanent afternoons, because I would never see my own family if I did, but I could work permanent nights, or so I thought at the time. Don agreed to train me if I would work a permanent cross shift. Armed with this agreement, and the fact that the company had already changed my job classification to vertical boring mill operator, I applied for the job on Don's machine. Actually I had already picked out Don as the operator that I would rather work with. He had style. Don had salvaged an armchair from some office clean up, and he made a point of operating his machine while sitting down, which drove the supervisors wild. In fact, one of Don's great contributions was the discovery of the art of sit-down machining. Sit-down machining was made possible by the development of pendant controls, but it was Don who recognized the possibility and developed the technique. In a pendant controlled machine, all the controls are buttons in a push button panel suspended from a counterbalanced arm. All feeds, speeds, and tool changes are automatic, so that the operator can literally work the machine while sitting down. In fact it could be operated while the operator lay down in bed. The only time the operator has to get up is when a part is finished and has to be taken out. Don used his accounting skills to make bonus, and he regarded his required daily attendance at shop C as the single greatest misfortune in his life after the death of his wife. His ambition was to be an insurance salesman so that he could play golf all day. Next to golf, his favourite hobby was going to the horse races. In spite of this, Don was a gifted operator, with a mind that instinctively worked within the parameters of scientific engineering: reducing every job to a set of cost-effective operations.

He was hated by the supervisors. They did not want me to work on the same machine with him, partly because they were afraid that he would corrupt me, and partly because they wanted to force him to work shifts in the hope that he would leave. So once again my transfer was blocked. This time they simply stalled and refused to make a decision. But the experience of the long strike had forged a caucus of operators in the machine shop who had learned how to support each other. After some discussion within the caucus, which overlapped to some extent with the coffee club, it was decided that I should simply transfer myself to Don's machine and he began to train me. We expected supervision to chase me back to my old machine, but they did not. They bowed to the *fait* *accompli*, and I began the difficult process of learning to be a vertical boring mill operator.

Don and I tried to arrange it so that my training period with him would be as long as possible. Whenever one of the three foremen in the shop would ask him whether or not he thought I was ready to work on my own, he would say no. This meant that I got to stay on days for a while, and Don got to walk around and talk to his friends. But eventually, I had to go on permanent nights. My production increased gradually, and I was able to make bonus on jobs that I was already familiar with, or on long runs where I had time to learn the necessary speed skills. I found that night shift tended to make me extremely tired and slow-witted, but Don was willing to cover for me once in a while,because he knew that I was just learning, and that I was covering for him by taking the night shift.

Then disaster struck. Ron's machine, one of the two other vertical boring mills in the shop, broke down, and he was transferred to our machine. This meant three men and three shifts on a machine — a double triangle. Don had to work shifts after all. I kept working steady nights. To make matters worse. Don and Ron hated each other. One was a evangelical Christian, the other an Irish cynic. They immedately began a production war using every trick in the book, and I was caught in the middle. If Ron was on days, he would grab the best job, run it off and bank all the gravy. When Don came in, he took what was left, and by the time I came in on nights, there was nothing left but bones and feathers. It was simply impossible for me to keep up production under these circumstances, although I did everything in my power to do so. I was acutely aware of the fact that my days in shop C were numbered, but I wanted to reach the level where it would be possible to move on to a boring mill job in another shop. The squeeze was on. I was sometimes forced to do three set-ups in one night without being able to make bonus. The strain of the job kept me from sleeping during the day, always difficult at best, and I became less and less alert at nights, which made me more nervous and less able to sleep during the day, and so on.

The work from Ron's machine was moved over to our machine, and this meant that I had to learn another run of jobs. The bottom line was that I was not doing well in the production numbers game. The supervisors must have realized that too many crooks ruin the production figures, so they decided to pressure me off the machine. After all, they had not wanted me there in the first place, and subsequent events had proven them right. It is difficult for me to be objective about what happened next. The best thing for me to do is to quote from my journal, to illustrate my state of mind at the time:

Last night I had a run-in with Charlie [a supervisor] about my production. When I came to work, Tom [one of the other foremen] approached me and told me that my production was down and that I had to see Charlie, who had apparently been deputized as my case-worker. I did and we had an argument. What had happened was that production was down all over the shop because it was the first week after the holidays and naturally no one felt like working. The foremen got a printout from the computer that gave them a list of everybody who was going in the hole, and my name was on it. They began to check up on all of us. In my case, they could not check up on me because there is no supervisor on nights, so they told Herman, the lead hand on nights, to "spy around" [Charlie's words] and see what was happening. Herman had to report someone so he reported me for taking long breaks, which I had been doing. Not only was I taking breaks, but my production was down. Nor was it simply that my production was down, but also that I didn't use checkouts to cover myself when I went in the hole; and, to make matters worse, I wasn't in Herman's close network of acquaintances who took even longer breaks. For all of these reasons, I was selected for special treatment, and became the object of an effort to extract at least a little more juice out of the lemon. In talking it over, Gord pointed out to me that Herman never reports drinking or smoking dope on the job — things which occur with clockwork regularity.

The factors which determine enforcement of standards are not strictly related to productivity, but reflect, as in other cases, the need to preserve and reproduce the social order. In the long run, productivity depends upon this social order, rather than on individual effort, this is why so much energy is expended in preserving it. Belief in the incentive system is an important part of belief in the social order. Like Tinker Bell, the social order can only exist if a lot of people believe in it. Some people are penalized for not using checkouts, while people who use checkouts to cheat the company are not penalized because they have at least internalized the social order. This is because when one really believes in the system, then abuse of the system is no longer abuse, but rather support. My friend Don is periodically attacked for using too many checkouts, because he does not believe and is therefore not entitled.

Looking back over my writing from that period, I realize how angry and desperate I had become. I was in a situation that I could not control and that has not happened to me very often. I was thinking abstractly in a situation that called for concreteness. The problem was that there was no concrete solution to the situation that I was in. My journal shows that I was beginning a retreat into rationalizing. My socialist ideas became an elaborate tool for covering over and avoiding the real situation — that I was powerless and had to knuckle under. In this way I could avoid recognizing the fact that I had miscalculated, and was in a no-win situation. I had depended on the militancy generated by the strike, the support of the coffee club, my friendship with Don, and my own native intelligence to get me through. As it turned out, none of these were enough. In retrospect, I think that this was what was most threatening; that all the assumptions that had led me to be where I was were now in question. I could have given up and left the boring mill, if it had not also meant that I would also have to give up my precious assumptions.

Underlying the immediate tactical assumption governing the specific situation were the long-range strategic assumptions that went back at least as far as my graduate student days in Berkeley. I was, after all, where I had always wanted to be and where I had always thought I would be. Of course, it was not working out the way I wanted it to, but I was there nonetheless. I was having a crisis of expectations. If I had been capable of any realism, I would have had to admit that I was not sure whether or not I really wanted to be there at all.

I think that what disturbed me the most was the conflict between Ron and Don. I could handle the flack from the foremen, especially as Ron's and Don's production was going down, and they were getting it too. But what I could not stand was labour's internalization of the conflict: the fact that the more pressure that was put on them from above, the more viciously they fought with each other. It was like being in a family that was constantly fighting with itself when it should have been presenting a united front to the world. After all, if we all stuck together and produced at the same rate, there was nothing that they could do to us. We had nothing to fear. This is what I told myself, and what I proposed to them.

But here I am not being completely honest. I think that I always favoured Don in the conflict because of his anti-religious attitudes, and that Ron was aware of this and did not completely trust me. In retrospect, it would seem that Ron, in spite of his religious ideas, was a better rock upon which to build. Prejudice is a luxury that only the rich can afford because they can always buy friends when they need them. Friendship and personal support had emerged as key elements in my "career strategy," and I was not making very intelligent use of them.

I cannot illustrate the conflict between Ron and Don in any detail because I was so freaked out by it that I never made any notes on it. I did, however, make notes on another conflict between Gord and Morris, who operated the vertical boring mill next to ours, and that conflict will have to serve as an example of the depths to which these things can sink. Morris was an old hand who had been there since the end of World War II. Gord drifted into the shop towards the end of my tenure there. He was a mod-hip young machinist who had been black-listed at the big steel mill where he had served his apprenticeship, and had drifted around the country, working or living on UIC as the mood struck him. Conflict between Morris and Gord was inevitable, but it was Morris who initiated it.

Before Gord came, Morris seemed to be a very relaxed guy. He did as little work as possible and made as much bonus as possible. He loved to take long coffee breaks in the morning and afternoon when he would come over and talk with Don and me. We always had three chairs around for this purpose. But when Gord was put on his machine he became nervous and withdrawn. People in the shop began to shake their heads and look disgusted. They knew that a long session of "screw your partner" was in the offing. They knew it, and they thought it was disgusting, but any one of them would have done the same thing in Morris' place.

Even though Gord made offers of friendship to Morris, Morris was threatened by Gord because Gord had served his apprenticeship and was a certified journeyman. Morris therefore had well established underdog credentials that gave him a licence to fight dirty. In pursuit of his effort to make friends with Morris, Gord went so far as to work steady nights so that Morris would not have to work shifts. This meant that if Morris began to attack Gord, he could easily lose his underdog status, because he was also indebted to Gord for this favour. In fact, Gord preferred nights because he was a night person and could not get up in the morning. Morris prepared for the conflict by sulking and going into a depression. He stopped talking to other people and became extremely solitary. He worked extra hard to make sure that he had completed each order by the end of the day so that there would be nothing set up on the machine when Gord came in on nights. If he finished early he would sit around for an hour or even two hours rather than start to set up a job which Gord could run. (Ron and Don also used this tactic against each other.) At first, Morris could easily out-produce Gord, because he had twenty years' experience on this particular run of work. But Gord gradually became more proficient, and Morris had to work feverishly to out-produce him.

Gord, on the other hand, became annoyed with Morris' petty attitude. When a long-run job with a bad time was on the machine, Morris would tear it off, put on a good job, make bonus, and then put the bad job back on for Gord to run. Morris would deliberately turn down the feeds and speeds so that Gord would spend hours working harder than necessary before he realized that he was running the job incorrectly. Gradually, Gord became angry and began to respond by trying to out-produce him, because he knew that this would really annoy Morris. The other men in the shop fanned the flames by telling Gord about the different ways in which Morris was trying to screw him, and they would never fail to tell Morris what a good machinist Gord was.

I was caught in the middle of a similar struggle. Then, in a completely unexpected humane gesture, Ron took sides with me and insisted that the company put me on days with him, and that he be allowed to train me on the run of work from his machine. It was one of those incidents that make all the pain and anxiety worthwhile. Ron could force the supervisors to do things when he set his mind to it because he did not withdraw into cynicism and alcoholism like Don, and because they regarded him as a "good" worker. Ron wanted someone to cover his back on his machine when it went back into production, and had seen that I could be trusted to keep my word and would work steady nights or afternoons. He wanted me on his side.

Ron taught me more about speed skills than anyone else ever has. Everything he did was calculated to maintain a rhythm and a pace of work that continued unbroken for eight or ten hours at a stretch. He was the ideal incentive plan worker, and once more illustrated to me the way in which most machine shops are totally dependent upon the individual skills and understanding of the operators. Ron was a master of the shadow zones of machine tool technology.

He had a fine understanding of the importance of sequences of operations in machining. Making a machine part was like skinning a goat; there was more than one way to do it, but Ron was convinced that there was only one fastest sequence. After the sheaves were turned, they had to be grooved so that they could hold the ropes or cables in position. The spacing, or pitch, of these grooves and their depth were critical dimensions. The grooves had to be centred with respect to the faces, or the sheaves would be thrown out of balance and would vibrate. Don began by finishing the faces of the sheaves; Ron, however, left the faces rough until he had finished the grooves. In this way, he could adjust the centre line at the last minute, if need be.

I learned a lot of technique from Ron and Don, and I was also given the key to the psychic content of informal technology by them. Workers do not evolve technology out of a linear rational response to economic incentives. Informal technology is a mechanism for survival in the daily jungle warfare of the modern industrial plant. As such, it takes its place along with other life-support systems, like families, friendship networks, clubs, cliques, and trade unions. To the extent that there is cooperation among industrial workers, there is a shared informal technology. To the extent that there is competition, and to the degree that this competition is brutal and destructive, technology is concealed and monopolized. Technology, then, is part of the defensive armour that the worker wears for protection inside the shop. It is more vital to survival than safety glasses or steel-toed boots. The psychic root of informal technology is fear.

The last chapter in my adventures at shop C closed as follows. Under Ron's tutelage, my production increased, but in obedience to the laws of fractional arithmetic, as my production went up, either Ron's or Don's went down. We were not getting any work. If anything, we were getting less. We were simply fighting over the division of a pie of fixed diameter. Increasing production was not the solution. The foremen knew that there were too many operators on the machine for the existing workload. In fact, they had hired two additional vertical boring mill operators, one of whom they had imported from Scotland, and were really overstaffed on that machine. So they renewed their efforts to force me off, though with less statistical justification this time. Slowly they began to tighten the screws on me. Under the contract, they were entitled to move me off my machine whenever there was more pressing work to be done on other machines, but they could not transfer me permanently without my consent, which they would never get, unless they were willing to train me on yet another machine.

About this time an overflow of rails was sent into the shop to be milled. There were no facilities to do this work, and the method devised would have made Rube Goldberg blush with shame. To make matters worse, time-study set an impossible time on the rail job and everybody refused to run it. They began to force me off the boring mill at nights to work on milling rails, using every conceivable pretext: there was no work; the castings were too hard; tools were missing; and so on. I do not know why, but I really panicked at this.

It was a situation that called for discretion but I chose valour. I tried to organize a bonus ban on the rails, and to defend my position on the boring mill by bringing my production up. The bonus ban went badly. I was reported to the general foreman by one of my fellow workers, and they began to attack my production figures. Even though there was an overall drop in production on the vertical boring mills, I would not use this in my defence, or in any case I did not know how to. Tension and sleeplessness increased. Work became a nightmare that I had to force myself to endure every night. My head constantly felt like it had been stuffed with cotton and immersed in water.

One night I walked up to my machine, and found a pleasant surprise waiting for me. Don had managed to find a good job and set it up for me. All I had to do was make one an hour and I would be home free, for that night anyway. It was a simple steel ring, weighing about 90 pounds, set on parallels and held between jaws. The first one took me a little more than an hour, and I realized that I would have to speed up. I began turning the outside diameter. The only tricky part was disengaging the tool and backing it away before it reached the bottom of the piece and crashed into the jaws. As I reached the bottom of the cut, I pushed the button to move the tool horizontally away from the piece, and at the same time, I pushed down the rapid traverse button. But apparently I was so fatigued that I did not immediately release the button that fed the tool down. The switch was defective and sometimes did not click out right away anyway. The result was that the tool continued down into the piece at rapid traverse, shearing off two of the jaws, flipping the ring up in the air and throwing it through the steel guard where it fell at my feet. The sight of so much destruction in such a little time paralyzed me. I managed to sidestep the flying ring but then I remained frozen to the spot. I felt utterly and totally defeated. The thundering crash brought everybody in the shop running over to see what had happened. The lead hand said I could always run another machine for the rest of the night. I mumbled an incoherent "no thank you," went home, and cracked my secret bottle of whiskey.

That was the end of my career at shop C. I quit within the week. The machine, I am glad to report, recovered from the accident and is still functioning at this time. I was fond of that machine, which is one of the reasons that I fought so hard to stay on it. I have gone on to operate other vertical boring mills in other shops, and I think that I have become a reasonably competent vertical boring mill operator, but I have yet to qualify as a general machinist. Every hurdle is followed by another and they seem to stretch endlessly towards the lowering horizon.

VII

I HAVE RE-READ THESE notes more than a year after they were made, hoping that the passages of time might have mellowed my perception of them. It has not. I still feel angry. I cannot accept the fact that it should be so extraordinarily difficult to learn to do something so obviously useful and necessary. It is not as though being a machinist is like being a doctor. The machinist cannot look forward to being exceptionally well paid for doing good. The best that can be hoped for is a modestly comfortable income. The chief benefits from a machinist's labour accrue to other people. Why then discourage people who want to become machinists? Why make it impossible to learn a useful trade?

Part of the answer lies in the Canadian business community's preference for slave labour, part in the willingness of too many Canadians to be slaves. But these are not the important parts of the answer. Slavery must be economical in order to survive. The key question is whether or not the Canadian manufacturing economy can continue to flourish on a foundation of slave labour. Economic planners are now looking to high technology to pull us out of the mess we are in. Is high technology compatible with a semiskilled, over-specialized labour force?

Clearly the system as it now exists is not capable of producing skilled labour. Skilled labour, that is, generalist labour, is not suited to Canadian industry as it now exists. The social structure in the most productive shops is based on specialist labour. Trades workers who are trained in Europe and then come to Canada almost invariably become specialists of one sort or another. I myself have seen many examples of fine workers whose productive potential has been wasted by Canadian industry; who have been well paid to work well below their capacity.

Our position in the product cycle has put a premium upon specialist labour. The branch-plant economy produces well established products from imported designs using imported methods. Little or no innovation is carried on, although there are exceptions to this rule. I worked in two shops where some innovative work was being done, and in both instances there was a much greater reliance upon skilled labour. In both instances, however, the skilled labour was imported from Europe. No training programmes were undertaken. In one case, a German multinational was introducing a new line of heavy-duty construction equipment that depended upon innovative hydraulics. They brought in their own mechanics to do the tricky bits. Canadians were used for the semiskilled assembly work. Similarly with one-off engineering projects, they had their own stable of machinists and mechanics that they moved around the world. In this way they retained a monopoly on decisive pieces of skilled labour technique. In another shop, trades workers from the United Kingdom were used to beef up the skill level in the shop when some big contracts were landed in northern Africa. They were guaranteed a year's employment and were dumped onto the employment rolls precisely at the end of the year.

The use of skilled labour by Canada's big producers thus tends to be limited in scope and confined to rather short periods of time. These are two conditions that militate against the training of skilled labour. Under the present circumstances, it is almost impossible to predict what skills will be needed, when they will be needed, where, and for how long. Without a national economic strategy that imposes some sort of order on the economy, it is difficult to see how these conditions will ever change, and the prospects for Canadians seeking decent industrial jobs are dim.

The main argument here has been that learning in the shops will never occur spontaneously. There is nothing in the industrial system as it now exists that will lead a worker to acquire the knowledge and habits of mind of a skilled tradesperson. The existing shops are a hostile environment for generalist skills. The intense personal competition between specialists, usually encouraged by line supervision, inhibits the exchange of information and makes experienced workers unwilling to teach newcomers. The lack of support systems for learners makes every change of specialty an agonizing experience that few would be willing to endure more than once or twice. The privatization of knowledge and technique leads each specialist to view acquired skills as personal property, and to demand an equivalent value in exchange for sharing them. Long-standing trends in job design towards deskilled jobs and shorter learning curves also making learning general skills on the job more difficult. The natural knowledge of the labour force, the working knowledge paradigm, is not taught in any systematic way and this leads to a serious contradiction. Though not formalized, working knowledge is often the only operational paradigm in the shop. When this is the case the collapse of learning entails a fall in productivity. Even specialist skills must be taught.

Throughout this essay, the possibility of change is implicit. But it may proceed in different directions. On the one hand, the self-organization of the labour force, or worker's self-management, presents itself as an attractive option. Self management integrates the functions of production, learning, and managing. It makes it possible, for the first time, to tap working knowledge and to utilize fully the intelligence and problem-solving capacities of the labour force. Within the context of self-management we can begin to imagine a technology that works in harmony with the technique of the worker without the development of counter-paradigms. On the other hand, the automated factory looms as an ominous and more likely possibility that entails the suppression of existing working knowledge and further reductions of general skill. In this latter case, we can only hope for the creation of new agendas and strategies by the labour force.