Bowed Piano Instrument

Detailed Write-Up

Design Philosophy

The piano exists as a mechanized harp—hammer strikes replaced plucking for speed and consistency, but at the cost of timbral nuance and sustain. A harpist can vary attack, decay, and harmonic content by altering pluck position along the string length. The bowed piano recovers this expressiveness while preserving keyboard accessibility.

Unlike experimental instruments that add bowing to existing pianos, this design is purpose-built from first principles: the keyboard controls bow pressure, speed, and position rather than hammer velocity.

Core Mechanism

Bow Actuation System

- **Linear reciprocating actuators** replace hammer assemblies
- **Rosined ribbon bows** on spool-feed cartridges (printer cartridge analogy)
- **Three bow positions per string**: bright (near bridge), normal (center), muted (near damper)
- Each position accesses distinct harmonic series, replicating harpist technique
- Bow position selected via dedicated controls (footswitch, touchpad, or auxiliary keyboard)

Ribbon Management

Bow ribbons wear through use and accumulate rosin buildup. The system addresses this through:

- **Lid-close advancement**: Primary ribbon feeding occurs when lid is closed (passive, zero user intervention)
- **Optional foot pedal**: Real-time advancement for virtuoso performances requiring pristine ribbon contact
- **Professional mode**: Micro-advancement during key release for extended sessions
- **Standardized cartridges**: Hot-swappable, keyed to prevent installation errors

String Architecture

Auto-Tuning System

- Microcontroller-managed tension per string
- Standardized, **note-labeled replacement strings** (e.g., "A4", "C3")
- User-serviceable string replacement without specialized knowledge
- Continuous tuning stability monitoring with drift correction

Multi-String Per Note

Following piano convention, each note uses 2-3 strings for:

- Increased volume and presence
- Timbral complexity from slight detuning
- Redundancy (one broken string doesn't silence the note)

Performance Interface

Multi-Keyboard Expansion

- **Physical expansion ports** for adding keyboards (chamber ensemble mode)
- All keyboards have full 88-key access
- **Onboard keyboard priority**: Guest keyboards cannot override local performer
- **Simultaneous keypresses on same note**: Accumulate bow pressure rather than creating conflict
- Enables collaborative performances with hierarchical control

Expressive Controls

- **Key velocity → bow pressure**: Harder strike = more aggressive bow engagement
- **Key hold duration → sustain**: Unlike piano, sustain continues as long as key is held
- **Aftertouch (optional)**: Modify bow speed/vibrato during sustained notes
- **Damper pedal**: Functions as traditional piano damper
- **Sostenuto pedal**: Sustains selected notes while allowing others to decay
- **Una corda equivalent**: Shifts to single-string mode for softer timbre

Business Model & Ecosystem

Concierge Service Tier

- **School subsidy program**: Instruments placed in educational institutions at reduced cost
- Funded by premium tier sales and licensing
- Includes maintenance, ribbon cartridge supply, and pedagogical resources
- Creates pipeline of trained performers and composers

Composer Commission Fund

- Funded by concierge tier revenue
- Supports creation of original repertoire
- Focuses on emerging composers exploring the instrument's unique capabilities
- All commissioned works remain copyright-owned by composers (company retains no rights)

Data-Driven Product Development

- **Anonymous usage statistics** collected (with explicit opt-in consent)
- Tracks ribbon wear patterns, common bow position transitions, string longevity
- **No music recording**: Timing/pressure data only, never audio capture
- Feeds string formulation improvements and software optimization
- Explicit disclaimer: "We improve strings, not surveil practice sessions"

Software Architecture

- **Default mode**: Single bow per string (conservative, proven)
- **Experimental mode**: Multi-bow-per-string for enthusiasts (opt-in)
- Community-driven discovery of extended techniques
- Feedback loop: Community findings inform future default features

Manufacturing & Supply Chain

Self-Manufacturing Components

- Actuator housings and mechanical assemblies
- Keyboard frame and case
- Electronics integration
- Software and firmware

Standardized External Components

- Electric motors (commodity industrial actuators)

- Strings (specialized wire, but standardized gauges)
- Ribbon material (rosined synthetic fiber, potentially co-developed with supplier)
- Electronics (microcontrollers, sensors, power supplies)

Technical Specifications (Preliminary)

Parameter	Value
Key Range	88 keys (A0-C8, standard piano)
Strings per Note	2-3 (bass: 2, mid/treble: 3)
Bow Positions	3 per string (bright, normal, muted)
Actuator Response Time	<50ms (key press to bow engagement)
Ribbon Cartridge Lifespan	~40-60 hours playing time
Auto-Tune Accuracy	±0.1 cents
Power Consumption	~200W typical, 400W peak (88 actuators active)
Expansion Ports	4 (supports up to 4 additional keyboards)

Design Priorities

1. **User-serviceable maintenance**: No specialized tools or training required for string/ribbon replacement
2. **Empirical testing over theory**: Prototype and iterate rather than model and predict
3. **Passive wear management**: Ribbon advancement tied to lid position (no habit-dependent intervention)
4. **Conservative defaults, advanced opt-ins**: Single-bow mode ships as default; multi-bow experimentation available for enthusiasts
5. **Transparent data practices**: Usage statistics explicitly described, audio never captured

Challenges & Open Questions

Engineering

- **Bow speed optimization**: What reciprocation frequency produces best tonal quality per register?

- **Ribbon material selection**: Balance between rosin grip, durability, and consistent friction
- **Harmonic damping**: How to suppress unwanted overtones from bow position transitions?

Musical

- **Performance pedagogy**: How do pianists adapt to sustain-based phrasing?
- **Repertoire gap**: Instrument needs dedicated compositions to demonstrate unique capabilities
- **Timbral vocabulary**: Establishing terminology for bow positions and techniques

Market

- **Price point sensitivity**: Where does instrument fall between upright piano and concert grand?
- **Education vs. professional**: Which market justifies R&D investment first?
- **Maintenance infrastructure**: Can standard piano technicians service bow mechanisms?
