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Fine Custom Furniture Produced With $17,000 CNC Router

Culin-Collela, Inc., Mamaroneck, New York, is a woodworking shop specializing in producing built-in and free-standing custom furniture and casework and paneling which typically is used in offices and homes worth $1,000,000 and up. The company handles jobs ranging from a complete millwork package including molding, cabinets, windows, doors and wainscoting paneling for the renovation of a $5,000,000 house down to a single chair sold for $1,200.

Culin-Collela usually works to a plan provided by an architect or contract, but also offers design services to clients who approach them directly. Most of the company's output requires contoured router work, and compound curves often must be produced. In the past, these were created by generating the design on a CAD system, laying out the geometry on a piece of fiberboard and cutting the template by hand with a router. Router work was also frequently required to generate templates and trammels needed to accurately produce the various contours required. Using conventional manual woodworking methods, the time required to generate contours was often so lengthy that the item could not be economically produced. Even less challenging pieces were quite time-consuming because of the need to produce router templates and trammels or beam compasses by hand for many contours. President Ray Culin had seen a number of computer controlled woodworking machines at prices in the neigborhood of $60,000 but felt they would be impossible to justify at the company's current workload.

Then, he heard about the Techno Series III. He purchased the router with MasterCAM® CNC programming system which, although originally designed for metalworking, is ideally suited for woodworking because of its ability to generate the most complex contours with little programming effort. The program features true 3-D geometry construction plus IGES, DXF and CADL converters so that geometry can be uploaded from nearly any CAD system. The Techno system, which has now been in use at the company for about three years, has made it possible to bid on and win jobs which would have been far too time-consuming to produce by hand. And, among projects which the company was previously able to produce, average production time has been cut in half and accuracy substantially increased.

An example of a part which could not have been produced previously by the company is a coffee table consisting of a circular wood frame with a hammered copper surface. The circular frame consists of a contour with a height of 2 inches at the outside diameter and 1/2 inch on the inside diameter. The top surface of the frame is sloped creating a shape that resembles a funnel.

Previously, without an economical production method, Culin-Collela would have had to charge about $6,000 for the table, which would have been prohibitive. With the Techno router, it was produced easily by drawing the frame in AutoCAD®, importing the drawing into MasterCAM®, and using the program's swept surface technique to generate a toolpath. Programming, including the original drawing, took only 1/2 hour and routing took another hour, allowing the company to make the table for only $3,000. Another piece which would have

been difficult or impossible to produce by hand is a cherry wood cabinet produced as part of a major house renovation. The cabinet features a profiled cove extending across its width onto round column base blocks on either side. The complete project consisted of 22 cabinets, each of which had two base blocks with coves on both top and bottom. The cove cut is a quarter circle recess with a 1-1/2 inch radius. The cabinet base and column base would normally be mitered together, but the existence of the concave molding shape means that a 3-inch deep compound-curve miter cut is required to produce a flush intersection. The intersection would have taken a tremendous amount of time just to calculate by hand, and producing the required 176 cuts to the level of accuracy required for a flush fit would have been a nightmare. On the computer, the intersection was calculated without major difficulty.

Looking at the flat section of the cove in elevation view, the CAD/CAM system operator divided it into 20 equal segments with a series of parallel lines. These segments were then copied up the curve at regular intervals, with the segments creating concentric circles, with the diameters growing smaller just like the lines marking latitude and longitude on a globe. Equally spaced lined segments were then generated on the flat section of the cove and copied up its height. The two drawings were then manipulated within AutoCAD® so that the straight lines intersected with the concentric circles. This manipulation determined the intersection of the flat section of the cabinet and the round corner blocks which turned out to be a two-dimensional complex contour. Once the geometry was determined, it was imported into MasterCAM® and the toolpath was generated by invoking the program's contouring function. Three passes at a depth of 1 inch each were used to contour each piece. To locate the blocks on the machine table, a 3/8 inch hole was drilled in the center of each and a simple plywood positioning fixture was devised which held three of the blocks at a time. This made it possible to completely produce all three in a single setup. The total project, consisting of producing 44 base blocks with 2 mitered surfaces each and an additional 88 mitered surfaces on the flat sections of the cabinets, was produced in about one week. It would have taken at least three weeks to produce by hand, and allowance would have had to have been made for a considerable amount of scrap material. These examples are typical of the gains achieved on nearly everything produced by the company with production time reduced by an average of 50% and quality significantly improved.

Woodworkers Can Expand Business By Using Computerized Router

Designer Woodworking, a custom woodworking business near Ft. Riley, Kansas, now takes on jobs it wouldn't have wanted in the past. Tricky one-of-a-kind restoration projects and intricate architectural milling work, that used to take too much time to be profitable, have become a source of growth and profit. By completing difficult jobs like these in hours rather than days, the company makes a profit on them yet keeps its fees in the range the customers can afford.

Designer Woodworking is one of the latest woodworking businesses to benefit from automation, although not in the large-scale mass production sense of the term. The company still does mostly one-of-a-kind jobs; but by doing them on a Techno computer-controlled router, its level of efficiency matches that of mass production operations. This efficiency has opened a wealth of new business opportunities as a result. In business for 10 years, Designer Woodworking specializes in restoration, of both antiques and modern furniture that have been damaged during moving or by excessive use. In addition to restoration work, which makes up about 75% of its business,

Designer Woodworking also does woodwork for local architectural projects. Examples include stair rails, custom redwood screen doors to match decks, unique moldings, and so on. For both types of projects, the company formerly lost some jobs and didn't bid on others in situations where too much time was involved to make their work cost-effective.

Typically, the problem was curved pieces. Prior to acquiring the computerized router, things like curved moldings in restorations and stair rails with sweeping curves were very time-consuming. Designer Woodworking personnel worked from templates and, in some cases, just getting the template right took many tries. Following the templates, they cut the pieces by hand, but since hand cutting was imprecise it was usually followed by a great deal of sanding.

In January, 1995, Designer Woodworking purchased a computer-controlled three-axis gantry router from Techno, New Hyde Park, New York. The router cuts according to instructions from a CNC programming package called MasterCAM. Once a program is generated, producing a part, even one with curves or ellipses, is the simple matter of loading a piece of wood and pushing a few buttons to start the machine.

A recent project involving a custom walnut door offers a good comparison of the computerized router versus Designer Woodworking's previous hand practices. The door was a narrow solid door designed to be placed between a shower and a hot tub room. The designer wanted the door to contain an ellipse-shaped inset starting at about two feet from the floor and going up to about six inches from the top of the door. The door itself was 1.5 inches thick; the inset panel was 3/4 inch thick.

Without a computerized method of cutting out the ellipse shape, Designer Woodworking would have attached a pattern to the door to guide the cutter. With the cutter's ball bearing riding against the pattern, the operator would have cut out the shape. The greatest difficulty was making the pattern perfectly. Typically, a number of tries would have been needed to get it right. In all, just making the pattern would have taken at least one day.

With the Techno router, creating the shape of the ellipse in the computer, then instructing the system to program the instructions for cutting, took between 15 and 20 minutes. Another 15 minutes were needed to set up the door on the table, so that within an hour Designer Woodworking was accurately cutting the ellipse. Because the Techno router eliminated at least seven hours on this project, Designer Woodworking's price of $800 was acceptable to the customer. Working by hand, the company would have charged between $1200 and $1300 and probably wouldn't have gotten the job.

The efficiency made possible by the Techno router has allowed Designer Woodworking to take on all kinds of jobs that previously weren't profitable. For example, the company is often asked to repair Schrunk wall units that local soldiers bring back from Germany. These units have crown moldings that often get broken in transport. The sweeping curves in the

moldings made this a difficult job in the past, but they are now easy to reproduce. Similarly, Designer Woodworking sees a lot of broken rockers on rocking chairs. These, too, had been difficult items to make profitably by hand due to their long curves. But it takes only a few minutes to program rockers on the computer. The actual cutting takes only minutes, as well, so that Designer Woodworking can handle a few dozen rocking chair repairs each week.

Although the efficiency made possible by the router has been key to winning new business, Designer Woodworking also finds that the greater accuracy they can now deliver also helps win work. In the past, the company didn't bid on projects like a 30-slot mail insert for a roll-top desk because dividing the area into 30 slots of identical size would have been nearly impossible by hand.

Using MasterCAM for this project, the operator simply created a line of the desired width, 1.5 inches, duplicated it 30 times, and then used the resulting geometry as the basis for the toolpath. This took about 15 minutes. Grooves for the dividers in both the top and bottom halves of the insert met perfectly and each slot was exactly 1.5 inch wide. Cutting took between 30 to 45 minutes compared to three hours by hand, but results would not have been nearly as accurate. The entire job took about eight hours, which included finishing and installation in the desk. This was about half the time this project would have required if done manually.

The Techno machine has a positioning accuracy of ±0.1mm (±0.004 inches) over 300 mm, and a repeatability of ±0.01 mm. Since this is far greater than hand cutting, manual finishing operations are minimal. This also cuts down on the time Designer Woodworking must allot for its projects.
The accuracy of the router is the result of several features inherent to the table, such as the use of ball screws and servomotors. For example, anti-backlash ball screws in Techno routers permit play-free motion that makes it possible to produce circles accurate to the 0.0005 inch machine resolution. These ballscrews also make it possible to produce wooden parts as accurate as the machine resolution. The ballscrews have excellent power transmission due to the rolling ball contact between the nut and screws. This type of contact also ensures low friction, low wear and long life.

Designer Woodworking opted to have its router equipped with servomotors rather than stepper motors because servomotors give smoother cuts on long curves. Normally, when a router hesitates, it either cuts too deeply or burns the wood. When working on a long curve like the ellipse in the walnut door, it is important for Designer Woodworking to have a continuous motion to prevent burning and inaccurate depth cuts. A servomotor is better than a stepper motor in providing continuous motion because it works on the principle of constant feedback. The program tells the router to follow a specific path by giving it a series of voltages. It drives to the locations by getting constant feedback along the way. In contrast, a stepper motor takes a large number of little steps.

Stepper motors have significantly less power than servomotors to change direction and follow curves. Stepper motors are less expensive than servomotors and are fine for straight line motions and simple circular arcs. But, in general, servos are up to three times faster and more reliable when performing arbitrary curves like splines or 3D carvings.

Designer Woodworking enhanced the functionality of its Techno machine even further by adding a Carter flip-pod vacuum piece-part holding system to the table. Designer Woodworking's table has 87 pods, into which any pattern can be utilized to align and hold pieces for cutting. The pod pattern is cut (on the Techno machine itself) out of UHMW plastic, assuring accurate alignment of the x, y and z axes. The pods serve dual purposes: they act as vacuum pods to hold work and they can also be used as fixed stops for locating edges of parts. If the pod is not needed for either function, it can be flipped so that its top sits flush with the table and is out of the way, allowing the operator to rout around edges or through boards while the piece is held on the table.

The accuracy provided by the machine/vacuum table combination came in handy when cutting the ellipse out of the walnut door. The door was so long that it exceeded the length of the machine but Designer Woodworking was able to cut half, flip the door over, and cut the other half. Both sides matched perfectly. Another advantage of the Carter system is that it makes possible to set up very quickly. It isn't necessary to make jigs or spoil boards to hold parts. This helps Designer Woodworking price jobs like rocker repairs competitively.

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Techno Gantry System Proves Indispensable for Antique Reproduction Manufacturer

Mount Royal Reproductions (Bristol, RI) is a furniture manufacturer which specializes in antique reproductions. These are not cheap reproductions, but very detailed wood pieces which can often cost about $500.00. One particular item which Mount Royal produces is a Windsor chair, which requires extensive, and elaborate milling and carving. The work required for these chairs can be a long, tedious, and costly process. However, when John Pasqual, owner of Mount Royal Reproductions, discovered Techno's CNC machine, he found a means of making the process easier, faster, and cheaper. Five years later Pasqual reports, "Without this machine, I wouldn't be where I am now."

The Techno machine has helped Pasqual revolutionize the way he shapes and saddles the chair seats, a process known as scooping. Originally, Pasqual says he would do the seats by hand with a draw knife. Each seat would take about two and a half hours to produce -- and remember that is only the seat, the rest of the chair would need to be produced and assembled in addition to that time. At one point, Mount Royal had an order for 40 such chairs. Says Pasqual, "I was killing myself doing it by hand." To improve the scooping process, Pasqual tried suspending the knives by chains. This did speed up the process somewhat, but cutting became very rough, and clearly antique reproductions are products requiring accuracy at all costs.

Enter the Techno Gantry system. Pasqual purchased a Techno table and MAC Controller. Using this, in conjunction with MasterCAM Software, Mount Royal Reproductions was able to drastically revise the way they scooped chair seats. What once took two and a half hours, Pasqual reports, can now be done in 17 minutes.

The fact that each chair seat, can now be manufactured in less than 1/8 the time it previously took, with no sacrifice of

detail or accuracy, has had tremendous production benefits for Mount Royal. Pasqual says he can now run the machine for 4 hours and produce enough chair seats to keep him busy for two to three weeks. Consequently, he finds that there are periods when he can go for days without running the machine at all; hence time can be spent assembling the chairs and creating other items.

The savings in the time provided by the Techno system translates directly into savings in dollars. This is immediately seen in the way the machinery cuts down man-hours. Mount Royal Reproductions is a small company, with a handful of workers, and Pasqual feels it is to their advantage to remain that way. The Techno machine allows them to do just that. Some companies need as many as four people to do scooping. With the Techno machine, the milling is done via a PC and the MAC Controller. Hence, one person can do the work of those four people. By eliminating the need for the extra workers, the Techno System allows Mount Royal to remain a small company and reap the financial benefits of remaining a small company. Without the machine, says Pasqual, labor costs would cause the prices he charges to be "blown out of the water." Instead, he can produce quality products at competitive prices.

In addition, Mount Royal has found that they can use the Techno System for applications beyond that which they originally intended. For example, at times the company is involved in doing case work. Cabinet doors often require reeded columns which would normally be carved by using a shaper. Once again the Techno machine makes the job easier without sacrificing attention to detail. The Techno system can also be used for cutting the ears for the backs of chairs. Finally, Mount Royal has recently discovered that the machinery is useful for making foot moldings. These require accuracy of 1/16th of an inch, a need the Techno machine, with an accuracy of 1/100th of an inch, has no problem fulfilling.

In the business of antique reproduction, detail and accuracy are all important. The Techno Series III System has allowed Mount Royal Reproductions to continue to produce the high quality furniture they once produced by hand. However, they can now do it more quickly, more easily, and more cheaply. The Techno machine has become an indispensable tool in their manufacturing process, and has allowed them to survive in today's competitive marketplace.

Inlay Artist Creates "An Enduring Tradition"

Using a Techno CNC router has greatly increased the number, size and complexity of inlay commissions that artist Eugene Jacobs is able to undertake.

When Eugene *Yehuda* Jacobs was only 10 years old and living in his native Romania, he carved a *menorah* (candelabrum) for his grandfather as a Hanukkah gift. The boy had already shown an interest in drawing and caligraphy, but this was his first attempt at woodworking.

It was also the beginning of a lifelong tradition of creating Jewish ceremonial objects such as Hanukkah lamps, prayer book coves and special bread trays, using wood inlay techniques to inset prayers and bible quotations. Three years ago, Jacobs, who is now 78, was honored with a special exhibit of his work, "An Enduring Tradition: Wood Inlay in Jewish Ceremonial Art", at Yeshiva University Museum, New York.

Jacobs and his family escaped from Romania after World War II and arrived in Canada in 1949. He was graduated from the University of Toronto and later came to the United States with his wife and children. After teaching in a number of Hebrew schools, he became the principal of the Torah Academy for Girls in Far Rockaway, NY. Throughout his career, Jacobs "stayed after school", teaching his students how to make ceremonial pieces that fulfill the biblical teaching to "beautify" the commandments.

After retiring from teaching several years ago, Jacobs finally was able to realize his dream of devoting himself to creating Judaica. He set up shop in the basement of his Brooklyn home where he not only designs and crafts ceremonial pieces, but also designs the individual Hebrew letters that embellish each one.

Jacobs works with exotic woods such as purpleheart, Gabon ebony, mahogany, lacewood, cocobollo and zebra wood. His inlay materials are silver, gold and semiprecious materials: ivory, malachite, mother-of-pearl, lapis lazuli and abalone shell – which take an enormous amount of time to cut by hand. Inlay artists can be limited by their tools or materials, and some artists require another person to physically create what they have designed. No matter who creates an inlay, it is grueling and repetitive work.

Four years ago, Jacobs purchased a Techno three-axis gantry CNC router which has enabled him to produce about six times more work than he could manually. Machine performance is more consistent than that of hand tools, and makes it easier to estimate the amount of time a job will take to produce.

Because of the router, Jacobs said he has overcome the usual difficulties of inlay work and is able to craft a wider range of religious artwork, particularly large pieces for the Jewish community. Major commissions include: arks for synagogues in England, Austria and Israel; a Sephardic Torah case of vermilion wood inlaid with silver; a 9-foot by 8-foot by 12-foot *huppah* wedding canopy in the permanent collection of Yeshiva University Museum.

The *huppah*, with its 5,000 inlaid pieces, would have taken four years to complete using normal hand tools, Jacobs estimated. He completed it in eight months using the CNC router. The router not only saved time, but the inlay fit was also much tighter because the router has a tolerance of ±0.1 mm. In addition, very few clients could afford the cost to commission a four-year project.

After Jacobs sketches his inlay designs, they are copied into a personal computer using MasterCAM, CAD and machining software. Sketching and programming for the

canopy required two months. Cutting and assembling were completed over a six-month period. Solid wood or veneer is precisely incised by the router, and the same program is used to cut the inlays and the negatives. Jacobs uses an hydraulic drill capable of speeds up to 400,000 rpm to cut hard stones and precious gems. After the inlays are glued, the entire piece is laquered.

A 2-foot-high octagonal Torah case (tik) in vermilion wood was commissioned for a Sephardic synagogue in New York. Sephardic Jews, who are of Spanish ancestry, read the Torah in its case while it is in vertical position. The silver crown represents the bible, and was not made by Jacobs.

Jacobs completes as much work as he can in his basement, and seeks outside help to assemble his large works. The canopy, weighing 1,200 pounds, was assembled by Al Chabot Woodworking of Brooklyn and taken to the museum by professional movers.

Across the front of the *huppah* is a 9-foot panel of African rosewood inlaid with 1,200 pieces of mother-of-pearl, abalone and silver. Suspended at the rear, a 7 1/2-foot walnut panel is inlaid with the prayers and blessings customarily said by the rabbi during the wedding ceremony. More than 1,600 pieces of gold, silver, mother-of-pearl, abalone and ivory form the Hebrew letters in this panel, itself a three-month project.

The ebony base has stainwood and purpleheart parquet centered with a circle of Carrara marble surrounded by silver and gold, where the wedding couple stands. A separate table for wine cups used during the ceremony has satinwood legs and an ebony top inlaid with a grape vine design.

Four satinwoods pillars with ebony bases support the aluminum alloy frame of the canopy. Its silk ceiling is centered on the underside with a needlepoint inset of doves, flowers and leaves, created by Malvina, Jacobs' wife of 54 years.

A porcelain sculpture of doves by Boehm tops the work. According to Jacobs, doves are images of lifetime fidelity. Olive branches within the work represent the universal symbols of peace as well as the emblem of the State of Israel.

Creating Templates With Techno Gantry, Saved Equipment Ltd. 50% of Production Costs

If you make wood moldings, then you are all too familiar with the profile grinding machine used to cut carbide and steel knives into the correct shape for carving a particular molding. However, before you can cut a knife, you must first make a template to place on the grinding machine. This early step to creating moldings can be time-consuming and troublesome. Most people cut such templates manually, filing them out of metal by hand. This process in itself, is a not major problem, but can be difficult to master.

Often it takes years to train someone to file templates correctly. Yet despite training, anytime something is done by hand, it is subjected to human error. If the person making the template files it inaccurately, the resulting knife will be inaccurate, and the final molding will be unsatisfactory. This may mean repeating the process, and hence additional costs. Another potential problem is the need to periodically replace templates. If a metal template is dropped, or just wears out, a new one must be filed. Once again, due to human error, this new template may not be exactly the same as the original. This will result in moldings which are not identical to those made with the original template, and if these moldings are for the same project, the customer may be unhappy. Finally, the use of hand-made metal templates leads to the problem of storing the templates for future use. Some organized filing system must be devised, and then space must be made for filing perhaps hundreds of templates. Some companies have drawers filled with such stored templates.

Clearly there are many potential difficulties with the templates, too many for what should be a simple, preliminary step in the process of making moldings.

However, Equipment Ltd. has come up with a solution. The company specializes in profile grinding machines so they well know the necessities and implications, along with the potential problems, of creating knife templates for a grinding machine. With these in mind Equipment Ltd. has developed a computer automated template maker with which you can create and store templates more accurately and easily than ever before.

With this new machine, you create the pattern for the template on a PC using a CAD program. This can be done in a variety of ways. An image can be scanned directly from a current molding or knife directly into the CAD program. Or, a molding sample can be projected on to a digitizing tablet. Tracing the image on the tablet produces XY coordinates which can be imported into a CAD program. The software converts this pattern into signals which are sent to a 3-axis gantry system (Techno, New Hyde Park NY) which has a router attached to the Z axis. All the user has to do is mount a piece of acrylic plastic onto the gantry table, and press a button. The template is automatically cut from the plastic in the pattern that was drawn on the screen. The result: a plastic template, more accurate than any done by hand, which can then be used directly on the grinding machine.

Equipment Ltd.'s system has numerous advantages over the manual production of templates. Not the least of these is the speed of the system. Libby Estes of Equipment Ltd. says the time to make templates can be cut by 50% using the new machine. In addition, when replacing templates, the time savings is even greater. Rather than starting over from scratch, as you do when filing manually, you can merely recall the saved pattern for the template, and run the program to re-cut the piece. At a touch of a button, a new, template, identical to the original is made. The time savings created with the Techno machine translates directly into cost savings.

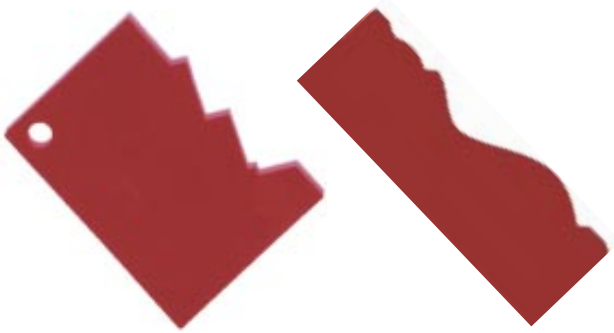
Another major advantage is the improvement in accuracy versus manual filing. With the inherent

accuracy of the Techno system, templates are cut to within .004" of the drawing every time. Hence one does not need to worry about human error. The template will be produced exactly as planned. Plus, if you need to replace a template, you can do so with a nearly identical version. Additionally, the router on the Z-axis uses a 1 mm diameter bit, so the .019" radius allows for extremely accurate corners, even when the corner is a 90° angle.

Another major difference in using Equipment Ltd.'s system is the use of acrylic plastic templates instead of metal. Such plastic templates cost about $.50 apiece to produce. You might think a plastic template would be less durable than a metal template. Yet actually, these 1/8" templates are quite durable, and if they do wear out, replacement is extremely quick and easy as mentioned above. In addition, with the plastic templates, storing and filing problems are solved: you no longer need to save plastic templates at all. Since you can save the patterns for the templates on the computer, you can throw a template away as soon as you are finished using it. When you need to use it again, merely call up the pattern (up to 24 can be viewed on-screen at one time), and re-cut. With the Equipment Ltd. machine, it is more efficient and cost-effective to throw away used plastic templates and create new ones, than it is to expend the time and space needed to store metal templates.

The price for the whole system, with all options is only $19,000, and the basic machinery and software can be purchased for as low as $13,000. In addition, the ease of the system means training time is very short: Equipment Ltd., says Estes, can train someone to use the system in three days. Contrast this to the years of training and practice which may be required for someone to learn how to correctly file templates manually.

Clearly the Equipment Ltd. system has tremendous advantages over the manual production of wood molding knife templates. Production time of the templates is cut in half, the templates can be reproduced with .004" accuracy, and storage is completely eliminated since patterns can be saved on the computer. The savings from the speed, accuracy, and storage capabilities of the Equipment Ltd. system means manual production of these templates is destined to become obsolete.



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Computerized Router Turns Yoga Instructor's Labor Of Love Into Profitable Exercise Machine

A well-known Yoga instructor helped express his artistic talent at a commercial level by turning a new exercise machine concept into a profitable business with the help of a Techno CNC router. The new concept involves wooden, multipurpose exercise machines that are designed to simulate the movements used in ballet, swimming, gymnastics and yoga. When Juliu Horvath began designing these machines about 10 years ago, he built them with a jig saw and templates. Each machine took so long to build by this approach that it seemed impossible to build a profitable business from his concept. Several years ago, however, he switched to a Techno computerized router that has allowed him to cut the time required to build the machines by 80% and turn what was previously merely a labor of love into a growing business.

Horvath began his career as a ballet dancer in Romania and defected to the United States in the late 1960's. Not long after his arrival, he gave up dance to pursue the study of Yoga. He developed a Yoga system based on the underlying principle of translating breathing patterns to movement patterns. Teachers and students from all over the world continue to flock to his studio in New York City to learn his original Yoga system. Horvath's system includes a unique series of floor exercises designed to enhance flexibility while increasing strength. Finding that many students had difficulty learning these exercises, he began building wooden machines to make it easier to perform them. "I saw that existing exercise machines were too rough and too linear," Horvath says. "Length and breadth were missing. They made it hard to build coordination and flexibility."

Horvath's machines incorporate the kind of sweeping organic curves one expects to find in Art Nouveau furniture. The platforms are curved in the Santa Cruz style of wavy red and blond woodwork and patterned after the swirling shapes of bonsai trees. They are created to command a "melodic movement" that increases the individual's effective range of motion. These sweeping, circular movements involve the whole body at once, building strength without adding bulk. Horvath's machines emphasize the articulation of the joints and strengthening of the surrounding ligaments in such a way that it makes the connection between the bones much stronger. According to Horvath, "My machines are designed for athletes, dancers and health conscious people, not body builders." While the concept was developed in the mid-1980s, it took until 1994 to develop the design to absolute fullness including determining the exact proportions to fit any body type.

Wood and aluminum parts of this exercise machine were fabricated using a Techno CNC router

Horvath set up the first machines in his Yoga studio in New York City called White Cloud Studio. The machines, which he calls the Gyrotonics Expansion System, developed an almost cult-like following from the very start among the New York dance community and since then the system has won followers worldwide at affiliated studios in Los Angeles, London, Paris, Seattle, Munich, Mexico City and Florence. New openings are scheduled in Puerto Rico and Tokyo. The machines are also used by a number of dance academies and studios. While the system was originally conceived for dancers, it has proven equally successful with children, the elderly, and those recovering from injuries and illness.

The Gyrotonics Expansion System is a patented design that uses hand and foot-operated wheel bases and pulley suspensions to precisely hone the body through some 130 variations on 50 different sets of exercises. The body moves in three dimensions and experiences multifunctional joint action on the order of a universal joint. The machines are easily adjustable to any length or breadth of movement. Workouts typically last between one and two hours and consist of slow turns synchronized with rhythmically-released deep breaths. Weights used are much lower than typical exercise machines – generally on the order of 30 pounds.

Horvath builds each machine himself and this is a key selling feature of the equipment. The base and support elements are made of wood while other components are machined aluminum. In the beginning, Horvath built wooden components with a jig saw using intricate template to guide his hands and heavily sanded each piece after cutting. There were two problems with this approach. It took so long to build each machine that, considering his other time commitments, Horvath was precluded from turning the exercise machines into a serious business. Second, the lack of precision provided by jig saw cutting meant that the components of each machine had to be individually fitted.

Then, about five years ago, Horvath heard about the Techno computer-controlled router that can produce wooden components in far less time than a jig saw. The 3-axis gantry router from Techno follows a pattern that is programmed with a drawing program. Rather than tediously trace the contours of the template, Horvath can now simply put a piece of wood on the Techno router and flip the switch. It produces parts in about 1/5 the time required on a jig saw. A key advantage is that the router can generate a 3-axis motion. This means that operations such as rounding the edges of a part, which would normally be done in a second operation after jigsawing, can now be accomplished in a single setup.

The accuracy of the computer-controlled router is also far greater, which provides additional time savings. The Techno system has an accuracy of ±0.1 mm (±.004") in 300 mm and a repeatability of ±0.01 mm (.0004"). This precision eliminates the need for most manual finishing operations and for individually fitting components. It makes it possible to build more accurate and better looking parts that are interchangeable with each other.

The Techno router was relatively inexpensive. Horvath estimates that he paid for its cost last year in one single order for five machines. Horvath himself is computer illiterate, but he has a friend who converts his sketches into AutoCAD drawings then uses a CNC programming package called Mastercam to produce a file that the router understands. Once the program is finished, Horvath operates the machine in his workshop. When he wants to produce a part, he simply loads a piece of wood and pushes a few buttons to start the machine. He does nearly all the manufacturing work himself although he does use part-time employees from time to time.

Techno routers have anti-backlash ball screws for play-free motion that make it possible to produce circles that are accurate to the .0005 inch machine resolution. These ballscrews also make it possible to produce wooden parts as accurate as the machine resolution. The ballscrews have excellent power transmission due to the rolling ball contact between the nut and screws. This type of contact also ensures low friction, low wear and long life.

In five years of operation, Horvath has never had any problems with the machine. This is partly due to the strength and rigidity of the table. The Techno machine is constructed from extruded aluminum profiles that can support all the materials that Horvath uses and provides easy clamping capability. The machine also has four ground and hardened steel shafts and eight recirculating bearings in each axis. This shaft and bearing system produces very smooth play-free motion and an extremely rigid system that produces high quality cuts.

All in all, since purchasing the new router, Horvath has been able to turn his exercise machine concept into a profitable business venture. The precision and repeatability of the router makes it possible for him to perform all production work himself and will make it easy to delegate manufacturing to others, if required by future growth, without sacrificing quality.