“It Returns to Shape” Is Not One Thing: Returning as a Spring and by Rearranging Store Energies Orders of Magnitude Apart

— a shape-memory alloy stores **40.000000** to **80.000000** times the energy of a steel spring, the factor of **2** depending on how it is counted — the separator is whether the return comes from atoms stretched apart or from a structure rearranged — [Paper 828]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— *From thinking to syncing.* —

Abstract

“It deforms and returns” is said of a spring and of a shape-memory alloy alike.This paper counts that the energies they store differ by orders of magnitude and that what they throw away differs in kind.No new theorem or law is claimed. First, what a spring can store is small——steel at an elastic limit of 0.002 and 400 MPa gives 0.400000 MJ/m³ (Section 2). **Second, and this is the core. What a rearranged structure returns is orders larger——a recovered strain of 0.08 at a plateau of 400 MPa gives 16.000000 MJ/m³ as a triangle and 32.000000 MJ/m³ across the plateau** (Section 3). **Third, the ratio moves by a factor of 2 with the counting——40.000000 as a triangle and 80.000000 across the plateau, the former matching the strain ratio of 40.000000** (Section 3). **Fourth, what is thrown away differs in kind——losing 25 percent per cycle leaves 24.000000 MJ/m³, while a steel spring loses 2 percent and leaves 0.392000 MJ/m³** (Section 4). **Fifth, the rearranging side still wins on quantity——24.000000 against 0.392000 MJ/m³ even after the loss** (Section 4). **Sixth, the separator is whether the return comes from stretched atoms or a rearranged structure——one phrase, “an elastic material”, points at two mechanisms** (Section 4). **Keywords**: shape-memory alloy, elastic strain energy, martensitic transformation, hysteresis, energy density, representative values.

Scope of this paper (scope note): **No new theorem or law is claimed——the elastic strain-energy formula, the large recoverable strain of shape-memory alloys, its origin in twinning and martensitic transformation, and the hysteresis of the cycle are all known.Every value is representative——an elastic limit of 0.002, a recoverable strain of 0.08, a plateau of 400 MPa and losses of 25 and 2 percent are values for comparison.No real alloy is discussed——composition, transformation temperatures, cycle life and fatigue are not treated.Thermodynamics is not entered——driving forces and phase diagrams are not the subject.No advice on choosing——which material to use is not treated.Relation to earlier papers**: **Paper 326 showed that the square-cube "law" is an identity, not a law——this paper stands beside it: the ratio here is fixed not by the merit of a material but by how the area is counted.Paper 300 showed that whether two things share a root is decidable——returning as a spring and returning by rearrangement are distinct roots and are not put under one word.**What is added is **counting the two returns on one footing, showing the ratio moving between 40.000000 and 80.000000 with the counting, measuring 24.000000 against 0.392000 MJ/m³ after losses**, and **placing the separator on stretched atoms versus rearranged structure**.

1. Notation and the Question

Setting: **a material is loaded to a stress σ and a strain ε and then unloaded, returning to its shape.The stored energy density is the area of a triangle if the stress-strain relation is straight, and of a rectangle if it is flat.**

$$u_{\text{triangle}} = \tfrac{1}{2}\sigma\varepsilon, \qquad u_{\text{plateau}} = \sigma\varepsilon$$

Question: **how much do the two "returning" materials store, and how much do they throw away?**

2. Returning as a Spring

Computation 2.1: **steel (Young's modulus 200 GPa, elastic limit 0.002) reaches 400 MPa and stores $\tfrac{1}{2} \times 400 \times 10^{6} \times 0.002 = 0.400000$ MJ/m³.**

> **Observation 2.2**
>
> **what a spring can store is small.Strength does not help once the strain caps at 0.002——it can return only within the range in which atoms are stretched apart.**

3. Returning by Rearrangement

Computation 3.1: **for a shape-memory alloy (recoverable strain 0.08, plateau 400 MPa), two counts were made.**

counting	energy (MJ/m³)	against steel
triangle (taken as straight)	16.000000	40.000000
plateau (the transformation plateau)	32.000000	80.000000

> **Observation 3.2**
>
> **this is the core. They differ by orders of magnitude.The strain ratio is 40.000000, and the energy ratio is 40.000000 or 80.000000 depending on the counting——the stress stays put while the strain extends, so the area grows flat rather than linearly.**

4. What Is Thrown Away, and the Separator

Computation 4.1: **losses per cycle were included.**

material	loss per cycle (representative)	recovered (MJ/m³)
shape-memory alloy	25 percent	24.000000
steel spring	2 percent	0.392000

> **Observation 4.2**
>
> **what is thrown away differs in kind.The rearranging side turns a substantial share into heat every cycle, while the spring loses almost none——yet the recovered amounts are 24.000000 against 0.392000 MJ/m³, and on quantity the rearranging side wins.**

> **Observation 4.3**
>
> **the separator is whether the return comes from stretched atoms or a rearranged structure.The first is small, fast and lossless; the second large, slow and lossy——one phrase, “an elastic material”, points at two mechanisms.**

Observation 4.4

placed beside Papers 326 and 300.Paper 326 showed that the square-cube “law” is an identity——here too the ratio is fixed by how the area is counted.Paper 300 showed that sharing a root is decidable——the two returns are distinct roots.

Observation 4.5

what is not said.Real alloys, the thermodynamics of transformation, cycle life and choice of material are not treated——what is shown is that one word covers quantities orders apart.

5. Census and Closing

1. **steel 0.400000 MJ/m³** (Computation 2.1): **elastic limit 0.002.**
2. **alloy 16.000000 MJ/m³ as a triangle** (Computation 3.1): **strain 0.08.**
3. **32.000000 MJ/m³ across the plateau** (Computation 3.1): **the core.**
4. **strain ratio 40.000000** (Observation 3.2): **0.08 against 0.002.**
5. **energy ratio 40.000000** (Computation 3.1): **counted as a triangle.**
6. **80.000000** (Computation 3.1): **counted across the plateau.**
7. **24.000000 MJ/m³ after loss** (Computation 4.1): **losing 25 percent.**
8. **steel 0.392000 MJ/m³** (Computation 4.1): **losing 2 percent.**
9. **quantity favours rearrangement** (Observation 4.2): **even after loss.**
10. **stretched atoms or rearranged structure** (Observation 4.3): **the separator; Papers 326, 300.**

Closing: **“It returns to shape” is not one thing: returning as a spring and returning by rearranging store energies orders of magnitude apart.Steel at an elastic limit of 0.002 and 400 MPa stores 0.400000 MJ/m³, while a shape-memory alloy recovering 0.08 stores 16.000000 MJ/m³ as a triangle and 32.000000 MJ/m³ across the plateau——the stress stays put while the strain extends.The ratio is 40.000000 in strain and 40.000000 to 80.000000 in energy, moving by a factor of 2 with the counting, and losing 25 percent per cycle still leaves 24.000000 MJ/m³ against the 0.392000 MJ/m³ of a steel spring that loses 2 percent——the losses differ in kind, but on quantity the rearranging side wins.The separator is whether the return comes from stretched atoms or a rearranged structure.Placed among the earlier papers——standing beside Paper 326’s “identity, not a law”, and keeping Paper 300’s discipline between the two returns.To be honest——every value is representative, and neither real alloys nor cycle life is treated.**

References

1. Yamagishi, Y. (2026). *The Three Hundredth Census: Whether Two Things Share a Root Is Decidable* [Paper 300]. Zenodo. 10.5281/zenodo.22171914
2. Yamagishi, Y. (2026). *The Square-Cube "Law" Is Not a Law but an Identity* [Paper 326]. Zenodo. 10.5281/zenodo.22209992

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Yuuki YAMAGISHI (山岸 勇輝)

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