Discoveries, Surprises, & Lessons Learned

On the Journey to *Pianos Inside Out*

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Discoveries

Impedance: Friend or Foe?

Answer these questions:

1. Increasing soundboard impedance:
   a) Lengthens sustain
   b) Shortens sustain
2. Making the soundboard stiffer:
   a) Lengthens sustain
   b) Shortens sustain

My editor questioned the answers—clearly, this is not intuitive

Why would impeding vibrations make them last longer?

Impedance: Friend or Foe?

- If the soundboard didn't **impede** vibrations, the string's energy would be transferred to it rapidly, causing:
  - Loud attack
  - Short sustain
- Impedance lengthens the transmission of energy by reducing its efficiency
- Arthur Benade calls this the "wave impedance" (*Fundamentals of Musical Acoustics*)

Impedance: Friend or Foe?

- Impedance is modulated by the **stiffness** of the soundboard and bridges

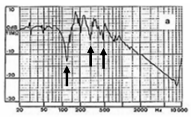
Impedance: Friend or Foe?

- **Stiffness** of the soundboard is a function of:
  - Material:
    - Spruce is stiff along the grain
    - Carbon fiber even stiffer, and in all directions--isotropic (Richard Dain, Phoenix pianos)
    - Finish (polyester, epoxy)
  - Ribs:
    - Increase stiffness of the board across the grain
    - Taller = stiffer
    - I-beam = stiffer
  - Rim material: the stiffer, the less energy loss on edges
  - Bridge cap material: maple, boxwood, ebony in treble (Petrof); metal; granite
  - Bridge pin material: steel (conventional), titanium (Ravenscroft, Sauter)

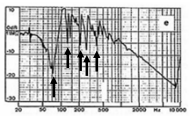
Impedance: Friend or Foe?

- Problems with impedance:
  - Impedance varies with frequency
  - Impedance dips = resonances: those notes (or partials) are boomy and short-sustained
  - Pitch affects string tension and, in turn, the loading of soundboard and its effective impedance
    (a half-tone pitch raise increases impedance, subtly shifts resonances, and improves tonal envelope)

With strings, tuned to A440:



Strings removed:



From Klaus Wogram, "The String and the Soundboard," *Five Lectures on the Acoustics of the Piano*. http://www.speech.kth.se/music/5_lectures/wogram/stringtension.html

Impedance: Friend or Foe?

- Problems with soundboard impedance:
  - With age and loss of compression:
    - Impedance drops
    - Resonances become more pronounced
    - Sound becomes tubby
    - Sustain shortens
  - Melody octave usually lacks sustain

Impedance: Friend or Foe?

- Solutions:
  - **Tighten** Mason & Hamlin Tension Resonator and Steinway compression bar (c. 1871-1880)
  - **Stiffen** soundboard with a coati
    (Del Fandrich, "Designer's Notebook," *P*
  - **Recrown** soundboard (controve
    - Shim the long bridge?
    - Shim ribs?
  - **Recompress** soundboard
    - Remove from ribs, dry, reglue
  - **Replace** soundboard:
    - Compression or rib-crowned?
    - Increase number and size of rib
    - Reduce the width of the board (cut-off bar, fish)

Impedance: Friend or Foe?

- Melody octave solutions:
  - Install Darrell Fandrich's Riblets (*PTJ*, August 2007, pp. 26-30; *PTJ*, November 2007, pp. 8-9)
  - Stiffen cross block
    - Add beam
    - Install Robert Grijalva's Tone Resonator (*PTJ*, October 2006, pp. 16-18)
  - Mass-load the soundboard
  - Notch bridge for uneven speaking lengths

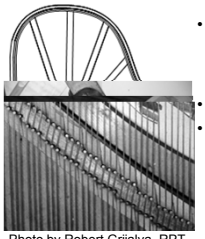
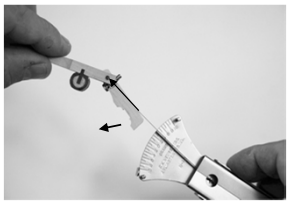


Photo by Robert Grijalva, RPT
Photo by Jude Reveley, RPT, Absolute Piano Restoration

Measuring Center Pin Friction

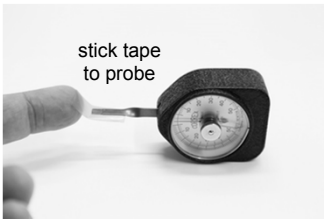
- Swing test? How about:

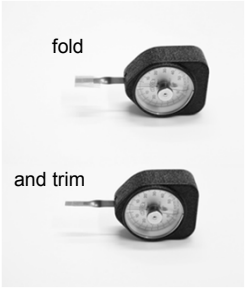


  - Follow the motion of the flange
  - Keep probe aimed at center pin
- Problem: erratic readings due to the probe digging into or binding on flange

Measuring Center Pin Friction

- Put mouse tape or slick tape on tip of the probe



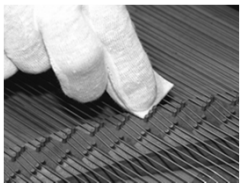


Measuring Center Pin Friction

- Circular force = **torque**
- Where along the radius you measure matters:
  - Steinway recommends: 32 mm (end of shank flange)
  - WNG recommends: 20 mm (middle of the hole sometimes)
  - My recommendation: 25 mm (1 inch)
- We should express center pin friction in mm-g (tuning pin torque is expressed in in-lbs or N-m):
  - Steinway: 4 g × 32 mm = 128 mm-g
  - WNG: 4 g × 20 mm = 80 mm-g (37% less)

Lubricating strings

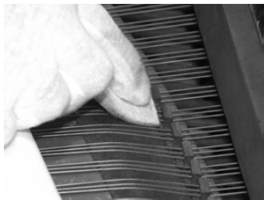
- Helps tuning and reduces string breakage

- A corroded string binds on bearing points
- Segment between tuning pin and counterbearing stressed the most
- Pounding doesn't equalize tensions sufficiently
- Impossible to set the pin (strings feel stretchy)

Lubricating strings

- Use Protek Prolube or CLP
- Do not use dry-film lubricants on felt
- Apply to each side of a bearing
- Don't spray
- Careful around tuning pins!
- Rub *liberally* on counterbearing felts:



Choosing Soundboard Finish

- Why do we finish the soundboard?
  - ~~Easier to clean (dust doesn't cling as readily)~~
  - ~~Looks "new"~~
  - ~~Protection from spills~~
  - ~~Tonal magic?~~

To slow down exchange of water vapor

Choosing Soundboard Finish

- Water vapor causes the soundboard to swell and shrink, affecting:
  - Crown
  - Downbearing
  - String tension
  - Tuning
- Slowing the exchange of water vapor:
  - Improves tuning stability
  - Slows dimensional changes in wood, reducing stress
  - Reduces exposure to compression set, cracking

Choosing Soundboard Finish

- The soundboard has two sides
  - Does it matter if only the top is refinished?
  - Does it matter if only the bottom is humidity-controlled?

Choosing Soundboard Finish

- Finishes are rated by their moisture-excluding effectiveness (MEE):

  from Bruce Hoadley, *Understanding Wood*, p. 208
  (14 days after applying 3 coats to ponderosa pine)

  - Nitrocellulose lacquer 19%
  - Spar varnish (oil) 30%
  - Shellac 42%
  - Urethane varnish 44%
  - 2-component polyurethane 66%
  - Polyester, epoxy even higher

Choosing Soundboard Finish

- Other characteristics of soundboard finish:
  - Resilience: less likely to crack at pressure ridges and small cracks in wood
  - Rigidity: can be used to increase impedance in old soundboards (Del Fandrich's coating epoxy)
  - Mass: insignificant except in extremely thick applications, e.g. polyester
  - High gloss: easier to clean
  - Reversibility: how easily can it be stripped?

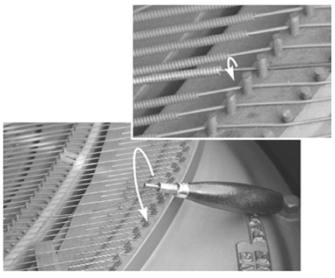
Choosing Soundboard Finish

- Summary:
  - The finish prevents rapid absorption and release of **moisture**
  - **Stretchy, resilient** finish will last longer than a brittle finish
  - Use **epoxy** as last resort

Surprises

Surprises

- Bass strings may require a twist in the "opposite" direction:
  - Mapes: counterclockwise
  - Hellerbass: clockwise



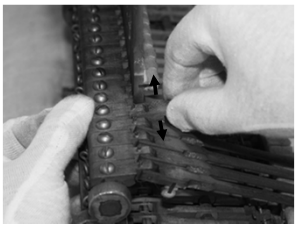
Surprises

- Acrylikey II ivory repair kit can be used with CA glue instead of the supplied monomer

Demonstration by Poppy Miles, RPT

Surprises

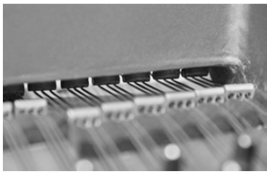
- Verdigris: Protek CLP much more effective when working the parts **parallel to** the center pin



- Reapply CLP multiple times—it's worth it

Surprises

- History of "Capo d'Astro":
  - Term *capo tasto* (master fret) used for transverse bar with V bar
  - Theodor Steinway uses the term *Capo d'astro* (tip of the star) for brass "agraffes" screwed to the bottom of the transverse bar (U.S. patent 170,646 of 1875):



Surprises

- Capo d'astro agraffes replaced with steel V bar plates in 1878
- Eventually were replaced with an integral V bar cast with the plate, but the name stuck
- For more, see Roy Kehl and David Kirkland, *The Official Guide to Steinway Pianos*, pp. 186–187, and item 1e. on p. 7.

Surprises

- Is all friction bad?
- In action: shock absorber
  - Rep lever centers—hammer line
  - Shank centers—bobbling
  - Knuckles—control in *pp*
- On string bearings:
  - Counters tuning pin twisting and flagpoling

Surprises

- Inertia:
  - Key leads 10%
  - Key stick 15%
  - Hammer mass 75%+
- Do we need:
  - Accelerated Action leading scheme?
  - Precise distribution of key leads?
- Is inertia always bad?
  - Slows down acceleration and repetition
    but…
  - Evens out touch
  - Sense of comfort
  - No inertia feels flyaway

Lessons Learned

Lessons Learned

- Second (and third) rebuildings teach us to avoid irreversible materials and techniques:
  - Epoxy on soundboard, soundboard shims
  - Epoxy, polyester finishes
  - Cutting into and shimming soundboard ribs
  - Strong, stiff glues under porous key tops
  - Cutting into or trimming key sticks
  - Irresponsible leading of keys
  - Epoxying or CA-ing pinblock to plate

Lessons Learned

- Question accepted “truths”
- Remaining true to original intent?
  - Modify?
  - Redesign?
  - Rescale?
- Balance duty to customer with duty to piano
  - Restoration vs. rebuilding
  - Conservation vs. restoration

Lessons Learned

- Observe myself from customer’s eyes
  - Would I call myself again?
  - Am I willing to remove the cheek blocks one more time?
  - Am I providing what the customer really needs?
- Seek efficiency:
  - Doing more work allows you to do more good but:
  - Slowing down enables breaking habits, experimenting, learning, improving quality
- Seek new insights

Lessons Learned

But keep in mind:

“Insights are tools; they aren’t the Truth”
—Dan Levitan, RPT

Thank You!

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