Wessel, Nickel & Gross

High Performance Action Parts

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There are a number of advantages that carbon fiber parts have over wood parts.

Wood	**Composites**
Varies in mass and strength	Built to microscopic tolerances
Deteriorates in strength with age	Parts do not deteriorate
Shrinks & swells with temperature shifts	Impervious to weather
Drill bits can wander in the grain	Stronger than wood: 31,000 psi
Wooden shanks swipe the string	Precise hammer contact: no swiping
Breakable (esp. cedar & mahogany)	Parts are adjustable
	Non-hydroscopic
	Uniform

Carbon fiber is strong, consistent and can be glued. The outside diameter is 4.5, progressively getting lighter to 8. The tubes are made in a continuous extrusion. All the parts are injection-molded, with the exception of the shanks that are nylon-carbon. Other materials could not be glued, but this can be glued. CA **glue** works best because it etches into the material. The time starts ticking when the hammer is spun; it will last for about 20 to 25 seconds before setting. When the hammer is spun the glue forms a collar on the shank. This material is rated at 32,000 psi, while wood is 2500 psi.

For the **damper lever** rail, different models require different lengths of spoons, so WNG offers three different lengths of spoons. For adjusting, there is a 1.5mm Allen wrench that will adjust both the capstans and the wire set screws on the damper rail.

Burning **shanks** is very easy. A CA gel is the best glue for hammer hanging and for repairing any broken parts. In a cup this glue will last for about 15 hammers. Hammer removal is actually easy.

Bushings are now hard bushings instead of felt. In the beginning WNG tested twelve different materials. Felt is soft and drags on the pin. Teflon is very soft. When Steinway started using Teflon, they didn't realize this, although in the day it looked good and was an innovative break-through. Knuckles are made from Escaine, a polyurethane derivative. Escaine doesn't ever leak lubrication. Since there is no grain on Escaine, it can be created in any direction. The previous wooden-core knuckles had a groove cut into the material, which weakened the shank and caused flexing. To counter this, at the beginning they drilled all the way through the butt. If the glue does not fill the entire hole the shank can click.

The **back-checks** are not very big. The checking system is incredible. WNG makes a special back-check installation tool.

Center pins are a stainless steel needle bearing that enables increments down to 10,000ths tolerance. There are five pin sizes in the 1000 range, in two lengths: 10mm (jack & repetition lever) and 11.8mm (flange). These pins are accurate, stiff and smooth. The bushings are not replaceable. Lubricant is not necessary. The side-to-side movement of the flange is solid.

<u>Installation of Shanks and Flanges</u>

- Composites
    - Higher strength
    - Hydroscopic
    - Equal strength in all axes
    - Can be pre-configured to match specific specs
- Responsive
    - Superior ton/more power/increased sustain
    - Lower rotating mass makes for a quicker action
    - Netter power transfer from the key to the strings
    - Does not whip like wood, which bends under the load and loses energy
- Low maintenance
    - No need to tighten flange screws
    - No need for lubrication on jack and balancier
    - No need to strength twisted shanks due to weather
    - Synthetic buckskin more durable than natural buckskin
    - Composite materials more durable than wood
    - Stainless steel springs more stable than traditional bronze springs
- Dd
- Dd
- Improved Structurally
    - Hard bushing
    - The forks are shorter to improve stiffness
    - Carbon tube through entire shank butt for stability
    - Material added to forks for rigidity
    - No knuckle slot
    - Precision knuckle location
        - adjustable from 15mm to 19mm in 5mm increments
        - one drop of glue in the center of the knuckle location
        - visual scale for easy knuckle location
        - special buckskin
    - The Carbon Tube
        - Shank tapering: three wall thicknesses
            - bass (1)
            - tenor (.8)
            - treble (.6)
        - Can be glued
    - Hard bushings provide negligible change in touch
        - Won’t change with humidity changes
        - Dimensionally stable: side-to-side doesn’t move
        - Resistant to breakage
        - Consistent piano touch

<u>Bushings</u>

Give Steinway credit. At the time they didn't see wood as the problem. When they brought out **Teflon** bushings in 1963 they were progressive. However, they were mounted in wood.

- Teflon lacked density
- Teflon was soft
- Teflon wore down

WNG hard bushings

- Do not deform or "give"
- Stable
- Extremely accurate

<u>Tools</u>

To install shanks & flanges you need tools

- Shop Tools
  - Bead blasting unit
- Hand tools
  - Phillips screwdriver
  - Slotted screwdriver
  - Right angle die grinder with quick-change disc holder for 2" discs
- Drill Bits
  - 4.8 mm slow spiral tub bit, available from WNG
- Supplies
  - Sand paper for rails (100 grit)
  - Sand paper to sand hammer rail (150 grit)
  - Travel paper – several sizes
  - WNG gel CA Hammer
  - ½" or ¾" masking tape
  - Quick change sanding disks (60 grit)
  - Dust mask, safety glasses and eye protection
- Jigs
  - Action center measuring jig
  - 72.88 strike gauge
- Tools you want but likely do not have
  - Compressed air die grinder ($25 from Harbor Freight)
  - Bead blaster
  - Treble strike gauge
  - Action measure jig for recording centers before making changes

Hammer Shank Video

(This video is available on the web site:
http://www.wessellnickelandgross.com)

A shank travels at five times the weight of the key. When a wooden hammer shank bends under the load, the energy is lost by dissipating into the wood in the form of heat. Lower treble mass provides enhanced sustain, while more massive shanks in the bass provide more power. All WNG shank tubes have the same outer diameter of 4.7mm, but the interior wall thicknesses are different. The WNG bit is smaller than that for wooden shanks.

The knuckle position is measured from the center of the Knuckles come in 8mm, 9mm and 10mm diameters. WNG has pre-set shanks with the knuckles properly positioned. Always compare the old parts with the new parts. Compare the original wooden part with the WNG kit part to determine which size and location to order. Custom sets of shanks and flanges can be ordered. Select the correct shank, knuckle and flange; allow an extra two to three weeks for delivery.

Determine the location of the action centers. Use the downloadable action breakdown work sheet and the measuring jig to record heights and measurements. Use a flat regulating bench, placing the gauge as closely as possible to the action. Use a quality decimal or metric ruler and measure notes 1 and 88. Measure the heights of the center pins of the hammer flange, the whippen flange, and the spread.

Number the old shanks before removal. Place the screws in a container. Bead blast or clean the action screws. Sand dirt and age off the rails and replace the sandpaper. Seal the wood with urethane or a sealer that does not become sticky with age. When replacing shanks and flanges, replace the whippens as well. Consider plating the action brackets. A refinished action will look and play like new.

Shanks are color-coded for easy location. Red is for bass, white is for tenor, blue is for treble. Install the shanks sequentially. A set contains 90 shanks. Gently push each flange toward the action rail for consistent installation of the shanks. Tighten lightly at first to allow room for spacing and squaring of the flanges.

Even a slight misalignment will cause problems later. Travel the shanks by placing paper shims on either side of the flange to tilt the flange and shank slightly. Use a square to travel every fifth shank. Travel the remaining shanks as a group. Check the travelling by placing a dowel under each section. Lift the group of shanks up and down and look for deviations. Use travel paper to correct.

If you purchase pre-drilled hammers, specify the diameter. Hammers are usually tapered and arced. Mark with a center line hammers 1, 72 and 88. Use CA glue.

If the alignment of the hammers is good, use the old hammers as guides. Glue the new hammer on the end sections. A better method is to set up some hammers as trial hammers and to set up the others between them. Mark the strike point on the string with two pieces of masking tape. The trial hammers on 1, 72 and 88 are set to maximize the strike point on the string. Determine the rake angle for these trial hammers; usually the rake is 90 degrees. Place the action in the piano, lift the shank with a hook and see if the hammer correctly strikes the string.

Now that the locations are established, mark the hammer positions on the shanks and glue the hammers onto the shanks. If the glued hammers are wrong, remove the hammer and start over. Verify the rake angle with a right angle tool. Use the WNG strike gauge on notes 72 and 88. The glue will set quickly but needs 24 hours to fully dry. If under time pressure, an accelerator can be sprayed on.

Trim the shanks. Do not use dog toe nail clippers for this will crush the tubes. Start by cutting off the excess shank material with a die grinder. The edge of the disc will also cut the tube. Vacuum the dust from the tubes. Round the hammer tails with a sanding-block using 100-grit, at a 45-degree angle making a 1mm radius. A heat gun or alcohol lamp can be used to "burn" the shanks. Do not use an open flame. Heat the tube from one end to the other until the tube becomes pliable. Avoid heating the flange. The tube will cool and firm up abruptly when the heat is removed. Don't try to use heat to alter the boring or rake angles.

When deciding on a hammer weight, check the number of lead weights in the keys. How heavy does the original action feel to play? If there is not much weight in the key, do a trial with the sample kit. Install several hammers and parts, regulate them, and do trial tests in the piano to determine which sizes are best.

Back Checks

- A good regulation requires good checking. What is good checking?
    - The hammers should catch on the softest blow from note 1 to 88.
    - The hammers should
    - The hammers should
- The back check is a sacrificial wear part. Replacement is normal. In addition to wear, geometry is another reason for replacement. When you change hammers, back check geometry changes.
    - Length of hammer
    - Thickness of molding
    - Squaring arc on the tail
    - Length of tail
- Design Features of WNG Back Check
    - Molding is fashioned from a modern composite
    - Can be made smaller and thinner, which helps with sostenuto clearance
    - Long
    - Synthetic buckskin
    - Dense felt
    - Stronger wire
- The Back Check Installation System
    - Hammer tailing jig
    - Back Check Drilling Line Marking Jig
    - Angle block for drilling and insertion
    - Back check height jig
    - Back check inserter
    - Back check drill

<u>Back Check Video</u>

Back checks wear out in a piano. The alignment of the check makes a big difference in the playing ability of the piano. Change back checks whenever the hammers are changed. The WNG tool kit makes replacement easy. There is a list of tools that make this job necessary, such as bar clamps, ½" dowel, sander, masking tape, WNG glue, short piece of piano wire, orbital sander & paper, 1/8" dowel that is 1 meter long for plugging all the holes.

Place the ½" dowel along the backs of the keys as a fulcrum. Grip the wire with wire cutters and pry the wire out of the key. Using calipers for the diameter measurement of the 1/8" dowel, find a drill bit that is slightly larger than the dowel and the old hole. Use masking tape on the bit as a flag for the correct depth. Drill the holes and vacuum out the dust. Test the dowel in the hole to see if it fits properly. When gluing in the dowel pieces, leave excess dowel sticking out of each hole. Dip the end of the dowel with glue and insert it in the hole, slowly rotating it to create a glue collar and to insure the hole is filled with glue. Once the glue is hard, clip off the dowels with wire cutters about 3/8" above. Cut the dowels flush with the die grinder. Sand with 120-grit to get rid of the scratch marks from the die grinder.

For custom boring, follow the WNG guide sheet. Use the hammer tailing jig. First become familiar with the features and functions of the jig. One slot is for tail arcing. The other is for cutting off the excess tail. This jig works for both WNG shanks and standard wood shanks. First choose a 4mm or 4.7mm pin to set the jig. Load the belt sander with 80-grit. Place the jig in the table miter slot. Position the jig so the face is 1" away and perpendicular to the sandpaper. Clamp the jig loosely into place and position the panel 4mm from the sandpaper. Use the clamping nuts to secure it to the base of the jig. Align the jig mark to the edge of the sandpaper. Hammer tails should be 1" or 25mm long.

Configure the jig to cut the hammer tails. Lift the swivel slider from the base and rotate it facing toward the sanding surface. Slide the hammer up to the paper until it stops cutting.

Configure the jig for hammer arcing: 3/8" or 1cm. Draw a line on the side of the hammer 6mm. Arc a sample. Place the spare hammer on the swivel. Place the swivel slider into the left slot of the base and rotate it until it is parallel to the sanding surface. Adjust the capstan about 1mm to the sanding surface. Turn the hammer on the swivel to sand a sample arc. Readjust the jig. Once correct, the arc is set for cutting all 88 hammers. Remember to use the correct pin size for the hammers.

To improve sustain, an optional step is to cove the bottom of the back of the hammer. A full bottom to top taper is the best. Hammers check better if the tail is 6mm from the tail edge. After arcing, the tails are sharp and can cut the back checks. Clamp the hammers together and sand off the edges in a 1mm radius to smooth them.

Block the keys to the correct rest height. Draw a center line on hammers 1, 72 and 88. Use the trial notes and the jig for determining the strike line. Rotate the line until the hammers are parallel. Move the jig down to rest on the jig slide block. Mark the trial keys. With a straight edge, mark all the key backs. Use a center punch to mark the spot for each drill hole. Clamp the back check drill block into the drill press table.

Set the stop so the bit stops 2mm about the back end of the block. Place sandpaper on the jig to grip the key. Drill all the back check holes.

Use the back-check height jig to set the height. This jig will need to be re-adjusted for each section of the piano. Measure from the center of the shank to the jig. Measure from the center line to the top head of the screw. Adjust the top & bottom screws. This should be about 1" or 25mm. Put the ruler under the flat side of the jig and adjust the screw. Measure the string height with the jig. Especially check the height of the strings at the beginning and end of each section. If there is a significant difference in heights, take the average for calculating the proper back check height.

Determine the distance where the back check must protrude from the key. Measure from the bottom of the screw to the back-check block. Mark on the front of the back check wire. Use the drill press to press the back check into the key; do not turn the drill on. If the wires are too long they will protrude through the bottom of the key, in which case they will need to be trimmed. Reset the jig for each section.

Kits and Tools

- Back-check/String-height jig
    - Mark pulled out the action from a Mason Hamlin grand. He then adjusted the back-check and string-height gauge to match an existing hammer. With the string height set, he measured the bottom of the tail to the bench in order to calculate the amount of back check that should stick out. This establishes the height of the back check. Depending on the string height, this works well on Mason Hamlin and most pianos. However, other pianos can vary, so WNG is designing an additional block that can be added for longer measurements. Once the back check is drilled properly and installed at the correct height, there will be very little adjustment to necessary.
    - The jig comes with a variety of pins. More sizes can be made. For the other jig, using the center line of the hammer enables us to mark on the key exactly where the back check wire should be drilled. There are three brass tools available for inserting into the drill press, for inserting the front pin, and a knurled one for adjusting the balance pin. Pull the old key frame pins out and with a plastic hammer tap the new pins in. These jigs make the job easy and accurate.
    - Normally the 86mm is the most common back check length. If the wires are too long use a pair of compound cutters, or use a grinder.
- Key Dip Block
    - There is a pin that moves up and down. Get the dip correct on one note. Have a 40,000ths after-touch. Set the key block and there should be an even feel from key to key. It's sort of like a Jarris tool.
    - This is the last step of regulation. Push the key down ever so gently so nothing is left over, then pull 40,000ths up and it should be there: there should be nothing afterward. Use LeRoy's Yamaha method.

- Scale Stick Kit
    - Mechanical pencil
    - Mylar strips
    - Stainless steel square
- Back action jig for damper flanges
    - Measure the string height
    - The screw from the belly rail tells how much wood to cut off for the supporting piece
    - There are three cuts -- three levels – that represent the spoon points for deciding which spoon contacts the center: medium, short or long
    - The side line shows whether or not it needs to be trimmed. (Seldom)
- Jig for center height of back action: spoons
    - Instead of assuming that the back action is the correct height, measure.
    - The half-stroke of the damper system in relation to the key is ¾. Half of the damper lifts to the ¾ stroke.
    - The jig measures the back action in relation to the ½ stroke.
    - Turn the tool around to adjust the spoon.
- Marking tool
    - Marks each hole to be drilled
    - Aluminum cutting oil is different from steel cutting oil
    - The line on the tool fits on the ledge and marks exactly where to tap and drill the holes on the rail.
- Helper spring
    - Fits fine on the large rail
    - The small rail requires a spacer to allow for the spring housing.
    - A 7' or 9' piano already has a large cavity for springs in the bass.
- Tool Pouch
    - Various sized pouches are available on line
    - Ergonomically correct tools
        - A big handle on a tiny tool provides leverage
        - Straight slot with a collar
        - Two lengths of repetition lever adjusting tools
        - Let-off tool with a relief cut
        - Back-check wire bender
        - Tool for bending the damper head in the piano
        - English & metric 1/16", 7/16", 18^{th}, ¼" block.
        - 55-48 thousandth straight burnishers
        - Re-pinning kit 15-53.5 thousandths increments
        - Compound pliers for removing hammers from shanks
- Perimeter bolts
    - This is a positive system that will hold up plates
    - A T-handle tool makes for easy adjustment

- Voicing platform
  - Supports the hammers instead of the shanks
  - Designed for one section at a time
- Re-pinning punch

<u>Hands-On Projects</u>

We set up models on the table for hands-on projects: re-pinning & sizing bushings, gluing hammers onto shanks, taking measurements, and adjusting action models.

Gluing Hammers

CA glue as a gel forms a good collar. Accelerants weaken glues; 5-minute epoxy is weaker than slow-hardening epoxy. The freshness of glue also makes a big difference.

When gluing on a hammer, put the hammer on dry and rotate it on the shank to feel how much gap there is. A #10 bit gives a gap between the shank and the hole. Is there enough glue between the pieces to make it stick? We need only a 4,000ths gap to make it stick. An 8,0000th gap is too much.

Pour enough glue into a cup to do about 15 hammers. Re-check the fit. The Spurlock jig is excellent, but sometimes it doesn't clear the top guide. A simple straight-edge is quick, which is good because this glue dries fast. A hammer-hanging jig assures straight lines. Don't push the hammer onto the shank too far and then pull it back. With a stick of wood, put some glue on the hammer hole and on the shank tip. The glue will remain pliable per se, but as soon as two parts are touched, it starts to set. Make a revolution and set it. As soon as you stop moving the glue is set. If the hammer is crooked, take a heat gun and remove the hammer before the glue is fully hard. Plan the twist and setting the hammer down all in one move so it stops right where you want it. When you stop moving, the glue starts sticking within seconds. Wear surgical gloves. Use ventilation. After 24 hours, trim off the stubs. Shake off the carbon dust before vacuuming.

Burning the shanks is fairly quick. The question is how much heat should be applied. Although the shanks are very forgiving, they can get too hot. Carbon fiber is flammable, as is wood. The nice thing about carbon fiber is that you don't see any black marks. Move the heat gun up and down with one hand while putting some pressure on the shank with the other hand. Remove the heat, hold the hammer in position and you can feel it set. Mason Hamlin uses a wet rag to set the heat. Wood can creep back, whereas carbon fiber will stay.

Carbon fiber tubes are a continuous extrusion with the epoxies added as it is extruded. A composite is two or more materials mixed together. Metals are alloys.
As a test, Dean proceeded to heat and twist a shank to the point that the hammer was turned about 45 degrees around – much farther than it should go. However, he heated the shank too long and the shank started to melt and deform. The position of the hammer and the shank must be held for ten seconds or so until the shank cools; otherwise the shank will return to its previous position.

Re-Pinning

Three grams of resistance is good. Sometimes the way to repair a tight pin is not to replace the pin but to relieve it: remove the pin, burnish it and replace the same pin. To modify a conventional re-pinning tool, take a piece of sheet metal, cut it down, clean it up and glue it on with a piece of epoxy. This is thin enough that it will not effect pushing. Mark accidentally pushed a pin into the bushing instead of into the bushing hole. This messed up the end of the bushing, so he carefully spun and pushed a burnisher into the hole. The pins start at 50.5 and go up. It is seldom necessary to go up all the sizes. The bushing material is dense, which is why it lasts so long and remains so firm.

On the end of an alligator clip attach a gram gauge. Because the pins are so hard, we can even use needle-nose pliers to pull out a pin without damaging it. If everything is totally damaged, replace the part. When done, feel the flange and count the swings. With an alligator clip on the tip of the pin you can measure the resistance.

Because the material springs back a bit, it is necessary to overshoot. There may be 1 or 2 grams of fallback. Ideally we want two to four grams. When the flange is loose it won't wobble the way it does in wood. We could be down to 1.5 grams and not have any issues. If there is any side-to-side movement, it should definitely be re-pinned. Two and a half swings produce three grams of resistance. Check each side and there should be 6 to 8 swings per side. The final test is wayward resistance. Two grams of resistance may come back about 1.5 grams. Even these pins vary a tiny bit.

Strike Point

WNG makes a jig for determining the strike point for note 72 and 88. This tool is very accurate. Slide the gauge on top of the strings. Bring the hammer up toward the string and the center of the hammer should come up to the low point on the gauge. Make sure the action is centered and the sharps are pushed into the fall board. If the action is not centered, reposition the cheek block.