

# Patent Valuation Report

## Helical Tubular Compression Spring

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U.S. Patent US 12,612,951 B1

## Patent Overview

- Patent Title: *Helical Tubular Compression Spring*
- Patent Number: US 12,612,951 B1
- Inventor and Assignee: Shantanu Singh
- Jurisdiction: United States
- Grant Date: 28 April 2026
- Priority Date: 28 September 2025
- Remaining Patent Life: >19 years (until 2045+)
- Status: Granted — 3 Independent/Dependent Claims, 6 Drawing Sheets
- Key Innovation: Passive programmable force via geometric mismatch between helical non-circular tubular guide-rod and complementary slider bore.

## Invention Summary

- Novel passive mechanical architecture using controlled elastic deformation from helical pitch mismatch and non-circular cross-sections.
- Integrates guiding function and tunable spring force in a single compact unit.
- Enables non-linear, programmable force-displacement characteristics without electronics, sensors, or hydraulics.
- Superior compactness, fatigue life (lower strain vs. coil springs), and multifunctionality.
- Broad applicability: Aerospace, defense (recoil), robotics, automotive/EV, industrial automation, and energy absorption systems.

## Core Protected Elements

- Non-circular tubular guide-rod swept along first helical path.
- Complementary slider bore swept along second helical path with different pitch.
- Geometric mismatch inducing controlled elastic deformation of the guide-rod.
- Programmable restoring force via pitch difference, eccentricity, wall thickness, and material.
- Method claims for generating restoring force.

## Strategic Scope

- Broad architectural protection covering multiple embodiments and variations.

## Claim Scope Analysis

- Strong defensibility — difficult to design around while maintaining compactness and performance.
- High barrier to substitution in space-constrained, high-cycle applications.
- Covers advanced implementations (material gradients, variable geometry, etc.).

## Patent Strength

- Recently granted U.S. utility patent with clear novelty over cited prior art.
- Strong differentiation: Passive, integrated guiding + tunable spring functionality.
- Excellent alignment with megatrends: lightweighting, robotics expansion, passive reliability, and electronics reduction.
- Long remaining term and broad industrial applicability.
- High defensibility due to functional and geometric integration.

### Current Estimated TRL: 3–4

- Analytical validation, detailed embodiments, and patent protection completed.
- Prototype fabrication and empirical testing pending.

### Development Roadmap

- Prototype fabrication and force-displacement characterization.
- Fatigue life and environmental testing.
- OEM integration studies and qualification (aerospace/defense).
- Manufacturing scale-up and cost optimization.

### Key Target Markets

- Aerospace & Defense springs market ( USD 309M in 2025, growing at 6.6% CAGR).
- Robotics & Automation actuators market (USD 17.9B–27.8B in 2025, 10–13% CAGR).
- Automotive/EV and industrial motion control components.
- Recoil/energy absorption systems.

Technology addresses critical needs for compact, passive, programmable, high-reliability force management.

## Cost-Based Approach

- R&D, engineering, prototyping, and patent prosecution costs.
- Replacement cost of developing equivalent protected IP.

## Market-Based Approach

- Comparable licensing deals in mechanical components, actuators, and aerospace subsystems.
- Benchmark transactions for similar passive mechanical innovations.

## Income-Based Approach (Primary)

- Projected licensing revenue (royalties + milestones).
- Discounted Cash Flow (DCF) analysis over patent life.

### Hybrid Licensing Structure (Recommended)

- **One-time Signing / Upfront Fee:** \$400K – \$1.2M per licensee (depending on exclusivity and field-of-use).
- **Milestone Payments:** Upon successful prototype validation, OEM qualification, and first commercial sale.
- **Running Royalties:** 4.5%–8% of net sales.
- Joint-development agreements and field-of-use exclusivity.

### Indicative Royalty Ranges (Mechanical / Industrial IP)

## Revenue Model & Royalty Benchmarks

- 4.5%–8% of net sales (strong benchmark for differentiated mechanical/automation components).
- Automotive / EV: 4.5%–6.5%.
- Industrial & Aerospace: 6%–8%.
- Defense and high-margin robotics applications: up to 8%–10% with exclusivity.

**Estimated Patent Portfolio Value: \$6.5M – \$18M**

(Conservative to highly optimistic scenarios, assuming successful prototyping and 4–8 licensing deals over the patent life).

### Key Value Drivers

- Successful prototype validation with compelling performance data.
- Manufacturing scalability and cost-competitiveness.
- Adoption speed in high-growth sectors (robotics, EV, defense).
- Licensing strategy (number of deals, exclusivity vs. non-exclusive).

### Major Risks

- Long OEM qualification timelines (especially aerospace/defense).
- Competition from incumbent suppliers and alternative technologies.
- Execution risk in prototype-to-commercial transition.

### Recommended Commercialization Strategy

- Target OEM licensing and joint-development partnerships.
- Field-specific exclusivity (e.g., defense recoil, robotics actuators, aerospace).
- Priority outreach: Aerospace OEMs (Boeing, Airbus, Lockheed), Defense contractors, Robotics manufacturers, Automotive Tier-1 suppliers, Precision actuator companies.

### Conclusion

- Strongly differentiated, programmable passive mechanical architecture with broad applicability and clear competitive advantages.

## Licensing Strategy and Conclusion

- Significant licensing and joint-development potential in multi-billion-dollar markets.
- High strategic value as a compact, reliable, sensor-free alternative to complex active systems.
- Well-positioned for substantial commercial returns over the long patent life, especially upon successful prototyping.