Crafting Organizational Transition:

Applying the Principles of Skilled Trade in Manufacturing

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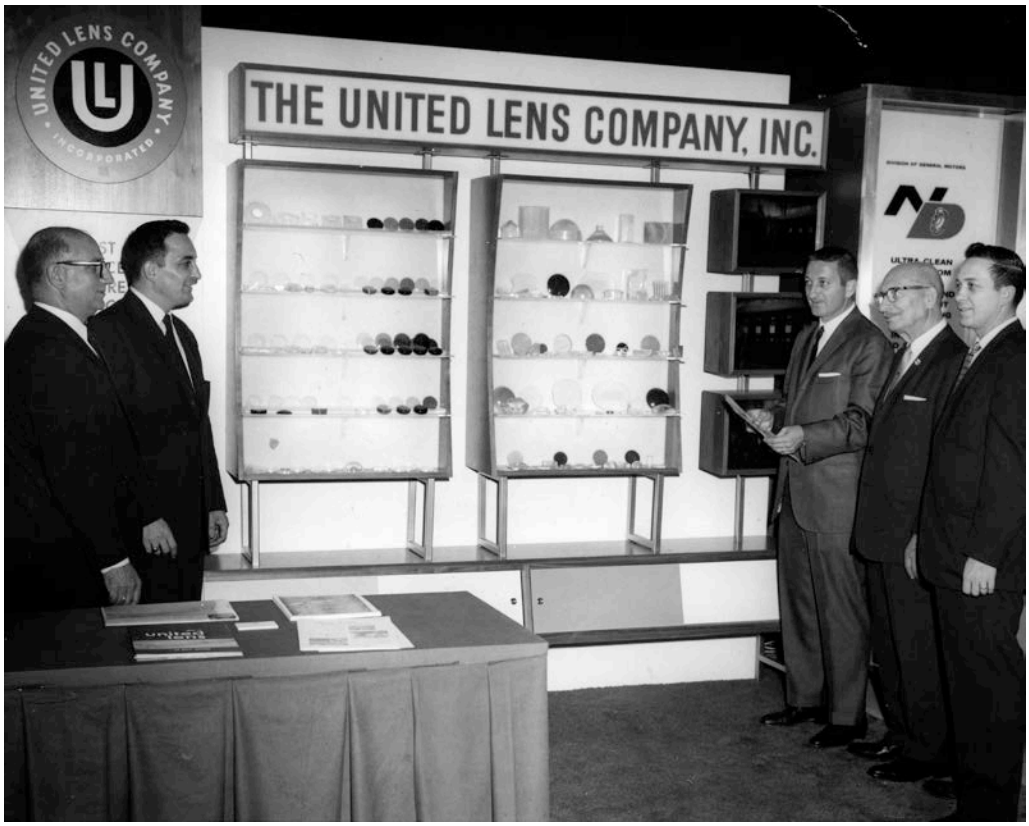
Abstract:

As the landscape of American manufacturing has changed over time, social, technological, and economic influences have had a profound effect in shaping broad ideas of quality, craftsmanship, and success. This thesis is an analysis of the transition of "craft" to technological work, and the role of organizational structure in facilitating or *inhibiting* this transition. Its orientation is neither ethnographic, nor is it properly autoethnographic; instead, it is a candid investigation through the lens of my trade apprenticeship in the postindustrial mill town of Southbridge, Massachusetts, at my own family's glass manufacturing business.

Front entrance at United Lens Company, June 2014.



Promoting at a trade show, year unknown. Left to right: Tony Detarando (Great Uncle), Ronnie DiGregorio (Great Uncle), Al DiGregorio (Grandfather), Fileno DiGregorio (Founder, Great Grandfather), and Richard DiGregorio (Great Uncle)

Switching Gears: from Book Learning to Hands-on Education

Growing up, my parents took my particular fascinations with Legos, mechanical toys, and architecture as a prophetic sign for a life dedicated to the field of engineering--an appropriate and exciting pursuit that could easily be applied in the family business: a glass manufacturing company, now in its third generation of family ownership. In hindsight, however, the interest in tinkering with Legos was not a particularly remarkable quality in children my age, and when I enrolled at the University of Massachusetts to pursue Chinese language and literature, along with anthropology, it had seemed that they had missed the mark. I graduated with every intention of pursuing archaeology, attended a brief field school, got a job doing archaeological survey work, then promptly learned a valuable lesson regarding the financial difficulties of seasonal contract employment, and ended up back in that same family factory where I had spent a handful of my summer and winter school vacations.

The majority of this period was spent in the laboratory-like Coating Department, doing meticulous, thoughtful work preparing glass and using equipment to apply a variety of unique coatings to make mirrors and lenses. It was a generous assignment; I enjoyed some of the work, and it afforded me a chance to learn all sorts of technical minutiae. Regardless of whether or not this was an intentional move by my father in an effort to fulfill the engineering prophecy that he and my mother made for me twenty years earlier, I was grateful--ever the dutiful son, however, I cannot ever let them believe that they were “right” in their predictions. They were half-right. At best. Two years later, I was surprised to find that I was being relocated: the new assistant to Richard--or, Dick--Lempicki, who up until that moment, I knew only as a very talented machinist and some sort of “inventor-in-residence” at the company.

It was the beginning of what could currently (at the time of writing this) be described as my apprenticeship--not a very traditional arrangement, and not reached through very traditional means. That being the case, it was no surprise when Dick asked me to teach him how to use the 3D printer that sits behind my desk: I doubt very much that it was a scenario envisioned by master tradesmen a thousand, hundred, or even *ten* years ago--not just because of the new technology, but also for the fact that my opinion and instruction was worth asking for (see Sennett 2008: 53)[1]. We had both been excited to try this new device, but when it had arrived a few months prior, he instructed me to set it up in my office and learn how to use it--he had used the same trick earlier in the year, assigning our youngest "apprentice" machinist the task of learning the newest CNC (*Computer Numerical Control*) lathe, which requires the use of a proprietary method of programming. This way, Dick had said, he would have something to teach the two more experienced machinists who are typically his mentors.

That this may have been an elaborate set-up as an exercise in my *own* education did not escape me, but the fact remains that it was an opportunity to reinforce my inexperienced understandings of the mechanical world. The whole lesson (if you could call it that) was conducted in less than an hour, the majority of which I spent struggling to find the terms to describe technical parts and processes that I am barely familiar with: *"...you need to level the build plate in reference to where the plastic is extruded: this guarantees adhesion as the plastic lays down on the plate--the thumbscrews beneath the table tighten and loosen to adjust height, shim between the plate and the extruder to maintain a constant distance; you'll be better than me at this…"*

My instructions were informed by the lessons that had been given to me--although a 3D

[1] For further reading, Chapter 2, "The Workshop" in Richard Sennett's *The Craftsman* (2008) is a particularly rich description of the master-apprentice relationship in various contexts.

printer sounds cutting edge, where the popular misconception seems to be that that it functions like a paper (or if you prefer, an antiquated-by-comparison "2D") printer, and will produce whatever is on your computer screen in all three of the physical dimensions, the reality is that it is just another mechanical tool. Having used tools all his life, Dick did not require much guidance--the printer is governed by the same mechanical principles as any other; its design has arrived through the reapplication of those principles in a fashion similar to many machines before it. There is no push-button miracle here: it requires a little training to use, has its own shortcomings and quirks to commit to memory, and works best with practice. Most of all, it needs the same thought as any other tool: a consideration of when it is best suited to an application, and how it can best be employed to meet our needs.

These last points reflect a particularly troubling set of assumptions in a world where tools and technology are becoming more capable: automation supplants employee training, machinery can be fool-proofed against its operator's need for practice and skill, and a computer's capacity for calculation eliminates the need for an educated human at the controls (see Holtzberg-Call 1992)[2]. If we allow it to be, the 3D printer is an embodiment of these assumptions: all the machinery, material, and *knowledge* required to make something, scaled down and delivered in an affordable desktop unit. Reality is slightly more complicated--regardless of changing technology, the fact remains that a tool is only as effective as the individual using it. In my office, for example, the printer is used for rapidly producing helpful knick-knacks like one-off (unique, single use) holding tools and racks for the convenience of people working on the manufacturing floor, or small, disposable prototypes for the development projects that Dick and I work on; we turn to the experienced machinists in our shop for designs of any real precision or

[2] First-person perspectives on the negative consequences of technology and management control can be found in the interviews in Maggie Holtzberg-Call's book, *The Lost World of the Craft Printer* (1992).

quality. For the same reasons that the design and use of the 3D printer is immediately apparent to a person with a background in machining, on the tool's own merit it does not compare to an individual's skill.

Asserting the value of this skill through the stories of individual craftsmen would be research and writing well spent, but those stories would be better served as entire volumes than in the short paper I have put together here. I cannot honor the life story of my mentor Dick Lempicki, nor can I provide an adequate family or company history--I have not even attempted it. Rather, this paper, and these relationships, have provided me with an opportunity to explore my own place within my family company and my apprenticeship in order to establish an analysis of interfaces between technology, organization, and craftsmanship.

As I write this, Dick and I have worked together for just over a year, with Dick in the role of teacher and manager, with a background in machining, mechanics, and design. My job has been to act as assistant and student, and though my own background in anthropology seems far afield, there is much to be said about our common ground; ultimately, it is the desire to do good work that drives us--an effort to understand and learn, whether the topic is human or mechanical, and often times, to make things *better*.

As it happens, a good mechanic (and a good anthropologist, for that matter) recognizes that "better" can be a very relative term: when an individual works on their car, are they aiming to make it faster, or more dependable? When it comes to making the workplace better, it is an intensely relevant analogy: the danger lies in prioritizing simple objectives like *speed* and *profitability* over values of *craftsmanship* and *tradition*. The histories of labor and industrialization attest that this is not a new or uncommon oversight in the world of organizational management; it can manifest itself in lower quality products, lower workplace

morale, and the elimination of jobs. Typically these are the products of managerial oversimplification: that quality is an independent equation of maximizing value to minimum cost, that morale is expected in new recruits rather than encouraged, and that an employee will slip into obsolescence as a particular method or job that they perform becomes dated. Though popular, these attitudes do not mean that concepts like *tradition* and *profitability* are irreconcilable. Making the workplace "better" in a modern, always-changing world is no small task, so we may choose to proceed as more experienced craftsman have before us: *carefully*, and with an eye for making things fit (see McCarl 1986 and 1992)[3].

With that in mind, this thesis revolves around the practical lessons of my work, some from personal experience, and some guided by my mentor, Dick. Diagnostics, design, adaptation and repair: these are the tools that I am learning to utilize, but they are not just for the sake of building and adapting equipment. These are exercises that are just as easily applied to myself, my company, and the act of *work* in general, and this is precisely what I intend to do with this paper. As a junior mechanic, it is best to think carefully before acting; similarly, as technology and the market changes, it is presumptuous to assume that I can even *determine* the best courses of action, let alone guide United Lens along those courses, but my role with the company would have me at least lend my voice. As I learn the trade from Dickie, I learn the equipment and work processes of each of the company's departments. I meet individuals doing the work. My task is fundamentally rooted in making sure that equipment is not just operational, but effective. Useful. As in the case with the 3D printer, it requires intimately familiarizing myself with a process, how it is performed, who it is performed by, and what might assist them in their work.

[3] Robert McCarl's 1992 publication "Exploring the Boundaries of Occupational Knowledge" as well as "Occupational Folklore" from 1986 are particularly informative guides for the study of the workplace, and are largely responsible for my choice of implying that the observed values of "care" and "finesse" are those of a craftsmen.

In that regard, the operation and efficacy of United Lens as a whole follows suit; taking my cues from the mechanic's guiding principle of *finesse*, I proceed in the same analytical manner that I continue to learn, setting my tools out in front of me, and giving ample consideration to their selection and implementation.

Much of my apprenticeship has revolved around thoughtfully solving problems through adaptation and invention--and so this paper follows suit by considering the company's many changes that have been performed over the years in the same fashion. In ***Step 1: Context***, I begin by contextualizing the place and process: this begins with considering history (Section **1a: Historical Context**), then the physical act of work as it is performed (Section **1b: Operational Context**). Often these change together: as time goes on, the work changes, and so it has been at United Lens--these changes tell us much about what is possible moving forward, and what options are available for improvement (Section **1c: Adaptability**).

The diagnostic process does not stop with considering context: in ***Step 2: Measurement*** we pay an important visit to the more tangible components of analysis. Understanding the value in how a measurement is made is discussed in section **2a: Tolerancing** and then revisited in **2b: Perspective**. Ambiguity is the main theme of this entire chapter, with the first section (2a) showing us that specifications are relative to how they are written, measured, and applied. The second section (2b) explains the critical role of the individual in this process, and the value of 'good judgment'.

In the third chapter, ***Step 3: Tools***, I detail the relationship that forms between an individual and the tools they use to perform a task, as well as the task itself. The product of these relationships is what I refer to as an individual's "mastery" of work.

Finally, I present my conclusion in ***Making Things Fit***. Each of these chapters describes facets of the workplace, but this is a discussion of those elements that might be considered most important. These are my considerations of how United Lens might continue to change adapt over time.

Molding in full production, year unknown.

Cutting glass for the molding process, year unknown.

Step 1: Context

1a: Historical Context

In reality, both machines and organizations can be as varied in their complexity as they are in their number, and there is no limit to the number of methods by which we could investigate each one. History is informative, but it is also convenient: it allows us to begin at the beginning (see Hopkins 1999)[4].

A machine's history can provide clues to its condition, the attention it might require for repairs, or even give insight on where it might be best utilized. Identical pieces of equipment, regardless of their design, that have been tasked to different ends will, in time, become entirely different animals--was it cleaned often? Was it well maintained? What was its environment like? What was it used for? All of these questions tell us what to expect--the machine used to the limits of its intended design, uncared for in a gritty or caustic workspace looks very different from the one that has been lightly used and religiously maintained. However, the distinction is rarely so simple; in reality machines go through life cycles that see many different transitions: different operators, different maintenance routines, different purposes entirely.

The case I aim to make is that a business--and in this particular case, the company where I work--is not so different; it can be analyzed in the same fashion. Taking even a brief moment to consider historical context is as valuable as what it might inform: speculation on the condition or performance of a company, for example, is typically considered worth valuable time (Peters and Waterman 2006: 51)[5]. In choosing the direction of an organization, the adage "to know

[4] For an interesting, workplace-oriented supplementary reading on historical analytical method, see "Using History for Strategic Problem-Solving: The Harley-Davidson Effect," by Donald Hopkins (1999).

[5] *In Search of Excellence: Lesson from America's Best Run Companies* by Thomas Peters and Robert Waterman, Jr. is dedicated entirely to the pursuit of understanding business performance. The consideration of history, rather than statistics, can find some validation in the quote: "We observed few, if any, bold new company directions that have come from goal precision or rational analysis. While it is true that the good companies have superb analytic skills, we believe that their major decisions are shaped more by their values than by their dexterity with numbers." (p.51)

where you're going, you have to know where you've been" is far from irrelevant: as a company changes over time, it does so with the agency of the people that compose it.

> *The United Lens Company has grown, from its simple start in 1916, into one of the foremost producers of molded lens blanks in the world. The work of processing molded lens blanks through its molding and annealing furnaces has reached such a high degree of skilled craftsmanship at United Lens that the company's sales are constantly increasing.*
>
> *The Optical Division handles some of the most sophisticated requirements in the Optical Industry. The products of this division are used in cameras, projectors, telescopes, microscopes, rifle scopes, fire control instruments, binoculars, copy machines, and in some of the amazing new instruments being used in the drive to conquer space and place a man on the moon.*
>
> *The Spectacle Division processes molded lens blanks for all types of prescription lenses and sun glasses. In addition to its regular line of opthalmic blanks this division also handles a wide range of colored lens blanks including a new glass that darkens in the sunlight and clears itself in the dark.*
>
> *The products of the United Lens Company are distributed in both national and foreign markets.*
>
> -Introduction to *The United Lens Company, Inc.: Serving the Optical Industry for Fifty Years 1916-1966*

Today, United Lens Company is nearing its one hundredth year in business, and it is not the same company it was when it was founded. In 1916, my great grandfather through my mother's side, Fileno DiGregorio, founded the company with a single furnace for molding optical blanks: a handwork process where a slug of glass, sized and cut to the appropriate weight necessary to yield the final product, is softened in a furnace until it can be pressed into a particular shape between two metal halves of a mold. He sold directly to opticians, who would finish the blank into a usable optic, typically for eyeglasses or the instrumentation used for prescribing them.

As the years went by, the single furnace became a line, and as the optical field expanded, so did the company. By the mid-sixties, there were separate divisions with separate specializations and manufacturing techniques. The "Optical Division" (as it is described in the quoted fiftieth anniversary book--today it is known as the Optical Shop) produced usable optics by taking optical blanks as raw material, finely grinding the surfaces, then giving them a

polished finish. Like molding, it is exacting work that is refined through practice--but unlike molding, a single operator runs sets of machines that typically process the material in batches. Rather than being constantly occupied by handwork, a grinder or polisher will constantly set up, load, monitor, and unload the machines under his or her charge.

The company continued to grow, and Al DiGregorio (my mother's father) succeeded his father as president. Further manufacturing processes were explored and developed into departments: the Service Center, and the Coating Department. The Service Center produces "blanks" like the Molding Department-- which is long past its former monikers of "Instrument Sales" or, as it is referred to in the opening quote, "Spectacle Division", but instead of a molding process, uses machine tools to cut, grind, and profile pieces of glass into the customer's desired size and shape. Other than a collection of more specialized equipment, the Service Center's tools are the same as those in a metalworking machine shop: computerized mills and lathes (the first CNC equipment in the company, in fact). The average person is more likely familiar with their technological predecessors, especially as they were used in woodworking shops to spin and shape table legs, or cut precise patterns into paneled surfaces. Some machines process groups of parts over a period of time, others require an operator's full attention to load, run, and unload a single piece every few-second-long cycle.

In the Coating Department--or coating lab, as it is frequently called--the process revolves around preparing glass for loading into large, computer-controlled vacuum chambers. The operators meticulously clean the glass and then inspect it for the tiniest stains and flaws; sets of glass are then set in tools, or *fixtured*, to be suspended inside those machines. Though it demands a detailed preparation process, the coating chamber itself does not typically require a manual operator; once the machine is loaded and set in operation, the atmosphere inside is

pumped away and materials are evaporated--in very precise amounts--up onto the glass to produce the effects desired by the customer. The results are batches of specialized laser reflectors, gold mirrors especially suited for infrared light, or antireflective surfaces like those found on some eyeglasses, to name just a portion.

A lot can change over the course of a hundred years; now in its third generation of family ownership and led by my own father, the building and the work are substantially different today from when the company was founded--the coating lab, for example, with its operators in surgical caps and masks, is by and large the opposite of the dusty, furnace-lined molding house that started the business. Although it all still revolves around the shaping of optical glass, it has been divided into four very specialized manufacturing departments: Coating, Service Center, Optical Shop, and Molding.

In reality, historical analysis is not going to provide us all the answers--it does not, for example, provide us the details of how a machine works, or why it should be repurposed to work differently. United Lens has changed significantly over time, but for what purpose? The typical answer from a business background might be simply, "to stay profitable", which is about as helpful as an engineer explaining that a mechanical adaptation was performed in order for a machine "to stay useful"[6]--sharing some small amount of detail in the effort may be prudent to explain the *why* and *how*, as well as let us reflect on whether these changes continue to be relevant and effective.

My experience continues to teach me that this sort of complexity requires detail: without asking *how* and *why*, next steps are all but impossible to determine. One helpful method is to review what has remained *constant*. At United Lens, what has remained constant throughout its

[6] If the humor is unclear: this is an example of an engineer giving an entirely *unhelpful* explanation.

history--other than the fact that it has always specifically concerned itself with glass--is the fact that the business has always been a job shop: customers send requests, and we fabricate a custom product to suit. This is much different than selling a single, or small variety of products, and can account for some of the changes that have been implemented through the company's history: accommodating more varied customer requests, means adding capability. Adding capability means adding complexity--which I investigate in the next section--and as a result, the specialized departments were born.

1b: Operational Context

Like a long-lived machine, United Lens has gone through a series of adaptations, repurposed to suit new tasks (Sennett 2008: 194-199). Taking our machine/business analysis into consideration, the development of those specialized manufacturing departments has provided a significant challenge: these are several very *different* departments, producing very *different* components, in very *different* ways. This means different working environments for employees, different management strategies, and different engineering problems and solutions to tackle. In this section, we explore the idea that the added complexity is, in part, driven by the specific nature of the work--and that the specific nature of the work can enlighten us to some of the details of those challenges that face operators, mechanics, and managers alike (see McCarl 1978; Ball 2000)[7].

For example, a mistake at the molding furnace is likely to yield a single defective piece; the loss of a single piece, very early in the manufacturing process, is unlikely to cause much heartache. The physical act of molding is an art: precision, speed, and timing are everything.

[7] Further reading on the reciprocal relationship between work *process* and worker can be found in Robert McCarl's "Occupational Folklife: A Theoretical Hypothesis" (1978) and Linden Ball's "Applying Ethnography in the Analysis and Support of Expertise in Engineering Design" (2000).

This is perhaps unsurprising, considering that for the majority of the company's history, molders were paid by piece[8]; watching a molder at full pace is unlikely to reveal much to the novice watching from the sidelines, trying to learn by example. By stark contrast, the Coating Department is slow and painstaking. The "raw" material is actually a finished optic, precision polished either in-house by our own optical shop, or sent directly from a customer (a common practice in Optical Shop and Coating). Mishandling could mean destroying a piece that has accumulated a significant amount of time and effort to produce. Worse, a mistake at one of the coating chambers could mean the destruction of all the glass inside--occasionally, hundreds of tiny pieces that have spent days in the department as a *coworker* prepared them. Having had the pleasure of both destroying my own work, as well as playing the role of the bearer of this bad news to my coworkers for my mistakes, I can attest that this is a motivating factor; a factor that motivates much differently than shrugging off a momentary lapse in judgment that produces a little wasted material and a few seconds of your own time. As such, slow and careful is the rule in the Coating Department.

Work context describes more than an individual's attitudes, however--perhaps what is more clear to the outside observer are the physical manifestations of the work process. The Molding Department, for example, is *filthy* compared to the coating lab. Saying that people employed in coating are more conscious and/or more clean is a tremendous oversimplification: the actual process of applying coatings to glass *demands* a clean environment, and therefore demands their attention. A speck of dust on the surface of the glass will become a "void" in the coating applied to that surface; a speck where the material adheres to dust instead of glass. As such, an operator in Coating is perpetually aware of any exposure of these dangers to the glass: a

[8] A brief discussion of "piecework" can be found in Appendix B.

table that isn't quite clean *enough*, a stray hair follicle, or the swirls of air (carrying who knows what particles) that occur in abrupt body movements or opening doors. A molder isn't *careless*, though the individual who sees the dust and dirt might assume so: the molder has to contend with a furnace that churns out carbon dust as fuel is consumed to feed the fire at a rate that is all but impossible to keep under control. They are mindful that every second spent worrying about the mess is a second *not* spent worrying about the temperatures the glass is exposed to, and sudden temperature transitions that could harm the material. These are seconds that could be spent being mindful and precise in their own movement and handling of the glass around those temperatures and tools--which is how their time *needs* to be spent in order to get the glass to customers and other departments.

In this regard, the physical and mental contexts of work are two sides of the same coin; both the environments and the attitudes that can be found in the molding and coating departments are an embodiment of the work that needs to be performed. We can see this idea at work when we consider another example: a machine that recently transitioned from Service Center to Optical Shop. Despite being a uniquely specific polisher for rods of glass, this machine historically "belonged" to Service Center: customers typically requiring parts from this machine would normally order work exclusively from this department; the polishing was only a single added step. Keeping it in close proximity to where the cutting and shaping took place in the Service Center was a fairly pragmatic choice. As a polishing machine, it was recently reasoned, it should belong to the department responsible for all polishing--*also* a fairly straightforward assertion.

With a pair of mechanics, Dick and I facilitated this move and, unfortunately, the *cleaning* of the machine, which looked like it hadn't been maintained in years (one engineer

actually asked why we bothered and exclaimed that it was “perfectly fine”--recall that “slowly and carefully” is not the credo of every department). The optical shop engineers have been adjusting to the machine, and before long Dick noticed them struggling with a long crowbar, attempting to adjust the spacing between two of the considerable cylindrical drums that act as polishing surfaces on the machine (the spacing of which determines the size of the part that can be polished).

This is where Dick got more involved, recognizing the need to design a fixture that would easily and securely change the drum positions. We were testing the product of his design--a pair of sturdy steel clamp sets that lock over axles of the cylinders and force them to spread apart by the turning of a screw--when I learned the history of the machine. It was designed and built in-house, but was never designed to accommodate different sizes of glass rods; the large drums were originally stationary within the machine. As requests came in for different sizes, it was quickly modified to suit.

Apparently the modification stopped short--the difficulty of changing drum position had not been made immediately apparent. Service Center filled the gap in mechanical oversight by using a crowbar--for years--and teaching Optical shop to do the same, even going so far as sending the appropriate “accompanying tools” along with the machine--the crowbar and two hex wrenches (or allen wrench, if one prefers: a tool that drives a variety of bolt with a hexagon-shaped socket). One wrench was for the bolts that held the polishing drums in their respective positions, and require adjustment every time the drums are moved to accommodate a new batch of differently-sized glass--a very reasonable set up process. The wrench, however, was metric and just slightly oversized, forcing an operator to struggle to pull it free after adjusting the bolts. When adjusted properly to achieve a precise finish, the bolts require loosening and tightening

several times to position the drums *just* so--which can rapidly make a reasonable set up process a very *frustrating* one, especially as the action of yanking the wrench free could inspire the tiniest shift in the drums' spacing...

Another wrench was permanently assigned to a home in a single bolt that determined the tension of a drive belt for one of the drums--changing the drum spacing meant changing the belt tension to make up for its new location, which is another reasonable action in setting up a machine for a particular process. Having never been considered in the redesign, however, the belt was kept at an incredibly high tension to prevent the motor from vibrating excessively and shaking the tensioning bolt entirely loose, which is considerably less reasonable. Over-tightening the belt reduces its life, as well as the life of the bearings in the motor assembly, and is likely to encourage misalignment in the entire machine and put high torque stress in the frame--all issues that could be addressed with redesigning the motor mount assembly.

In this case, the history of the machine gives us some amount of detail about the current need for adaptation--I later learned that Dick himself had been directly involved in its design and construction, all for a single customer request. The design made it possible to accommodate other, similar orders that were received later, but the machine was in the Service Center--a very different environment from the Optical shop, with very different work attitudes. The issues stemming from the design adaptation were not worth mentioning in the service center, where people were more likely to make a rough adjustment and continue with their work. In the optical shop, however, these issues were an oversight that needed to be corrected in order to achieve the precision finishes that the department produces through more careful work--as it happens, Dick's own work experience has fostered an attitude that is very similar to that of the optical shop, so it was an oversight he was more than happy to revisit and correct.

When we begin to diagnose and adapt a machine, the process starts very simply: what do we intend the machine to do? Or, more specifically: What do we intend the machine to do that it isn't doing *now*? The answers vary in complexity, from simply refining a machine's normal operation so it better suits a new work context, like adjusting the set up procedure on our polishing machine; to slight adaptations of similar nature, as the polishing machine was first adapted to accept larger sizes in the service center; to a complete repurposing of the tool into something entirely new--this last is the most difficult, with the least chance of success (see Astrachan 1988)[9]. This is the topic of the next section: try as we might, our polishing machine lacks any of the relevant components for turning into any sort of slicing equipment without tearing it completely down and starting from scratch--and I would not call this a particularly easy or practical endeavor. By the end of the project, you may find that it would have been easier to adapt a saw--or buy a new one entirely.

1c: Adaptability

The story of the polishing machine serves a particular purpose: it shows us that both the history and the work environment of a machine are meaningful to its operation; in this section I expand and reflect on what that means for United Lens as an organization. We have seen that businesses change. It is not so different from the fact that machines are constantly repurposed.

Sometimes equipment is purchased new and immediately put to a specific task, unadvertised and less-than-endorsed by the manufacturer. This shouldn't be an unfamiliar concept, especially when we start to remember that individuals frequently have their clothes tailored--a relatively simple change, in most cases; that cars can be customized far beyond their

[9] For another example of this concept at the organizational scale, see Joseph Astrachan's "Family Firm and Community Culture" (1998), where departures from a business's core values were negatively received by its community.

original design (though don't expect to have the warranty honored), or that pharmaceuticals can sometimes have useful (or abused!), off-label applications.

The example of tailoring clothes is a particularly good example, consistent with the polishing machine in the previous section. While the potential of a machine or garment is *technically* unlimited, the question revolves around the ease with which the original design may be adapted to the new objective--like the polishing machine, a suit jacket can either retain its purpose as a suit jacket and simply fit better, or it can be torn apart so the fabric can be fashioned into something entirely new.

There is a very important analogue at United Lens, and for the sake of simplicity, I have not yet discussed the machine shop. Though it does not directly manufacture glass, it is a department in its own right. Traditionally considered part of Molding, its initial purpose was to furnish all the metal molds and tools required; since each unique customer request required a unique mold, this was a considerable task. Today, the machine shop serves the entire factory, producing the various tools and fixtures required for *all* the departments, including a great deal of the prototype and experimental tool and machine designs; along with several machinists, this is where Dick and I work. Here, the work environment and the history of the shop has not changed: the machine shop still produces molds, albeit far fewer than before. The machinists are still expected to do work carefully and precisely--the quality of their work carries directly into the resulting product that performs some function in the factory; for this reason, flaws are rare.

Now, the machine shop constantly sees new and different varieties of work. Some of these projects present challenges that require training or equipment, but never a dramatic departure from the shop's context or *purpose*: we continue to develop and manufacture tools and

machines, but with each new project outside the existing body of knowledge, the collective talent within this department simply expands (see Chansler, et al. 2003)[10].

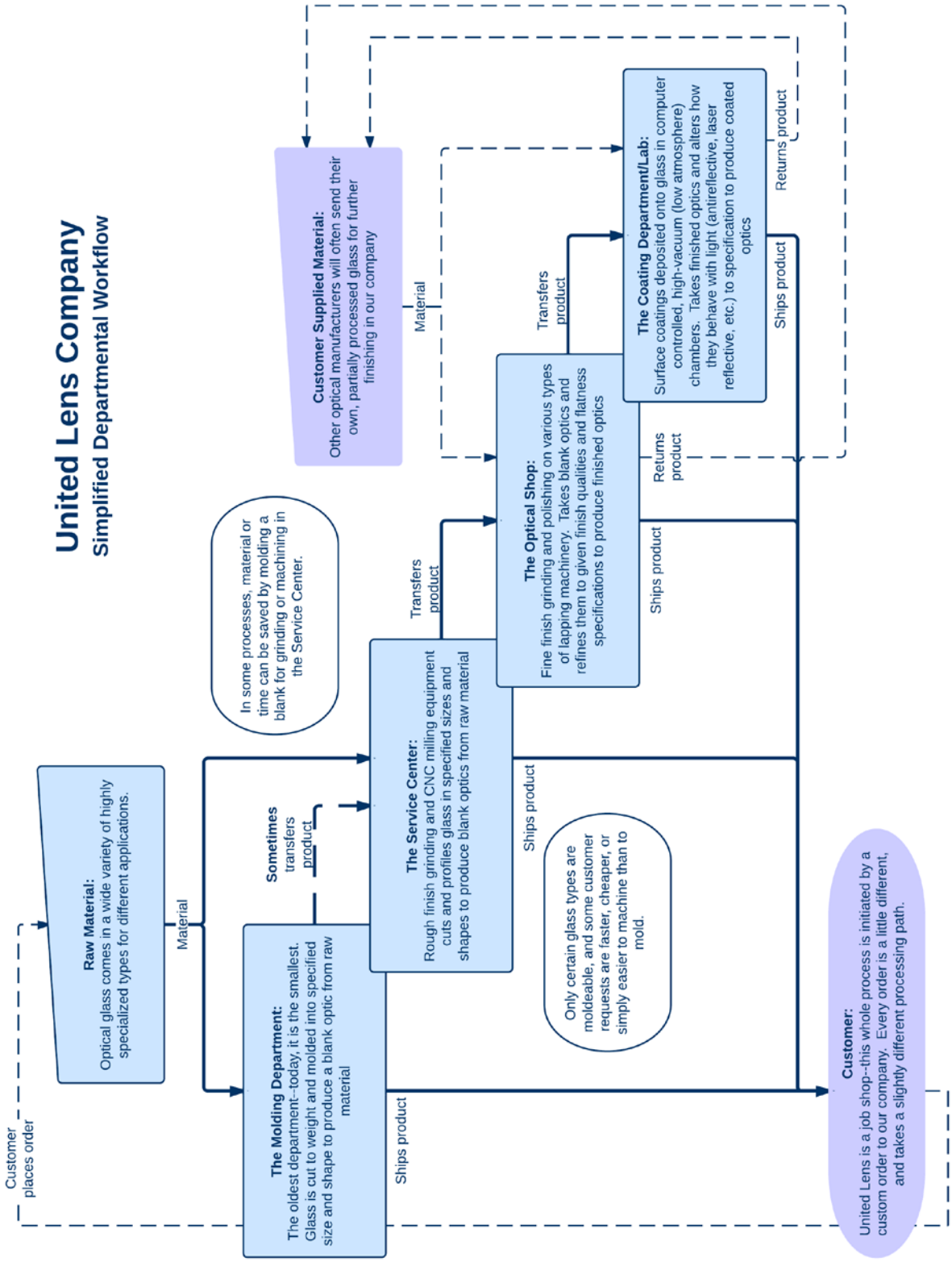
United Lens has come a long way, but in tremendous departures from its original form: the remaining molding furnaces sit just outside what is currently my shared office--the landscape that makes up the view from our only windows. Molding once composed the bulk of the business, but is now the smallest division: using a furnace to shape glass still has value, especially in its ability to utilize greater volumes of raw material to yield products. The Service Center produces similar unfinished optical blanks, but the nature of the machining process means starting with a larger piece of material and cutting away the excess to reveal the target shape inside--molding, by contrast, presses the weight of glass to shape with less of the leavings. Still, the savings in material cost did not guarantee the endurance of the molding tradition; as time went on, skilled molders began to retire and customer requests began to change. Not every material can be molded, and certainly not every shape--and some of those customer requests were simply faster or easier to machine than to mold. When United Lens takes an order for a blank today, all these factors determine whether or not it is molded or machined. The large majority is machined.

When I begin to consider this change in the company as an adaptation, there is much to consider: Molding, though it is the means through which the company was started, does not represent the extent of the company's intended scope and purpose--evident in the fact that the company has continued to adapt and thrive in other directions as this particular department has dwindled. The historical context of the Molding Department is informative to us, but the role of "job shop" remains consistent throughout that history, and provides some satisfactory level of

[10] For a study on the positive effects of learning work environments and self-management, see Chansler, Swamidass, and Cammann's article: "Self Managing Work Teams: An Empirical Study of Group Cohesiveness in "Natural Work Groups" at a Harley-Davidson Motor Company Plant" (2003).

explanation for these changes--as the orders requested of the company have changed, the company has followed suit. Like a machine, this is part of the lifecycle of United Lens, and it adapts to accommodate new and different utilities. Yet there is an element that I find very troubling: as the call for molded blanks has continued to dwindle, the company has long since stopped training people to continue the tradition, and this does not fit as perfectly with the "added capability" explanation as I might like. Consider the machine shop as a microcosm for United Lens as a whole: as new projects arrive, the collective skill of the shop expands. For the company, allowing the department to close entirely is a scenario that eliminates some of the company's collective skill, literally a loss of utility that could fruitfully inform an as-of-yet-unknown customer request, and this is a facet of the problem that gives me considerable pause.

In determining the direction of United Lens, there is no predicting the future. In the case of Molding, this means there is no way of evaluating whether the *potential* value this department might have in the future would be greater than the value it has exhibited in the past. Context creates the framework for us to make an educated guess. Ideally, we would fill the gaps in that framework with more discrete forms of assessment--which is the theme of the next chapter, ***Measurement***.


United Lens Company
Simplified Departmental Workflow
Customer places order
Raw Material:
Optical glass comes in a wide variety of highly specialized types for different applications.
Material
The Molding Department:
The oldest department--today, it is the smallest. Glass is cut to weight and molded into specified size and shape to produce a blank optic from raw material
Sometimes transfers product
In some processes, material or time can be saved by molding a blank for grinding or machining in the Service Center.
The Service Center:
Rough finish grinding and CNC milling equipment cuts and profiles glass in specified sizes and shapes to produce blank optics from raw material
Ships product
Transfers product
Customer Supplied Material:
Other optical manufacturers will often send their own, partially processed glass for further finishing in our company
Material
The Optical Shop:
Fine finish grinding and polishing on various types of lapping machinery. Takes blank optics and refines them to given finish qualities and flatness specifications to produce finished optics
Ships product
Returns product
Only certain glass types are moldeable, and some customer requests are faster, cheaper, or simply easier to machine than to mold.
Transfers product
The Coating Department/Lab:
Surface coatings deposited onto glass in computer controlled, high-vacuum (low atmosphere) chambers. Takes finished optics and alters how they behave with light (antireflective, laser reflective, etc.) to specification to produce coated optics
Ships product
Returns product
Customer:
United Lens is a job shop--this whole process is initiated by a custom order to our company. Every order is a little different, and takes a slightly different processing path.

Step 2: Measurement

2a: Tolerancing

The concept of context has been an important facet of my mechanical education--but this is not the only analytical tool that has needed development. What about the *physical acts* of mechanical assessment, design, and construction? This is the majority of my education within the company, even before I worked with Dick--running machines, handling glass, and evaluating the results of my efforts with micrometers (to gauge thickness), eyeloops[11] and high intensity lights (to observe finish quality), and other sophisticated equipment like the spectrophotometers in Coating (to determine if the coated optic reflects or transmits light as required, after processing). Taking measurements is not just for evaluating your completed work, however. Now that I am getting my education out of the machine shop, the old adage, "measure twice, cut once" continues to be good advice.

One of my first jobs in the factory was grinding glass in the optical shop, a process which typically takes round and square parts of varying thicknesses and laps them between two large (two to four foot diameter) grinding stones on a machine, as they ride along in little cut outs in cog-like carriers. We used grit slurry as a coolant and abrasive cutting agent--thick grey fluid that got on everything and dried you out. Mix slurry, load glass into carriers, drop lap, run machine the estimated time to take off target thickness, stop machine, lift lap, check thickness, repeat as necessary. Unload, rinse, repeat, moving from machine to machine; as some grind, others stop and get measured, unloaded, etc. This process was one of constant evaluation: measure the glass before it is loaded, measure it during the grinding cycle, measure afterward to

[11] A layperson will recognize this as the small magnifying-glass tubes that jewelers seem to constantly be using in popular culture.

ensure it is the anticipated size for the polishing steps.

If the work can provide us any evidence (and my argument is that it certainly can), then the saying should really be "measure twice, cut half, consider measuring again, cut the rest, and measure again when you've finished." Business and management literature will reflect this: strategies are *evaluated* before they are ever instituted, then again during their implementation, and revisited after they are fully in place.

Just as discerning *context* in the previous chapter proved worthwhile, so too do the finer points of measurement: the analytical lessons are duly applicable to United Lens and business in a broader sense. In these sections I will be focused particularly on the idea that *understanding* a measurement is much different than just taking one--a distinction that will hopefully make itself very clear. I have started with the idea of "tolerancing": the tolerance is the amount of "wiggle room" every design specification has built-in; the tighter the tolerance, the closer the finished product is to the designated measurement… and the more difficult the piece is to produce. If you were to ask me for a glass disc, one inch in diameter and half of an inch thick, I would immediately ask for more information: what are the tolerances on the diameter and thickness? What are the surfaces supposed to look like? In essence, I am asking a simple question: "How close does it have to be? How '*perfect*'? "

When an order is sent to the company, it usually arrives with a blueprint and series of specifications to describe the desired optic. Surface quality is a specification that is often discussed for a product, especially those finished, polished optics produced by the Optical Shop. It is a straightforward measurement: the size and number of tiny scratches and pits in the surface of the glass determines its quality--here, "perfect" is a relative term; with microscopes and other inspection equipment, most every surface has some level of miniscule defect. Still, we can

achieve a finish that is very near “flawless”. Surface irregularity is another specification that describes the *shape* of the surface; if a piece was intended to be as flat as possible, for example, the surface irregularity would be a description of the very, very miniscule curvature that remains after manufacture. A very high surface quality combined with very low surface irregularity (as in, very close to the target shape) is ideal; the low number of surface defects and very close adherence to the designed shape mean that the optic directs light as the optical designer intended.

Often times, customers will send us order requests that are “over spec’d”--this means they request technical specifications that would be considered “the best quality”, but actually far exceed the needs of their application. In some cases, the measurements required for particular requests could actually be considered misleading for the desired qualities of their order. In one recent case, the request involved measuring the surface irregularity on an optic that is intended to be very flat, but also happened to be very *thin* and *wide*. There are many ways to go about making this measurement, but in this case there was a great deal of confusion regarding what represented “ideal” flatness, and our engineers ended up measuring the glass on a laser interferometer--a sophisticated piece of equipment which maps the surfaces of an optic, allowing us to view all the minute (literally, millionths of an inch) peaks and valleys in the glass, as though it were an actual landscape. Unfortunately, due to its shape this particular piece was actually capable of sagging under its own weight, changing the curve and shape of its surface depending on how it was held during the measurement process.

To go a step further, this request begs the question of how the glass will be used: if a very low surface irregularity is required on such a thin, changeable sheet, is it safe to assume that the glass will eventually be fastened in some assembly? Ultimately, it is not uncommon for a customer that builds optical devices to place glass in a fixture that will essentially tension or

tweak the surface shape "into spec". It is hard for people to imagine that glass can be flexible, so carpentry can be used as an analogue: even from the most precise sawmills, no two pieces of wood are exactly alike, so the straightness and squareness of a wall frame is as much a testament to the carpenter's skill in orienting and joining long lengths of subtly curved wood--they fit and fasten those lengths until they have the straight, square wall they set out to achieve.

The oversight that this occasion describes is not an uncommon one--engineers and designers often make assumptions about what they "need" in a product without fully understanding the finer details of their requests. In my own training, I constantly look to the machinists that I work with: a very typical day will see me handling blueprints for tools and concepts that the machine shop will produce. More often than not, they pull me aside to ask questions--pointed questions that highlight the error of my own requests: *"Do these parts fit together? What type of fit are you looking to have?"* …this is the manner in which I learned there are different types of mechanical "fits", each with different applications; these fits ultimately affect the final dimensions of where parts fit together. The clearance between two parts with a press fit (forced together with pressure) is very tight, and each piece must be machined with that precise intent. A "light press" is less critical, where the pieces will bond together and pull apart by hand as they snap tightly together. A slip fit is the opposite, in that the pieces must be machined so that they may slide freely past one another. Without knowing exactly what I wanted for a final product, and what that product was intended to do, our machinists would be left to guess my intentions; either in my ignorance or simple oversight, I may not receive what I had hoped for.

As these lessons exhibit, the best measurement practices are typically dictated by context--I have not internalized these lessons of "tolerance" solely to keep myself from wasting my

coworkers' time[12], rather, they are developed alongside lessons of *context* in order to reinforce a larger method of analytical reasoning. The previous chapter allowed us a convenient window into United Lens, but becoming acquainted with the details of varying *context* is required learning--*tolerancing* gives us a practical picture of context at work. To expand these concepts even further, we turn to the next section: Perspective.

2b: Perspective

The bulk of this paper has ultimately revolved around my on-the-job training in analytical reasoning. There is a good reason for this amount of discussion: there is a tremendous amount of value placed on precision--and being precise is slow, calculating work. Just as I mentioned the adage "measure twice, cut once" in the preceding section, before we put saw to wood (or glass, or metal, as the case may be), it is important to have the plan in place; in my day to day work routine, this attention to detail has repeatedly proven to be worth my time. This section is the culmination of that detail; no amount of forethought or planning is complete without its consideration. The concept of *perspective* is what simultaneously validates and questions an individual's engagement with a topic--all the contextualizing, the measurement, and the act of analysis in general--by exhibiting that this interaction is very much open to interpretation.

During my stint in the coating lab, a tremendous amount of my time was spent inspecting glass for the same defects I described in the previous section. In this department we examined the optics both before *and* after the coating process: this insured that we did not waste our time coating glass that was either stained (which we would simply rewash), or of a surface quality that was less than what the customer required (which we would send back out to the Optical Shop for

[12] Though, arguably, this is an excellent reason!

repolishing). Since we cannot assume that they come out of the coating chambers in the same condition they entered, we inspect again--the coating is technically a new "surface" on the glass, and can exhibit its own defects.

I have mentioned that surface quality is ultimately based on the size and number of these defects, and in some inspection methods, it is possible to use a microscope to obtain a measurement of each small mark… but not always. For one, this is a time consuming method, especially when performed on each individual piece. Another issue in Coating is that the surfaces of the glass must be pristine, and even placing a glass part on a microscope stage runs the risk of leaving a mark. Instead, inspectors are trained with comparators: ours are framed sheets of glass, each representing a distinct category of "quality". Each surface displays just one of the largest allowable scratches and pits (the main types of defects--the latter could be visualized as a tiny little crater) as a reference for an inspector to compare their work to.

Unsurprisingly, there is an art to this. Beyond simply handling the glass--only by the ground surfaces on the edges of each part, so as not to stain or smudge (even when wearing gloves)--the ability to find flaws starts with raw talent that has to be trained and refined. Many individuals start training in inspection and quickly find that they simply cannot see the tiny marks that they are looking for--my own beginnings had me constantly using eyeloops, making measurements, and promptly going back to wash my inevitably stained piece of glass… and then inspecting it all over again to make sure that I hadn't scratched the surface in the process. Each type of glass would exhibit a unique "look" under an inspection lamp, and different types of optics would have their own tricks and challenges. The first dozen pieces of a new order would always be a learning experience--finding the right positions to hold the glass under the light to make the surfaces stand out in the ways that would make the flaws the most apparent, then

committing them to muscle memory to inspect the rest: pick up a piece, hold it *here* at just the right angle, at just the right distance… turn it around and hold it *here* to look again… and finally *here*, with the edge to the light. I would hassle other inspectors constantly; less so as time went on, but even after a year of inspecting glass, "*What does this look like to you?*"

The very obvious lesson here is that different qualities are revealed under different circumstances--whether it is holding the glass at a slightly different angle, getting a slightly different amount of light… whether the same eyes are novice or practiced to inspection, or most importantly, whether it is a different set of eyes entirely. Corroboration becomes a key element in validating whether or not a piece of glass has a particular *value*.

A very compelling argument could be made, as I have to point out, against the validity of this example. A nuanced reader might recognize that the method I have described would not be considered very *precise*--that of course each set of eyes are different, but why should that change anything about the presence or measurement of a surface defect? This happens to be the same question that I raised about the entire process, and I was quickly educated that there *were*, in fact, efforts to "control" these examinations: the industry standard is a set of military specifications that very thoroughly define and outline quality control methods. In this case, this is the physical measure of allowable defects and the manner in which they are inspected, right down to the wattage of the inspection lamps and the maximum distance the surface of the glass can be held from the inspector's eye[13] (Military Specification MIL-PRF-13830B). Even when inspecting to mil-spec, there is obviously some room for debate. This is particularly apparent when customers inspect their goods upon arrival and determine that the quality they have received is not sufficient; typically, the first question anyone asks is "who inspected the parts *properly*?"

[13] It happens to be eighteen inches, when inspecting the surface of a coating.

There is an intersection here, between the precise and the practical; one where the individual plays a critical role. This section is a discussion of that role, and being critical of it: obtaining *precise* information is not always practical or even possible, but even if we were somehow able to have flawless, perfectly controlled data to review, it was still collected at the behest of an individual, in the method of their choosing, and then interpreted (see Chia 1999)[14]. Each of these very human interfaces represents an opportunity to exercise judgment, and since our species very famously takes opportunities to exercise *lapses* in judgment, this is a fact we should be extremely aware of--both in ourselves and others. Just as the quality of an inspector's work can be validated or disputed by a different set of eyes, the entire method of inquiry is stronger when collectively agreed upon as logically valid.

Consider what should be a much more straightforward example: using a micrometer, which is a very accurate hand tool that "pinches" an object between a solid base and a moveable column, to measure thickness. The measurement is displayed by the alignment of graduated lines on the handle as the column rotates into position against the measured surface--and this is another chance to discuss perspective. In the literal sense of the word, I've often found myself shifting how I hold the tool in my hand, trying to look directly down on the curved, cylindrical handle to assess whether one of the tick marks is directly aligned with, or *just* past the reference mark. A digital micrometer does the reading for you, and removes the human element from this reconciliation, but then there is the question of method: on the optical shop floor, the best practice is to pinch the part as lightly as possible. Cranking the column down tightly against the surface of the glass is not only bad for the micrometer, but can also damage the glass--and will yield a different measurement from someone who measures the same piece with a lighter touch.

[14] Robert Chia's "A 'Rhizomic' Model of Organizational Change and Transformation: Perspectives from a Metaphysics of Change" can provide a more thorough critique of categorical analysis, but is also a considerable supplementary reading to understanding the concept of "change" as developed in this paper.

Many micrometers are made with a slip-fit sleeve on the handle, taking *this* variable out of the process as well: when the user rotates the column, the sleeve will begin to slip uselessly as soon as it meets the surface of the measured part. This makes the "pinch"--and therefore the measurement--more consistent. As a side note regarding these particular micrometers, I am of the opinion that they still produce a "pinch" that is a little firm (albeit consistent) for a polished surface; in this particular operational context, the column can leave a stain on the part that is hard to clean, although a very skilled operator can get a good measurement without leaving a mark.

So, if an individual is using a particular variety of micrometer, some of the trickier aspects of its use can be mitigated--the human element removed or reduced. Yet there are still more questions to its use. Should we take a measurement at the very edge of a piece of glass, or closer to the center? Alternatively, we can take several measurements at varying points and average them together as "thickness". Depending on how critical this particular specification is, as we discussed in the previous section on **Tolerance**, it may be determined that the micrometer is not the appropriate tool to use at all. In terms of the analytical method that I have laid out throughout this paper, the appropriate selection of this micrometer would ideally be based on the context of its use, the skill and good judgment of the individual using the tool, and the collective confirmation of its use by his or her peers.

Unfortunately, this is easier said than done. The last of these criteria--peer review--is not always practical or immediately possible. Just as a craftsmen is capable of doing quality work alone in his or her garage, an operator is expected to exhibit this good judgment and skill in assessing the quality of their work on the shop floor, without constantly interrupting their coworkers to validate each measurement. Since United Lens has been founded, there has always

been this type of technical skill to the work that goes on in the factory--and though the work has continued to change, this has remained true with the introduction of each new specialized department. For the company, this is the added challenge behind the lessons discussed throughout this chapter: as the work changes, it drives the need to continuously self-assess under new and changing conditions.

Optician's workspace with interferometer and irregularity readout on screen, July 2014.

Step 3: Tools

A description of my experience learning from Dick Lempicki would not be complete without a discussion on tools; after all, they are the focal point of all the analytical forethought, the reason for all the time and effort spent in making sure a design or repair is *just so*. I continue to learn that my work is a dynamic relationship with my tools: in the literal sense, this includes everything from wrenches to sophisticated design software. The dynamism of the software is somewhat more evident, as it is updated routinely, changing as computer hardware advances, and the accompanying software advances, become available. That fact aside, it is an expansive tool that I could spend years mastering and not see the full capability of. A wrench set, on the other hand, tends to stay fairly consistent. Getting past a few principles of leverage to gain an advantage on particularly stubborn bolts, it is harder to see how much further their use could be developed.

What *does* continue to develop is my understanding of a wrench as it relates to *new* work: in the coating lab, it was a trick of tightening bolts in explicit patterns to create robust seals between joined parts. As I use my design software, it is a better understanding of placing bolt holes for an assembly. Recall the discussions of forethought and planning: a critical-yet-inaccessible bolt is an oversight in the design process that can quickly turn into very real regret. The wrench set is dynamic in that I continue to learn where a wrench is best suited for a job, where a ratchet would be simpler or more appropriate, or when the last-resort option of drilling or cutting out a stubborn bolt becomes reasonable.

As the method of performing a particular task is refined, there is a trajectory to how the specialized tools and skills develop. The common misconception is that this is a straightforward, linear process where each new, better technique or tool replaces its predecessor until the optimal

process is achieved. I first recognized that this could not be further from the truth in the Coating Department, where the glass cleaning and preparation process has been a long time in the making. The reality of any type of development is much more a matter of trial and error, and success and failure is an integral, informative part of the development process.

Initially, glass was prepared for the coating chambers starting with soap and water, then finished by hand cleaning with facial tissues and alcohol. To describe the process as painstaking would not do it justice: Each tissue is methodically folded, dabbed with acetone, and then wiped across the glass with even pressure, then thrown away. The width of the surface determines how many tissues are necessary, each representing a "stripe" on the optic that could be considered clean--although, the wrong pressure, incorrect amount of alcohol, or poor folding of the tissue can all easily leave tiny sleeks behind. To add to the difficulty, yanking a Kleenex from the box creates a cloud of paper dust that floats down onto that surface that needs to be so critically clean.

As time has passed, there have been an incredible number of changes: from the soaps and sponges we use to do the initial cleaning, to microfiber wipes that create no dust and are manufactured with a more consistent "grain" that makes their sleeking behavior somewhat more predictable. Hand cleaning has never gone away, and the microfiber wipes make these jobs significantly more manageable--from a relative standpoint. Today there is also an automated cleaning system that can accommodate the majority of the work, carrying it through a series of dipping and spraying tanks, before ultimately delivering a set of clean, dry parts. Each different type of optical glass that has arrived at the Coating Department has received, through years of trial and error, a detailed "best method" of cleaning--a particular pre-wash, followed either by a particular sequence through the tanks of the automated machine or the hand wiping process.

Despite having spent a lot of time cleaning glass, I am not ashamed to admit that I am abysmal at the hand cleaning method. Every time I tried and failed, there was a good natured joke to follow, "*now try it with a tissue!*" I would always politely decline--but the joke is striking. Even if I were to succeed with hand cleaning, it would only be through the good graces of having the new, refined processes to practice with. The trial and error that characterized the development of the new cleaning processes were the lessons that delivered the most expertise. Those lessons don't become obsolete with the method; they become mastery. As new challenges present themselves, this is the level of skill that is most useful, the best suited for finding workable solutions for novel scenarios.

I continue to see this in my apprenticeship: Dick Lempicki is living proof. So far, machining as a field has changed substantially over the course of his lifetime--and he has adapted right along with it, from manually operated mills and lathes, to CNC machine programming, and then on to the Computer-Aided Manufacturing (CAM) software that drives the majority of sophisticated machining work today. The story of the 3D printer in the introduction is a prime example, and the exact type of mastery that I'm trying to describe--Dickie graduated from trade school in 1971, and I am fairly confident that 3D printers were not part of his education there. It is simply another tool, another method that is easily acquired alongside a lifetime of experience.

Again, these relationships an individual forms with their tools and methods is a dynamic one. I seem to encounter individuals who think just the opposite: that there is an "end" to these cycles of mastery and process improvement, a pinnacle of skill and method. The consequences of this frame of mind can manifest in a variety of ways, the most obvious being that a technical process becomes stagnant in an ever-changing world--a particularly harmful mindset in a job

shop like United Lens, where the contracts are constantly changing.

Picture the previously mentioned machine shop, operating under the assumption that their skills, equipment, and products represent all that is necessary to do the work requested of them. The rest of the company is unlikely to allow this attitude to continue: as the world of optical technology continues to evolve and change, so does the work requested of our manufacturing departments--and so the machine shop must continuously adapt its capability to suit. Even the process of cleaning glass in the Coating Department, which seems more direct in the action required, cannot allow the added cleaning machine and other developments to create a false sense of security--there are always new projects, and the individuals that have developed their own ability alongside the method itself are most likely to recognize the nuances that those new jobs present.

A more subtle consequence of this same mindset usually arrives alongside these "straightforward" tasks, where there is just a single operation taking place; not every manufacturing operation, after all, is a job shop. Other companies produce products, and the difference in manufacturing environment is substantial. It allows a great deal of energy to be focused on refining the process along any given quality, to make a product more robust or higher quality for example--although more often than not, it is to make a product faster, easier, and cheaper to produce. In these instances, it is a very popular management strategy to invest heavily in sophisticated equipment that can be set up once and then left to repeat the required operation. This way, they can be operated not by a trained machinist, but by an unskilled temporary worker or entry-level employee (see Littler 1978)[15].

Left to rely on my background in anthropology, I would point out that this is unlikely to

[15] To say that this topic composes an entire body of literature would be an incredible understatement. See "Understanding Taylorism" (1978) by Craig Littler as a comprehensive starting point.

yield positive results, at least insofar as the human elements are concerned. If an individual is left to boring, repetitive work and low responsibility, apathy would be the only principle left to permeate and guide their work experience. Fortunately I have had the pleasure of testing this theory firsthand: there are many repetitive tasks to be performed even at United Lens. A particularly potent example would be the act of beveling glass--a bevel is also known as a chamfer, and in layman's terms, beveling a piece of glass is the act of taking away the sharp point where two faces meet. This is done by grinding it away, and turning it into another small, faceted face all its own. It is a small but critical procedure--this pointed edge is susceptible to chipping away, and makes the piece fragile even to handling. If the piece is moving on to a polishing process it is even more important, as the portion which chips away off is likely to roll across the face, scratching it and potentially ruining the piece entirely.

Currently, the fastest strategy for accomplishing this task looks very similar to those in a highly refined, product-oriented manufacturing environment: three automated machines are fed and operated by a single person, who slips the piece into a receiver, presses a button (actually two buttons simultaneously, a safety precaution that insures that one hand isn't catastrophically close to any moving parts), and sends the machine into a cycle. This process has been designed to optimize speed and efficiency, and to that end, the system works: a single person can certainly bevel a tremendous quantity of glass--however, I have spent a few shifts in front of these machines, passing my day by alternating between counting the parts in front of me, the seconds ticking by, and the cycles of the machine: place, press, step to the next machine, place, press, step to the next machine, ad infinitum.

Unfortunately, the act does not exactly instill an overwhelming amount of motivation. I can only speak from my personal experience, but I cannot report a staggering sense of obligation

to maintain a consistent rhythm by the sixth or seventh hour in the workday, nor would I feel confident that the quality of my work--what little control over it that I retained in this regimented process--had not fluctuated with my attention span over the course of the workday. Is it easier than beveling each piece manually? My personal opinion is yes, absolutely, but only in the sense that it requires even less of my attention. Manually grinding the corners off glass takes only marginally more focus, and is still a mind numbing experience when stretched over the span of eight hours…and then a week, a month...etc. Both of these tasks were jobs I performed early in my experience at United Lens, and neither were successful in fostering a deep, lasting interest in pursuing a career at the company, and apparently others agree--I have watched a few temporary workers spend a day beveling and then not return to work the following day. High employee turnover, however, could be considered a perfectly reasonable management strategy for some organizations. In this conceptualization of an employee's relationship with tools, motivation and skill are negligible factors.

Where the employee experience is not a concern, my more recent background in mechanics *also* furnishes compelling evidence on why this attitude is unsatisfactory: a technical aspect of why tools could be considered "dynamic". As I have previously discussed, a discussion on the historical context of United Lens is a discussion of change. This is a fairly macroscopic concept: even if the company had tried to maintain a constant, unchanging model of the day it was founded, the world would have continued to change around it. Different employees would come and go, as would customers. On a microscopic scale, the same is true for tools, even when they are applied in a very direct, seemingly consistent task. Tools and machines have lifecycles that are in constant ebb and flow, no matter the application. For this reason, a great deal of tooling is replaceable: the edges of cutting tools start to dull, the surfaces

of polishing machines start to wear and breakdown--as these tools deteriorate, they become less effective, and eventually require replacing. It is also the reason that machines require routine maintenance: motors require service, drive belts stop delivering power when they wear down and start to slip. Age takes its toll.

All of these factors have quantifiable effects on the work being performed. When machining bevels into glass, for example, distinguishing between bevels ground with fresh grinding wheels versus worn ones may produce several results. The physical size of the beveled edge could be substantially different, as could the quality of the finish of the newly ground surface. One wheel might chip or fracture more pieces of the glass than the other, a particularly difficult quality to get a feel for when it could be the difference of one piece in every two hundred against one piece in every five hundred. These differences are rarely available for side-by-side comparison, either: rather, these qualities shift little by little, as the tools and machines slowly fluctuate over the course of their lifecycles.

No matter how controlled, a process is always changing. It is the nature of having moving parts and existing in the physical world--everything is in flux, including the raw material that is being supplied to process and turn into products, and the manufacturers of replaceable tools and parts for the machines that continue to age. To excel at performing a task means to constantly interact with this constant change, to understand and develop alongside it. Eventually, it becomes an eye for intensely subtle distinction, and the constant refinement of the process itself; it becomes “mastery”.

Checking early flight simulator screen for stress, circa 1983-1984. Left to right: Mary Iozzo, Richard DiGregorio (Great Uncle), Dick Lempicki

Conclusion: Making it all Fit

As I continue to learn and apply the principles of my mechanical apprenticeship, United Lens continues to change and adapt as it has since it was founded. Some of this change is well and truly outside our control, driven by the changing world around us. This paper would have been considerably shorter if the company had been able to preserve itself as it was founded, but reality drives on without much consideration to our organization; to be frank, there isn't much to be done about that. More important is the change that we can guide, and our interactions with the world around us can allow us to take *change* and channel it into a direction of our choosing. This paper is more than a narrative of my education with Dickie and the company: it is meant to make these inevitable changes open for discussion.

The final chapter is perhaps the most direct in describing how the work environment is linked to work and worker. Just as a relationship with the tools and knowledge of a trade is dynamic, so too is the relationship between an individual with an organization. A discussion of concepts like "employee morale" and "work ethic" is empty without considering this relationship. For some reason, however, the explanation that seems more frequent is the oversimplified version: that these qualities have somehow, very suddenly, changed in people on a fundamental level--as though a switch has been flipped, and a new generation of disinterested employees has taken to the workplace.

In reality, these changes are the results of the world around us. Interest and effort are not qualities that will always exist in a vacuum, of their own accord; a certain sense of stewardship is required on the part of both the individual and the organization at large. On the business side of

this equation, facilitating an environment or an opportunity where an individual can learn, and then familiarize, and then *master* the work is a good place to start.

At United Lens, my work revolves more and more around the creation and development of new work processes, like the manufacturing of highly precise prisms, or lenses with cylindrical faces--projects that have existed for some time in the optical industry, but are entirely novel to our company. Entirely new processes are an exciting challenge, and while some of the elements of these processes will undoubtedly be shaped by the task they aim to achieve, the amount of personal responsibility in this role is considerably greater. Aside from determining the company's ability to take on new work, the methods that are developed and taught to others in the company will directly shape their working life, from the manner in which they interact with their tools to the environment in which they spend their day.

The concepts I have laid out in this paper are the thoughts that I revisit on a daily basis: the tenets that help me puzzle through mechanical odd jobs that I have never seen before, and guide me in contemplating the broader implications of my work, and the operation of the company. The change it will see is, in my eyes, inevitable, but there should always be opportunities to facilitate the development of masterful, quality work.

For the ardent, self-identified rationalist, the reason for all of this effort should be clear through the body of the work. Ultimately, whatever you're selling relies on *some* specification of quality. It relies on *some* level of human judgment and effort, somewhere within the process. It is a product that has been arrived at over time, even if that time is brief. For these reasons, it is not so much an "effort" for this theoretical business and its product; rather, it seems simpler to follow a model that fits more closely to the traits inherent in good work. In this scenario, people

and processes involved are allowed to grow and adapt, to exercise their judgment and mastery, and to *participate* in what will inevitably change.

Dick Lempicki checks on the progress of a CNC machine, July 2014.

Afterword: Maintenance

I occasionally have the opportunity to attend training seminars or classes for work. One particular session, only a day long, revolved around electrical code and safety: "Safety rules are written in blood," the instructor repeated, and showed us videos of electrical boxes exploding violently. Here in the afterword, I can express some disappointment in what was left *out* of my paper. Some cuts were made for the sake of preserving the narrative of my work experience and Dickie's instruction. Some cuts were made because the material was simply too broad and too sensitive to properly address: Like safety rules, a great deal of work history is written in blood.

There is a certain gravity to the topic of *labor* that I would have liked to incorporate, and there have certainly been encounters and experiences at my own company that have made me feel that it was deeply important to do so: typically in discussions of work ethic and operator skill, or the design and operation of repetitive tasks. Navigating these issues with some level of neutrality and patience has, at times, been very difficult.

By the same token, I recognize the difficult position that my working peer group is in, owing to my family status, especially when I raise arguments against some of these issues. For that matter, there is a legitimate point to be raised against the fact that I speak and write about work experience while, as the youngest in the "engineering group", I have close to none myself. Attempting to supplement my own experience with the stories and knowledge of others and pass it off as "knowing" is an especially poor substitute in an environment where experience is practically defined by working with your hands, but outright objection to this method of learning also highlights some of the subtler dangers of self-assured decision making: here, 30 years of experience doing the same thing is the penultimate mastery, and at its worst can excuse even the

most basic considerations. In managers and executives, I worry about this attitude very deeply.

My research journal has recorded a considerable amount of material, from engaging with my research, to work frustrations and self-doubt, all of which could not be included in the paper. Instead, I have boiled down a few and attached them here as appendixes for readers to browse. Some sensitive information has been redacted, but *all* of the entries are otherwise unedited and therefore fairly underdeveloped--they cannot stand alone yet, but maybe someday they will make interesting papers. In the meantime, it is my hope that they provide interested readers some insight about the writing of this thesis.

Self portrait in coating inspection room, October 2012.

Appendix A: Selection from Journal Entry for December 18, 2013

This entry revolves around a troubling encounter with a peer. It considers wage-to-effort ratio, and the attitudes surrounding promotions and "intellectual work". Selection:

[...]Last week I had an encounter with another engineer that should have been journaled about immediately after the instance. First, some context: essentially my boss and I had "lent" the two mechanics which we manage to the department in question [...] and they repaired a machine under the direction of this engineer. Several days later, we were told that the machine was not operating correctly, which naturally raises some questions. I go up to investigate with one of the mechanics in tow, discover a simple installation problem--which, at least by the mechanic's account, was something that the engineer himself was working on--and inquire as to why it took three days for us to find a problem that should have been diagnosed immediately after the machine was repaired. The answer, according to the engineer, was that it was an unfortunate oversight due in part to the repair finishing close to lunch time on a saturday.

Days later, another machine (in the same department) is in total disrepair--not the kind caused from a sudden catastrophe like a failed component or reckless operation, but the kind of disrepair that creeps up as components begin to wear. The engineer raises an alarm [...] that the routine maintenance has not been getting done--which was true, in fact. (A brief aside, the routine maintenance of the entire factory was transferred to the charge of my boss maybe… a year or so ago, and I am still untangling the knots and secrets of this transition and trying to get them into an organized and accurate schedule)

This was the setting for the actual encounter. I confronted the first engineer and put on what I hoped was a reasonably friendly face, hoping to get some honesty instead of causing conflict. I have to paraphrase what was said, but I did scrawl some notes in my work notebook right after it occurred and ripped the page out to bring home--this was last thursday or friday, I believe.

Me: "The operators must see this happening. The machine didn't suddenly stop working, it's been [getting worse and worse] over time."

Him: "They do but they don't tell us--we will tell them a hundred times to let us know--there's a reason they're on a certain pay grade. These guys are button-pushers. I know they're skilled operators but they're just not on the same level."

This response did not sit well with my boss and I. I'm thankful that he and I are on the same page and open enough to talk about these issues, and our interpretations of what work and work problems are tend to align--when we discussed this answer, we reflected on something that we've seen time and time again [...] : an attitude to deskill the operator-level work as much as possible, and to push as much glass as fast as possible. It's something I'm often distressed about for a number of reasons--

One, the work in that department is fairly [...] repetitive.

Two, the work is not high quality--it's constantly argued that it is better quality than the competitors', but I don't think "comparable" is the same as "better".

Three, the strategy incorporates overproducing to compensate for the parts which don't meet spec in quality control-

-which in itself is not alarming, but it is my personal feeling that developing a process which minimizes rejects saves the time required to make the initial overstock, as well as time spent repairing parts to insure they make spec--in the critical words of my boss “never enough time to do it right, always enough time to do it over”.

Four, [...] is responsible for the majority of what is essentially a rough shaping or generating step in the process--that means they serve the rest of the factory with raw material for further refinement--specifically polishing and coating. This compounds what I just said--flaws in [initial] manufacturing [...] mean more time and difficult in polishing steps later in the process. [...]

I feel like I could write a paper about just this. My thought, however, is that re-skilling the labor is a big component in this. In the machine shop, a small department with two machinists/toolmakers and one apprentice with a trade school background, components and tools are made for the rest of the factory, and they seem to operate under the exact opposite strategy--it does help that it is run by my boss, Dick, who did the work himself for a number of years. [...]

Appendix B: Selection from December 30, 2013

More on wage allocation, the company history of piecework compensation, and the entanglement of socio-political context. Selection:

Today while I was reading, I carried on a conversation with my friend [...], who asked what I thought about the fact that most jobs don't *make* anything, as in a physical product. This is how I replied:
I don't think that actually matters. Service is a product. But it depends. Some products aren't productive, same with some services. I don't think the boundary exists on a physical line, I think it exists on an effort and… utility line. My thoughts are that there should be appropriate returns, if there is going to be a generality about it--for investments and for effort. Keep putting in effort, keep making money. [...] I think it's great that people can be set up for life if they do something really witty and clever, but I don't think they should be set up for 100 lifetimes. That shit needs to reallocate to people who are still doing productive work.

It's a good segue into what I was reading from Singlejack solidarity--regarding the distinction between the Workers Party, where there were "progressive union caucuses that were trying to keep the employers from using the war effort as an excuse for taking back gains made by workers during the '30s." The other half of this rift in liberal America at the time was a relatively conservative Communist Party: "Suddenly, the Communists made all out attempts to put unions on record for a wartime and post-war 'No Strike Pledge,' 'National Labor Conscription,' and 'A Return to Piecework'."

This touches on a lot of interesting components in my own company's history. My past fieldwork certainly hinted at a particular pride in being a part of wartime efforts, even on behalf of what Weir would call rank-and-file workers. It's unsurprising that the war would polarize people in ways that aren't easily expressed by political affiliations. However, to hear Dick and other people [...] talk about the original molding business… It certainly wasn't the organized and communal labor force that maybe Archie Green or Stan Weir might have me expect of every trade.[16]

"[...*Name*...] (I believe this is the former manager of the molding department) used to say that molders are mercenaries," [...]. Dick affirmed this, talking about the extremely protective and combative work methods that existed between each molder--I couldn't name a number yet, but I would expect that at one time, there were at least one hundred molders in the company, manning furnaces that were packed into corners, tucked into back rooms, and were lined up down the majority of the first floor of the company as it exists today (there are only a few furnaces left, isolated in a section of the "original" [newly original, after a fire or two in...the sixties or seventies? I think] structure). The ability to mold a particular geometry or with a particular speed and quality was a mastery that was protected fiercely from other molders, given their piecework pay.

To hear others tell it, it was what the molders themselves preferred--In one of his articles (I forget which

[16] *Singlejack Solidarity* actually gets into some excellent detail about the not-always-unified elements of union life. Note that at this point in my research I had not delved very deeply in this particular book.

right now) McCarl references welders which “commanded excellent rates” for their piecework, which they were capable of doing based on their skill. That is the molding that I hear stories about--but with stiff competition from furnace to furnace.

Maybe this transition in the company appears so difficult. The nature of the business is changing on a very rudimentary level. The problem is, it’s been changing for more than 30 years, and the individualistic qualities should have been hammered out long before now--or is that too much for me to really expect? The lack of teamwork and collaboration between the departments is a focal point for a lot of my frustrations. [...] cuts for it’s own customers, and all I ever hear is “well they get their orders out on time”. That’s fantastic for them, it is, but when they serve blank parts to the optical shop, who in turn serves the coating department… the majority of the late work from those two departments usually stem from problems all the way back in [...]. Every cut and shaping process with a focus on speed instead of on the quality--quality that Optical Shop and Coating Department sells product on--is lost time and product later in the manufacturing process.

We don’t need to do piecework anymore, and that fact should be a good thing for us--I hear stories of molders skipping their breaks and eating a sandwich at their furnaces on days where they get into a good groove. Allegedly they would be making too much money to want to stop. [...]

Appendix C: Selection from January 1, 2014

Some self-examination, reflexivity, and cross referencing education, experience, and ethics. Selection:

Maybe an idea for a title: Tradition in Transition…? Maybe with a subhead like "Fostering Craftsmanship in American Industry" or something like that. Maybe a little bit of a misnomer given the varying ideals of what constitutes "traditional craft", but maybe I'll get back to that. For now, I'd like to try and wrap up some ideas from yesterday.

To sum up, I don't find it particularly surprising that I expect a certain level of effort from people who have some kind of influence--it's why I am critical of myself, often times my family, and the management my work. It's the same expectation I have for friends--particularly the sort of kids who have the financial freedom to attend school and then seem to half ass it. Indecisiveness I can understand. Making mistakes or outright failure I can forgive. Even taking advantage of the situation for personal gain, I can excuse in a lot of cases--I'm thinking kids who get their education paid for (Full disclosure, I'm so lucky I was one of those kids, and the accumulated debt of some of my best friends from school frequently reminds me of that fact) and make the best of that opportunity. But there is a particular attitude, maybe an indifference, that people in those positions occasionally exhibit… that is a combination that drives me crazy.

Just to be clear, my family doesn't exhibit that sort of indifference. I've rooted through the sorts of personal dilemmas that revolve around these implications, and hopefully done a fair job of putting them to rest. I try to remain critical of myself, and to understand where I'm lucky--and where that luck, in my own mind, should be… I don't know how to phrase this, but maybe *fulfilled* in a deserving, almost reciprocal fashion. I feel I'm secure enough to not take offense when certain implications are made about my character, but I do feel that this area is one of the shortest paths to giving me pause. Recently, before one of the advisory meetings for this paper, Robert made a comment regarding whether or not my laborlore and history readings were allowing me to "sympathize more". It's a shame my camera was broken, because I'd be surprised if that didn't illicit an unconsciously raised brow.

So what do I expect? I expect things to work, and human-created things can be made to work in a variety of ways. The natural sciences can inform us in a number of ways, on how things maybe *ought* to work, especially from a strategically environmentally conscious standpoint, but by the same token, I dismiss the misappropriation of those sciences for drawing conclusions on divides of race, gender, and class. This is a topic that's beaten to death in the social sciences, but could stand to be revived and beaten past death in the world at large, so I'll take a moment to mention it here.

In the context of my work, there were some relevant and early debates in my early anthro/archaeology classes, namely those that debunked the notion that technology progresses in a linear, or even just evolutionary,

pattern. My thoughts frequently revolve around this topic; it's certainly evident on a small scale in a manufacturing setting, and I have to believe the same is true at other workplaces--a decision made for progress does not necessarily...progress make (terrible). It's not so difficult to imagine a long era during which humans domesticated crops and animals, accidentally careening past a point of diminishing returns until they're on the upward (downward) spiral to full blown agriculture, sedentism, city center formation, hierarchal civilization, etc. I don't need to revisit the too much of the argument here, but the point was that things got much, much worse for significant periods of time before they ever got better. Fast forward a few thousand years and we're at the dawn of the industrial revolution, having spent a great deal of time and effort refining our skills, speeding up agricultural and trade processes to create more surplus for less work, but not yet recovered from the last time we screwed up the sweet spot we had secured in the paleolithic (violent, sure, relatively high infant mortality rate, yes, but once people were living, they seemed to typically live long and well, for relatively little effort--so, sweet spot). The industrial revolution was another step toward securing greater surplus, but that doesn't mean it was another step in the right direction. By my account, wealth still stratified the same way, there was just *more* of it.

When we allocate that surplus to the upper tiers of our hierarchy, we're not solving anything. The entire point of innovation and machinery is to generate the needs for humanity more easily, with less input--to return us to that paleolithic sweet spot. We're *hoping* we can innovate in a positive trend, but bureaucratic bulk (not to say that job specialization is a negative thing, I actually think it's tremendously positive… just as a species we mismanage the whole idea) and notions of economic darwinism keep us from the philosophical *point* of all this. So people live better, more easily. More happily.

Let's return to my company. A job shop--no set product to speak of, sustains itself solely on the custom orders and contracts it receives. I often hear it is tough to hire good people into the company, which I think is absolutely true. As a company, I think we aren't achieving the quality that we should be able to achieve, and we lack organization--the effects of which I've described before, which ultimately means taking more time, for less parts, with more waste, for less money. Re-skilling the labor happens alongside the repair of these problems, it happens alongside bringing more responsibility and autonomy and craft to the operator's role. Putting the investment of sophisticated machinery on hold and working with what we have, I think we can bring the shop into order and create faster, more effective processes to create a surplus--in this case a surplus in time is a surplus in money, they mean the same thing.

A time surplus could be allocated to any sharing of information and education between varying skill levels of operators to bring up the skill average of the shop. It could be allocated to giving employees less hours--we bank on paying them forty hours a week at the least (it's often more), and even though they're hourly employees, if we can get through an allotted amount of work in four days and pay them for the fifth off, we're talking about a very attractive feature to offer people when we need to make a new hire, as well as an attractive offer to existing employees--an offer which I believe would pay off, at the very least, in happiness. A time surplus could also simply be used to put effort toward taking in even more work--though this an instance where we would see a speed-up; time surplus allocated to more work means an even greater surplus generated in *profit.*

So what can we do with a profit surplus? We can offer it to our employees, for one--again, an attractive feature for new hires, a generous offer to existing employees. Older employees may remember a time in the seventies when getting a job out of high school still meant you could buy a house and support a family with one earner (I think societal surplus misallocation has largely led us down this path of inflation in terms of education and the value of the dollar). We could also outright invest in their education in instances where we don't have the expertise in-house--something we already do very often, which again, is something I admire within the company. I've personally attended a number of classes ranging from a few hours to a week or so long, having been sent with the intention of getting better at my job. And I did get better.

Now, it might be a slightly more complicated understanding, but… none of this really **has** to generate a financial surplus. I think that if people have an opportunity to obtain a level of mastery and pride in their work, and then, a very critical step beyond that point: a level of *influence* in their work--a recognition of expertise at the very least, but ideally a position from which their expertise means their problem solving skills and diagnosis can be exercised and listened to in larger contexts--than this effort has some kind of inherent merit.

Appendix D: Selection from Journal for January 16, 2014

This entry is a reflexive piece revolving around scientific management and UL.

Selection:

I got through "Understanding Taylorism" by Littler the other day, and finished transcribing the notes just yesterday. I have… a lot of thoughts. The article was excellent, for one, a little difficult to read, and should maybe be required reading in this program--it does a good job pointing out confusions in the literature on the topic, laying them out intelligently, and navigating through them to still come to some compelling conclusions: that scientific management strategies and structures were actively fragmenting labor and knowledge structures before Taylor, and the fact that Taylorism had lasting impacts are two conclusions that particularly stand out in my mind.

The idea that it was a failed framework is a nightmare in my mind--it seems to show a real disconnect between the academic review of the topic and what is actually going on in the world. Granted, Taylorism can still be construed a number of ways (and not necessarily associated with Taylor himself, particularly), but I believe the reality is this: [as in Taylorism] there are many employers which bureaucratize with no or minimal career path, work is fragmented and deskilled, and pay to effort ratios are not transparent--this last one is troubling, especially, because… while Taylor had a very explicit method of doing this, I actually see it rear its head along the segregation of manual vs. intellectual labor.

My company pays well with raises based on time as well as effort. But is that enough? Opportunities to transition from manual to desk job are rare--in no small part because of the size of the company. Engineers and managers certainly have a lot of work to do--but do they do that work with the greater effort and intensity that their pay scale maybe implies? This is worth its own discussion, especially if we can assert that experience has its own value, independent of work "intensity", but the short version is that I can think of some people who work harder than what (I can only guess) they are paid… and some that do not work hard enough. This 'fact', based on my not-always-fair judgement alone, has certainly caused me some frustration.

On one of my first business trips with the company, I got an opportunity to tour another optical job shop called [...]. It's a smaller operation, fewer people, more niche industry--they specialize in prototype optics and producing them quickly. The thing that struck me at the time was how pleased everyone seemed to be to work there--and not in the Willy Wonka-ized, family-friendly presentation sort of context. Having spent the preceding week at a trade show, employees of this company--why are so many employees from this place just walking the floor of this show? It's mostly students and salespeople--kept trickling by. Several visited the booth. All of them struck up conversation and related how pleased they were working at [...], so much so that I was beginning to feel like it *was* staged.

Anyhow, aside from some very obvious community and team-building efforts on behalf of the company (reduced summer hours, basketball hoop in the parking lot, bowling team… little things but a lot of them--[...]), their manufacturing strategy was also very different[...]. Here, a small team of people worked together in a single

manufacturing "cell" specializing in a type of glass product that is determined… for the sake of outsider understanding, by the shape or geometry (in insider terms--plano, spherical, aspherical, and 'other' optics). Every machine necessary to complete their task was arranged within their space, which happened to be cramped… but pictures of motorcycles and hotrods were on the pegboards that held their tools--[...].

The idea behind this arrangement was that each team was led by one of their own members, working with them on the floor, and that the team had control over each stage of a piece's production--from the CNC machine that generated the rough shape, to the fine grinding, the polishing… the operators learned and mastered all these tools. If a piece wasn't prepared to go to the next step, it was corrected first--that's a pretty simple idea in concept, but in practice, it actually gets very complicated. In batch processing like we do in my company, many machines are intended to operate with a certain quantity--or more accurately, a surface area. In terms of my brief account of my time in grinding: surface dimensions of single part/ becomes surface area of single part/ becomes surface area of "full load" for run/… which finally dictates the amount of pressure distributed by the stone grinding lap--there's no running a single solitary piece; it would be crushed.

There's a lot of opportunity for obsessive compulsive behaviors here, ranging everywhere from "did I set this right? I should check it five more times" to counting the rows and columns of pieces stacked between sheets of cardboard and feverishly estimating the amount of time it will take to get through them--not that that will affect the length of the day at all. When your mind turns toward questioning why you're receiving bad parts that need someone else's attention before *you* can do a damn thing with them (who do I tell, is my manager going to ask me to push the parts through, will I need to jump through hoops to make this happen), the lean manufacturing system starts to make a lot of sense. Instead of "kicking it back" to a previous stage or department, an [...] operator just carries a reject two steps to the last machine (assuming that is the way to correct whatever issue).

Is every boost in efficiency something that we should rally against? The operator's greater responsibility at [...] certainly isn't Taylorism by definition, but I could see how anything that makes a certain amount of sense would be quickly grouped into "scientific management" and dismissed. But this efficiency is what buys [...] those reduced summer hours and a bowling team and community events--and a lot more than that. More than one employee alluded to their pay being above industry standard. "I work two days and get paid for three" is a quote from one that stands out in my mind. They also get a lot of cross training to use the wider array of tools at their disposal; they become specialists. Job specialization is a very different thing from the job fragmentation in Taylorism, and in terms of their happiness, it seemed to be paying off. Where happiness is a metric that makes businessmen uncomfortable, it can be put in more concrete terms--these well trained operators are simply worth more, by having more knowledge and by producing more. At the risk of making this a cost benefit analysis rather than inherently valuable: they are worth the company's investment.

This last statement is something I want to avoid in my paper. I'm here to champion the sensible, without promoting the scientific management that has been a tool of class oppression:

(Littler 1978: 188) "Taylorism grew out of the systematic management movement in the USA in the 1880/90s. Like some of the other early management reformers, only with a greater intensity, Taylor believed in the original sin and the original stupidity of the worker… Moreover, any man phlegmatic enough to do manual work was too stupid to

develop the best say, the 'scientific way' of doing a job."

For the people who don't believe that this really gained leverage… of course it did. Concepts of fragmentation and calculability are repeated almost word for word in my Project Management Professional handbook--a strategy and school of management with so much leverage that it has a governing body and a standardized test that has to be *applied* for in order to take it and receive their formal accreditation. Entire schools of economics and economic legislation could be associated with these principles--I won't be told that trickle-down economics does not have assumptions on where knowledge is located in the class system embedded within its framework.

The unsteady territory that I'm in makes itself very clear in these terms. Even lean manufacturing is based on time studies and measuring *throughput*, the hope being that the increased efficiency is actually faster and cheaper than batch processing speeds--at least this is my understanding, not having formally partaken in "the kool-aid", so to speak. Optimax leverages this, if not purely for the sake of, than at least to the positive end of their employees… but I don't know that that is part of the wider philosophy. The fact of the matter is that there are a great number of managerial and organizational tools that exist (I even happen to *like* PMP strategies, despite seeing their potential for being destructively employed) and can be *owned* by the laborers--here a phrase too steeped in rhetoric to be as clear and as effective as I intend.

The idea is much like what Archie Green describes: shipwright unions owning their hand tools, then redistributing those tools of deceased members in order to retain them for their own sakes, away from the control of a potentially exploitative contractor. It is my hope that these tactics can be openly and effectively used for the productive good of the *entire* organization, and as far from the *intention* of the Taylorism movement as possible.

Appendix E: Selection from Journal for February 9, 2014

Navigating between roles of researcher, employee, and management. Selection:

[...] is helping some of my thoughts accumulate--particularly regarding fears on communicating clearly and from the heart. There's truth in saying that every tool can be a weapon--this is a clear distinction in the technology good vs. evil debate. When it comes to my ability to communicate, or the purpose of this thesis as a whole, I see the risk in tipping the scale and becoming destructive.

So here is the requested post on my ethical position in this paper and in the company. I think it makes sense to write this *before* I start to dig more deeply into the IRB process… as a sort of baseline, I suppose, for what I feel is ethically appropriate, before it becomes a matter of altering my paper based on the logistical requirements of that process.

[...]

I believe strongly in "First, do no harm." My ideal scenario is certainly one where every individual stays employed, communicates with and learns from one another, where problems can be addressed and solved openly and collectively. This isn't a particularly distant vision-- my further ideal is one where the organizational structure of the company is formally flattened to more effectively foster that team orientation. Both of these ideals are scenarios that I think *work*--too often this seems to be the basis for their rejection; though the environment has to be right, I do not think it is particularly difficult to create the conditions for these ideals to become a reality.

I also understand that this can be a slow process, developed with care, where people maintain positive attitudes toward one another and the work.

However, the presentation by Erik Assadourian during residency is also strong in my mind: there is a clock, and it is ticking. There are plenty of discussions about what we, as academics or researchers or whatever an individual cares to call themselves, in operating from a position of leverage, can or *should* do when we encounter injustice--I spoke on this topic at AFS in 2012; I entered the MACs program with some distrust, having grown a certain distaste for individuals calling themselves "activist anthropologists". Reality is complex, so too are the ethical frameworks that people construct to navigate it.

I feel the clock ticking. On the national level, we see the struggle between two political parties as well as two dominant schools of economic thought, both issues that are too complex to deserve binary answers--I find this particularly infuriating when individuals determine "School A" or "Party B" yields the correct philosophy *all* the time, as though they can be decontextualized from the circumstances that they inform and are informed by. I see the cultural prevalence of American Individualism, the implication that a man's circumstance is a result of his wits and hard work. Closely behind this is that technology is a tool that either helps or hinders, but apparently not one to be understood and consciously guided--Cech puts this all very tidily in her article *"Culture of Disengagement in Engineering Education?"* which investigates engineering students' understanding of the human element in their work (my own experience corroborates her findings: they do not).

Not last, and not least of all these factors is the recent stockholder's meeting where it was allegedly

revealed the company had a second year in the red: this is not a surprise given the rest of the industry, but still somewhat foreboding. All of these issues, and many others, are what I would call *codeterminants* in my sense of alarm, as well as what I believe is the ethically appropriate approach to my work and to my thesis.

[...] As Assadourian mentioned, we have a habit, as a species, to allow our catastrophes to stratify themselves along the lines that already divide us--race, class, sex… It just depends on the calamity in question. When I see the socioeconomic climate leaning one way, when I see our company performing one way… I ask myself who will have to bare the brunt of the impacts made by our choices--the choices of politicians, bankers, or the management within my own company?

There seems to be a tradition, for right or wrong, for the academics embroiled in these debates to take the side of "the oppressed". For me this is a loaded issue, as it quickly devolves into participating with the same hegemonic devices which actively do *the oppressing*. We see this manifest as white savior complexes, as patronizing communities, or as fetishization of particular ways of life. I have sometimes said that I hate people who agree with me for the wrong reasons far more than I hate those who disagree with me for the right reasons-- my ethical standing has always been important to me, but I make no claims that it keeps me from *judging* people. It's not a fact I am proud of, either, but I am, after all, human.

The joke is that I'm the prodigal son at United Lens--it used to be funny because, as another operator on the shop floor, I did not have much, if any leverage, to influence change. It's a different story now; at the very least I have more visibility. I'm no longer isolated in a closed (coating requires a strict level of cleanliness, which means Authorized Personnel Only) department. I am well aware that a passing comment could actually take root, and perhaps affect negative change for a coworker. I worry about this.

On a personal level, I fear becoming the stereotype of the son who has bought his position in the company through his bloodline, and denies the reality of his still-green, short lived experience behind a shield of education and arrogance. I know the engineers and managers have been at this longer than I have, and some of their behavior has been developed under the demands (for better or worse) of my grandfather before my father. I worry about this, too.

I don't claim that there is not reasonable explanation for some of the challenges I see--in fact it makes it all the more difficult when I consider them honest mistakes. It is difficult to untangle "fault" from an individual who, in a hypothetical scenario, has strived to excel for the sake of themselves and the company, and in doing so has picked up strategies of taylorism (perhaps even from training that they pursued *for* the company!) for their employees and keeping their head low to avoid the ire of their own employer. This is not my diagnosis of any individual within my company, but I could certainly *imagine* an instance where it isn't so far from the truth. I think it is good practice to be able to empathize with what seems wrong to me, and understand how it may have arrived--outwardly assigning blame is not going to accomplish me much in my goals for the company.

However, there is still that tradition among anthropologists, and more than that, there is what I *feel* about the situation: I feel that the managers and engineers have carried a responsibility to the people that are employed

with them. Failure to serve them in the past is a sad but understandable situation, absolutely one I can forgive. Failure to move forward in a fashion which serves them in the future is *not.*

The changing economy and market is something that the company always has and will be a variable that the company has to adapt to; it should *not* manifest as a calamity that escalates to the point of *any* kind of failure. That is mismanagement that the management should be responsible for. At the deepest point of my frustrations, it is impossible to trust managers who won't assume their responsibilities and face the consequences. To put this in plain terms, there are managers who are only now learning how to use the new computer system, having made the conscious choice to remain blissfully unaware of how it was directly effecting their employees, and leaving their voices conspicuously absent in conversations that could have shaped the system for the better.

In summation, my ethical responsibilities are highly contextual--this isn't a revelation; it is always the case. Acting as member of the family within the company, my responsibility lies with *every* employee of the company, as well as the community of Southbridge as a whole, where the company makes its home--this fits tidily with my responsibilities as a researcher; there is no conflict here. *However*, when my work demands action, and that action demands a rapid response… my responsibility lies with the employees that are most subjected to their circumstance, and my blame lies with those that are most expected to carry responsibility with their positions of power. Here is where my conflict lies--as a researcher, I prefer not to have to make that distinction.

Appendix F: Selection from Journal for April 12, 2014

"Rationalizing" a quality approach: global economic context for fostering a slow-and-steady method at work. Selection:

[...]

At some point the conversation shifted into recent frustrations at work… it came to light that recent problems[...] could have easily been solved with an extra hour of processing at [...] this is a frequent trend, it seems. [...] insisted that the strategy was appropriate, that [...] was given what was necessary to complete the job, and that an extra hour [...] costs money. The [...] has had an employee doing 12 hour shifts for over a week, including Saturdays, chasing a flatness that takes considerable time to be achieved with his machines, with the raw material he was given. To address future issues with this order, [...] outsourced the processing of the raw material--now it is sliced on a Wire Saw machine, which maintains extremely flat and parallel cuts. We have several of the machines, but none are large enough to slice this particularly large part.

Dick and I have pointed out that the Blanchard Grinder, a surface grinding machine [...] has several of, can bring a part of that size into a flatness within millionths of an inch, providing a much better foundation for the work [...] but the suggestion fell on deaf ears--[...] argument remains that the added time to grind to that specification (like I said, it would be an added hour or so) costs money.

I relayed this in our conversation, and joked about a comment my father had made during the conference call a week or so before--that "we" [...] had to be careful not to turn me into (have me spend my time as, is what they meant) an accountant. If that is the level of accounting that Engineering ends their technical analysis at, then I *have* to be an accountant for the company. [...] our main competitor for low-spec work was in China, and that their government is subsidizing highly competitive education and releasing those students into the workforce--they will be compensated appropriately for their level of education, but their labor rate in USD could very well remain lower than our *cheapest* temporary labor.

This means their prices will be lower than ours, if we ignore any technological difference in processing--though, as I see it, more and more corporate investment goes overseas everyday, which means the technological playing field is levelling rapidly. The educational playing field is levelling rapidly. Customers at *this moment* choose to purchase from our company, at least in part, with the understanding that the added cost *does* mean added value, but this window may be closing fast.

If all of that is true (and I believe it is), that means this latest processing failure was more considerable than we are really giving it credit for. Not only did we not save labor expense (we increased it [...] considerably!), the quality of the product went down considerably, exposing us to a scenario where our customers bring the order overseas. Outsourcing the initial processing is the cherry on top--we learned nothing from our mistake.

[...]--we didn't save money, we lost it, and every time we *think* we are saving labor costs, we're really losing the ability to solve problems--we may as well take the "saved" money and invest overseas.

Literature Review

The academic research for my capstone was conducted in two very discrete discrete directions: work from the social sciences, with an emphasis on laborlore literature; and academic works conducted on business and management. Neither of the two categories maintained a *dominant* role in providing relevant source material, instead, they offered very different insight into my topic: most typically, the social science materials were observational or historical accounts of work experiences on very personal or social levels, while the business management materials were provocative pieces on what type of work environments and strategies could be considered "effective".

I started my research in laborlore with authors Archie Green and Robert McCarl. I was initially hesitant to use my own voice in my thesis, and in this regard, Green was profoundly influential: his style of delivering academic work through the lens of his own life and work experience assured me that this mechanic was a valid one. McCarl's work provided me a methodological roadmap to workplace ethnography, as he guides his readers through the steps of his studies. Not all folklore literature was helpful, however, and I found myself taking issue with a common theme of technology dehumanizing the workplace, like those in the work of Maggie Holtzberg-Call--while the first-person accounts were deeply meaningful and well written, I often felt that this text (and others) lost sight of the fact that this violence is very explicitly man-made in nature.

The best of the business-oriented literature was *In Search of Excellence* by Peters and Waterman, a surprisingly reflexive piece that posits achievable, human-oriented tenets to running a profitable business. My other sources included articles revolving around family and small business performance (Nicolas Kachaner as well as Pramodita Sharma), as well as several works

on the restructuring efforts of Harley Davidson (Phillip Chansler et. al., and Rajesh Sharma). The bulk of this section of my research was valuable in its ability to share insight on varieties of management strategies, especially those that emphasized cooperative efforts with the labor force. There were several less-useful sources, as well, particularly those that went through great lengths to establish statistical studies to test management- or labor-oriented hypothesis. Holger Mueller and Thomas Phillipon provided one such source, and though their study was thorough--even helpful--in addressing the many interfaces of family ownership and labor relations, the reliance on reconstructing and controlling data from decades-old, survey-based studies struck me as a considerable weakness in describing contemporary social phenomena.

Other sources that do not fall explicitly into these two categories, but were still extraordinarily influential to this paper, include Robert Sennett's *The Craftsmen*, an excellent insight to the mind and act of work--though, like Holtzberg-Call, at times unsteady in attributing structural violence as a sickness of technology--and Craig Littler's *Understanding Taylorism*, an incredibly informative critical analysis of the effects and scholarship on Taylorist philosophy. Last, and almost certainly the most important, were my sources for union history, culture, and scholarship, which included the writings of Stan Weir and work by Bruce Nissen.

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