Consistently Unique

Balancing the Opposing Elements of Quality inside the Bach Plant

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September, 2017

There is no brass instrument design more copied and imitated, in whole or in part, than that of the Bach Stradivarius trumpet. Not since Besson released the 1880 trumpet with its characteristic wrap and valve placement that virtually every trumpet since has utilized, has any maker had such a wide-reaching impact. Bach did not originate most of the elements of that design – the basic form coming, as noted, from the original Besson, but elements of the Bach design such as the favored bell tapers, the leadpipe tapers, that distinctive big square-ish tuning slide, and even the construction of the third valve slide have spread from Bach to countless variants. Be they hand-built artist models, or super-cheap toys spit out by machines for web sale to unsuspecting band parents, the majority of trumpets available in the modern world are either Bach Stradivarius 37 look-alikes, or utilize many of its constituent parts and forms.

Of the other trumpets out there that are not "Bach-like", the majority make up a second family of trumpets that provide a counter to the "Bach style" in several ways. While a Bach-inspired horn centers solidly, due in large part to that characteristic slide and then secondarily to leadpipe taper and mass distribution, these are designed to be more loose – usually identifiable by their single-radius slides. The marketplace has grouped another characteristic into this second family, which is lightweight and minimally braced construction. Both of these key traits seen generally as "non-Bach" are easily transplantable and found on even Bach-made instruments (such as the LT180 series lightweight horns with an optional single-radius slide). Finally, there are usually other low-resistance attributes such as fast leadpipes and reversed construction. These together constitute a separation, however theoretical and perceptual it may be, in the trumpet world.

What is most interesting about this split in the trumpet, is that both classic Bach design and the loose, open design trumpets originate in the same place – the Frank Holton Company. While the first Bach horns (at least beginning with #2, #1 was lost), resemble a Besson more strongly, with fairly light gage metal and a "D" radius tuning slide. By the time Bach had built 100 horns, he had made many with slides more closely resembling the traditional "New Holton Trumpet" he played personally before his own. When Bach drew his first designs, the Holton Revelation, which would in several successive iterations test the boundaries of reducing bracing, loosening centering, and being built light, was still a design concept. Ultimately, the Holton Revelation Don Berry model would be the first to take-on the large-bore (.485"), lightweight, open-blowing, loose-centering, fast-responding maximal traits now associated with the "non-Bach" trumpets.

Bach however, after starting with the tighter wrap and "D" slide, migrated slowly to a much more New-Holton-like design. The first 1100 horns built in New York varied in geometry, weight, and tapers as Bach experimented to find the combinations that worked. This was an era where building a great horn depended on learning from the experience of a master (as Bach was drawing on the Besson and Holton designs) or experimentation (which Bach seemed to be passionate about). There were no papers or books on acoustical design of brass instruments that could provide the level of detail necessary to engineer characteristics into a horn as there are today. Bach's first horns varied widely, and yet he found eager customers for a great many of them – noting that those who detested one horn might love another. In this we find demonstration of the reality that as trumpet players are physically different, and often have different tonal and stylistic musical tastes, the perfect match for a given player will be unique to that player and his use for the instrument.

After the move to the Bronx facility, the New York Bach design coalesced with a more rectilinear slide, though not the pure-Holton flat-front of today, and perhaps a slightly taller wrap, though certainly not as tall as at Elkhart. During this time, Bach began to build more of his "standard" combinations of leadpipe and bell. 6s and 7s initially dominated the mix, but by 1950, the 37, 38, and 43 were beginning to emerge as market favorite bells. At Mt. Vernon, the 25 leadpipe would become the standard. Finally, with the Selmer acquisition, Bach redesigned the wrap to its final dimensions, adding length at the tuning slide to reduce the pull required, and making the two main braces standard. Selmer would then select the 25 (L bore), 37 (ML bore), 38 (M bore), 43 (ML bore), 65 (ML bore) and 72 (ML bore) bell-bore combinations as the stock versions of the renamed Model 180 Stradivarius.

In terms of construction, Bach varied his brass thicknesses, with some of the lightest at .018" early on. By the Mt. Vernon period (serials 11000-22500 or so), the preferred brass weights seem to have been a .023" tube wall in the body, which continues as standard today, and a .020" in the bell, which is the lightweight bell today. Throughout the time that Bach was in charge, and for a short time after, valve casings were always 2-piece. This also added mass in the core of the body, and the lack of which in Elkhart horns may well explain the demand for heavy caps for the modern design.

Mass provides inertia, and whether in sum or localized, the placement of inertia along the sound wave propagation path has effects on the way the horn filters and amplifies frequencies as it transforms the pink noise at the embouchure to the final tone. A key element of inertial manipulation change in Bach trumpets comes with the move to Elkhart in 1963 when Selmer acquired the Buescher plant. Either then, or by the 1971 move to the current former Conn facility, the bell rim wire was changed from brass to steel. This concentrated more inertia at the very edge where the final wave-front shaped, while removing mass from the core with the change to one-piece casings. This makes for a faster response, but with more focused propagation and core. Subsequently, the rim wire was changed back to brass and the 180 sound became softer and broader. The Bach 190 series now offers a unique mix of the 2-piece pre-Elkhart casings and the steel wire of the Elkhart rim for a uniquely increased sum and local inertia together. The 190s can be very powerful horns, while still retaining a strong core and classic Bach sound.

Thus we can see that variability on the scale of tapers and construction elements has been a constant since the first Bach trumpet. But what is not as easily seen unless you play on a great many samples, is that variation on a more subtle scale has also always been a Bach characteristic. Placement of braces, alignment of mass, thickness of metal in the bell, or the body, or the bell vs the body, and application of finish materials can all affect subtly the playing characteristics of the instrument. So too can port alignment, wall dislocation, joint alignment and a host of other factors where any digression from "correct" will only have detrimental effect. What this means is that certain aspects of trumpet fabrication need to be tightly controlled to a consistent optimized form, while others should vary to accommodate the unique needs of the widest spectrum of individual players.

This is when it becomes important to recognize a key way in which musical instrument manufacturing differs from almost any other product. Inconsistency is the opposite of "quality" in most any industrial, manufacturing or even general business sense. This is not true with instruments. Instead, "quality" is a composite domain of many overlapping sub-domains where the ranges of overlap produce superior results of a given type – those types being as widely varied as the customers who will play them and the styles of music in which they intend to do so.

This issue of what constitutes "quality" in brass instruments today is one of the most contentious. This contention is driven on one side by the boutique manufacturers who hand-build instruments in the old-world tradition, tailoring the process to the individual customer. Among their "products", variation is not only maximal relative to the rest of the industry, but is actually core to their business model. These makers produce very few instruments at extremely high prices. At the other end of the spectrum within the "quality" domain can be found one maker in particular - Yamaha. If you pick up a Yamaha model and play it, you can buy another sight-unseen, made ten years apart from the first, and when it arrives it will play exactly the same. Yamaha has built their business model around taking the most popular quality instruments on the market, identifying the traits, and degrees of characteristic, to which the largest number of potential customers will respond positively, and applying those elements to their designs. They build for the average player, with enough model variety, to capture the largest single segment of the quality market at a "good enough" level of satisfaction. In other words, they sell a product that the majority of customers will be happy with for a lifetime, even though it may not be a true "perfect fit".

The Vincent Bach Division of Conn-Selmer is faced by a particularly daunting challenge in that, as the architype of the mainstream modern trumpet, they need to produce significant volumes. To do otherwise would neither satisfy demand, nor be profitable given the scale of the corporation they belong to and the costs of manufacturing at a price-point that can align with the ability to pay of their demand market. If Bach follows Yamaha to the average, they would become neither the trend-setter, nor the source for truly exceptional horns that fit serious professional players perfectly. As such, they would quickly fail. Conversely, if Bach built every horn to order, they could never meet the volume or price point demands of the broader professional trumpet market.

Bach today is in transition, following on the heels of recovery. For decades, they relied on the skill of experienced craftsmen, and a quality ethic that demands each horn not only be made, but play, to high standards. When that ethos was lost for a time in the 1990s, Bach's reputation and then sales suffered dramatically. Only after the three year strike, and the ouster of the same UAW that had made entitlements to do poor work and get paid based on seniority rather than performance the operative drivers in the auto industry as well, that the culture at the Bach plant was transformed back to what it had once been and the product restored in parallel. But, that resurrection of the past ten years has been accomplished by employees who are typically two to three times the age of their customer, and a large number of whom are now beyond retirement age. As they leave, the skills on which Bach quality relies are simply not available in the skillset of the younger workforce. No-one learns to machine on a manual lathe anymore. Outside of Conn-Selmer, Kanstul and Getzen, there are no large-scale brass instrument makers in the United States anymore. The skillset of the present generation revolves around digitally controlled machining and a multitude of other technology-based tools and practices that, by their very digital nature, enforce consistency on manufacturing.

So what is Bach to do? The new employees coming in are not predisposed to achieving high levels of consistency in those aspects of fabrication that require it while using manual tooling any more than they are comprehending of the idea that variation in output is desirable in some, but only some, aspects of fabrication. The answer lies in a combination of careful mentoring of these new employees as apprentices in the specific crafts where variation is essential, while replacing manual tooling and methods in those aspects of fabrication where the product requires consistency.

The traumatic corporate transition from division of a down-sizing private instrumental conglomerate, to division of a publicly traded Steinway, to the failed Samick take-over fiasco, and now to private ownership again by a venture capital firm, has left a great deal of consternation in the trumpet community with regard to the ability of Bach to rise to this challenge. This author's recent visits to the Bach plant in Elkhart, first in the company of noted players, restorers, makers, designers and academics, and then more recently with Bach's Director of Operations Tedd Waggoner and the renowned Bach historian Roy Hempley, have offered insight into Bach's plans and opportunities to move forward in coming years.

If one is fortunate enough to be led through the plant by Tedd Waggoner, the tour begins with an in-depth history of the modern Bach corporation – and he has been there for a lot of it, having joined the company in 1972 with a dream of being a play-tester. (Ironically, Tedd only got to live this dream briefly during the strike – and then it was mostly testing trombones) It then progresses to one of the many collections of small parts racks in the plant to develop an understanding of the level of fabrication still taking place at Bach today. Yes, there are parts that are sourced, such as threaded rod for the 3rd slide stop, but even most small parts, such as the posts for that rod, brace ends, piston ports, rotors and so on are all still fabricated by Bach. As with any division of a larger company, there are some common materials or supplied minor parts like screws that can be obtained from other Conn-Selmer operations, and this plant plays its role in that synergy as well, using the high-end forming and heat treating equipment to produce the bell of the Eastlake-made TR-300 to standards not seen elsewhere in student instruments.

As far as the issue of assuring quality in components goes, and without quality at the component level, quality at the macro-level is impossible, Bach still does many things the “old fashioned way”. Modern extrusion and staged-stamping systems have made possible the high pressure forming of brass tube or sheet stock into components that traditionally required both materials. A sheet today can be forced, through several strikes, into both the escutcheon and the riser tube of the end of a brace for instance. But when one looks to the low-cost instruments made by companies that use such machinery, the failure of braces that crack where the end meets the escutcheon is far too common. The same can be said for valve casings. Even among some higher-priced models from the upstart companies of the 21st century, one may find valve casings that have been formed by subjecting a closely sized tubing stock to a process that mixes stamping with high pressure molding to essentially extrude, but without the drawing associated with extrusion, the form of the casing – and with very light thin walls. Instruments built with these casings are prone to warping issues and also lack the mass at the core of the horn that Is necessary to superior playing characteristics. The process is, however, massively faster and cheaper, so the makers of aggressively priced trumpets tend to favor it. One will not find such modern and product-killing efficiencies in the Bach plant.

This is not to say that technology and automation have been barred from Bach. The present situation at Bach is one that is both surprising and encouraging for the future of the trumpet.

Bach is a division of Conn-Selmer, which is owned by a venture capital entity in which hedge-fund manager John Paulson is the controlling partner. Such firms invest for the purpose of making profit, which is usually achieved through reducing costs and selling assets that individually are worth more than the firm (such as brand names). Clearly, the Bach brand name would have considerable market value, and maximal profit would be realized by selling it, as the Bundy name was sold by Steinway shortly before being taken private, to importers of low-cost-country-made instruments to use as a stencil name on inferior instruments. Paulson, however, has thus far not followed that model and instead, has proclaimed himself in financial publications as the “guardian” of Steinway – which desire he credits to coming from a family of piano players that aspired to own a Steinway, but could not afford one when he was young. Now he will have as many as he wants.

The first place that Paulson’s commitment to investing in the operation of Bach, rather than treating the investment in Steinway’s portfolio of companies purely as an exercise in asset maximization, can be found in the mouthpiece manufacturing at Bach. The Bach mouthpiece sizing has become the most widely used, or at least imitated, in the brass industry. And while Bach may not make the majority, the company still turns out a staggering number of them every year. Vincent Bach’s first commercial venture was making mouthpieces on a small improvised mouthpiece lathe in the back of the New York Selmer store. (George Bundy did many great things for Selmer, both before and after buying it, but perhaps the best investment he ever made in terms of cost relative to return was helping-out a very young Vince Bach. It ultimately resulted in Bach trusting his company to Selmer despite their offer not being at the top of the range) Over the course of the summer of 2017, several brand new and highly advanced automated lathes and CNC mills have arrived for the manufacturing of Bach mouthpieces. These devices include some of the latest technology in alignment assurance and wear management as well as allowing for a level of consistency at tight tolerances that humans are simply not prone to.

While unique characteristics in a trumpet may be desirable, a mouthpiece is something that needs to be consistent. One needs to know that a Bach 3C off the shelf will feel and respond exactly like the Bach 3C one needs to replace. The new equipment will help Bach attain this level of consistency with future mouthpiece production. It was the inability, or so the story goes, of Vincent to find a replacement when his mouthpiece was damaged, that prompted the Maschinenbauschule trained Bach (which was an education in both the engineering and the practical fabrication of all forms of machinery and metal working) to make his own. It is a good story, not unlike the story of CG Conn doing the same after losing a bar fight and needing to invent the padded mouthpiece, but it may be exaggerated as Bach's 1914 Boston Symphony publicity photo shows a stock, and thus replaceable, Holton mouthpiece on his horn.

This is a major investment, and the willingness of the new owners to make it is a strong statement of commitment to ongoing operations that will realize improved returns through better serving the needs of professional musicians. To fully grasp the degree to which this will both increase capacity and consistency, one need only inquire, as this author did, what the prior machinery was. Tedd Waggoner will then show off a couple of fully manual lathes that epitomize the peak of American industrial might and ability, with every part of these great old machines made and marked by hand, by designers who could do math without a computer and knew what a slide-rule did, but which were once cranking out armaments for World War Two. And "cranking" is an apt choice of words, as these machines do not have servo drives to reduce the effort required, or even multi-axis co-ordinate reporting systems – one must read the indexing on those cranks while turning them.

The now idled lathes are not the only veterans of the 1940s in the plant. Bach bells today get their start in a unique hydroforming process that utilizes the only two examples of this forming machine still in existence. Made under military contract for the production of materials for the Navy during the build-up to World War Two, these units can form sheet stock in a manner that adopts elements of both stamping and injection molding processes. Tremendous hydraulic pressure is used inside what look like, and probably are, boiler jackets, to conform sheet stock to a mold. This can be viewed as similar to stamping in that it is a single-stroke forcing of the sheet against a profile, but also like molding in that the material is conformed by a fluid pressure that allows for more easing and movement of the sheet than being slammed between metal dies ever could. The result is that, unlike doing the same with traditional stamping, the metal deforms more uniformly and does not develop severely stretched zones at the points where the contour of the mold abruptly changes.

This was perhaps the first automation of fabrication at Bach. And, coincidentally, at Holton (where the second machine came from in 2007). The net effect of utilizing this process is to repeatably produce a fairly consistent starting point for the bell makers with considerably less time and labor expended. It takes two consecutive processes to achieve the fully formed bell blank, which makes the availability of the second machine now a considerable time-saver. Quite a lot of brass sheet remains to be trimmed away from the blank after forming, the additional material being critical to providing an anchor in balance to the pulling forces of the hydroforming process on the involved portion of the brass.

After trimming, the bell blank goes through several steps, including the heavily touted “hand hammering” on the way to becoming a somewhat tubular form resembling the bloom of a weigela bush. Hand hammering, or hammering in general, is a bit of a unique obsession in the trumpet world. It was the F.E. Olds firm that really created this obsession with the peened finish option on the Military and other models in the 1930s. The basic theory appears to be that variation in thickness would make for more robust formation of the final sound wave (a theory that does not stand up to scrutiny) and that the uneven outer surface would help the sound of the horn disperse (again, a theory that does not hold up when tested scientifically other than with regard to how the player hears himself). One thing hammering did do was work-harden the brass, which then required extra and very carefully controlled annealing of the Olds bells. Overall, it was a labor-intensive and expensive process that produced little more than a special appearance.

Hand hammering today consists of two activities. The first, and most critical, is the initial forming of the conical shape by smoothing the bell blank, which initially looks something like two half-bells hinged together on a flat plane, over mandrels to achieve the aforementioned blossom form. The hammers used for this occur in several unique shapes, and are hand-made just for this purpose out of wood. Both practical and entertaining is the manner in which one of the two primary mandrels used for this purpose, which is perhaps better described as an anvil, is mounted at each of the workstations. It is secured to the top of a log about 15 inches in diameter and maybe 2 feet in height, with the bark still on, that in turn is mounted to a caster plate so that it can be moved around the workstation to achieve the optimal angle on the work-piece. The juxtaposition of this ancient anvil mounted to a heavy chunk of tree trunk, just as would have been done in the 15th century, with the hydro-formed blank perhaps best sums up the initiative today at Bach to mix the best of both old and new technology to produce a superior product, not just an efficient or uniform one.

The other “hand hammering” is perhaps a bit of a marketing stretch. The hammers involved are steel, but they are power hammers, with the hand work part being the manipulation of the bell blank under these hammers as shaped tips strike down with consistently repeated force against shaped anvils. The bell of the TR-300, being a 2-piece bell, makes extensive use of these hammers as the seam must be pounded down until the brass essentially blends and the thickness of the bell is made uniform. This is a truly a hand process, using a power hammer, but relying on the skill of the fabricator to assure a seam that is not only structural, but sonically non-intrusive, has been created. And when it is underway, the floor shakes by the annealing furnace monitoring panels just outside the hammering room.

Bell thicknesses are not absolutely uniform, rather they are reasonably uniform and without sudden change that, due to the impact of density on sound wave propagation, would compromise the production of superior tone. Both thickness and temper must be achieved with that same reasonable uniformity if a bell is to produce an even and full tone. In that regard, the bell seam also comes into play on a Bach Strad.

The seaming process is another of those old-world technologies that has yet to be improved upon. While some firms do utilize “laser fusion welding” in the belief that, as the heat source will be consistent in temperature, and will remain in the same location the same amount of time on every bell, the results should be absolutely consistent. The problem with that theory is that the overlap of the edges of blank as well as the somewhat unique thickness, temper, alloy mix and cut edges all can necessitate minor variation in how heat is applied to achieve fusion of the two sides into one.

Since the dawn of the bronze age, humans have known that color tells all in the art and science of fusing metal together. When looking to the flame of the torch, and these are massive torch heads at Bach, the inner blue cone of a properly adjusted flame varies in temperature considerably from what can best be called “hot” in the middle to “wow that’s really hot” at the tip. Around that, a brazing flame plume also needs to be present. The experienced seamers at Bach will utilize the highest temperature portion of the flame (the tip of the blue cone), moving quickly up the length of the seam – because if they hesitate, they will form a hole and the bell will be scrap. When challenged by the gentleman at the workstation, Tedd Waggoner gamely picked up the torch and demonstrated why he has so competently restructured the way Bach manufactures trumpets since taking the helm during the strike – he doesn’t ask employees to do things he is not willing, and at least somewhat able, to do himself.

Tedd’s demonstration was much slower than that of his employee, but really served to make apparent the key aspects of the task. Not having done this in a while, Tedd initially experimented with different torch distances looking for a temperature in the flame cone best suited to his reaction time – he did not opt for the tip. By holding the torch at an angle leaning back over the seamed work and sloping out onto the unseamed, the plume of the flame is used to create a pre-heat zone ahead of the primary work zone. The metal in this region deforms as the heat rapidly expands it and this preps the seam, which is minimally held together by a very few notches in one edge that then lock in the opposing edge, for the additional expansion that will accompany heating to the melting point under the cone of the torch flame. That heat-to-melt zone glows a cherry red, becoming a blazing orange and finally forming a bright, almost white, yellow at the back. The brightest spot is kept quite small, and must move continuously as the brass at that color is molten. For a practiced seamer, this is a smooth motion up the bell. For Tedd, there was a bit of back and forth as he watched his colors carefully, always making sure that the seam fused, but being very cautious not to hover too long - which sometimes required backing up to achieve the necessary full fusion.

As the material can have variances, the most uniform and high-quality seams can only be achieved by the eyes and hands of a skilled craftsman. A computer with a laser, at least until such time as additional strides are made in both the processing capacity and affordability of machine vision systems, simply cannot produce consistent results from inconsistent inputs like a human can.

That being said, the bell after fusing has a big ridge running down it that must be, as with the seam of the TR-300, conformed in thickness to the rest of the bell. This is currently done in a way that, while sensible, still makes any brass player not aware of the process cringe: A hard steel plate is inserted into the bell and it is then crushed to a pre-set thickness that assures the seam is reduced to the same dimension as the surrounding brass. The stem is addressed by a precision rolling device, but the flare must be hand manipulated under the power hammers. There is a newer machine sitting in the plant that may replace both these processes at some future date, but it has yet to be brought online. What comes out of this step distressingly resembles a bell run over by a car.

It is worth following the bell process further, as the bell, being the part of the horn that determines the final filtration and the amplification characteristics of the trumpet, is really the heart and soul of the instrument. To go on, the bell must be re-rounded, and to do that, it must be annealed.

Annealing is the true alchemy of brass instrument making, far more than the actual metallurgy. How the brass reacts to various forming processes is determined almost entirely by the annealing of the brass prior to the process. That reaction then has long term impact on critical issues such as thickness, tension, and (hopefully not) micro-fracture, as well as the final annealing being critical to the resonance and frequency reflectance/absorption profile of the bell. Annealing strategy is the most closely guarded secret of any brass instrument maker, and there is little one can learn about Bach's processes other than that they do indeed anneal more than once, using it as a key component of fabrication methodology, that they anneal at different temperatures for different times depending on the workability desired at the subsequent steps, and that they cool at different rates engineered to produce specific structural characteristics. Brass, depending on the alloy, will first increase in pliability around 300 to 500 degrees. Annealing that erases all prior hardening characteristics requires temperatures in excess of 900 degrees. Again, depending on alloy, temperatures between 1100 and 1300 degrees mark the point at which brass will become so soft that forms will collapse under their own weight. Bach operates its kilns across this entire range depending on the material being treated and the process goals – goals which include making metal parts for certain woodwinds that will then be shipped to the other plant for assembly.

Instruments that are stamped-out, assembled and then heat-treated just once can never develop the depth of playing characteristics that instruments formed through the slow and laborious traditional metal working and conditioning processes used at facilities like the Bach plant will attain.

Once restored to a non-run-over condition, the bell makes its way through additional steps to the part of the process most often associated with bell fabrication – the spinning room. Several processes take place there which play key roles in producing the final personality of the trumpet. This is where the bell is pressed, by a few quick strokes of a forming tool, against the mandrels that one thinks of when considering what model Bach to play: the 37, the 43, the 72 – this is the step where the bell is conformed to that shape. The next process on the lathe is to trim excess bell flare material and then lift the edge to where it can trap a wire ring. The ring, either steel for 190s or brass for the 180s, is inserted and the edge is then rolled back enclosing that ring and giving the bell rim its final dimension.

After the bell taper and rim bead have been formed, the bell moves to a rotating table in the middle of the spinning lathes where a huge torch evenly heats the flare and solder is flooded in to solidify wire and sheet as a single solid mass, which is required for it to behave as a resonant system. The bell then returns to a lathe where the pool of solder trapped by the bead is cut away with a tool and then the last remnants hand sanded to polished brass. After some finish work, the bell is close to its final form and ready for bending.

Traditionally, tubing was bent by filling sized tube stock with lead to preserve the tubular form against the stresses of bending around a form. When lead became undesirable in the 1970s, forms of resin or pitch became the next choice of brass makers. Bach has invested in a unique approach that involves filling the bell with a water-based solution and freezing it to cryogenic temperatures. Once bent, instead of having to use large amounts of heat to remove this fill, simply hanging the bells over a collection vat allows ambient temperatures to melt it away. It is a slower, but more energy and material-cost efficient method. One drawback is that this fill is not as dense as the other technologies, and ovaling of crooks has been an issue. Bach institutes a rigorous quality check at the end of the bending process and then re-rounds any crook tubing that has become deformed.

There is one other step in bell fabrication that also plays a key role in developing a unique personality to each Bach instrument: buffing. The buffing room resembles some sort of 19th century industrial caricature with belts and wheels and strange shapes spinning all through the space as people hold instruments up to these mildly abrasive surfaces, working them to a mirror shine. One might expect a cloud of dust, but between modern abrasives, light force, and the fact that brass dust is relatively heavy, there is nothing in the air. The dust from this work covers the floor and machines, but is actually surprisingly light, as so little brass is typically removed. This is the final buffing and burnishing, where the human eye is again key to detecting and resolving any slight surface defect that might adversely impact the appearance of the finished instrument. It will take great advances in robotic controls to ever replace this, among the most valued skills in the craft, with automation.

The same does not hold true for the initial buffing, the polish work that has to be done to smooth out all of the normal rough edges on a newly fabricated horn. Tedd Wagoner took the author and Roy Hempley to see a brand new robot, still being programmed and tested, that offers to free up these ever scarcer skilled craftsmen from the rough polishing work, so that there will be enough of them to meet the demand for final finish where their skill and keen observation abilities are irreplaceable. This system, standing in a back room inside of a proper safety cage to protect it's human counterparts from unexpected motion (a robot like this can crush a human just by turning), not only has the ability to clamp onto all manner of components and instrument bodies and then articulate them to every conceivable position relative to the buffing media, but it has many channels of outputs from positional, pressure and other sensors that make this robot "aware" of the amount of friction being imparted to the piece. The application of this 5Hz sensory data to the control logic of the robot then allows it to react to changing media conditions, changing compound density or make-up, minor dimensional variance in the work piece, and the influence of the weather (humidity) on friction. The robot essentially can "feel". This robot is another of the Paulson contributions to moving Bach forward to long term revenue growth rather than just optimizing returns in the near term.

With polishing, we are now talking about complete instruments in addition to the bell, so some discussion of the other parts and processes would be in order.

Another key element in determining the characteristics of any brass instrument is the leadpipe. This is the critical region where the complex pink noise produced by the embouchure, and then sectioned by the venturi of the mouthpiece throat, continues the rapid expansion of the wavefront that began in the backbore. As a sound wave, a pressure pulsation in fluid air, progresses along a raceway, it is first influenced by frictional drag at the raceway wall. As that wall moves outward it is also influenced by the need to spread its energy across an ever larger mass. The profile, which one may think of as mechanical timing for the expansion process, regulates how energy is directed in that wave front expansion. This in turn has effects on what frequencies are favored and what are absorbed, as well as on how much energy in total the player has to put into the horn to achieve a given pitch or change. Together with the radius of the tuning slide, the leadpipe taper has a critical controlling function on intonation and centering (or "slotting").

There are new methods out there for the creation of a tapered pipe. These include what amounts to stamping, where a tapered die is rammed into a piece in a tapered mold, variable diameter extrusion, which involves forcing through a die that can expand, but leaves a seam in the work, and even a method pioneered at Olds in the 1970s that involved setting off an explosive charge in a tube in a mold to make their bells which can be replicated with hydraulic pressure for the forming of a leadpipe. Hydraulic molding is an optimal technology for making multi-inflexion leadpipes such as the famed Holton 48 or those advocated by Schilke in his research writings, as it does not create stretching at the inflexions, but most pipe tapers, including the Bach tapers, are more linear. The best way to make most leadpipes is to draw tubing stock over a mandrel just as was done hundreds of years ago. The Bach factory has a number of hydraulic drawing machines that do the actual pulling rather than a block and tackle with human power, but the process is essentially the same that makes all of the unique diameters of tubing required to construct the Bach product portfolio.

The valves blocks and pistons are also fabricated at Elkhart starting from raw materials. Throughout the horn, tubing must be drawn and bent and considerable effort goes into making these parts, which are then binned up adjacent to the assembly area. As the parts come together to form first slides and valve clusters, and then are united into a single core, both hard and soft soldering must be used. Hard soldering, or "silver soldering", yields superior durability for attaching escutcheons to braces, valve ports and any part that is expected to encounter significant lateral loading on the joint. Soft soldering, using a lead-free solder today, then is used to join all the components and sub-assemblies. Several years back, the author used a TSA scanner at Detroit/Wayne County Metropolitan Airport to examine the joints of a Bach Strad. The solder was remarkably even and complete in every joint, resulting in even density and minimized propensity to set-up spurious sympathetic vibrations that could adversely color the tone of the horn.

Many of these processes, as with machining of metals in general, contribute grime and lubricants to the surfaces of the work piece, both internal and external. The Bach plant makes use of a considerable number of larger (near to a cubic yard) ultrasonic immersion cleaning tanks. At various stages throughout fabrication, groups of parts or instruments pass though these tanks to prevent any interference by the contaminants in subsequent processes.

If one observes the assembly of the core of the trumpet, it becomes readily apparent just how valuable the experience of the long-time employees at Bach is to the current production efficiency and quality. At a workstation, co-incidentally close by that at which Ted Waggoner's son was working, Bach being the kind of company a person can feel good enough about to actually encourage folks they care about to aspire to working at, a third valve slide assembly (slide, ring, dump slide, etc.) was being mounted. If the slide is not perpendicular to the valve casing, it will not only look, but feel, wrong. For the player to be able to actuate that slide without any conscious effort, it needs to work smoothly, and in that plane parallel to the leadpipe that the player is conditioned to. Otherwise, it will result in an awareness on the part of the player that amounts to a distraction, and thereby impede performance. To straighten the assembly, the employee wacked it against a folded cloth on the bench top. This, of course, seems alarming to anyone who is conditioned to the norms of a repair shop, but it is important to remember that the casings are not yet honed, so this, so long as it is done precisely and lightly, poses no hazard to valve fit. Years of practice allow for this quick and effective method to be performed, that in the hands of an amateur, would easily result in excess, or mis-focused forces being brought to bear, or even deforming of the round tubes making up the assembly, but the experienced worked can thwack a slide just hard enough on the cushioned bench to instantly bring that into alignment with her square.

The neatly assembled and perfectly polished horns then get tested for quality. This is done not by any objective metrology, but rather by talented musicians who pick them up and play them. This is the final, but certainly not the only, quality check.

When walking through the plant, especially if one has an industrial background, one thing that becomes very apparent is the amount of material that is pulled from the line for quality reasons. Throughout the plant, scrap and rework carts can be seen, often loaded-up with shiny brass. On the rework carts, the defects noted by one the many quality gates in the fabrication process are clearly marked in grease pencil – which is a good thing considering how subtle most of these appear to be. Defects that in the 1990s would have been allowed to pass through under the "they'll never notice that" logic of the time, are rigorously stopped today. Even after rework reduces this, for every pound of brass leaving the plant as a horn, there are probably two or three pounds of tailings and scrap headed to recycling.

Many of these defects, such as those that are cosmetic, or which would only be noticed if the structure of the horn were unduly stressed, are of a nature that any lower cost manufacturer would simply pass through. The author has noted that lower cost manufacturers, who are thusly so due in large part to minimal labor cost, resist scrap at great extremes. The author, while examining a brand new $600 MSRP trumpet noticed that the first valve slide inner leg had been damaged early in assembly. The Asian maker of this horn could easily have just swapped in another slide leg tube but instead expended the labor to work the dent out and buff until the slide moved smoothly. While it worked, the result was a tube buffed thin, weakened further by the work-hardened region of the dent, and which still had a surface deviation in the tube that would attract debris – especially given the maintenance such a student horn would likely receive. Such practices are the exact opposite of the present-day philosophy demonstrated at Bach, which can be summed up as it is better to lose a horn than a customer.

Having passed all QC, shiny new Bach Strads then move on to get their final finish. If lacquer, this happens in a clean room near the front office, where the air flow is managed to such a degree that not only are not foreign particles that might spoil the finish brought in, but the air is kept flowing past such that no overspray aerosol can condense and fall as a contaminant into the catalyzed epoxy clear coat. This air flow system also has the benefit that breathing protections, which are expensive, uncomfortable, and require burdensome training and records, are not required to apply the lacquer. Horns destined for plating follow the mouthpieces across the street to Anderson Silver Plating.

The mouthpieces bring us back to where this view into the plant started, and to the ongoing nature of this transformation of the Bach plant to meet the economic and musical challenges of the new century. One of the earlier automation devices brought into the plant was a buffing robot for mouthpieces. Unlike the new body buffing system, this robot lacks any tactile awareness, or awareness of any kind other than position in space. Without constant human attention, the media can wear, the compound can be heavy or light, and the force applied from one piece to another can vary widely. Updating or replacement of this robot with one that "feels" will eventually be necessary in order to assure that Bach mouthpieces are consistent as finished, while not consuming excessive time from an ever more scarce resource – employees with in depth knowledge of quality brass making.

Ultimately, producing a Bach Stradivarius trumpet requires both art and science, both unique variation and consistent tolerances, and most of all, the judgement to know which elements fall into which category. The greatest challenge facing Bach moving forward is its uniqueness – the same attribute that is its greatest strength. Finding employees who understand not only how to operate machines, but why things are done the way they are done, will continue to get more difficult as the technologies core to brass instrument making become ever further removed from the corn-resin injection-molded world of tomorrow. Tedd Waggoner has 45 years in, and many around him are in the same situation. There are no nearby lower tier manufacturers for new workers to get their start at, and the knowledge of the craft itself is becoming ever more rarified as mass production replaces true craftsmanship globally. Finding a balance that allows for documenting and systematizing as much of the old-world craft skill and knowledge as possible, together with consistency-enforcing automation and a few specifically chosen points for artistic variation in the process, for which employees are mentored and apprenticed into the skill, is the challenge that Bach must continue to rise to as the prior generation eventually decides to spend their golden years elsewhere. Hopefully the commitment of Paulson to this transformation will continue to bring it to fruition.