Grand Action Rebuilding

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ACTION PREPARATION

Take measurements before removing the action parts

- Note damper lift with keys before removing the action. It is important to know how early or late dampers lift if back rail cloth is replaced. The harder the back-rail cloth, the louder the return.
- Take string height measurements at the piano when removing action.
- Take dip measurements on all C's at the piano.
  - Rough-in regulation on the bench. Do not try to achieve final dip at this time.
- Take touch weight samples.
  - Install new parts on two or three samples and record touch weight specs.
  - Touch weight formula.
    - Take down weight and up weight. Down weight is the least amount to make the key fall. Up weight is the most it will take for the key to rise up to position. When doing this in the piano, make sure to press the pedal; remove the dampers from the factors.
      - The formula for Weight Resistance is DW+UW/2=WR
      - Friction resistance is (Dw-Uw)/2=FR
    - Ranges
      - Weight Resistance + Friction Resistance = Down Weight
      - DW range = 48-56 grams
      - UW range = 20-30 grams
      - FR range = 11-14 grams
    - Example: Steinway action measurements from the workshop
      - Old Touch Weight
        - C4: DW 54, UW 20, Total 74, WR 37, FR 17
        - C5: DW 53, UW 18, Total 71, WR 35.5, FR 17.5
      - New Touch Weight
        - C4: DW 58, UW 30
        - C5: DW 57, UW 27
- Measure & record original hammers
  - *Flange swing*. In the old days the swing was 5-7 swings. Now Steinway likes 10-15 swings because they have Teflon centers. This made a big difference from the old vertigry problem.
  - *Head bore*. Head bore is the distance from center of the shank hole to the tip of the hammer.
  - *Tail bore*. The tail bore is the distance from the center of the shank hole to the end of the tail.
  - *Rake*

        - Usually if hammers are raked, they tilt back away from the flange to compensate for the swing. Some pianos have angled strings because the bridge is higher than the agraffe, so the design of the piano can also require a slight rake.
    - *Fan*. Use the Renner protractor for measuring the hammer angle. This is the angle that the hammer tilts sideways to match the angle of the string.
    - *Hanging distance*
        - The hanging distance is crucial to be precise. It is the distance from the center pin to the centerline of the hammer molding.
    - *String marks*
        - Steve uses a jig for recording the string marks.
            - Stick a length of clear plastic packing tape to an aluminum L bracket. Locate the standards in a position that can be replicated.
            - Mark the position of the jig. Measure from the flange screw to the rail.
        - Were the hammers over-striking, over-centering or over-swinging?
            - The only way to correct over-centering is to raise the stack up by shimming. This raises the center pins.
            - Wally Brooks recommends adding 1/8" over the original in head bore and in tail bore to compensate for future wear.
            - The closer we can get to checking to the string, the better the action. The closest a hammer can check is about an inch, which gives terrible repetition. When a hammer checks too far from the string, the result is catastrophic.
    - *Example:* measurements from Steinway in workshop
        - Old C40: Head bore 1-3/4", Tail bore 1", Rake .5 degrees, Hanging Distance 5-1/8", Fan (bass=10 degrees, tenor=12 degrees, #52= 0 degrees)
        - New (3" hammers): Head bore 1-7/8', Tail bore=1-1/8"
        - New bass hammers (3-1/4"): Head bore=2-1/8", Tail bore=1-1/8"
- The <u>action leverage</u> is critical. It is crucial to have proper leverage. The measurement is the distance from the center pin to the centerline of the knuckle molding. Moving the knuckle position by 1mm will change the touch weight by 10 grams. Also, with greater leverage there will have to be more dip. Modern pianos require a distance of 17-18 mm.

Choosing parts

- *Hammers.* For a New York Steinway use NY Steinway hammers. There are no other hammers with as much felt over the moldings. This extra amount of felt provides a cushioning effect. These hammers are very soft compared with the German hammers. These hammers are easy to file, whereas Renner hammers are difficult to reshape. German hammers can be made to sound good in an hour. However, five years later, they are difficult to keep sounding good and will require more voicing. Steinway hammers are easier to service and keep voiced once the tone has been built. They last longer. The Steinway hammers are also wider than other hammers.
- *Steinway vs. German parts*. Nowadays there is not much difference. On the hammer shanks, the drop screws, instead of being vertical, the angles can be all over the place

with Abel shanks. The wippen screw heads vary in size and some don't quite fit the screwdriver. Steve considers Steinway parts far more consistent.

Removal of old parts

- Remove stack
  - Keep screws in a holder to retain the correct positions.
  - Place keys in key clamps.
- Tape the hammers together in each section and place them in a labeled box.
- Number all the parts.
- Analyze the condition of the key frame felt, and decide what needs to be replaced.

Servicing the Key Frame

- Clean the key frame and examine the punchings & back rail cloth.
  - Only replace punchings if necessary.
  - Store new balance rail punchings on compression rods to compact them.
  - Remove old punchings.
  - Straighten front rail pins.
    - Keep the front of the key bed in line with the edge of the bench.
    - Use a tapered key spacer.
- Tighten slat/rail screws
- Sand all bearing surfaces on bottom of key frame, including shift lever notch.
  - Particularly sand away any dark spots on the bottom of the key frame. These spots are sources of friction and noise.
- Clean and polish key frame glides. Clean the surfaces before lubricating. ("Don't grease the grease.") Rub Brasso on the pins to clean off the oxidation. Use a Scotchbrite pad and rub the glides to remove the marks and ridges.
- Sand or plane end block.
- Clean up the right side of the key frame. Remove dimples & lubricants with a sanding block. The spring always leaves divots at each end of the shift, so removing these grooves will make the contact smooth again. Check the condition of stop leather and replace if necessary. With an arch punch, make a new leather stop. Clean out the old stop hole and glue in the new one.
- Clean, polish, lubricate key pins. Use Ballistol on a cloth & rub by hand. Ballistol cleans, lubricates, doesn't leave a residue, is non-toxic. Then spray ProLube on the pins.
- Replace punching and back-rail cloth if needed. Leaving the existing paper punchings and replacing only the felt punchings saves a lot of time.
- Clean & polish the capstans with Brasso, followed by ProLube.
- Clean the key frame end pins and then lubricate them with Ballistol.
- With the wippens and hammers removed from the stack, clean up the let-off button felts with a wire brush to remove the old lubricants and to level out the grooves. Remove deep divots with a single needle. (Key bushings can also be needled. It makes a big difference and lasts a long time.)
- Clean the metal action rails with Brasso.
  - Remove the flange felt and clean with sandpaper and/or Brasso.

- Replace the flange felt with sandpaper strips. Use a razor blade and a straight edge to cut these strips. Use a scratch-all to poke holes through the sandpaper for the screw holes.
    - Tap holes for the screws at the ends of each sandpaper strip and place a screw in each end hole to keep the sandpaper strips in place.
    - Avoid overlaps of the sandpaper strips.

Install new wippens

- Install the wippens in the order they arrived. They come in order of tightness. Treble wippens use a lighter spring, so keep them separate. Hamburg Steinways use five different gauges of springs. Use a micrometer to check the diameters of the wippen springs in order to determine the changes in spring strength.
    - Align the end of the balancier to the hammer flange screw hole.
    - Line up the jack tender to the let-off button.
- To repair stripped screw holes, cut a small strip of leather, fold it in half, add some glue, poke it in the hole, cut off the excess with a razor blade, and reinstall the screw.
- Space and travel the wippens.
    - Goal
        - Lift the wippen and line up the top center with the hammer flange screw hole.
        - Make the jack tender contact the center of the let-off button.
        - Check that the screws are tight when finished.
    - Technique
        - Begin with the gross left-right adjustment with the screw loose and moving the flange, taking advantage of the oversized flange hole.
        - Paper one side of the flange to complete the adjustment.
        - Sometimes the wippen might need to be tilted as well, and the flange rail might allow for a slight tilt with the screw.
            - For a fine tilt adjustment, paper only one of the four corners on the flange.
            - If the wippen is traveling off to one side, paper opposite (diagonal) corners of the flange.
        - Travel wippens the way you would space hammers, and space wippens the way you would travel hammers, because wippen flanges are vertical and hammer flanges are horizontal.
            - To travel the flange, paper the horizontal portions of the flange curve.
            - To space the flange, paper the vertical portions of the flange.

Installing new shanks

- Preparation
    - Prepare rail with sandpaper if needed.
    - Repair stripped screw holes as shanks are being installed
    - Once all the shanks are on, do an initial rough traveling.
        - Check the best ones with a straight edge to confirm that they are true.
        - Paper the worst shanks so that they all move fairly straight.
        - Use long strips so you can keep track of what you've done. Afterwards these can quickly be torn off.

HAMMERS

Preparing new hammer heads

- Number new heads & select discards.
- Boring the hammers. Steve uses a high-density polyethylene jig clamped with a large C-clamp to the drill press table.
  - Set the head bore guide.
  - Set the fan. Count how many hammers are to be drilled for the section. Measure the change in fan from one end of the section to the other. Divide the fan change by the number of hammers to bore to know how often to readjust the fan. For example, for every other hammer plan on changing the fan angle by one degree.
  - Set the rake.
  - Set the drill bore depth.
  - Adjust the drill bit to the center of the hammer by tapping the jig with a hammer.
    - For Steinway shanks use a 7/32" drill bit.
  - Bore the hammers.
    - Steve always drills with the cove up. He puts his finger in the cove and slides the hammer up to the stop.
    - Keep track of how often the fan needs to be changed.
    - Periodically check the measurements.
    - Make sure the hammer is flush and in position before drilling.
- Tapering
  - Range
    - Tapering can take quite a bit of weight off a hammer.
    - Anywhere from 3/8" to ¼" taper is acceptable.
  - Technique
    - Hand holding hammers against a disk sander is quick but inconsistent.
    - Bill Spurlock's teflon jig on a table saw makes tapering quick and uniform.
      - Set the adjustments
      - Run a test taper on a throw-away hammer
      - Hold the jig with the left hand only in case you slip.
      - Taper all the hammers on one side. Keep the hammers in order.
      - Re-adjust the jig for the missing wood and taper all the other sides.
      - Be careful not to trim too close to one side or to expose the shank hole.
- Tail arcing
  - Bill Spurlock's method
    - After tapering the hammers with Bill's jig, set up the arcing jig on a sander.
    - Secure a shank or a drill bit into the holding slot, fit a hammer on the end, and adjust the stop screw so the hammer top just touches the sanding disc.
    - Trim a sample hammer first before arcing the entire set of hammers.
    - Watch that the set-screw doesn't vibrate loose and change the adjustment.
    - Advantages of this method
      - Quick and consistent
      - Logical sequence

        - Handling everything only once saves time. (Don't have to install, remove and reinstall the hammers.)
    - Other methods
        - Some people cut off the stubs and arc the tails on a sanding disc at the same time.
        - Some people hand the hammers on the stack, then remove all the hammers in order to arc the tails. Fasten the flange to a jig and use a vertical disc sander.

Hanging hammers

- Preparation for hanging
    - On Steinways, first remove the *sostenuto* rod.
    - Select *samples*: the end hammers of each section
    - Steinway *hanging distance* is 5-1/8" from the center pin to the center of the hammer molding.
    - Draw a *line* on the outside of each sample hammer. Use a little square or a straight edge. The line goes form the tip of the striking point to the end of the tail. This is strictly for convenience in measuring hanging distance.
    - The spec for the *hole* in the hammer is that it is loose enough that there is some wobble on the shank. Think of the tip moving in and out and back and forth. There should be about 1/8" of wobble forward and back, but not much sideways.
    - Set up Bill Spurlock's hammer hanging jig.
        - Loosen the wippen flange screws on the two sample hammers.
        - Hook a rubber band from the shank to this screw on each sample.
        - Set the jig so that the lower rail contacts the tails of the two sample hammers.
        - Set the upper rail to contact the fattest part of each hammer.
        - Clamp a board holding the hammers to be hung to the bass of the jig.
        - Pour some glue into a small container and have a small applicator stick handy.
- Setting the samples
    - *Glue* on the samples without reaming. Slightly ream all the other hammers.
        - Squirt a small amount of cold hide glue into the hammer hole and a little on the tip of the shank. Place the hammer on the shank and spin it around a few times.
            - Advantages of cold hide glue
                - Better glue collars
                - Much longer working time
            - Disadvantages of cold hide glue
                - If it goes past the expiration date it will loose its strength and effectiveness, to the point that it may never set up
        - As soon as the hammer is glued, immediately measure the hanging distance and adjust the hammer to the proper position.
            - With a steel ruler, measure from the center of the center pin to the line on the side of the hammer.
        - Take a small square and move the hammer to be perfectly vertical.
            - Bass hammers are canted slightly towards the treble to allow for clearance.

        - Look at the bottom of the tail where it hits the deck. It should be perfectly level. You shouldn't see any daylight.
        - Let the samples set up for a while before continuing to hang the hammers.
    - *Measure*
        - As soon as the hammer is glued, immediately measure the hanging distance and adjust the hammer to the proper position.
            - With a steel ruler, measure from the center of the center pin to the line on the side of the hammer.
        - Take a small square and move the hammer to be perfectly vertical.
            - Bass hammers are canted slightly towards the treble to allow for clearance.
        - Look at the bottom of the tail where it hits the deck. It should be perfectly level. You shouldn't see any daylight.
        - Set the jig to these samples.
            - To hold the sample hammers in place, secure the two sample hammers of the section to the wippen below with rubber bands.
- <u>Hang</u> the hammers
    - Ream
        - Only ream if the fit is too snug.
        - Ream as little as possible.
        - Keep the reamer in line with the original angle.
    - Glue
        - Begin with one at a time to see how it goes for the first hammer or two. To speed things up, hang about four at a time.
        - Apply the glue with a thin stick to both inside the hole and around the shank.
        - Set the hammer on the shank.
            - When pushing the hammer onto the shank, put your finger over the hole to keep the glue inside.
                - Keep a damp rag handy for wiping your fingers.
            - Spin the hammer on the shank, and set it roughly in position.
            - Drop the hammer into the jig.
    - Align
        - Line up the inside of the tail with the stop rail on the jig.
        - Line up the shoulder with the top rail.
        - Eyeball the spacing between the hammers.
            - Get down low and eyeball the tilt. Periodically check with a square. All the hammers should be parallel with each other.
            - Don't try spacing the hammers at the top, because this space is related to the shanks and the positions of the flanges. Adjusting the top spacing might create a tilt. When hanging, be consistent with the tilt. Compare the hammers to each other and the sample; they should all be parallel.
- <u>Trim the tails</u>
    - Cut off the shank stubs (one section at a time)
        - Clamp the feet of the stack to the bench
        - Lay a support board across the hammer rest felts

        - Tighten a shank clamp at the base of the hammers.
        - With a long Shark saw or Japanese saw, cut off all the stubs at once, while supporting the hammers with the other hand.
        - With 60 grit on a disc sander, sand off the remaining stub nubs and any glue.
    - In a sweeping motion with the disc sander, bevel the bottom back sharp edges of the tails so that they are rounded and won't gouge the back checks.
- <u>Fine-travel the hammers</u>
    - Space the hammers by loosening the screws so the hammers clear and look even.
    - For more of a change in the travel, put the travel paper closer to the screw. For less of a change, put the travel paper farther away from the screw.
    - Use the heat gun to adjust bends, twists and crooked hammers.
        - This must be done after traveling.
        - Susan calls this making "laser lines" so that everything is straight
            - If one hammer is tilted, it will appear to be getting closer to the adjacent hammer. Straighten it to be parallel with all the others.
        - All wood has moisture in it. It's like you are steam bending.
        - You can feel the wood relax. Take it a bit beyond the point where you want it, hold it for a few seconds and then release.
    - If after traveling, spacing and heating the hammers still do not clear, remove the hammers that are catching on the adjacent hammers and thin them on a sanding disc. Replace and re-space the thinner hammers.
- <u>Burning in the shanks</u>
    - Some hammers obviously cant toward the bass of the treble. These obviously need to be straightened.
    - Play the note and watch the space between the hammers. If the top of the hammer appears to move to the bass, burn and twist the hammer towards the bass.
        - Steve watches the space change from the shank down to the tip of the tail, and asks, "Does the space between the tail of the hammer being played and the two neighboring hammers change? If so, does the space between the tails diminish on the treble or the bass side? If the Space diminishes on the treble side of the tails, then twist the top of the hammer towards the bass. Conversely, it will look as though the top of the hammer moves towards the bass, so twist it towards the bass.
        - The reference is the tails rather than the tops of the hammers, because when the note is being depressed the hammer is above the others and there is nothing to compare to. The tail remains adjacent to the two neighboring reference hammers.
- <u>Sanding the sides</u>
    - If the hammers still do not clear, particularly in the bass, sometimes it is necessary to remove each binding hammer and to sand off the sides.
        - Be careful to sand them straight. They look better, plus the wider part might still bind.
        - Re-space and possibly re-burn the final adjustment.
    - Another reason to sand the sides of the hammers is to lighten them.

        - For example, if new heavier hammers are hung on old shanks that were designed for lighter hammers, the keys will be harder to push down: the down weight will be too heavy. If it is not possible to move the knuckles out farther away from the flanges or to install new shanks to compensate for the increased weight, then the other option is to decrease the weight of the new hammers by removing material from the sides.
- <u>Filing the hammers</u>
    - Sandpaper paddles
        - Advantages
            - Sometimes essential for extremely worn hammers
            - More precise for individual hammers
        - Disadvantages
            - Slower, more time-consuming
            - Inconsistent
            - More aggressive
    - Gang filing
        - Technique for skinning the hammers
            - Front shoulders
                - On the front shoulders, hold the strip tight and anchor it at the bottom. Start low on the shoulders, then bring it up to and slightly over the top. Six strokes on the shoulder, a couple on the top.
            - On the top and the back, hold the paper at each end and use a buffing stroke. Follow this brushing move down the back. We're just removing a little layer.
            - For angled hammers, pull the strip one hammer at a time in order to maintain the original hammer angle.
        - Buffing
            - Afterward come along with a finer grit
    - Vacuum up the filings
- <u>Spacing the hammers</u>
    - Set up the spacing jig that we made before removing the original hammers
        - Clamp the jig to the bench
        - Measure the distance from the edge of the rail to the center of the flange screw, and adjust the action to the originally measured distance.
    - Space the hammers
        - Hold the hammer up to the tape with one hand and turn the screw with the other hand.
        - Center the hammers on the marks.
    - Mark any hammers that now rub.
        - Now some of the hammers that cleared before might catch on adjacent hammers.
        - Correct these binding hammers with the heat gun.
        - In the early 80's Steinway used to space the hammers on the rail so they looked nice, then traveled them so they hit the strings. This made the

hammers all swinging at an angle. Bill Garlick thought this was backwards and changed their procedure.

- The final hammer spacing ultimately has to be done in the piano.
  - The jig is close but doesn't allow for precision positioning.
  - The bottom line is where the hammers actually hit the strings.

- <u>Voicing the hammers</u>
  - *Lacquer*
    - 3 parts acetone to 1 part lacquer
    - Apply to shoulders & top
    - Focus particularly on the treble section, with most on the high treble
    - Leave the tenor section as is
    - Soak the bass a small amount
      - Apply more on the bottom five hammers

KEYS

Removing & replacing back checks

- Removing a back check and wire
  - Save three or four height samples – one from each section. Remove all but these.
  - Place the key vertically in a vice, with the back check at the top.
  - With a flush wire cutter, grip the wire and pry the cutter against the vice in order to pull the wire straight out of the wood.
- Installing new back checks on wires
  - Steve uses two jigs.
    - The pushing jig looks like a tuning fork.
      - Lock the metal "handle" shank into a drill press chuck so that the jig is in line with the direction of the key.
      - Possibly add a guide block on the side to keep the back check vertical.
      - Add or remove tape (duct tape/masking tape) to make a snug fit for the new back check.
    - The support jig is cut at the angle of the original back check and has a stop.
      - Clamp the to the drill press bed. It will need to be moved periodically

Key bushings

- Remove the old key bushings. Use steam, dry heat, or chemicals, depending on the type of bushing adhesive.
  - *Set* the keys in a key clamp, and rest the entire section across two 3' 2x4's.
  - *Soak* out the bushings
    - Soaking is preferable to steaming if there is a concern about ungluing the key buttons on the balance rail or ungluing the ivories when doing the front rail.
    - Drip a softener onto the bushings
      - Spray 409 with a fine tube
      - Drip with a long-tube applicator containing wallpaper remover and water
    - Use key felt skivings cut into wedges
      - Dip them into a bowl of water with something in it to reduce the surface tension (wallpaper remover, TSP, alcohol, vinegar, ammonia)
      - Wear latex gloves when handling these wet and sticky items
      - Insert each soaked felt wedge into the bushing hole
    - Pull out the felts and insert sizing cauls
  - *Steam* out the bushings
    - Pre-soak the felts with wallpaper remover and water or with 409
    - Steam out the felts
      - Wet a rag and lay it over the bushings. Place a hot iron on the rag until the felts loosen.
      - Use a traveling clothes steamer. Add salt to activate the heating element, add water, and press the steam hole over the bushings.
      - Use a soldering iron with a brass fitting designed to fit into the bushing holes. Steam each bushing individually, and pull out those felts right away before moving to the next.

        - Quickly pull out the felts with tweezers while they are still warm and moist
        - Insert mortice-sizing caws as soon as the damp bushing felts have been removed
        - Scrape off any remaining felt residue from front rail shoulders with an Exacto knife, a tiny chisel or a sharp flat screwdriver
- <u>Leave them</u>. Let the keys rest and dry out at least overnight before re-bushing. Never install new bushing felts right after removing the old ones or your keys will stick.
- <u>Installing new key bushings</u>
    - *Tools*
        - Bushing cloth
            - Medium is generally good for all pianos.
            - Thick usually binds.
            - Thin is usually too loose.
        - Sharp knife or chisel
            - Sharpening
                - Fine sharpening tools
                    - Diamond stone
                    - Arkansas stone
                    - Leather strop with a polishing powder
            - Sharpening chisels
                - On the bevel side there is also a micro bevel. That's where the real cutting
                - Pull the bevel on the strop.
                - Keep the flat side flat on the strop and pull.
        - Use two-caul method for balance-rail bushings
        - Use Bushmaster method for front-rail bushings
        - Use key bushing iron to size bushings uniformly
    - *Technique*
        - Balance rail key bushings
            - Spread a thin layer of glue on the cloth using the glue bottle nozzle.
                - If the glue is too thick,
                    - It will ooze out.
                    - It could penetrate the cloth and make it hard and stiff and noisy.
            - Lay the cloth, glue-side down, over the bushing hole so that the end of the cloth reaches across the hole and ends just at the other side of the hole. This should result in a bushing about 3/8" deep.
            - Hole the cloth tightly with one hand and insert the caul into the hole with the other.
            - With the bevel side down, press a sharp chisel into the felt against the caul to cut the bushing cloth flush with the top of the key.
        - Front rail key bushings
            - Lay the keys upside down.
            - Start with the sharps, so that the cauls won't be in your way when you bush the white keys.

        - Cut a length of cloth strip about a hand's width longer than the keys.
        - Poke the Bushmaster into each hole to poke the felt down.
        - For the first hole, hold the cloth on both sides of the key when pushing the Bushmaster in.
        - Make two cuts – one in the front and one in the back of the felt.
        - Stick the caul into the hole.
        - For the rest of the cuts, hold the felt on the side without cauls and continue cutting and sticking in cauls.
        - When all the cauls are in, tap each caul into the hole with a small hammer.
        - With a Japanese gardening knife, cut each felt straight down along the cauls into the wood of the key.
        - With tweezers, remove all the cut pieces.
        - Once all the accidentals are bushed, glue and lay a second cloth strip and bush the white key holes.
        - Leave the cauls in overnight if possible.
    - Size the bushings
- <u>Easing the bushings</u>
    - Key bushing *iron*
        - Iron tip sizes
            - The tips for the key bushing iron come with instructions as to which tip to use for which size of caul
            - #5 for 162 on the Steinway balance rail
            - #4 for 146 on the Steinway front rail
        - Ironing
            - Heat the iron
            - For each bushing, insert and remove the iron quickly
            - This process is quick, consistent and not tiring
    - Key bushing *pliers*
        - Advantages
            - Key bushing pliers are good for random quick repairs
        - Disadvantages
            - Using key bushing pliers for an entire set is tiring
            - The results are inconsistent and can vary by the strength of the squeeze
    - Spray *ProLube* onto all the key bushings

Key repairs

- <u>Capstans</u>
    - To remove burrs from capstans, use a buffer with white EEE, or rouge
    - Polish the capstans with Brasso
        - Rub the capstans with Brasso on a cloth
        - Let the Brasso thoroughly dry, for about five minutes
        - Wipe off the residue with a dry cloth
    - Spray ProLube onto all the capstans
- <u>Check balance rail holes</u>

- Check for "pulling keys." If the keys move forwards and backwards, then the balance rail holes are elongated.
    - Pull each key forwards and backwards. Mark with chalk those that move.
- Glue-size the holes that are too big.
    - Just about any kind of glue will work. Add water. The water swells up the wood and the glue locks it.
    - Apply the glue
        - Use watered-down glue, like Titebond.
        - Dip a sharpened hammer shank into the glue.
        - Twirl the glued tip into the hole so that the watery glue creates a little bubble.
        - The wood will soak up the glue.
        - Don't drip the glue into the key bushing.
    - Once the glue is dry, the glue-sized hole will have to be eased.
- Check the sizing
    - Lightly push down on the capstan, pick up the front of the key about an eighth of an inch and see if the front of the key drops freely.
    - If it does not drop, use a balance-hole sizing-tool.
        - Insert the tool through the balance hole from above through the bushings.
        - Watch from the bottom of the key as you turn the oval-shaped tool so that it slightly widens the sides of the key (not the front and backsides of the hole).
        - Check the forward-backward play again to feel the results.

- Repair chips on keytops
    - Use AcryliKey to patch chips and nicks on ivory and plastic
    - If the key lip is far too chipped to repair, file it flush
    - Replace damaged or missing key tops.
- Miscellaneous repairs
    - Glue split *key buttons*, or replace missing key buttons
    - Repair any nicks or broken parts

Key leveling

- Place lead weights on the back-checks
    - When leveling the keys in the piano, hand the lead weights on the front of the back checks to allow the action to be slid farther towards the dampers
    - Hang them on the back side of the back checks
        - The farther back, the more weight
        - The lead doesn't mark the back check leather
- Setting the key height
    - Look at the specs and measure the existing height.
    - Factors to consider:
        - Clearance of the balance pin above the key
        - How much front rail pin is poking up into the front rail hole
        - How much of the front of the key rises above the key slip
        - How much clearance there is from the key up-stop rail

- Support the two end keys
  - Cardboard punchings
  - Upright damper head blocks
  - Wood jig with a hole to fit over the front rail pin and a screw for adjusting the key height
  - Wood jig with a front rail pin hole and a capstan screw to make height adjustment easier from the front
- Set a straight edge across the keys.
  - Rest the straight edge on the two end keys.
  - Lay the straight edge a hair back from the front edge of the keys.
  - Some people lay the straight edge over the front rail pins.

- <u>Level the white keys</u> first
  - Select *punchings*
    - Make an estimated guess as to the appropriate punching thickness for each key.
    - A comfortable way to get your eye level directly at the level of the key fronts is to sit on a piano dolly covered with a board and a blanket or pillow.
    - If uncertain as to the right thickness, insert two equal punchings between the key and the straight edge. If the key moves, then that size is too thick. One punching on the balance rail is almost equivalent to (slightly less than) double its thickness at the front end of the key.
    - Places to set the selected punchings.
      - On top of the key button.
      - On the key, directly under the straight edge.
        - This is the quickest and most immediate place
        - The problem is that all the selected punchings can be knocked off if the straight edge is bumped, or they might stick to the straight edge.
      - Steve pokes each punching onto the tip of the balance rail pin to prevent it from being bumped or blown away.
  - The circle *of refinement* and the point of diminishing returns:
    - Go through the leveling process three times
      - The first time go quickly to get everything in the ball park
      - The second time, be precise.
      - The third time, check for the few remaining missing spaces.
      - The last pass should be by touch, floating your fingers over the key tops
- <u>Square the keys</u>
  - After the first rough leveling and the ivories are close to the straightedge, square all the keys.
  - If the key tilts to the left, tap the top of the balance rail pin to the right until the top of the key is parallel to the straight edge.
  - Tools
    - Steve inserts a brass rod into his universal handle. There is a dimple in the end of the rod. He sets the dimple on top of the key pin and taps the handle with the heal of his hand.
    - Dean taps the pin tops with a piece of wood with a small hammer.
- <u>Level the black keys</u>

- Tools
  - George uses a 6" ruler with the wing slides.
    - He has to get down and eyeball each key.
    - This process is tedious and slow.
  - Mark and Steve use a Jaris key leveler
    - Use a ruler to find or make one black key that is at the exact right key height, which is usually just a hair under ½".
    - Calibrate the tool to that sample key.
    - Select punchings to make the leveler gauge flush.
    - For odd measurements, reposition the tool farther forward or back on the key.
  - Dean uses a wooden block.
    - This block sits on top of the white keys and fits around the black key with a beveled slot. The height differences can be felt with a light finger touch.
    - The final check can be done with a straight edge.
- Process
  - Estimate the punchings
    - For the black keys the tolerance is smaller, so the punching choices are a bit thinner than they would be for the white keys
    - Set the selected punchings on the keys somewhere.
  - Lift the keys and insert the punchings.
  - Check everything, then do it all again.
  - Remember to level the two end keys that were used to hold the straight edge.
  - Turn the punchings so that the felt punchings are on top of the paper ones.

Re-gluing ivories
- Breathe on the ivory before putting it on
- Glue options
  - Glue on with either three or four dots of CA glue.
  - Reconstitute the original glue
    - Moisten the ivory wafer, clamp with brass plates, then heat the brass clamp with a heat gun.
  - Use new ivory wafers.
  - Mix titanium dioxide with cold hide glue.

REGULATION

Regulation
- <u>Replace the stack</u>
  - Replace the screws in the exact same location
    - Start from the center front screw, then tighten the center back, and work your way out.
    - There is a certain deformation in both the key frame and the stack, so tightening the screws from the middle out keeps it in the same pattern. When

stretching a canvas on a frame, start in the middle of both sides, skip fan out alternately, and then fill in.

- Set samples.
  - Start with the hammers on each end of the center section. Do a preview regulation on two samples without even putting weights on it.
  - Move the *hammers* so they don't interfere with each other. We are not spacing the hammers. A lot of things are going to change during this process.
  - Make sure the *back-checks* are all out of the way and not holding the hammers.
  - When you put new parts on, the *drop* will almost always be too high, so lower the drop right away.
  - Test the *wippen springs*.
    - Steve prefers starting with the springs on the weaker side.
    - By adjusting the balancier spring from the back you won't cross the coil. Steve likes to adjust them from the front. Either way, it is best to pop the spring out on the same side as it comes out from the coil.
  - Adjust the *capstans* so that the hammer shank floats about one shank's width above the hammer rest rail.
- Rough-in regulation.
  - The most important thing with this first time around is the speed with which everything is set. Do quick passes, since at first all the adjustments are much too far out to worry about perfection. Equate this to a pitch-raise. The goal is to get everything to work so that the piano will then be able to be regulated. For speed, do everything by feel, go all one way way and get everything in the ballpark. Zip through and get everything close, then go through again accurately. If you can't really tell, then it's not enough to worry about. Go through all the key adjustments on the stack as fast as possible.
    - Set all the adjustments in each section to the samples
  - Hammer leveling straight edge
    - Rest the base on the flange rail and set the straight edge to be in line with the two sample end hammers.
    - Use this jig for eyeballing let-off, dip, hammer height, etc.
  - Weight the hammer shanks to compress the new knuckles overnight. When new parts are installed they will change a lot within the first couple months.
    - Steve uses a long narrow section of pin block material, and sets a box of lead weights on top of that.
    - He used to use a 1" diameter, 4' long solid brass rod.
- Fine regulation
  - *Space the hammers* with the hammer line jig and the heat gun.
  - *Space the wippens* to the shank knuckles on the newly spaced hammers.
    - Initially line the end of the wippen to the flange.
    - Fine-adjust the wippen to the knuckle, since the flanges might not be straight.
  - *Jack to knuckle*
    - Comments
      - Do this job accurately because it will not need to be done again.

        - Adjust this after the preliminary hammer blow adjustment (capstans) but before the accurate capstan adjustment.
        - Since the hammer is lifted off the key and the key is down, push down on the front of the wippen to make sure the wippen assembly is in the rest position.
            - Push the adjacent wippen low so you can see what you're doing.
    - Methods
        - Align the back edge of the jack to the back edge of the knuckle core.
        - A quicker but less accurate way is to compare the jack to the knuckle of the adjacent knuckle.
        - Some people will set sample balanciers, notch the end samples, put two washers on a thread to hold it tight, and follow the thread line.
        - Check how well the markings coincide with the back of the knuckle core. If the lines are exact, follow the lines. Normally these lines are simply a guide for the initial factory setting.
- *Balancier height*
    - Goal
        - The balancier should be a little higher than the top of the jack by about the thickness of a piece of paper.
        - Do the final spring adjustment before doing the final balancier height
    - Methods
        - Eyeball (tiring on the back)
        - Fingernail nicking (fingernails vary in thickness)
        - Use a piece of paper as a gauge (too time consuming)
        - Fingertip feel (Steve's method)
    - Techniques
        - Put the tool on the screw, lift slightly, make the adjustment, and then put it down.
        - To lower the balancier, turn the screw adjustment clockwise.
        - If you don't lift the screw, you have felt turning against felt so the fibers bunch up, giving the wrong adjustment.
        - Tap the top of the balancier a couple times. By working it up and down sets the spring to where it will actually rest.
        - Both sides of the window won't be the same, so as you do this checking both sides. If you don't feel either side as being too high, then it's OK. You get clearance from whichever side is higher. Neither side should hold the knuckle up. This is easiest to do from the backside.
    - Wink the jacks
        - After the rep springs are set at the final setting, winking the jacks is the most precise check.
        - Push the jack tender down and you should feel a little drag.
        - As you move the jack tender slightly up and down, the hammer should move slightly up and down.
        - When you get the balancier and the jack supporting the knuckle together, then you have an ideal hammer line.

- *Space and square the back checks*
  - Space the back checks to the hammers
    - Make a lower bend to the left or the right to line up with the hammer.
    - Make an upper bend to make the back check vertical.
  - Square the back checks
    - Is the surface of the back check square to the back of the hammer?
    - We don't want one corner of the hammer tail digging in to the back check.
    - To best see the squaring to the tail, look straight down from above.
    - With parallel jaw pliers, grip the sides of the back check block and twist it to be parallel with the back of the hammer.
- *Adjust the capstans*
  - Set up a jig (e.g. Jaris key height jig) over a section of hammers
  - Set end sample heights with a gauge (or a ruler)
  - Set up a straight edge (or John Hartman's leveling gauge) on top of the hammer flange rail for eyeballing the hammer height while adjusting the capstans
  - Turn the capstan screws to set the hammer height
    - Yamaha makes a nice capstan stick with a wooden handle
- *Set let-off*
  - Spurlock gauge
    - This adjustment is quick but not totally accurate or consistent.
    - Pre-set sample hammers a couple hammers in from the ends of the section.
    - Set up the jig resting on the hammer rest felts and fasten the jig to the end hammer shanks.
    - Adjust the let-off screws so that the hammers just wink above the bar.
      - If the let-off is too low, the hammer will not lift at all when the key is depressed.
      - If the let-off is too high, the hammer will noticeably lift above the bar.
  - Jaris gauge
    - Set the gauge $1/16^{th}$ of an inch lower than the string height for the sample hammers on the ends of the section.
    - Adjust let-off to just touch the gauge. The hammer should just kiss the bar.
  - In the piano, set let-off by feel and sound.
    - It should just wink.
    - Adjustment by feel makes the piano play better
- *Drop*
  - We roughed in the drop during the initial rough-in regulation.
  - This time, without using a gauge or ruler, eyeball the drop.
    - Look for two things at the same time: both the wink and the drop distance.
      - Start by adjusting the first hammer so there is just a hint of drop.
        - The hammer should drop a scant1/8"
        - The let-off wink should be noticeable.
    - Adjust three hammers at a time.
      - Set one, then adjust the next two to that one, et cetera

        - Increasing or decreasing the dip will change the drop because of the after touch.
        - There are two different actions working at the same time. One is for power, one is for speed. Take out the repetition lever and there will be lots of power. The hammer would have to rest on the rest cushion and there would be a tiny amount of lost motion. Will the hammer play without the jack? There would be a lot of power. The minute you put a lot of power into it, the repetition spring. Let-off is power, and drop is speed. This is high repetition.
    - The final drop adjustment must b e done in the piano.
- *Back checks*
    - To do a rough on-the-bench, look for the bottom of the hammer tails to be at the top of the next hammer shank.
    - Put one into check, let off the hammer next to it and see if you have about 5/8" between the tops of the two hammers. One is in check, the other is in drop.
- Set the *repetition springs* in the home.
- *After-touch*
    - After touch is the amount of hammer rise after drop as the key is depressed.
    - If there is too much after touch
        - Add front rail punchings
        - If the dip is exact, then to reduce the after touch, lower the hammer line

ESTIMATING AND PRICING

Price & fees

- Pricing, rates & fees
- Steve figures that your yearly income should total 1000 times the price of your tunings.
    - Because most piano tuners are do-it-yourselfers, they are not used to hiring outside maintenance people. Consequently they frequently under-price their work.
    - Allow for over-run.
    - Have an hourly rate
    - Have a trip charge policy.
    - Have a no-show policy.
        - Call them later. Wait for them to apologize and offer to pay for the failed appointment. Steve charges 75% of the tuning fee.
    - Tuning should be twice your hourly rate, plus your trip charge, which should be imbedded in your tuning fee.
        - In Stephen's case, that's 2 x $90= $180 (he actually charges $175 in Seattle and $185 on the eastside). Of that, his trip charge amounts to $40 in Seattle, $50 on the eastside. So he's charging for 1.5 hours of working time, plus a trip.
    - Have a clear sense how long each type of job takes.
    - Know the current cost of materials.
        - Charge 40%-45% mark-up, minimum. Double the catalogue price and the shipping cost is covered.
    - Taxable
        - Moving
        - Cost of new parts
        - Labor on installation of new parts
        - Anything we do that materially improves the value.
- Estimating
- By charging to do an estimate, there is no feeling of trying to sell a job they don't need.
- Include in the overall price the cost of your travel time out and back for removing and picking up parts and for delivering and reinstalling parts.
- Include free follow-up service in the fee.
- Time estimates
    - For an action rebuild, allow 2-3 weeks
    - For restringing, especially with a new pin block, allow a month

MISCELLANEOUS

Bending metal

- To bend metal, heat it to cherry red, put it in the vice and bend it. This takes the temper out and leaves it soft.
- Once it is bent, heat the bend up to cherry red again and plunge it into cold water. This sudden cold re-tempers the metal hard again.
- If the metal it not tempered, it will remain soft. To temper it to different levels of hardness, let it cool for awhile and then dip it in water, or dip it in oil to cool it slower.

Sharpening tools

- Use fine stones, a strop and powder.
- Pull the blade, holding it at the desired angle.

Jigs used

- Renner protractor for hammer angle
- Bill Spurlock's teflon key boring jig
- Bill Spurlock's hammer tapering jig
- Bill Spurlock's arcing jig
- Bill Spurlock's hammer hanging jig
- Bill Spurlock's let-off gauge
- Steve Brady's back check inserter and angled block
- Jaris let-off gauge

Facts

- Shanks have a fundamental frequency and an overtone frequency.