A History of our Industry

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Outline

• The early years, emerging themes	Keith
• Milestones on the road to success	Keith
• The dive into medical devices	Tom
• The future	Tom

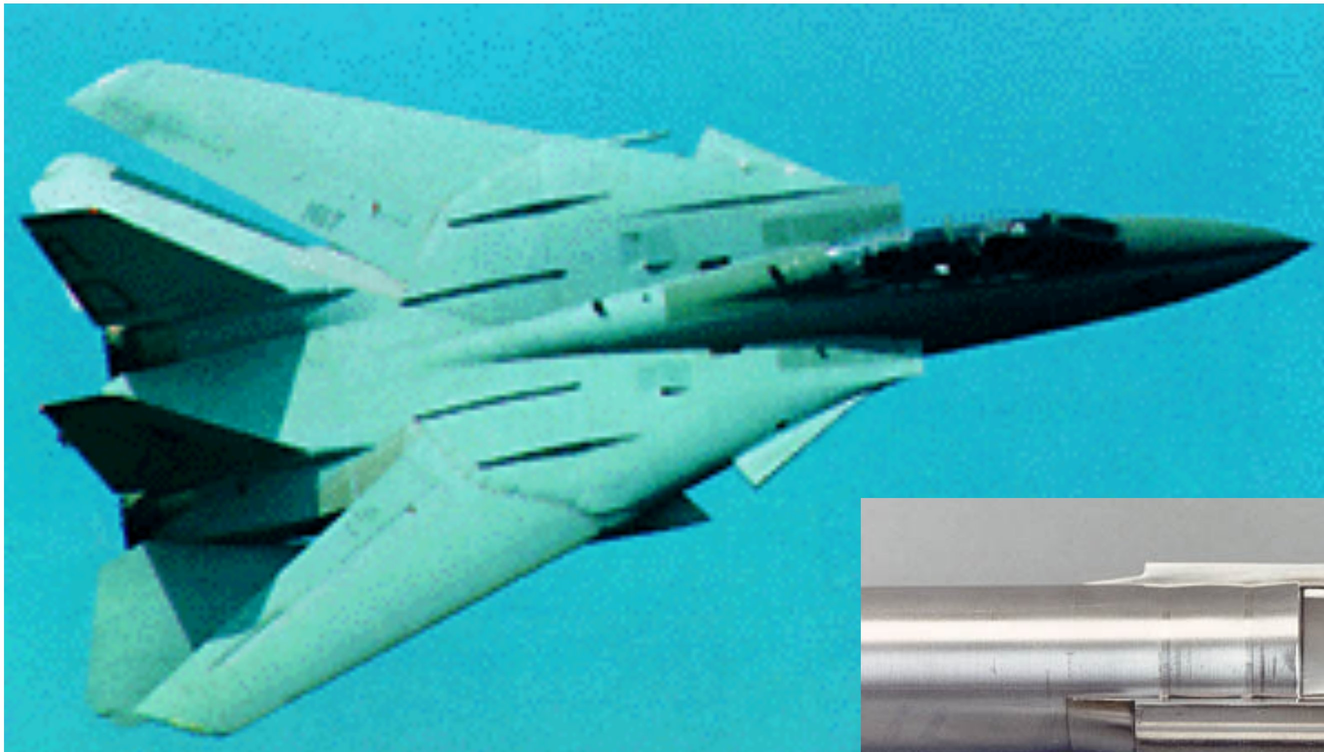
The early years

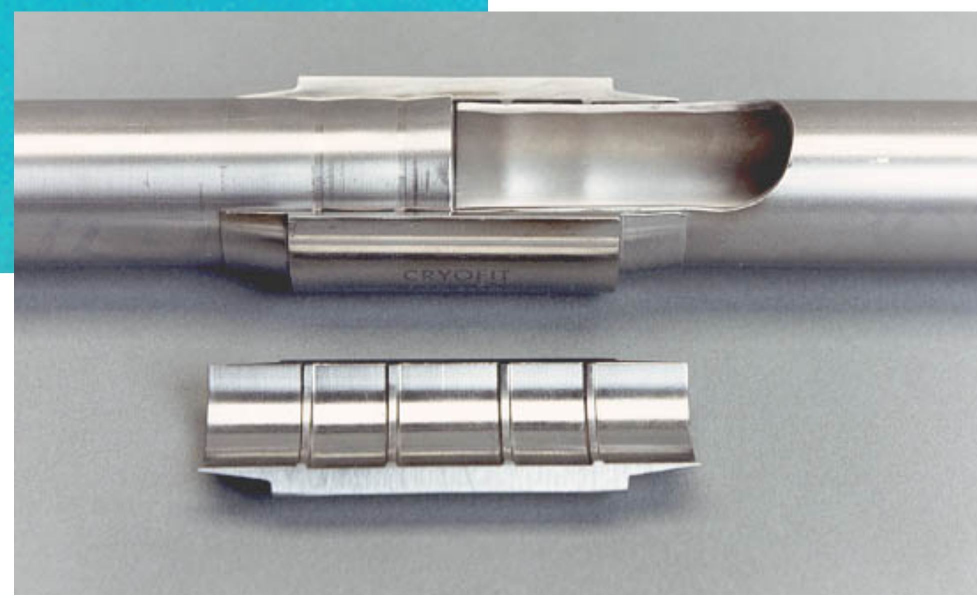
- Initial focus was on shape memory with competition between Cu based and Nitinol
- Cu based – cheaper, easier to make homogeneous ingots, poorer corrosion resistance
- Nitinol – consistent control of M_s difficult, larger heat recoverable strains (tolerances in couplings)
- Nitinol won
- But material not available, you had to make it yourself

Patents

- Letter from Buehler's lawyer – set the scene for the Industry
- To protect development costs, early companies looked for composition of matter patents
  - Raychem NiTiFe
  - Brown Boveri NiTiCu
- Raychem's position not helpful to new entrants
- "Engineering Aspects" to change mind set
- Changing attitude to IP

Hydraulic Tube Connections: circa 1978

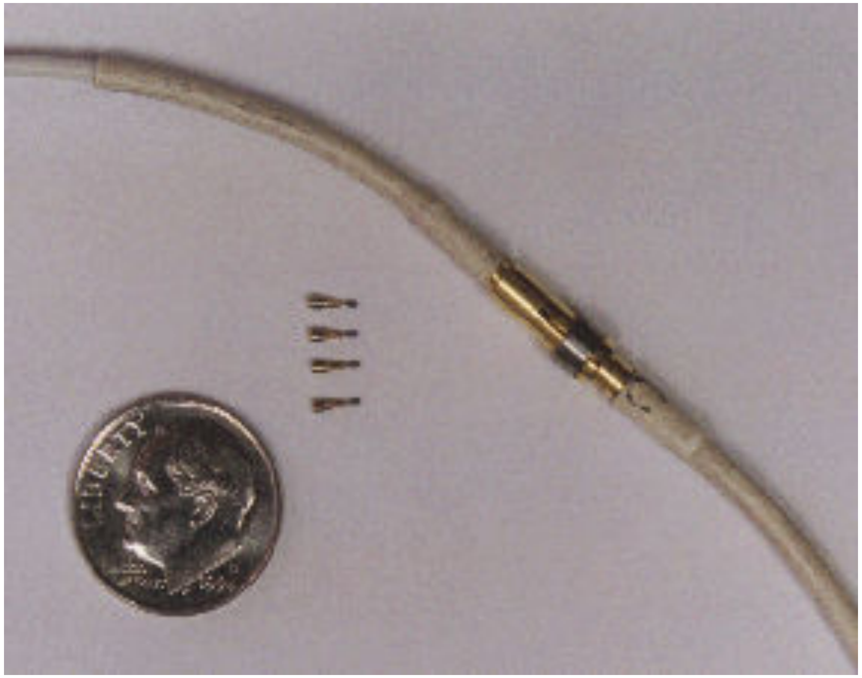




Nitinol, first major application

- Hydraulic couplings for the F14
- Decision to use Ti tubing before joining technology defined
- Nitinol solved a real technical problem
- Drove melting and processing technology, but access restricted by Raychem

Electrical connectors: circa 1983

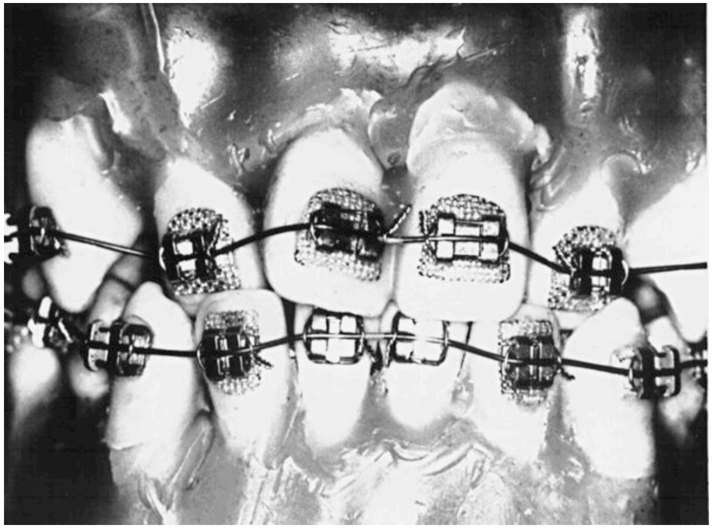


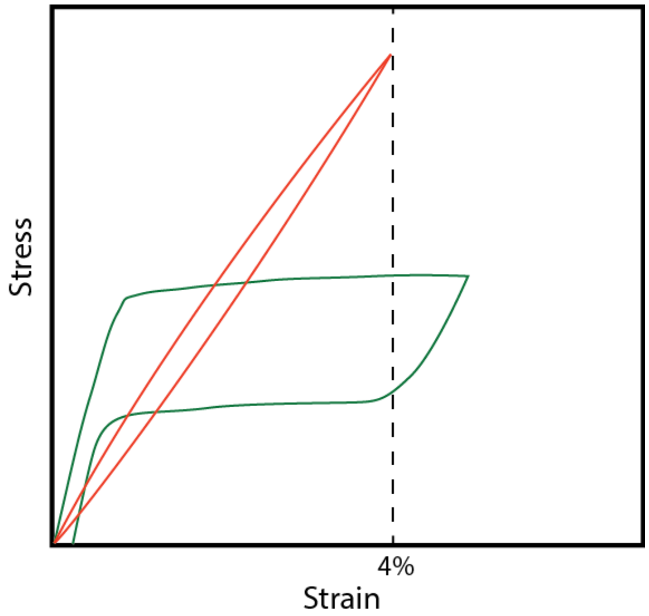
- At the time, best performance in high G forces
- Military application could support price
- Dematable design used rings
- Made from short lengths of tube and cut
- Formed basis for tube manufacture for other applications

Raychem Alloy Screening: mid 1980's

- Massive effort to establish composition of matter patents
- Pioneering modelling to understand stress–strain–temperature space
- Weekly meetings with CEO to report progress
- Electron beam furnace out of action for extended period
- Program of processing (cold work, low temperature anneals) on binary
- Together with modelling gave a better understanding of superelasicity

Orthodontic Arch Wire: 1976





- Started as cold worked martensite,
- Understanding of superelasticity led to this being offered
- Mouth, relatively benign environment

Breast tumour localisation device: circa 1986

Inserted into body but removed

Mitek Bone anchor: circa 1988

Implant, step too far for Lawyers, Ni as known carcinogen

Superelastic Applications

- Orthodontic arch wire
  - Started as cold worked martensite,
  - Understanding of Superelasticity led to this being offered
  - Mouth, relatively benign environment
- Breast tumour localisation device
  - Inserted into body but removed
- Bone anchor
  - Implant, step too far for Lawyers, Ni as known carcinogen

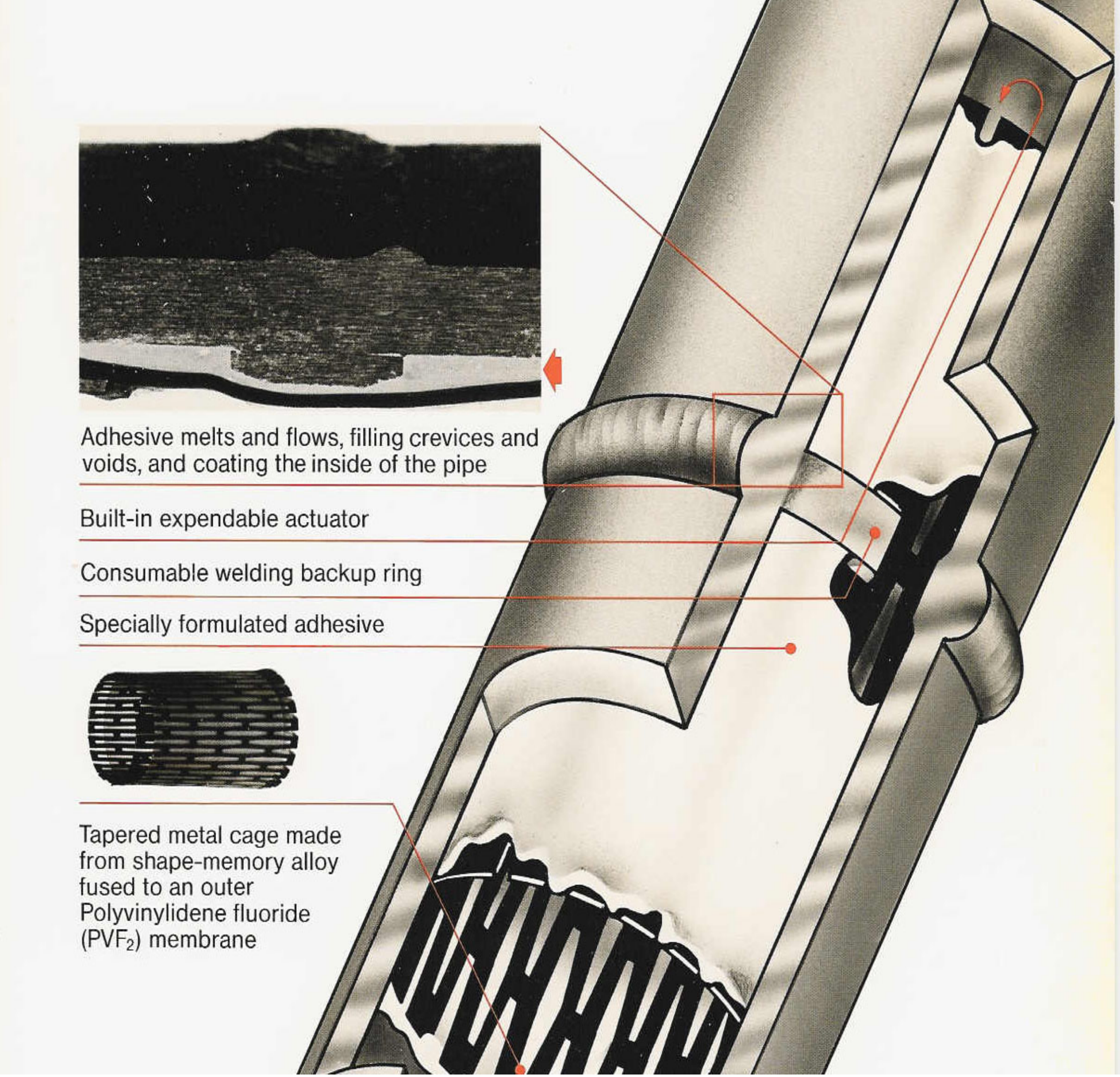
Medical Applications

- A market which could support the price if a real problem was solved
- Controlled temperature
- Initial successes in bone anchors, dental implants
- Stents was the game changer

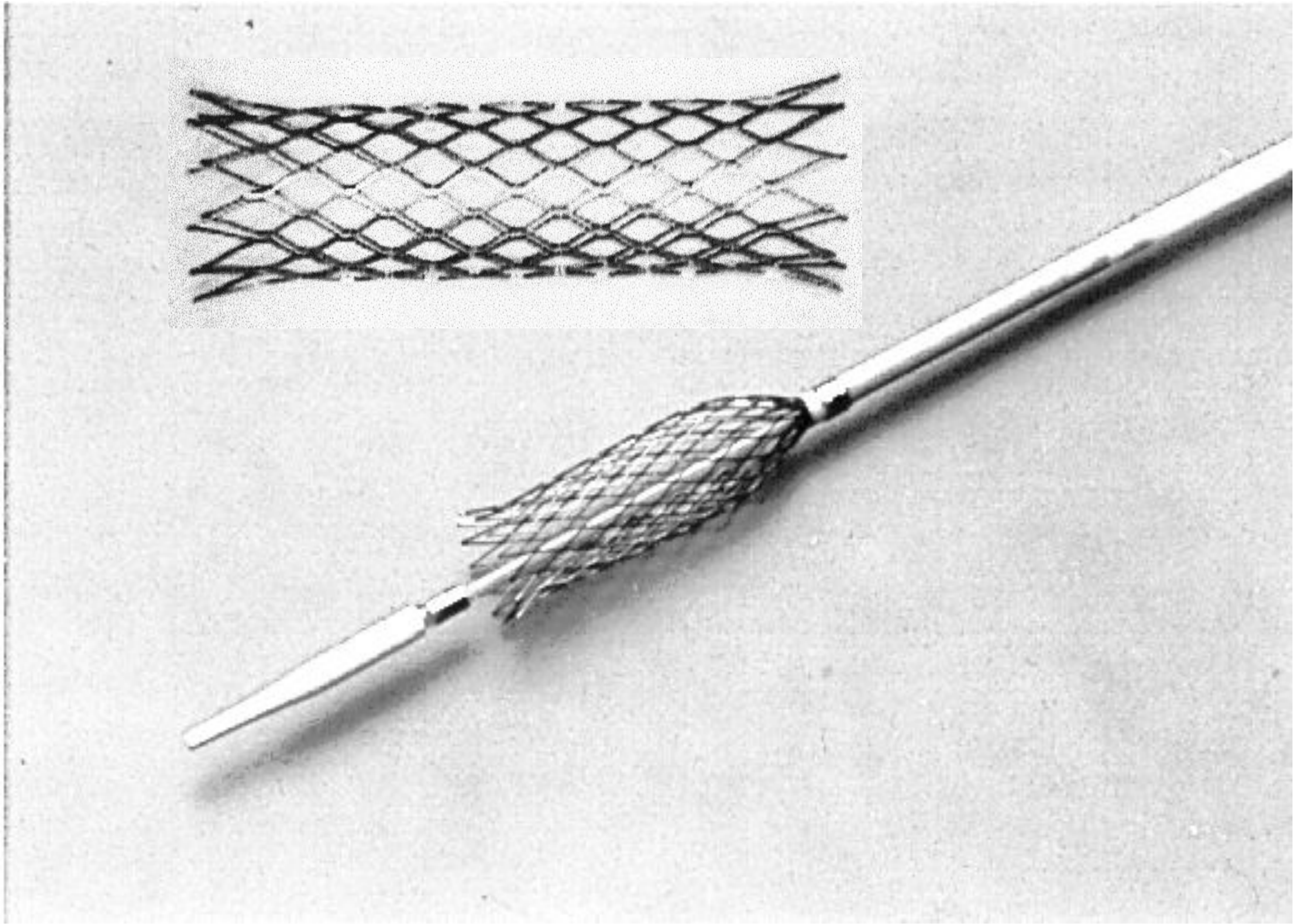
The stage is set

- Couplings gave basis for melting technology
- Electrical connectors gave basis for tube making
- Understanding processing of binary to optimise superelasticity
- New companies eg NDC had flexible approach to IP and understood risks
- Medical profession innovative and entrepreneurial

Circa 1980:
Linaweld

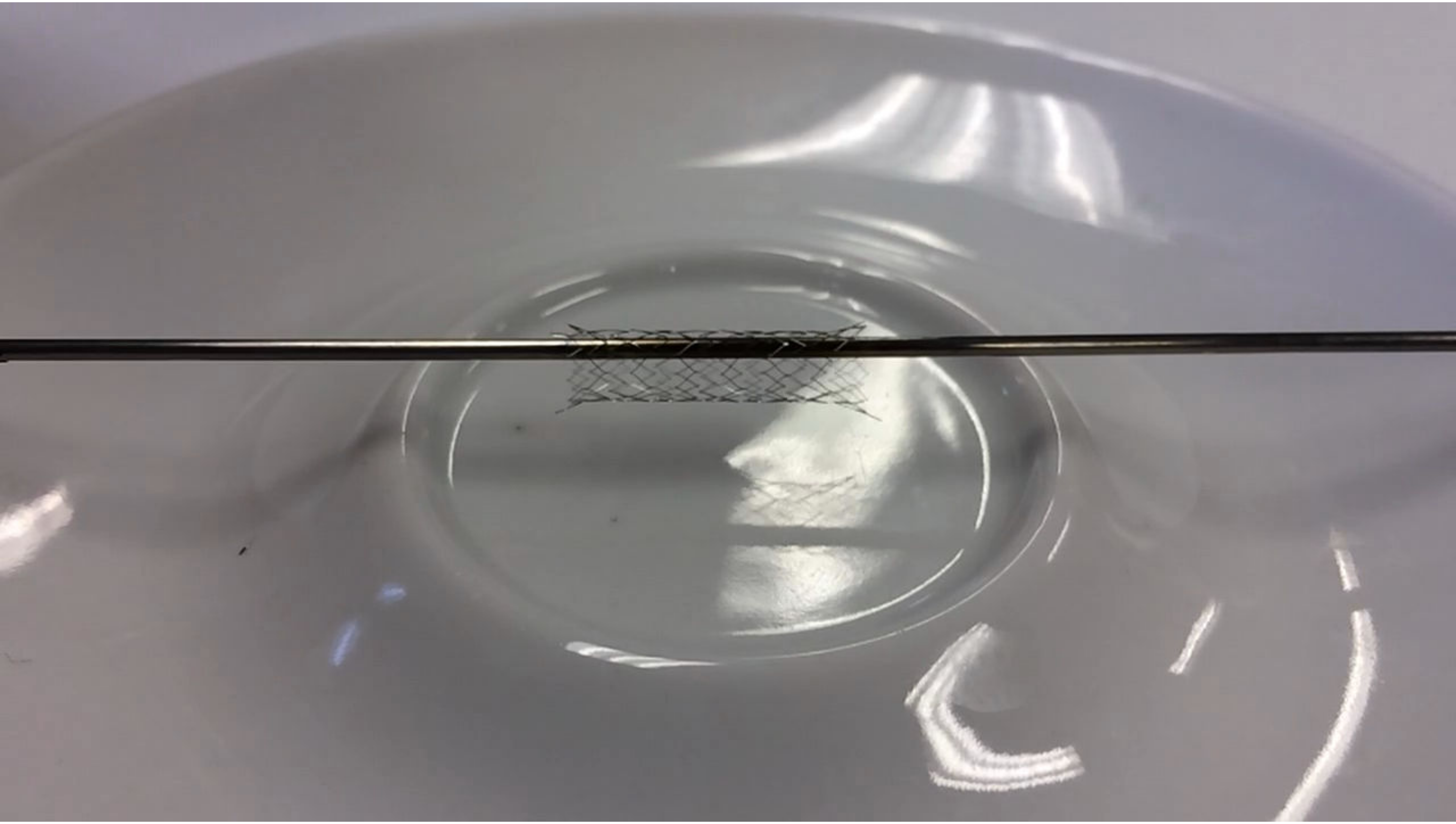

Adhesive melts and flows, filling crevices and voids, and coating the inside of the pipe
Built-in expendable actuator
Consumable welding backup ring
Specially formulated adhesive
Tapered metal cage made from shape-memory alloy fused to an outer Polyvinylidene fluoride (PVF_2) membrane

1992: Angiomed Memotherm

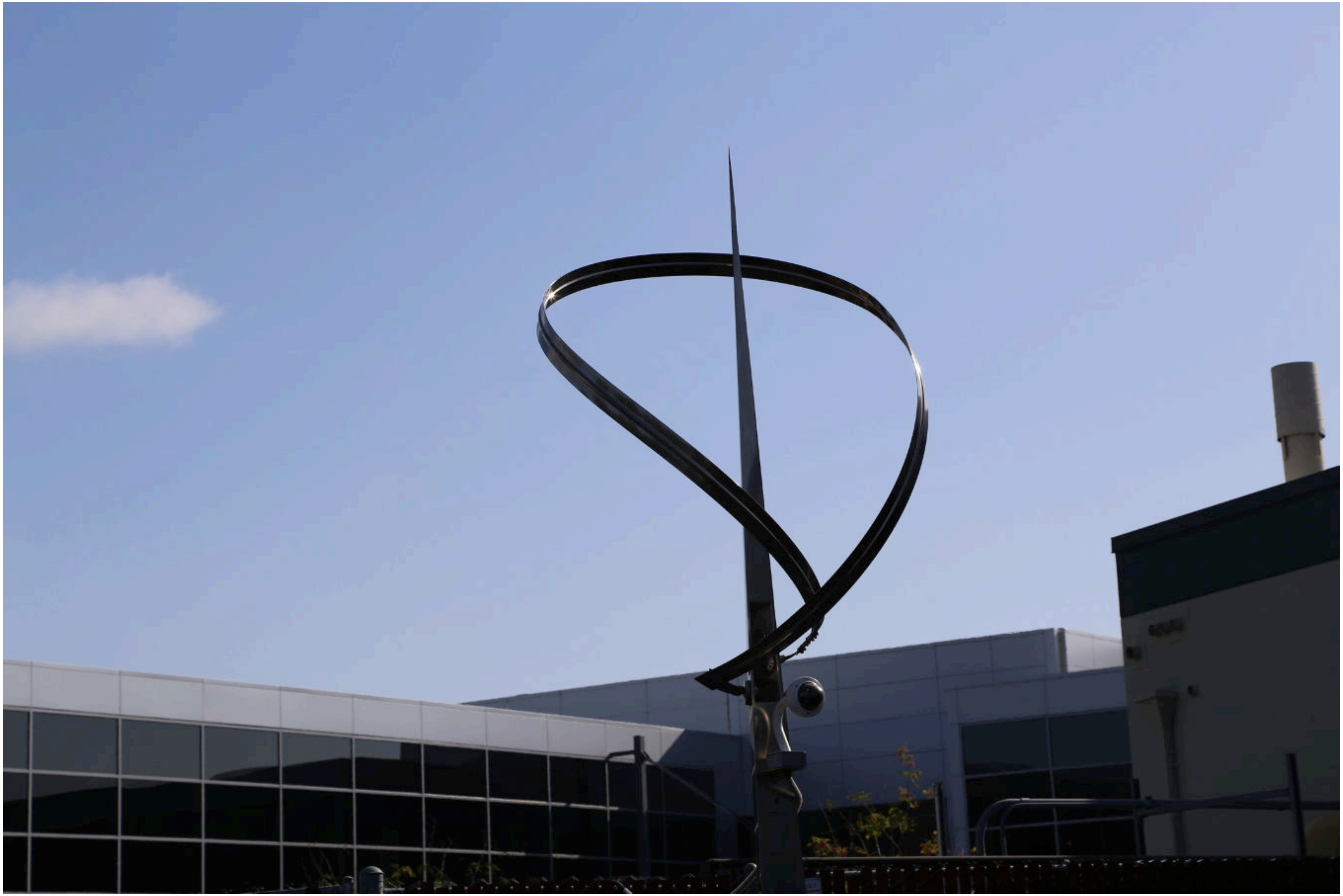


2001


MEGA
PROTEGE
PIXEL
flex
Med-Xflexy
Boston Scientific
Symphony
VISTAFLEX BILIARY
expander
Nitinol
Zenith AAA
Penta
SMART Stent
ZA-STENT
EuroCOR
RADIMAX
EndoCoil
RADIUS
ZILVER STENT
Bifurcated Stent Graft
AneuRx
Iliac Leg
Iliac Extension Cuff
GUIDANT
VascuFlex SE
CELLULAR FUNCTIONALITY
OptiMed
ACS MULTI-LINK RX DUET
PASSAGER
IntraCoil
SORIN BIOMEDICA
INTEGRA
ORINOCO
BioDiamond
HORIZON
NIR
VELOCITY
LP-Stent
ENDFORCE TECHNOLOGY
ORBUS
essure
TALENT
DEVON
Bridge SE Biliary
Medtronic AVE
PRECISE Stent
SULZER MEDICA
JOMED
SAXX
sinus-SuperFlex

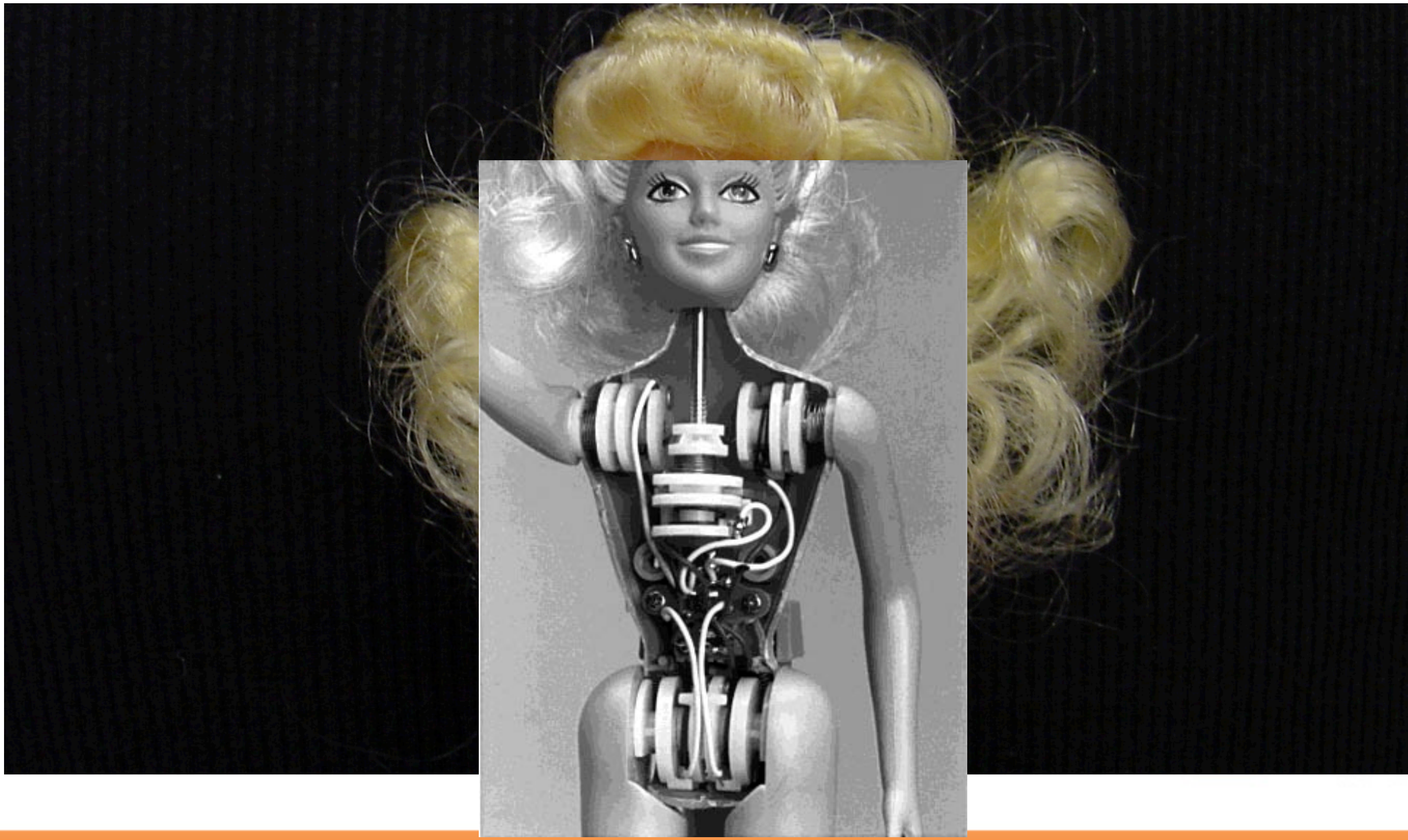


Introduction to Nitinol Actuators

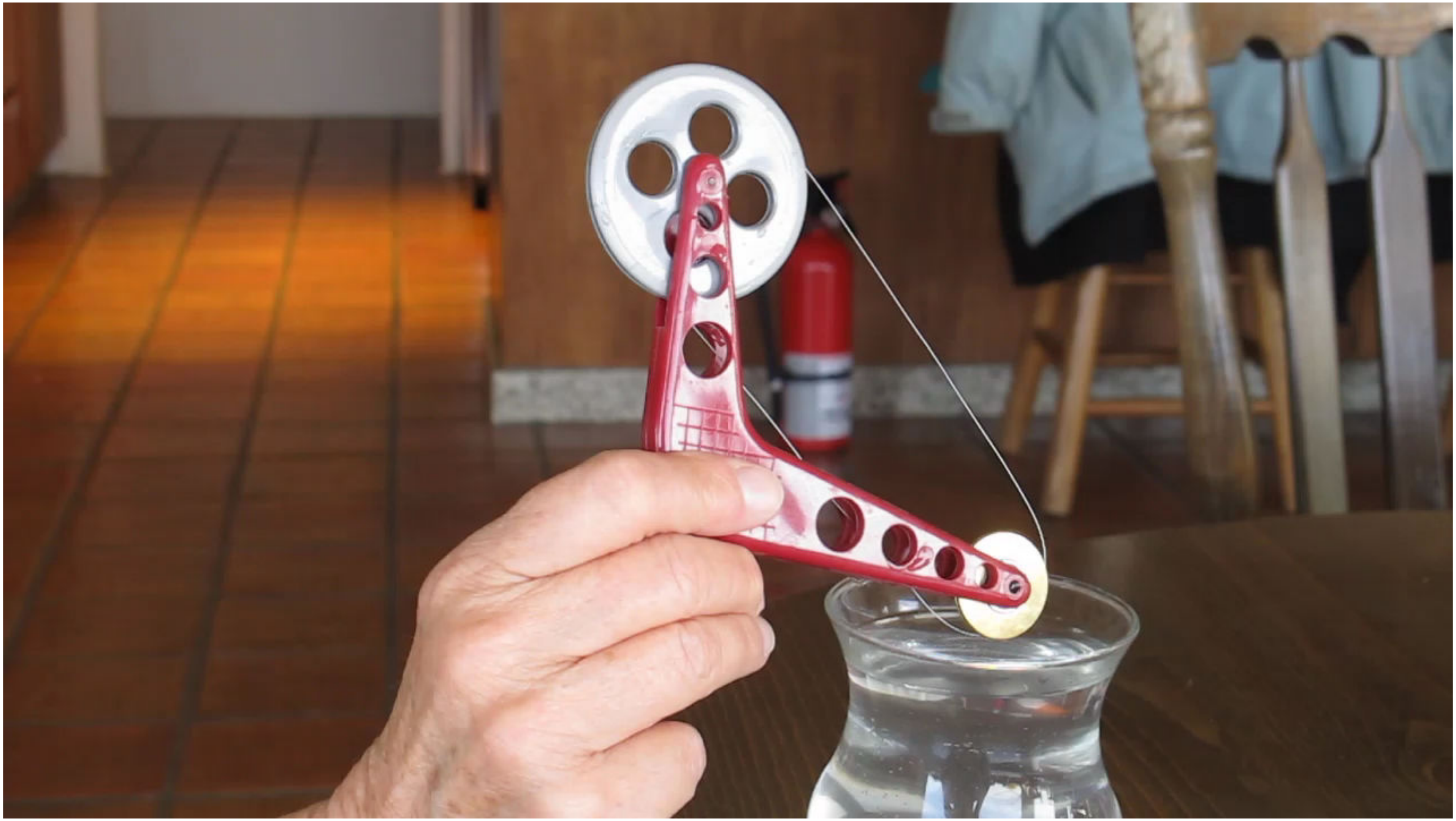


Posing Posey: 1988

But Posin Posey is no ordinary girl
… she's a shape memory android



The Actuator Challenge



http://www.witnessthis.co.za/2010/10/18/shape-memory-alloy/

FUTURE CARS: Memory metal allows cars to repair themselves

CARS are great to own and drive and even admire, but it is clear on so many levels that they are not globally sustainable. Our roads are already over-crowded, accidents happen daily, lives are lost, and they fart out enough carbon monoxide to choke a large Redwood plantation.

New cars are being pumped out the assembly line at an alarming rate. There are currently over 800 million cars and light trucks on the roads today — consuming over 260 billion gallons of petrol and diesel every year.

Coupled with the fuel crisis are motor vehicle accidents. If you are not killed or severely injured in a car accident, you are at least left with a hefty bill to pay. I was involved in quite a bad car accident earlier this year. It took six months to get my car back from the panel beaters. The only injuries sustained were to my patience and wallet.

Transport should be so much higher on the technological agenda and it's high time that vehicle-related problems were met. What's more is that the technology for safer and more environment-friendly transport is already available; it just needs to be put into proper use.

Shape Memory Alloy

Shape memory alloy is at the forefront of future transport. This cheaply produced metal, also known as smart metal, memory metal, muscle wire and Nitinol, is able to regain its original shape when heated. This can be demonstrated with a memory alloy spring. The object is deformed and disfigured beyond recognition and springs back to its original shape when heated. Here's a video demonstrating this process:

Memory Alloy in Action

To put it very simply, memory materials are created at a specific temperature and then held in place until cooled. Applying any heat source after the object is disfigured will return it to its original shape.

Shape memory alloy is already being used in medical applications, such as optometry and dentistry, as well as aerospace; but why not use it more vigorously in vehicle production? Serious research advances in the field of memory materials have been ongoing since the 1960s. This lightweight, solid-state material is the perfect alternative to conventional materials used to manufacture cars.

Shape memory alloy is at the forefront of future transport. This cheaply produced metal is able to regain its original shape when heated.

Cars in the Future

Safety and fuel-efficiency are the two major factors when it comes to considering cars of the future. To be more fuel-efficient, cars need to be more aerodynamic and lightweight on top of having better, eco-friendlier engines. To achieve this, more consideration needs to be given to vehicle shape and the material used to make cars.

Many cars today might seem more plastic than metal — the cheaper ones certainly feel that way. The good news is that there are also memory plastics and textiles, which behave very similarly to memory metals. Future vehicles would be made from a combination of these memory materials — eliminating the need to waste time and resources at the panel beater.

This is, of course, if accidents were even to occur in the future. Social engineer and industrial designer, Jacque Fresco, believes that there is no reason for accidents to happen at all in the future.

But as an extra precaution, Fresco explains how the front end of future cars would be equipped with radar or sonar, or other sensory devices. These would be able to detect the distance between other vehicles and maintain that separation automatically.

Like the human body, cars of the future could even have memory systems of their entire configuration built in — allowing them to regenerate automatically if entire parts were lost. "The technology of the future will enable our automotive vehicles to repair and regenerate damaged areas automatically," says Fresco.

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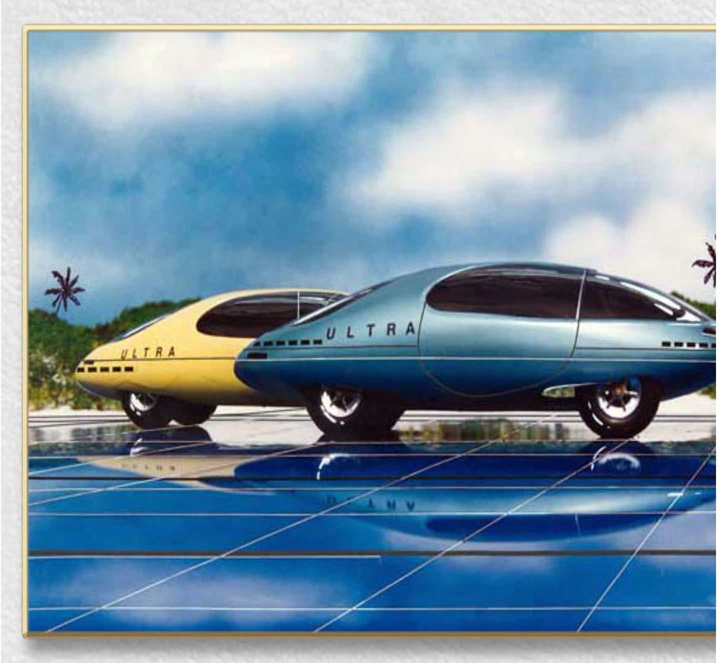

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What's next?

- Fatigue lifetime
  - Is it really just a strain problem?
  - Inclusions: Size, Frequency or type?
  - Pre-strain effects: Why, and how?
- Modeling
  - Strain localization
  - Tension/compression and multiaxial effects
  - DIC
  - Neutron Diffraction
- New Alloys
- Single Crystals
- CS porous Nitinol
- Thin Films