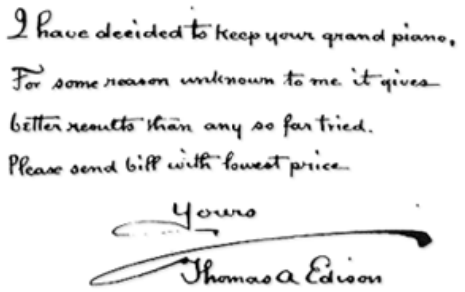
TUCK SCHOOL OF BUSINESS AT DARTMOUTH
GLASSMEYER/MCNAMEE CENTER FOR DIGITAL STRATEGIES
VINCENT L. LACORTE CASE SERIES

Case #6-0023

Technology and Quality at Steinway & Sons


I have decided to keep your grand piano,
For some reason unknown to me it gives
better results than any so far tried.
Please send bill with lowest price.
Yours
Thomas A Edison

Bruce Stevens (CEO), Ronald Penatzer (General Manager of Manufacturing Operations), and Robert Berger (Director of Quality) watched the delivery team carefully uncrate the new computer numerically controlled (CNC) shaping machine. The million dollar piece of equipment, one of several CNC machines Steinway & Sons had purchased in the past five years, would allow the supporting wooden members of a piano to be produced in one integrated machining operation, ensuring snug, square joints between the legs and the piano. These leg joints were particularly important because they received punishing jolts as pianos were moved across uneven surfaces. Traditionally, these shaping operations were manually performed in a dozen steps and often reworked to achieve the quality joints Steinway required.

The new equipment sent shock waves through the factory, reverberating with customers around the world. The three men, with over 75 years of piano-building experience between them, knew that changes at Steinway could not be taken lightly. Berger, pointing at the machine, commented “some think that Steinway is automating to save on labor costs or improve productivity. But these investments are all about *quality*. We are making a few specific technology investments in areas where we can improve the quality of our product.” Everyone nodded and the three headed into the rambling, multi-story production facility to review quality improvement at the CNC machines in the action department.

The Early Years

Heinrich E. Steinweg, a German cabinetmaker, was well-known for the quality of his pianos. He took first honors for craftsmanship and tone at a competition in Brunswick, Germany in

This case was written by Professors M. Eric Johnson, Joseph Hall, and David Pyke of the Tuck School of Business at Dartmouth. It was written as a basis for class discussion and not to illustrate effective or ineffective management practices. Version: March 2, 2009.

1839. Prolific, by the time he and his family set sail for New York in 1850, Heinrich had made more than 400 pianos. While he quickly landed jobs at various piano manufactories, Heinrich was an entrepreneur at heart. In 1853, he anglicized his name and opened the doors to his own firm, Steinway & Sons.

The very first piano Steinway & Sons sold went to a New York family for $500.[1] In 1855 several Steinway & Sons pianos were entered at the American Institute Exhibition. The firm won a gold medal, which Heinrich publicized, helping to double the firm's sales each of the following three years. In 1867 the company extended its reputation and sales abroad when it won the Grand Gold Medal of Honor for excellence in engineering and manufacturing at the Paris Exhibition.

Recognizing that public acclaim was at least as important to success as craftsmanship, Steinway soon leveraged the testimonials of artists and wealthy patrons to market their products, and in 1866 opened a concert hall, Steinway Hall.

After Heinrich's death in 1871, Steinway & Sons continued to grow under the direction of his son William. In the 1870s, he opened a huge factory complex, including a residential and commercial village for the employees, in Queens, New York. The new facilities were equipped to manufacture every part of a Steinway piano except its ivory keys.[2] The company also extended its international influence, unveiling a London showroom in 1875 and a factory in Hamburg, Germany in 1880.

Toward the late 1800s, political unrest abroad and a troubled economy at home reduced demand for pianos. The company teetered on the verge of bankruptcy and, after William died in 1896, his nephews tried to sell it. Fortunately, they were unsuccessful, as the economy rebounded soon after and new trends, such as ragtime and silent pictures, had the public clamoring for more and better pianos.

Twentieth-Century Changes

Over the next century, Steinway & Sons continued to bank sales mostly on its grand pianos, which led to mixed results. Although an upright piano had been created as early as 1862, and upright models were marketed along with the firm's line of grand pianos during the mid-nineteenth century, Steinway believed most American consumers wanted grands and concentrated its efforts on that market.

> *The bottom line at Steinway & Sons was that if you were making grands you were making money, whereas if you were making uprights you were just selling pianos.*[3]

When, in the 1930s, uprights suddenly became fashionable, Steinway was ill-equipped to churn them out in sufficient volume and did not seriously enter the market until 1937. By that time, competitors Baldwin and Kimball were firmly entrenched. Of the 88,000 uprights produced in 1939, only 2,175 were Steinways.

Piano manufacture all but halted during World War II as raw materials were siphoned by the war effort. Steinway retooled to make wooden parts for military glider aircraft, but the company did produce a number of plain "Victory" model uprights for use by America's armed forces. At Steinway's plant in Germany, the Nazi party similarly diverted production for the German war effort.

Steinway resumed piano manufacture after the war, but its U.S. facilities desperately needed an overhaul. Operations were divided between two New York plants, both with outdated equipment. The company decided to consolidate the two factories, re-mortgaging and eventually selling Steinway Hall to help pay for the costs.

By the early 1960s, Steinway was producing a wide variety of models, including the "Contemporary Vertical," and orders for grands were backlogged. But the rising costs of labor and materials, combined with Steinway's inventory-intensive production process increasingly ate into the company's profits. Furthermore, the consolidation effort did not sufficiently increase space or speed up production. The entrance of lower-priced competitors into the market compounded these problems.

For the second time in the company's history, the Steinway family considered selling out. This time, they did so. In 1972 they sold their company to CBS, which incorporated Steinway & Sons into its Musical Instruments Division. This division included Rhodes electric pianos, Fender guitars and amplifiers, Rogers drums, and Leslie speakers. Although, like Steinway, these instruments were renowned for their quality, some people wondered aloud whether CBS would try to increase profits by compromising Steinway quality. CBS poured money into its new venture, increasing annual capital spending at Steinway from $100,000 to $1–2 million. Profits picked up, but rumors that Steinway quality had declined continued to circulate.

In 1985, when CBS sold off Musical Instruments Division to a Boston group led by brothers John P. and Robert Birmingham, Steinway & Sons was rolled into the newly created Steinway Musical Properties. Seven years later, Steinway introduced its first mid-priced line. Designed to Steinway specifications, the new Boston piano was manufactured by the Japanese firm Kawai, using sophisticated technology.

In 1995 Steinway Musical Properties was sold to Selmer Co., the number one U.S. manufacturer of band instruments, including Selmer Paris saxophones, Bach trumpets and trombones, and Ludwig drums. Regrouped under the Steinway Musical Instruments umbrella, Steinway continued to grow with an eye on vertical integration and modernization. In late 1998, Steinway Musical Instruments acquired Kluge, Europe's largest manufacturer of piano keys. Noted Steinway president Bruce A. Stevens, "We are very excited about this opportunity. Kluge has produced the industry's finest piano keys since 1876 and for virtually that entire period Steinway & Sons has been a major customer. Vertically integrating this acquisition will greatly improve our manufacturing efficiency."[4]

Continuing in this vein, in 1999 Steinway Musical Instruments, Inc. purchased O.S. Kelly, the largest U.S. manufacturer of piano plates. The piano plate provides a rigid frame needed to anchor the piano strings under tension. That same year, the New York City Industrial

Development Agency (IDA) awarded Steinway approximately $4.2 million in "land tax abatements, building tax stabilization, and sales tax exemptions on hard construction costs" to renovate and modernize Steinway's nearly 100-year old, 421,000-square-foot factory. "The ability to proceed with the modernization of our factory in Long Island City was vital to our long-term growth strategy," noted Steinway controller Dennis Tortora.[5] The upgrade also ensured the firm would stay in New York for a while longer.

The year 1999 also marked the repurchase of Steinway Hall. Steinway had continued to lease its retail space in the hall after selling it in 1958. In announcing the $31 million deal, Stevens remarked that the company, "[could] now enter the new millennium with this valuable asset safely back where it belongs—at Steinway."[6]

By 2005, net sales of Steinway pianos reached $203 million and demand for Steinway grands exceeded domestic production (see Exhibit 1).

Steinway Tradition of Superior Quality

Steinway had been a popular choice among artists throughout its history. Early on, the firm had solicited the testimonials of renowned musicians, providing them with special pianos and personal tuners at concert appearances to cultivate their favor (see Exhibit 2). By the early twenty-first century, over 95 percent of piano soloists performing with major orchestras chose to perform exclusively on Steinway pianos.[7] Its roster of "Steinway Artists" listed more than 900 popular ensembles and concert pianists, including Van Cliburn, Harry Connick Jr., and Billy Joel. In North America, artists selected their Steinway piano for concert performances from the company's unique "piano bank," an inventory of more than 300 pianos valued at over $15 million.[8] In exchange for valuable feedback on its pianos, Steinway Artists were assured access to the best pianos anywhere in the world. Steinway would sometimes go to extraordinary lengths to ensure concert pianists had a piano that matched their liking and style, including flying a piano to Buenos Aires for legendary pianist Arthur Rubinstein when his usual instrument was waylaid in a dock-worker strike. Stevens noted, "the artists are our biggest fans and our toughest critics. Who knows better than concert pianists what quality means? We have to work very hard to satisfy them because their life depends on our piano. They love us, but if they found a better piano, they would switch. We know that and it motivates us every day."

Quality handcraftsmanship and innovative techniques were part of the tradition Heinrich Steinway had established from the firm's inception. Nearly half the company's 120 patented inventions were developed during its first 40 years in business, becoming the basis for the so-called Steinway system, the eventual standard for piano manufacture.[9] Particularly notable among these were the technique of overstringing a grand piano to improve its bass sound and an improved cast-iron plate to support the tension of the strings.

Subsequent management did not relax this quest for excellence over the years. In the 1920s, for instance, Steinway modified its manufacturing process, improving its rib-shaping process and veneer techniques, and substituting lacquer for slow-drying varnish. The company also reconfigured operations to allow more efficient use of skilled workers' time. By the end of the 1930s, Steinway stopped producing iron plates and ivory keys, choosing instead to

concentrate its efforts on its core competencies. After the war, Steinway replaced ivory keys with a polymeric material, successfully reducing costs without reducing quality.

Creating a Steinway

150 years after its humble beginning, Steinway was producing about 3,000 pianos a year on its 11-acre site in Queens. However, the company's meticulous craftsmanship and attention to detail could not always keep pace with the demand for its grand pianos, despite a workforce of about 450. Many of these employees were highly skilled craftsmen, often with 15 or more years experience in the industry.

Each piano began as nothing more than raw lumber. Steinway wood buyers constantly searched the globe for the world's finest wood: Sitka Spruce from the Pacific Northwest, oak and maple from northeast forests, birch, poplar, mahogany, and exotic wood such as East Indian Rosewood, Kewazinga Bubinga (West Africa), and Macassar Ebony (African East Indies) that would be applied in a veneer to give the piano a custom, unique appearance. The veneer of each Steinway piano used wood from a single tree. The wood was cut to size, matched, and identified with the piano number. This costly attention to detail ensured a uniform appearance and attractiveness. The quality grades required by Steinway were unique. For wood suppliers, Steinway was their toughest customer—requiring a quality far beyond even their most demanding customers. Beyond typical quality measures, the Steinway buyers measured such things as the number of grains per inch of the wood. Spruce required 8-10 grains per inch—too few meant the wood would be less dense and thus less capable of transmitting sound vibrations. Even the smallest knot or pin-hole in the wood meant part of the board would be scrapped. Much of the lumber never even made it into the production facility. In the end, nearly 50 percent of wood ended up in the scrap bin.

In addition, the woods used in the rims, tops, soundboards, and actions were cured for months outside, in Steinway's lumberyard, and inside, in computer-controlled kilns and conditioning rooms, until they stabilized at a specific moisture content. Production incorporated many of the labor-intensive techniques that had been created and patented years earlier. For example, shaping the inner and outer piano rims by bending them as a single continuous piece, a process Steinway patented in 1878, was still used in 2005. These time-honored techniques, combined with top-of-the-line materials, were the chief ingredients of Steinway's production process.

In a series of articles celebrating Steinway's 150th anniversary, the *New York Times* colorfully described key parts of the manufacturing process:

> The contest was between a giant sandwich of wood—18 strips of maple, each about half as long as a city bus—and half a dozen workers with muscles, a pneumatic wrench and a time-conscious foreman. The workers were supposed to bend and shove those 18 strips into a familiar-looking shape, and beat the clock. "We're allotted 20 minutes," the foreman muttered.
>
> After 14 minutes of pushing and pulling and flexing and grunting that another boss standing nearby called "the Fred Flintstone part of the operation," the wood was

forced into a curve. And, in the too-warm basement of a gritty factory that opened when Ulysses S. Grant was president, piano No. K0862 was born.

Like other newborns, it came with hopes for greatness and fears that it might not measure up despite a distinguished family name, Steinway.

Or that it would be grumbled about by Steinway's customers—temperamental, obsessive, finicky pianists whose love-hate relationship with the company and its products is as complicated and emotional as anything in Chekhov. Yes, pianists grouse that Steinways are not what they used to be. Yes, pianists ascribe whatever faults they found in whatever Steinway they just played to every Steinway. And no, the majority would never play anything but.

Steinway knows all this. Like No. K0862, every new piano that rolls out of the Steinway & Sons factory—in Astoria, Queens, next to oil tanks that block the view of the Rikers Island jails—is an attempt to refute the notion that the only good Steinway is an old Steinway.

So how good will No. K0862 be? Will it sound like "a squadron of dive bombers," as the pianist Gary Graffman said of a Steinway he hated on first hearing but came to love? Or will it begin life with the enormous bass and sweet-singing treble that pianists prize the way wine lovers prize a 1989 Romanée-Conti? Will it be good enough for Steinway's concert division, which supplies pianos to big-name artists?

No one can say. Not yet.

It will take about eight months to finish No. K0862, an 8-foot 11 3/4-inch concert grand. Along the way, the rim will be aged in a room as dim as a wine cellar. It will be sprayed with lacquer, rubbed and sprayed again.

Its 340-pound iron plate will be lowered in and lifted out 10 or 12 times. It will spend time in rooms where workers wear oxygen masks to avoid getting headaches (or getting high) from smelly glues. It will be broken in by a machine that plays scales without complaint, unlike a student.

Someone walking through the factory, following the progress of No. K0862, could forget a basic fact about what goes on there: Every Steinway is made the same way from the same materials by the same workers. Yet every Steinway ends up being different from every other—not in appearance, perhaps, but in ways that are not easily put into words: colorations of sound, nuances of strength or delicacy, what some pianists call personality. Some Steinways end up sounding small or mellow, fine for chamber music. Some are so percussive a full-strength orchestra cannot drown them out. On some, the keys move with little effort. On others, the pianist's hands and arms get a workout.

Why? No one at Steinway can really say.

Perhaps it is the wood. No matter how carefully Steinway selects or prepares each batch, some trees get more sunlight than others in the forest, and some get more water. Certain piano technicians say uncontrollable factors make the difference.[10]

...

The big, curved rim of Steinway piano No. K0862 had been parked since early March in a hot, dark room, aging so it would never pop out of shape. Soon it would emerge, and workers would start putting things inside, from tiny hammers that strike the strings to the 340-pound cast-iron plate that anchors them.

First, though, early in May, Paul Verasammy had to glue together 15 or so strips of spruce to make one of the components that will leave listeners either applauding No. K0862 as a great instrument or wondering why the pianist is having a bad night.

He was working on the sounding board.

Once it has been fitted into place beneath the piano's strings, it will look like a five-by-nine-foot slab made of planks and rounded off at one end. It will be the piano's amplification system, a triumph of physics that can transform the weak vibrations from the strings into sound powerful enough to fill a concert hall.

This hunk of glued-together wood will give No. K0862 its recognizable tonal signature. The sounding board, more than any other of the 12,000 parts that make up a Steinway concert grand, will largely determine whether No. K0862 is big and gutsy for Rachmaninoff or Tchaikovsky or warm and mellow for Mozart or Beethoven.

All Steinways are made the same way by the same people in the same factory, yet each is different. The reasons for this are a mystery, but the workers, each playing a different role, are certainly at the heart of the answer.

Take Jagdesh Sukhu, one of the woodworkers who pick boards from a stack of wood that spent the winter in Steinway's lumberyard. Mr. Sukhu has 14 years of experience in deciding what is right for a sounding board and what is not. On the day he was choosing wood for the sounding board for No. K0862, he rejected more than half of the wood in the stack for blemishes, knots, wormholes and other imperfections almost too small to see. (Never mind that spruce costs about $7 a running foot.)

"How much we reject depends on the bundle," Mr. Sukhu said as he marked the rejects with a blue crayon. "Sometimes we reject three-quarters, sometimes one-quarter, sometimes more than three-quarters. When you do it every day, you know exactly what you want and what you don't want."

After so many years, his eyes can see flaws that ordinary eyes cannot.[11]

After the soundboard and plate were fitted to the piano case, the strings were attached. Until the 1980s, craftsmen did this job by hand, a two-hour task each piano. Steinway later converted to a less labor-intensive process. A stringer inserted a wire through a hole in a tuning-pin and guided a machine as it turned the pin three times, wrapping three wire coils around it. The pin was then placed through one of the more than 200 holes in the cast-iron plate and driven into the pin-block.

The action's felt hammers, which gave Steinway pianos their distinctive feel, were made from a single strip of felt pressed into shape. Hammers were formed by applying glue to the inside of the felt strip, placing the strip in a long, grooved copper form, and then pressing it around a three-foot long wooden molding into the pear shape of a hammer. Once the felt was pressed and removed from the machine, the hammer was sliced apart. The resulting hammer was twirled onto a hammershank. Sometimes, placement was adjusted by lightly heating the wood of the hammershank. Steinway had also tried using Teflon plastic parts in the action and, in fact, believed it offered advantages over felt bushings, but pianists rebelled, so they moved to an improved version of felt impregnated with Teflon.

Dampers, which prevented the strings from unintentionally vibrating after being hit by the hammers, were carefully matched to the strings by skilled craftsmen. Once this painstaking task was completed, the master technicians reached underneath the piano and, using mirrors, adjusted the levers that controlled each individual damper.

In a process called the action weigh-off, weights were placed on each key in the keyboard, and lead was inserted into the body of the key until the pressure needed to depress each key was uniform. This calibration process provided a consistent feel across the keyboard.

Finally the very subtle sound of the piano was perfected by voicing technicians. Voicing involved minute adjustments to the hammer and required the expertise of a master voicer (tone regulator), who was responsible for approving the tone quality of each note. This technician adjusted the hammer's resiliency by sticking the hammer's felt with a small row of needles, reducing its stiffness and mellowing its tone. To increase the brilliance, a small amount of lacquer was applied to the felt. Next, a final tuner adjusted each piano's pitch by turning the tuning pins with a tuning hammer to alter string tension. When the piano was regulated, it was ready for final inspection.

The Competition

Steinway competed in the high-end grand market with long-time European firms such as Bosendorfer, Grotrian, and Fazioli. While the U.S. once had many piano makers, by 2000, most had either failed or been acquired by foreign firms. In the mid markets, Steinway's competitors included Mason & Hamlin, an old New England firm rescued from bankruptcy in the mid-1990s by newcomer PianoDisc; Korean powerhouse Samick, established in 1958 and owner of many old brands such as Kohler & Campbell; Asian competitors and partners like Kawai and Young Chang; and longtime rivals Baldwin and Yamaha (see Exhibit 3).

Baldwin. Baldwin, the largest American piano builder, was the brainchild of Dwight Hamilton Baldwin, a reed organ and violin teacher. Baldwin opened a music store in Cincinnati, Ohio, in 1862, but dreamed of creating "the best piano that could be built." In 1891 he unveiled an upright model and four years later introduced the first Baldwin grand piano, a 5'4" model.

By 1913 Baldwin was exporting pianos to 32 countries around the world. Over the years, the company expanded its lines of uprights and grands to include player pianos, popular during the 1920s. As at Steinway, the Depression and World War II took its toll on piano sales, but by 1953, Baldwin had doubled its pre-war production.

Baldwin introduced its flagship model, the nine-foot SD10 Concert Grand, which the company touted as "a major advancement in piano design" in 1965. The company further enhanced its lines in 1988 with the purchase of The Wurlitzer Company's keyboard division and seven years later with the reintroduction of the Chickering name—a nineteenth century rival of Steinway—on a line of its grand pianos.

In the 1990s Baldwin went digital. The Baldwin Pianovelle digital piano product line was introduced in 1995. Two years later, Baldwin debuted a player piano system that the company promised "would transform [an owner's] Baldwin, Chickering or Wurlitzer piano into a complete, state-of-the-art home entertainment system."[12] In 2001, Baldwin was acquired by prestigious guitar and musical instrument manufacturer Gibson Guitar Corp. Under the Gibson umbrella, Baldwin offered several lines of grand pianos as well as uprights, digitals, and piano software in a wide range of pricing.

Yamaha. Yamaha was founded in Japan by Torakusu Yamaha in 1887 to produce reed organs. The first upright piano was crafted in 1900 and a new grand model in 1902. The company thrived until the 1920s, when it was nearly destroyed by a series of natural and economic catastrophes. Yamaha regained its footing and flourished until World War II when most of its factories were bombed. It revived once more, this time with U.S. assistance, and by the 1940s, the firm was again crafting pianos.

In 1954 Yamaha began manufacturing motorcycles. This venture proved useful to the firm's piano business in two respects. First, Yamaha acquired experience in metal casting and other technology that it applied to piano manufacture. Second, the company promoted its name by using revenues from motorcycle sales to underwrite the Yamaha Music School system.

Yamaha did not have a product to rival Steinway's high-end grand pianos at this time and so approached the New York firm about becoming its agent in Japan. Steinway already had an agent in Tokyo, however, and rebuffed its advances. Yamaha's response was to create its own concert grand piano in the 1960s. These grands, like Steinway's, were crafted by hand of top-grade materials. This craftsmanship, combined with savvy marketing and affordable pricing, quickly gained favor with American consumers. By the end of the decade, 44 percent of all grand pianos purchased in the U.S. were imported, and most of these were Yamahas. Yamaha's biggest consumer base was institutions—schools and universities—that wanted excellent sound at an affordable price. One of Yamaha's strategies was to encourage young

pianists in music schools to use their pianos, hoping that they would trade up to a Yamaha concert grand when they advanced in their careers.

Yamaha could afford to keep its prices low because of several factors. Vertical integration allowed Yamaha to make most of its piano parts, including the metal frames on which the strings were strung. New technology and assembly line techniques sped up production for all pianos, including uprights and grands, but not concert grands. Yamaha was able to fabricate 1,000 piano plates a day, and an automated production process reduced handling and moved materials quickly throughout the factory. Technology also insured a more consistent product as workers had fewer opportunities to make their own value judgments. In fact, Yamaha actively worked to minimize worker discretion (see Exhibit 4 for a photograph of the Yamaha assembly line). And, finally, Japanese labor costs were lower than American labor costs.

As a result, Yamaha was able to realize a profit selling grand pianos to American consumers for as little as one half the Steinway price.

> *Once it was a Steinway grand in the auditorium and a Baldwin upright in the classroom; now it was almost all Yamaha. Japan had become the largest piano-producing nation, manufacturing 273,000 instruments (one-third of the world's output)."*[13]

Yamaha continued to import most of its grand pianos into the U.S. even after it opened a factory in Thomaston, Georgia in the late 1970s. In 1999 the plant produced its first American-made grand piano.

New Products for a New Era of Distribution

In January 2001, Steinway & Sons introduced a third line of pianos, the Essex line, manufactured through an agreement with Korean piano manufacturer Young Chang. While Steinway promoted the stylish art deco cabinetry as the key feature of its new line, its price (25 percent below the Boston model, which ranged from $5,200 to $17,800) was clearly the new line's major selling point. Like the Boston brand, the Essex piano was designed by Steinway engineers and manufactured to exacting Steinway specifications. Young Chang's assembly lines ensured consistent quality. "Now, with the Essex, Steinway provides pianos for every level of musical ability and budget"[14] boasted a promotional release.

The Essex introduction was part of Steinway's long-term distribution strategy to strengthen its dealer channel. In the decade leading up to the mid-1980s, Steinway's share of its dealers' business had dwindled as dealers sold more and more lower-cost pianos. With Steinway sales representing less than 20 percent for some dealers, their attention to Steinway and its customers sometimes faltered. So Steinway began trimming its dealers and expanding their territories. In the U.S. alone the number dropped from 150 dealers in the 1980s to 75 in 2005. In exchange, Steinway asked dealers to invest in upgraded showrooms, larger inventories, and better promotional support. Then Steinway added new offerings to fill out a portfolio of models at different price points—first the Boston in 1991 and then the Essex. With expanded

offerings and territories, Steinway products grew to represent 40-60 percent of the dealers' business. Stevens estimated that, while those dealers only represented about 5-6 percent of all keyboard dealerships in the U.S., they represented nearly 25 percent of the industry sales and 30 percent of the profit. Worldwide Steinway maintained 160 dealers.

Yet, with all these changes, Steinway dealers complained that they still had one very stiff competitor—used Steinways. Used Steinways had always competed with new ones, but with the installed base growing and perception among some that the older pianos were better, the competition kept growing. "Older is not better, and we can prove it," said Stevens. "Where that [notion] started was with people who make their living rebuilding Steinways, and they tell their customers that. We've just about given up rebutting it." In 2003, Steinway decided to get into the refurbishing business itself, offering a line of rebuilt pianos under the brand Heirloom Collection. The pianos were procured on the used piano market and shipped back to the factory for a complete overhaul. When finished, the pianos were re-branded with an Heirloom insignia and distributed through the Steinway dealers. Stevens noted that there were two important reasons for Steinway to jump into this business. First, it provided another offering for their dealers—linking them more tightly to the firm. Second, it protected the brand. For years, many other rebuilders had refurbished Steinway pianos with varying skill. However, when they were done, the piano was still sold as a Steinway so their work impacted the brand—sometimes for the worse. Through the Heirloom Collection, Steinway could differentiate between those pianos rebuilt by Steinway and those that were not. More importantly, they could ensure that the rebuilding process met with Steinway's quality standards.

Technology in Action Fabrication

As Stevens, Penatzer, and Berger entered the action department, the clicking and humming of machines interrupted their conversation. Around the large room were scattered a number of CNC machines interspersed with manual work areas. The department created the intricate set of small wooden parts that together would be assembled into an action. Each time a pianist struck a key, the action transmitted the motion of the key to throw a hammer against a group of strings inside the piano (see Exhibit 5). Each of the 88 keys on the piano had its own action and there were 58 parts in each action. The tiny action parts were fabricated from maple to very tight tolerances—in some cases 3-4 thousandths of an inch. The tight tolerance for each action part was particularly important since, when assembled, the overall variance of the action assembly would grow. When Penatzer joined Steinway 43 years ago, action parts were manually fabricated. Controlling the tight tolerances manually was extremely challenging and required painstaking attention to detail at each step in the fabrication process. With the CNC machine, many shaping and drilling operations could be done at once with the part held securely in a fixture. The machines were very specialized—many were custom built by Steinway.

Berger stopped by one of the machines and peered over the shoulder of two members of his quality control group who were running experiments on one of the machines. He saw an opportunity to show Stevens and Penatzer how the science of quality could be coupled with technology to improve the manufacturing process. The new machine was producing a

complex action part (see the "support" shown as part #28 in Exhibit 5) that had been particularly challenging. At one end of the part, a slot was first carefully milled and then a hole drilled through the slotted shaft (see Exhibit 6). In action assembly, a pin would slide through the hole, attaching this action part to another piece. The tolerance of the hole was very important because it linked the part with the others. The engineering specifications called for the hole to be positioned 0.200 inches from the end of the shaft, plus or minus .015 inches[15]. If this could be achieved, the machine would certainly produce a better part than could be fabricated manually. Berger noted, "our goal is to make the automated process capable of very high quality. When the process is robustly designed, we generally do not need to continue the expensive activity of manually collecting quality data simply to see that the process is working. In a few cases, where the economics are attractive, we might consider implementing an automated computer vision system to track quality. Such an automated system could dramatically reduce the cost of collecting data."

The three executives studied the results from 100 test parts (see sample 1 in Exhibit 7). The quality control experts explained to Berger that they were concerned that the machine was not yet capable of producing the high tolerances required. So they had been experimenting on ideas to improve the process.

One idea was to reverse the order of the operations. They hypothesized that when the hole was drilled through the already slotted shaft, the pressure of the drill bit would slightly bend the wood making the hole out of tolerance. If they drilled the hole first, before milling the slot, they hypothesized that the shaft would be stronger and less likely to deform. After the hole was drilled, the slot could be machined.

Using this approach, they had made 100 sample parts and measured the results (see sample 2 in Exhibit 7). The approach looked promising, but they were not sure if the new approach was really an improvement. Berger agreed the results offered a possible breakthrough and agreed to spend the rest of the morning helping them analyze the data. Stevens and Penatzer had to rush on to a pressing customer meeting, but promised to stop by at the end of the day to hear their conclusion.

Exhibit 1a: Steinway Financial Information

For the years ended December 31,	2005		2004		Change $	Change %
Net sales						
Band	$ 183,626		$ 171,346		12,280	7.2
Piano	203,517		203,688		(171)	(0.1)
Total sales	387,143		375,034		12,109	3.2
Cost of sales						
Band	146,168		137,779		8,389	6.1
Piano	129,441		128,122		1,319	1.0
Total cost of sales	275,609		265,901		9,708	3.7
Gross profit						
Band	37,458	20.4%	33,567	19.6%	3,891	11.6
Piano	74,076	36.4%	75,566	37.1%	(1,490)	(2.0)
Total gross profit	111,534		109,133		2,401	2.2
	28.8%		29.1%			
Operating expenses	76,697		75,255		1,442	1.9
Facility rationalization	—		(363)		363	(100.0)
Total operating expenses	76,697		74,892		1,805	2.4
Income from operations	34,837		34,241		596	1.7
Other income, net	(800)		(3,163)		2,363	(74.7)
Net interest expense	13,645		13,437		208	1.5
Income before income taxes	21,992		23,967		(1,975)	(8.2)
Income tax provision	8,200	37.3%	8,100	33.8%	100	1.2
Net income	$ 13,792		$ 15,867		(2,075)	(13.1)

Exhibit 1b: Steinway Financial Information

December 31,	2005	2004
Assets		
Current assets:		
Cash	$ 34,952	$ 27,372
Accounts, notes and other receivables, net	81,880	88,059
Inventories	159,310	172,346
Prepaid expenses and other current assets	11,653	5,937
Deferred tax assets	7,936	15,047
Total current assets	295,731	308,761
Property, plant and equipment, net	96,664	102,944
Trademarks	13,233	12,325
Goodwill	30,088	31,854
Other intangibles, net	4,128	5,290
Other assets	15,811	16,371
Total assets	$ 455,655	$ 477,545
Liabilities and stockholders' equity		
Current liabilities:		
Current portion of long-term debt	$ 12,977	$ 14,212
Accounts payable	13,805	14,789
Other current liabilities	45,099	43,892
Total current liabilities	71,881	72,893
Long-term debt	191,715	208,580
Deferred tax liabilities	15,326	26,240
Other non-current liabilities	27,903	24,279
Total liabilities	306,825	331,992
Commitments and contingent liabilities		
Stockholders' equity:		
Class A common stock, $.001 par value, 5,000,000 shares authorized, 477,952 shares issued and outstanding	—	—
Ordinary common stock, $.001 par value, 90,000,000 shares authorized, 9,680,508 and 9,595,745 shares issued in 2005 and 2004, respectively, and 7,635,058 and 7,550,295 shares outstanding in 2005 and 2004, respectively	10	10
Additional paid-in capital	83,062	81,129
Retained earnings	126,379	112,587
Accumulated other comprehensive loss	(13,185)	(737)
Treasury stock, at cost (2,045,450 shares of Ordinary common stock in 2005 and 2004)	(47,436)	(47,436)
Total stockholders' equity	148,830	145,553
Total liabilities and stockholders' equity	$ 455,655	$ 477,545

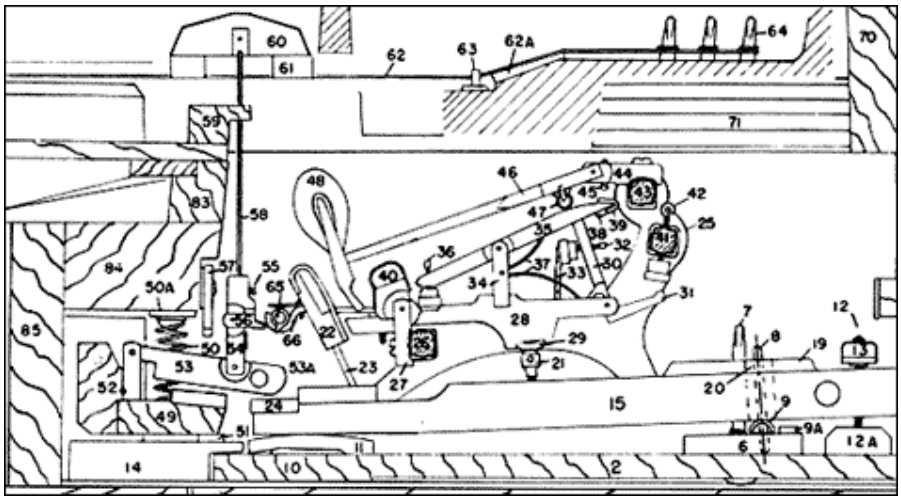
Exhibit 2: Steinway Grand Piano

Exhibit 3: Steinway Competitors

Exhibit 4: Yamaha Assembly Line

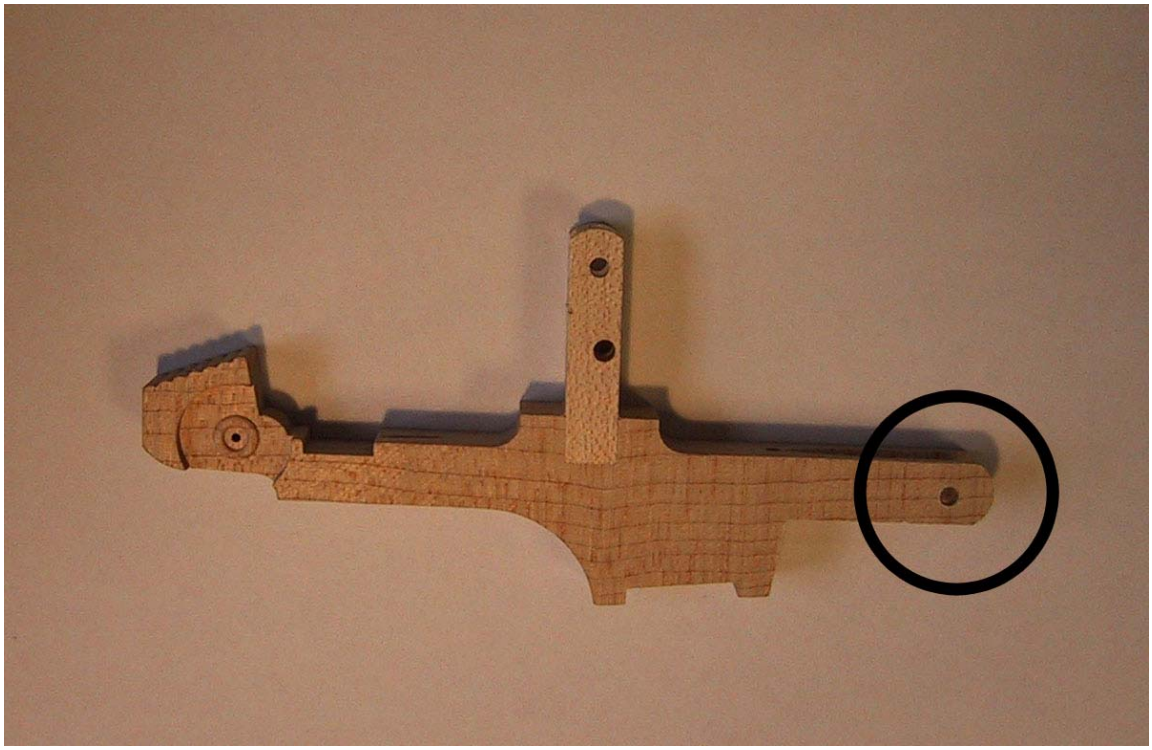
From "On Yamaha's Assembly Line," *New York Times*, 2/22/1981

Exhibit 5: Action Mechanism



2 - Keyframe	29 - Support Cushion	51 - Underlever Frame Cushion
6 - Balance Rail	30 - Fly	52 - Underlever Flange
7 - Balance Rail Stud	31 - Tender	53 - Underlever
8 - Balance Rain Pin	32 - Fly Regulating Screw	53A - Underlever Lead
9 - Balance Rail Bearing	33 - Spoon	54 - Underlever Top Flange
9A - Balance Rail Bearing Strip	34 - Support Top Flange	55 - Damper Wire Screw
10 - Back Rail	35 - Balancier	56 - Tab
11 - Back Rail Cloth	36 - Balancier Regulating Screw	57 - Damper Stop Rail
12 - Key Stop Rail Prop	37 - Repetition Spring	57 - Damper Stop Rail
13 - Key Stop Rail	38 - Repetition Felt Block	58 - Damper wire
14 - Dag	39 - Balancier Covering	59 - Damper Guide Rail
15 - Key	40 - Hammer Rest	60 - Damper Head
19 - Key Button	41 - Regulating Rail	61 - Damper Felts
20 - Balance Pin Bushing	42 - Letoff Screw	62 - String
21 - Capstan Screw	43 - Hammer Rail	62A - String Rest Felt
22 - Backcheck	44 - Hammershank Flange	63 - Agraffe
23 - Backcheck Wire	45 - Drop Screw	64 - Tuning Pins
24 - Underlever Key Cushion	46 - Hammershank	65 - Sostenuto Rod
25 - Action Hanger	47 - Knuckle	66 - Sostenuto Bracket
26 - Support Rail	48 - Hammer	70 - Case Cornice
27 - Support Flange	49 - Underlever Frame	71 - Wrestplank
28 - Support	50 - Underlever Frame Spring	83 - Front Rail
	50A - Underlever Frame Spring Punching	84 - Crossblock Spruce
		85 - Crossblock Block

Exhibit 6: Hole and Slot in Action Part



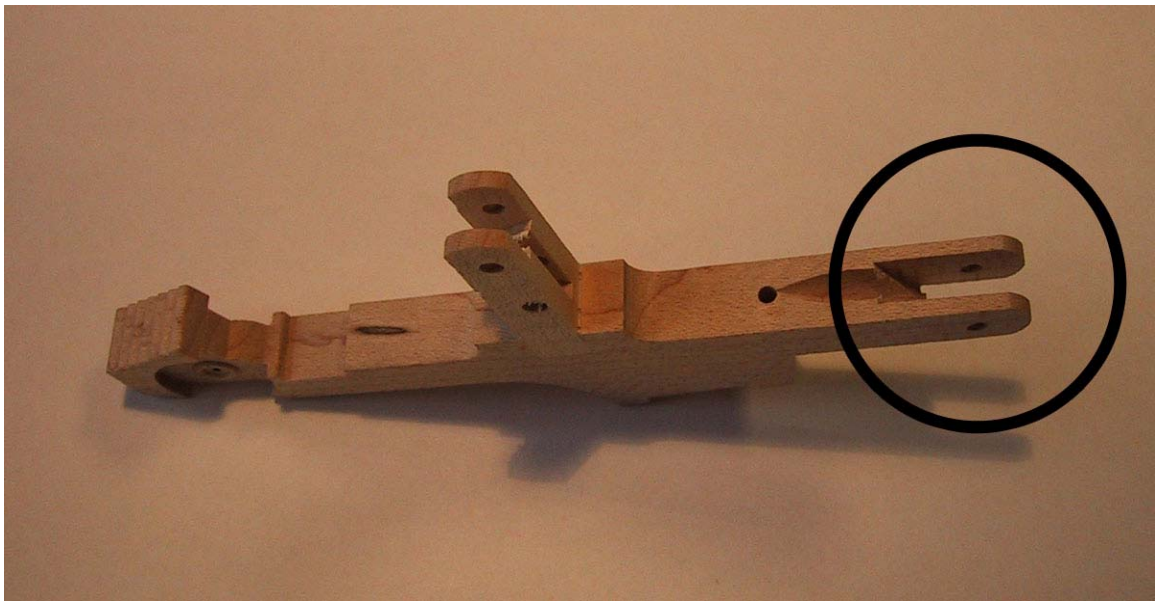


Exhibit 7: Hole Position Data for Two Experiments[16]

Sample 1: Mill slot then drill hole				Sample 2: Drill hole then mill slot			
Item #		Item #		Item #		Item #	
1	0.208	51	0.197	1	0.193	51	0.194
2	0.200	52	0.193	2	0.201	52	0.198
3	0.195	53	0.208	3	0.185	53	0.187
4	0.192	54	0.205	4	0.214	54	0.194
5	0.195	55	0.204	5	0.196	55	0.202
6	0.201	56	0.199	6	0.196	56	0.207
7	0.201	57	0.195	7	0.194	57	0.196
8	0.194	58	0.181	8	0.200	58	0.206
9	0.179	59	0.220	9	0.200	59	0.190
10	0.184	60	0.214	10	0.205	60	0.205
11	0.202	61	0.211	11	0.198	61	0.195
12	0.213	62	0.208	12	0.189	62	0.197
13	0.203	63	0.221	13	0.199	63	0.208
14	0.203	64	0.199	14	0.204	64	0.200
15	0.194	65	0.197	15	0.197	65	0.188
16	0.198	66	0.209	16	0.201	66	0.196
17	0.189	67	0.200	17	0.201	67	0.203
18	0.209	68	0.203	18	0.200	68	0.197
19	0.192	69	0.183	19	0.205	69	0.196
20	0.196	70	0.199	20	0.197	70	0.199
21	0.198	71	0.205	21	0.201	71	0.194
22	0.176	72	0.193	22	0.189	72	0.192
23	0.198	73	0.188	23	0.206	73	0.205
24	0.199	74	0.216	24	0.222	74	0.202
25	0.206	75	0.209	25	0.208	75	0.204
26	0.199	76	0.208	26	0.189	76	0.195
27	0.210	77	0.208	27	0.205	77	0.202
28	0.184	78	0.195	28	0.203	78	0.211
29	0.199	79	0.208	29	0.206	79	0.204
30	0.205	80	0.189	30	0.203	80	0.215
31	0.190	81	0.200	31	0.206	81	0.202
32	0.196	82	0.194	32	0.205	82	0.198
33	0.200	83	0.206	33	0.206	83	0.196
34	0.183	84	0.203	34	0.204	84	0.202
35	0.186	85	0.212	35	0.202	85	0.209
36	0.222	86	0.205	36	0.215	86	0.200
37	0.192	87	0.196	37	0.192	87	0.215
38	0.192	88	0.209	38	0.198	88	0.192
39	0.184	89	0.205	39	0.206	89	0.197
40	0.205	90	0.206	40	0.183	90	0.199
41	0.207	91	0.222	41	0.204	91	0.203
42	0.192	92	0.191	42	0.203	92	0.200
43	0.206	93	0.182	43	0.195	93	0.196
44	0.195	94	0.204	44	0.200	94	0.195
45	0.203	95	0.191	45	0.194	95	0.200
46	0.192	96	0.194	46	0.204	96	0.187
47	0.207	97	0.231	47	0.188	97	0.210
48	0.195	98	0.203	48	0.199	98	0.206
49	0.207	99	0.202	49	0.205	99	0.202
50	0.206	100	0.197	50	0.194	100	0.195

[1] *Steinway & Sons*, Richard K. Lieberman, Yale University Press: New Haven and London, 1995.
[2] *Ibid.*
[3] *Ibid.*, p. 190.
[4] Steinway Musical Instruments, Inc. News Release, January 4, 1999.
[5] Office of the Mayor, News Release 267-99, July 16, 1999.
[6] Steinway Musical Instruments, Inc. News Release, January 28, 1999.
[7] Steinway Musical Instruments, Inc. News Release, October 21, 1999.
[8] Steinway.com, March 2001.
[9] Steinway.com and *Steinway & Sons*, p. 29.
[10] Barron, J., "How Does a Piano Get to Carnegie Hall?" *New York Times*, May 11, 2003.
[11] Barron, J., "Seeking the Perfect Piano Piece, in Spruce," *New York Times*, June 10, 2003.
[12] Baldwinpiano.com, March 2001.
[13] *Steinway & Sons*, p. 299.
[14] Steinway Musical Instruments, Inc. News Release, January 23, 2001.
[15] Part description, specification, and data are disguised.
[16] Data are disguised.