INDUSTRIAL DESIGN WITHOUT ENGINEERING DESIGN: "CHEAP, PLASTIC AND BROKEN!"

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Hales & Gooch Ltd.

Chicago USA and Christchurch NZ

www.halesgooch.com

1967 - THE GRADUATE

Mr. McGuire: ***I just want to say one word to you - just one word.***
Ben: *Yes sir.*
Mr. McGuire: *Are you listening?*
Ben: *Yes I am.*
Mr. McGuire: ***'Plastics.'***
Ben: *Exactly how do you mean?*
Mr. McGuire: *There's a great future in plastics. Think about it. Will you think about it?*
Ben: *Yes I will.*
Mr. McGuire: *Shh! Enough said. That's a deal.*

PLASTICS ARE WONDERFUL
BUT DON'T FORGET SHIGLEY!

Chapter 1. Stress Analysis!

Chapter 2. Deflection Analysis!

Chapter 3. Selection of Materials!

Chapter 4. Strength of Mechanical Elements!

Chapter 5. Principles of Design!

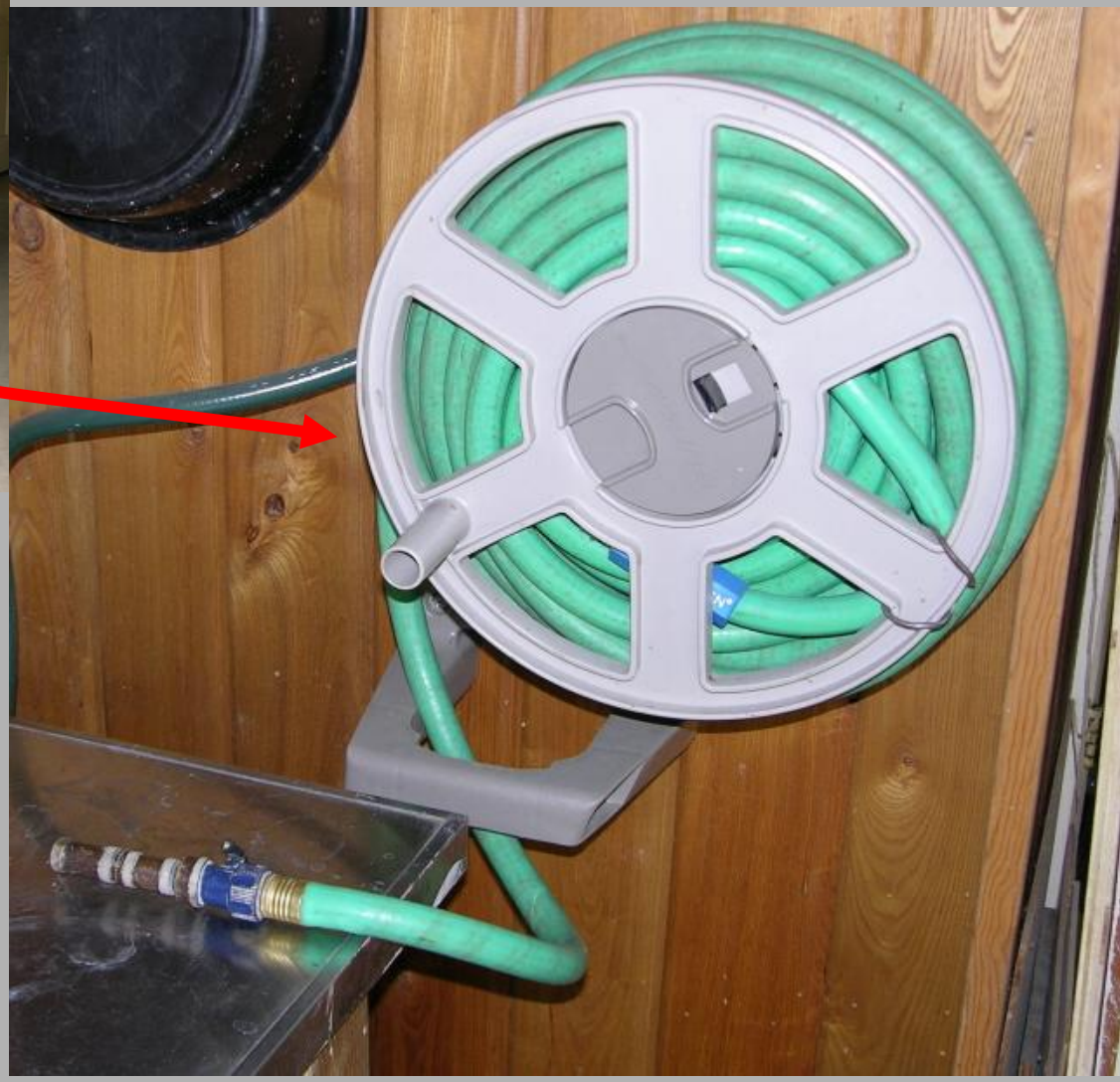
Mechanical Engineering Design (Student Edition)
by Joseph E. Shigley, 1963
Part 1: Fundamentals of Mechanical Design

CRASH!!

– what the devil was that?!

DISTORTION WITH HEAT OVER TIME CAUSED UPPER TABS TO COME OUT OF HOLES – FIXED BY INSERTING SHIMS UNDER LOWER TABS

THAT BENDY-TWISTY PLASTIC HOSE-REEL



Why can't I have one that feels nice and strong like my good old rusty steel one from 30 years ago?!

PULLING THE COLD HOSE OUT IN WINTER TO WASH THE SALT OFF THE CAR:

TUG! TUG! WHAT A JOB!

F = A Big Tensile Force!

SNAP!!

– What was that?!

WHAT'S THIS MISERABLE LITTLE PLASTIC SPINDLE DOING ON A 100 ft HOSE-REEL?!

Snapped like a carrot!

Think in terms of:

- *Force transmission paths*
- *Flowlines of force*
- *Uniform strength*

Also note excessive wear:

- *Bearing area too small*
- *High bearing loads*
- *No lubrication*

THE CAR

James Bond Feature

Procedure:

1. Turn on lights.

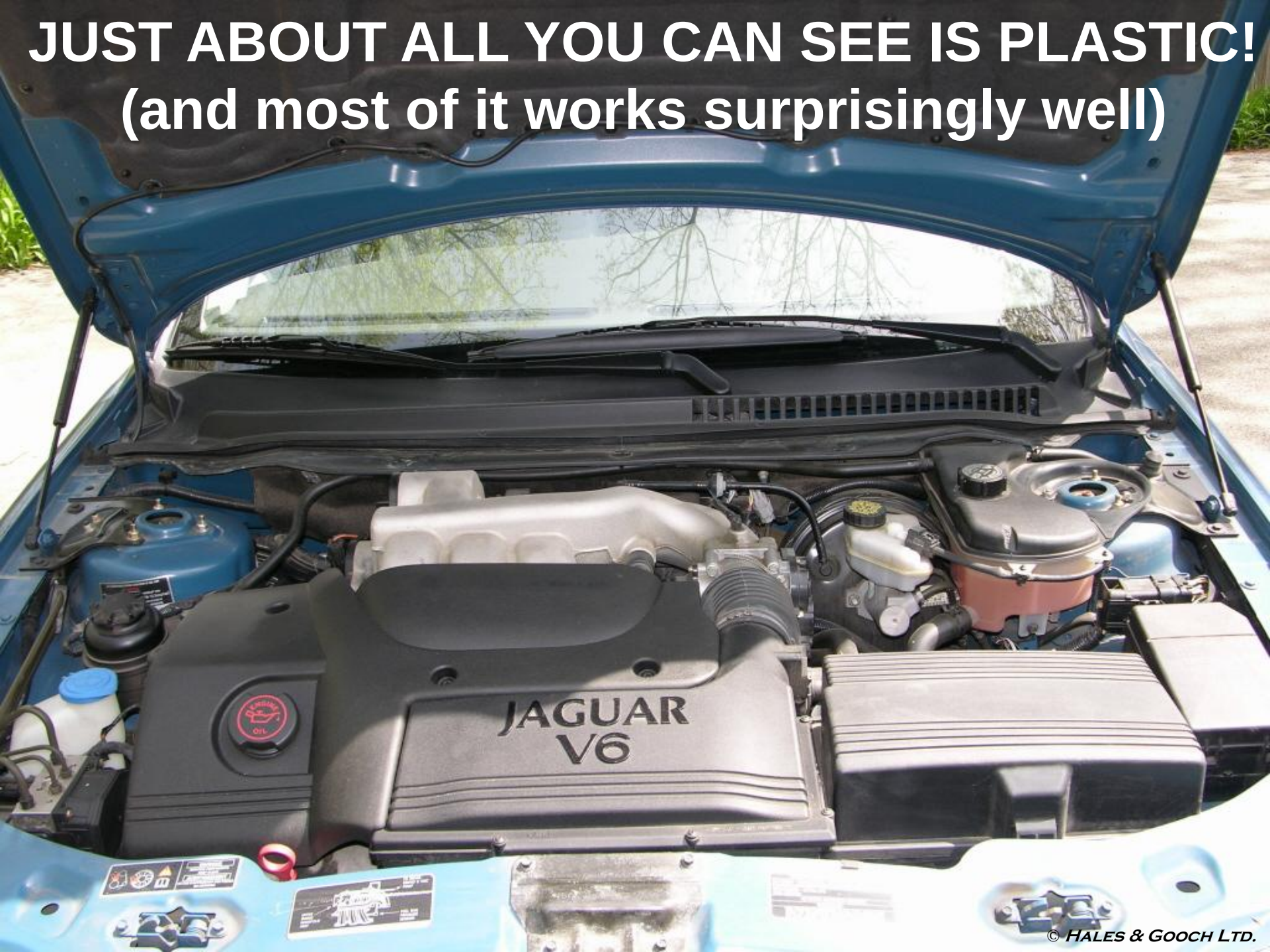
2. Squirt windshield four times.
3. Once more and then James Bond squirts the lights!

5. Squirters retract, blue cover **whacks** back, flies off and disappears!
7. Visit to dealer: ***"Hey look at this bullet hole."***
8. Blank plastic cover arrives in 2 weeks.
9. Paint cover blue with clear top coat.
10. Fit complete new squirter assembly.
11. Go back to Step 1 and repeat cycle!

JAMES BOND SQUIRTER

"One eighth of an inch diameter plastic gimbals against Chicago snow and ice in winter – you've got to be joking my old mate!"

JUST ABOUT ALL YOU CAN SEE IS PLASTIC!
(and most of it works surprisingly well)



SIMPLE FAILURES - BAD VIBES

- Screws, Fasteners and Joints
- Mechanical Springs
- Bearings
- Gears
- Shafts
- Clutches, Brakes and Couplings
- Flexible Mechanical Elements

Mechanical Engineering Design (Student Edition)
by Joseph E. Shigley, 1963

Part 2: Design and Selection of Mechanical Elements

FAN AND LIGHT UNIT

CRASH, SMASH IN THE MIDDLE OF THE NIGHT!!

– what the devil was that?!

Hello, the fan light cover has fallen out and smashed all over the floor! What a horrible mess, and where do you get another one?

Option 1: Call an electrician and pay $$$$ to throw out the whole unit and install a new one (which, given time, will fail in the same way).

Option 2: Waste yet another weekend fixing some blighter's screwed up plastic design.

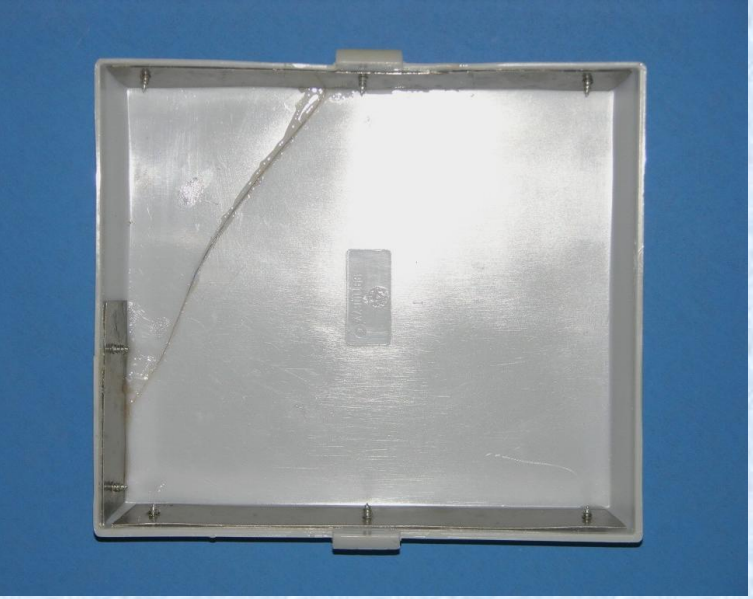
O.K. I'll fix the stupid thing, but there had better be wine with dinner!

Sod's Law

and

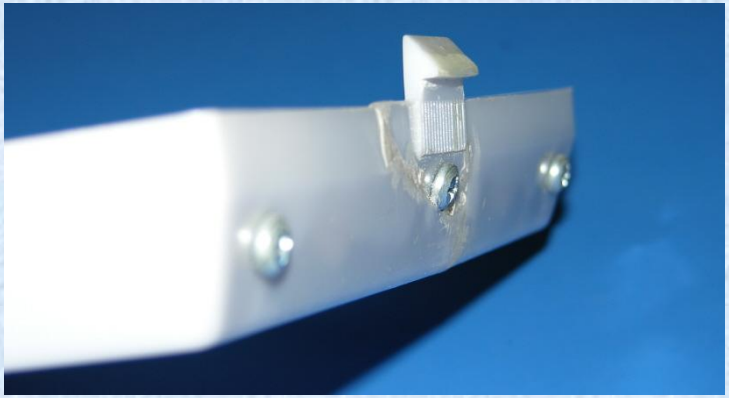
The Plastic Equation

Tabs + Thin Plastic + Heat + Time = Crash Smash



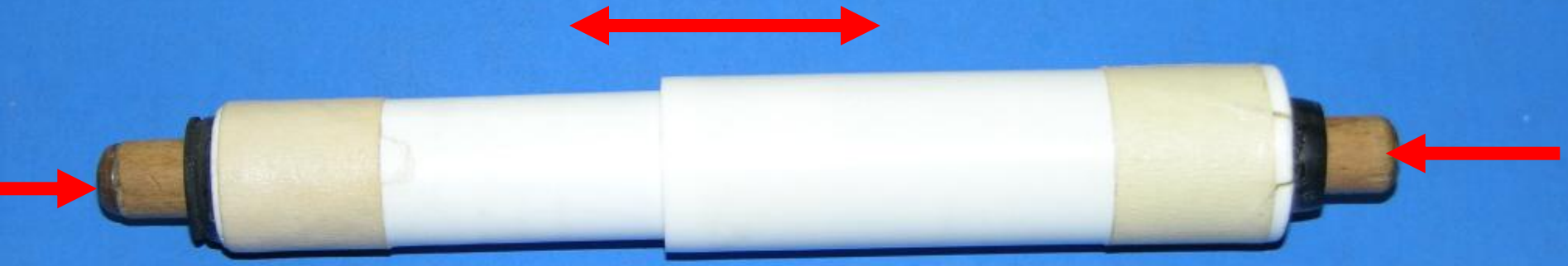
FIXING THE PROBLEM

1. Stainless steel bands bent to provide outward spring force and hold the bits together.
2. Epoxy glue to extend the tabs and fill the cracks.

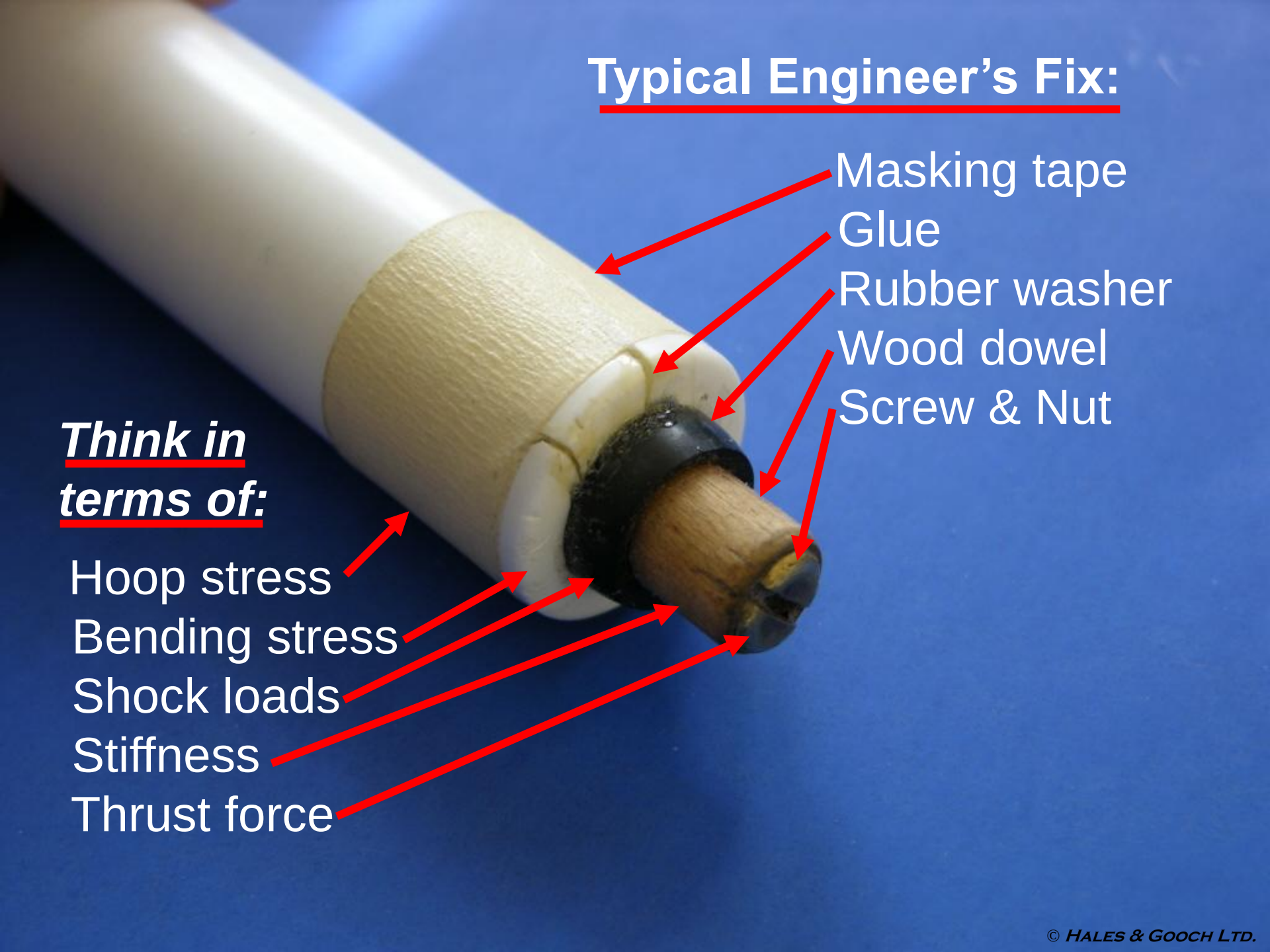


BUT THE AXLE BROKE!

Axial spring force inside pushes against **outer** rim of plastic ends.



Radially offset axial reaction forces on original plastic stubs cause diaphragming of ends and overload failure.



A VERY NEAT SHAVER - 1999

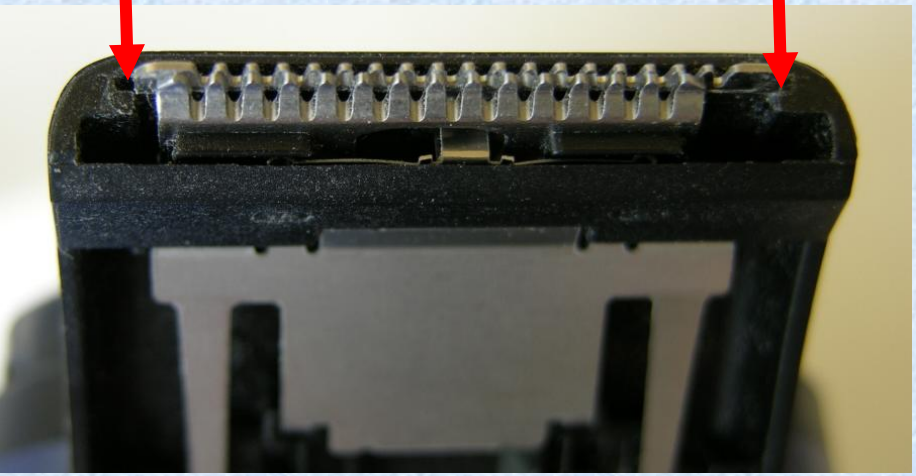
ATTENTION TO DETAIL

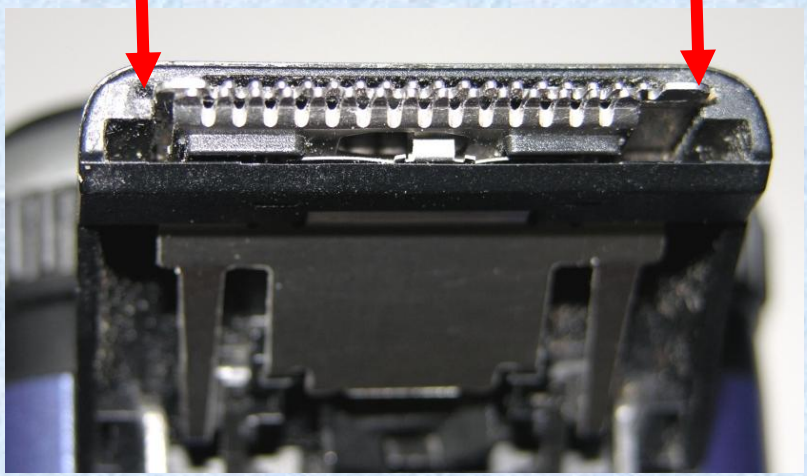
- Nice to hold
- Worked fine
- Compact unit
- Rechargeable
- Well-fitting case
- Would buy again

Only four problems:

- *Cutter bar clips broke*
- *Head cover tabs broke*
- *Sometimes switched on by itself inside case*
- *Had to discard when battery died after 6 yrs*

Cutter bar kept popping out - glued it in permanently!





AVAILABLE REPLACEMENTS IN 2006

All seem to have:

- Bulbous bodies
- Weird shapes
- Garish looks
- Clumsy cases
- More nibs & tabs!

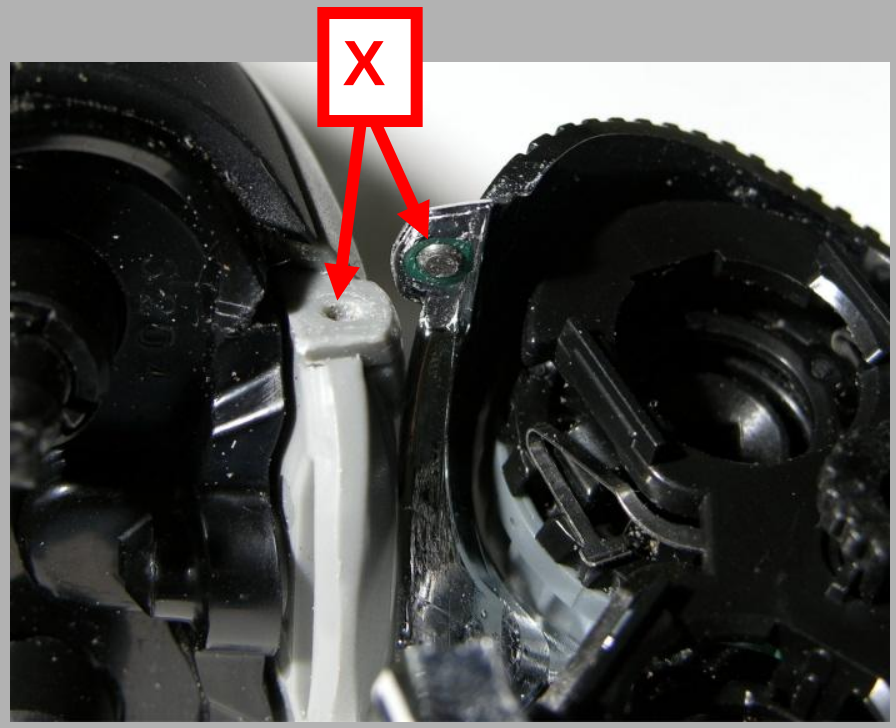
Oh no!

Even nibs as hinges now!

No good!

Don't do it!

Won't work!



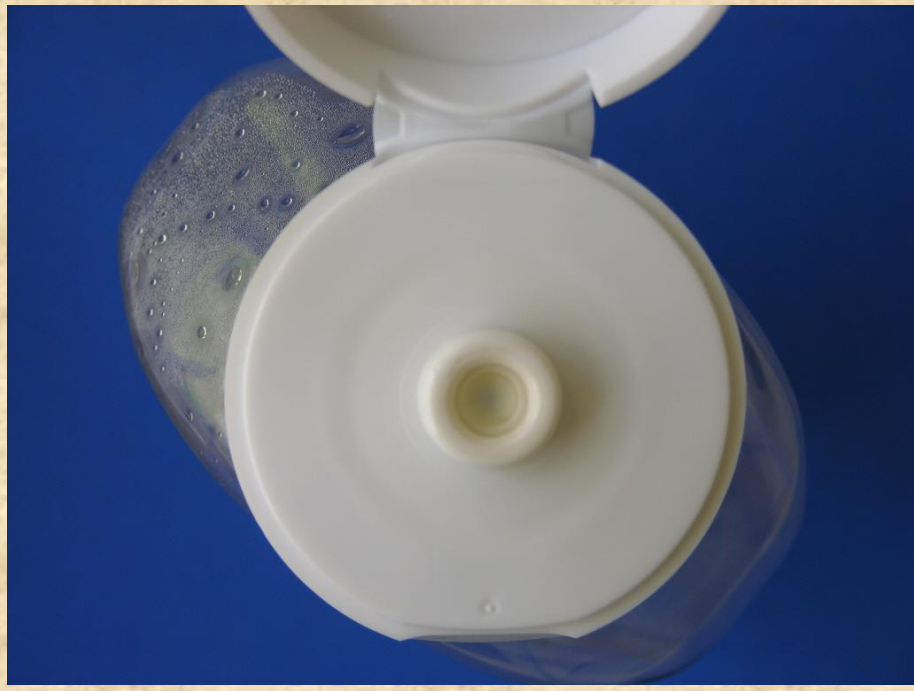
THE PLASTIC HINGE

Hinge failed before sauce was finished!

Thick plastic hinge bending in three directions – rapid failure.

DETAIL DESIGN CRITICAL

White top hinge – has similar geometry but thinner section and more flexible plastic – no failure during operational life.

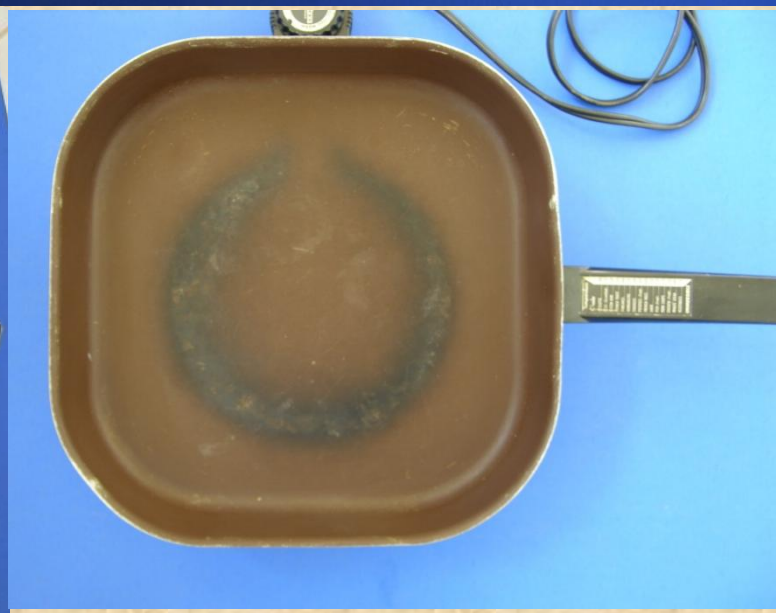


QUALITY DETAIL DESIGN SHOWS!

White cap also serves as a base, with “non-return” valve

ELECTRIC FRYING PAN
(over 35 years old)

Plastic leg broke off -
all else working fine



INVESTIGATION

Failure not in plastic but in resistance weld of threaded anchor to bottom of aluminum PTFE-coated pan!

Note problematic force path:
Resistance weld is loaded in ***tension,*** *when screw tightened to clamp the hollow plastic leg against underneath of pan.*

REPAIR OF FRYING PAN

Indented aluminum doubling plate accepts screw to attach threaded anchor, and high strength epoxy fixes plate to pan without damaging coating.

Note improved force transmission paths

THREADED CAP FAILURE

Detergent gums up the spout, making lid stick tight shut!

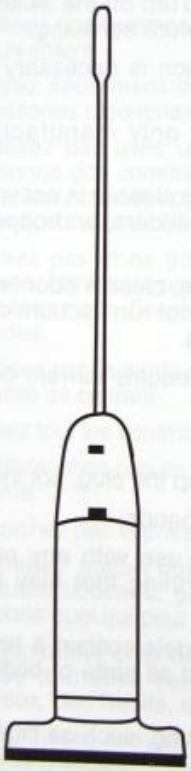
WHAT HAPPENS WHEN LID IS STUCK TIGHT?

Torsional failure when trying to open screw cap!

NOW HAVE NO CLOSURE AT ALL!

USEFUL VACUUM CLEANER

Note hollow plastic handle



Lightweight
Vacuum Cleaner
Household Type
Owner's Guide
160 Series

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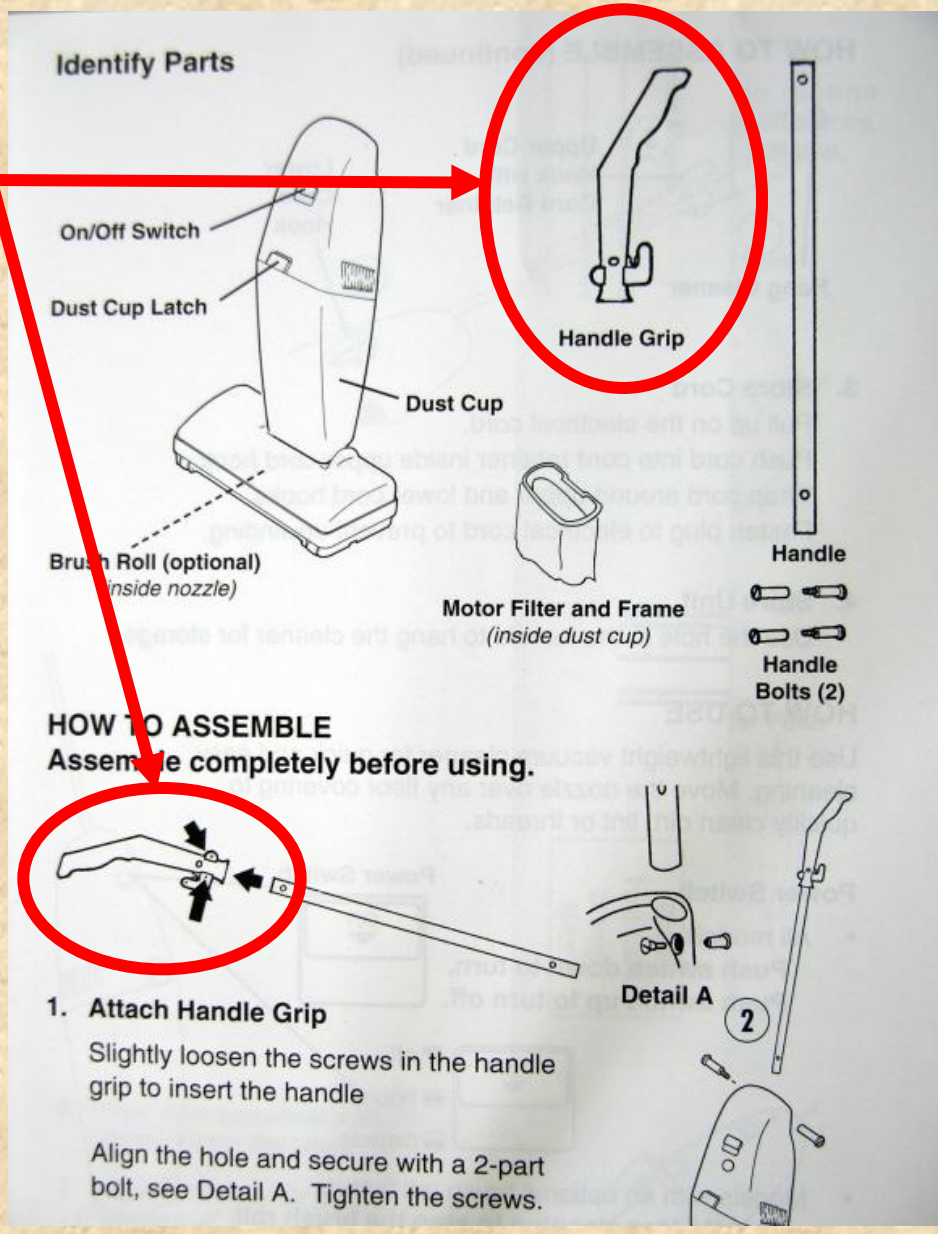
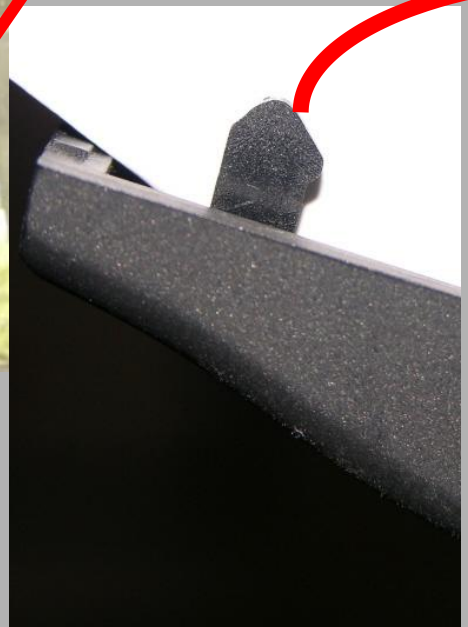


Snapped off like a carrot!

Note cantilevered bending with no reinforcement at point of maximum stress - fixed with a wooden dowel and a threaded file handle.

VIDEO MACHINE

Door swings down with plastic spring clips to hold up & closed.

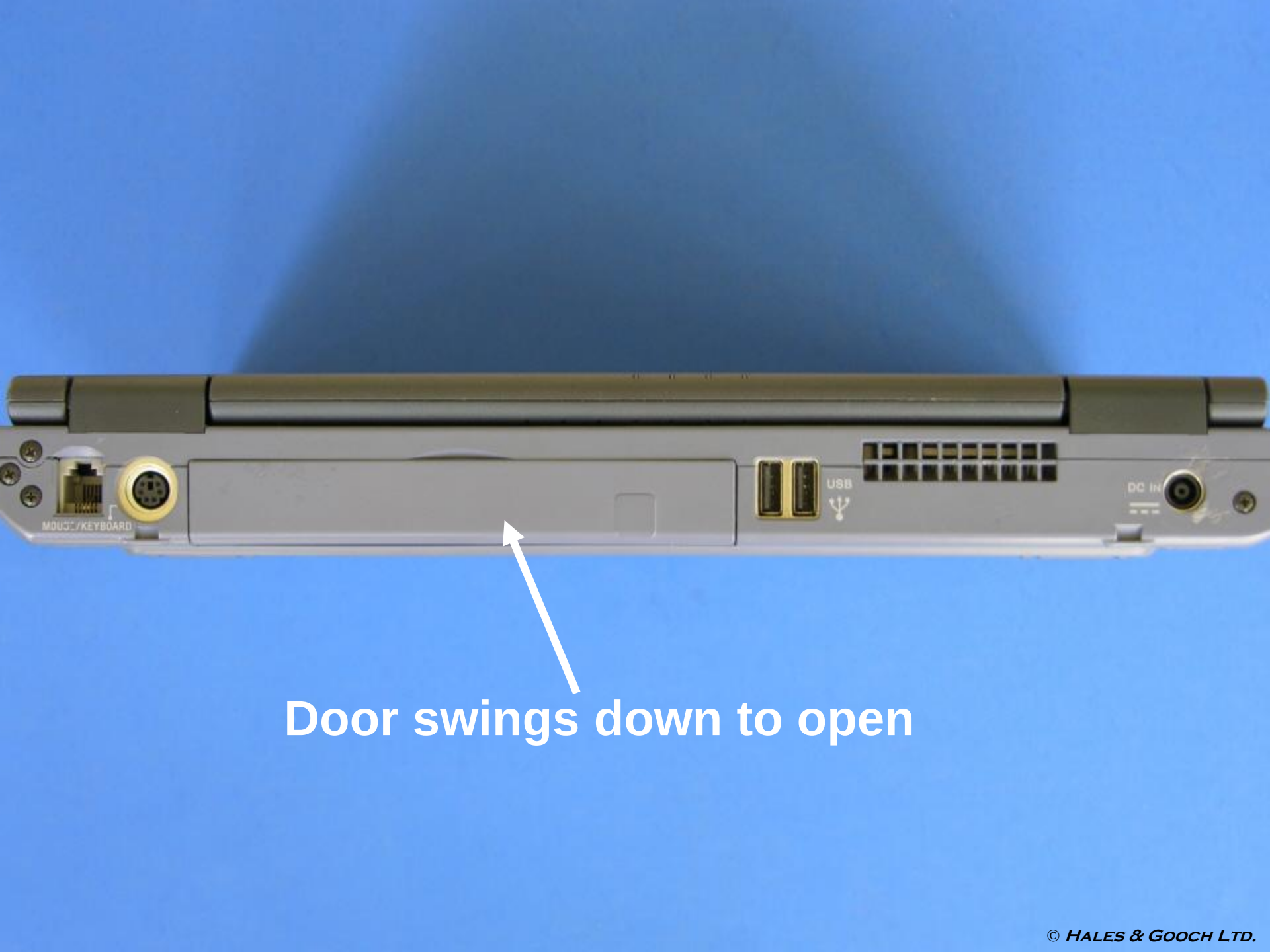


PLOP!

- and down she comes!

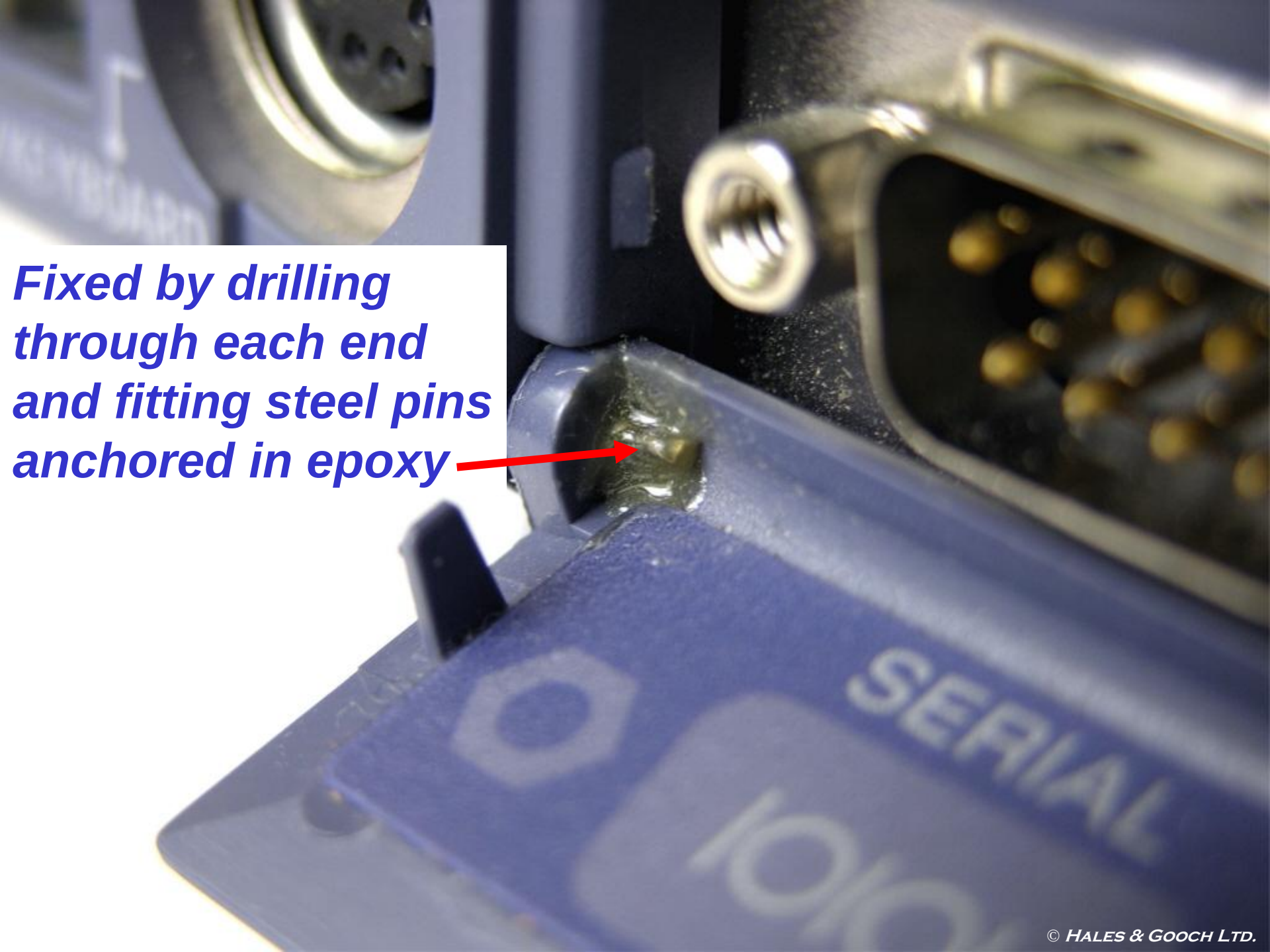
Plastic spring clips relaxed to point of failure to hold.

LAPTOP COMPUTER



Tiny plastic hinge nibs broke off and door fell out

Note high cantilevered bending load on nibs when molded in as stub axle hinge pins!



LARGE CAST OF CHARACTERS

Represents a lot of wasted personal time and energy, with unnecessary user aggravation!

A GREAT MILLENIUM PROJECT

Mt. Taranaki

LEN LYE
KINETIC SCULPTURE

New Plymouth:

Like a giant conductors baton,
Our Wind Wand, dances boldly,
in the Taranaki breeze,
giving true meaning...
'Composing Motion'

www.windwand.co.nz

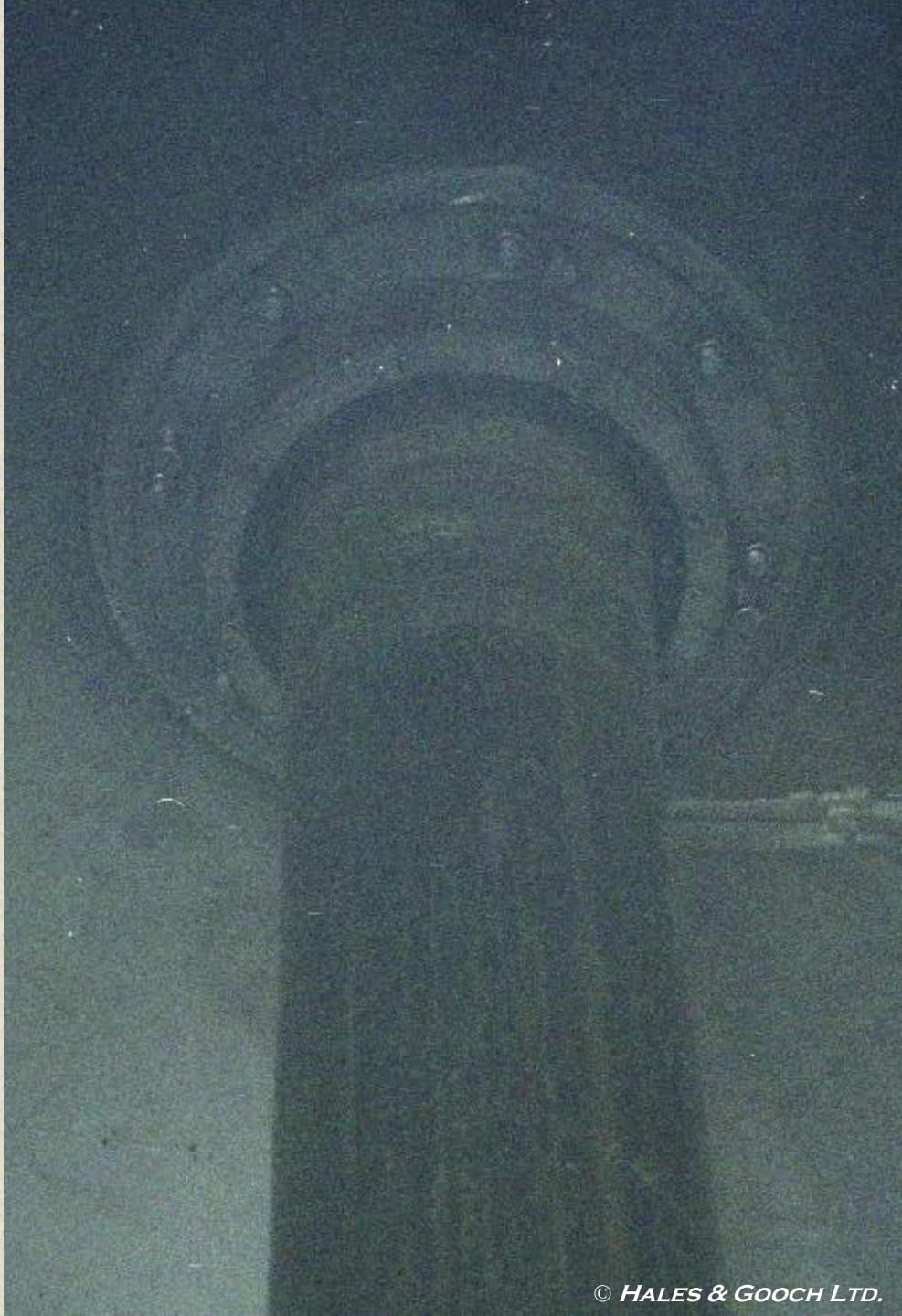
The Wind Wand was officially opened on 31 December 1999 for the millennium celebration. About a month later it was damaged in a storm and the Wind Wand was removed for repairs, returning on 5 July 2001 to mark the centenary of Len Lye's birth.

Courtesy of the New Plymouth District Council website: http://www.newplymouthnz.com

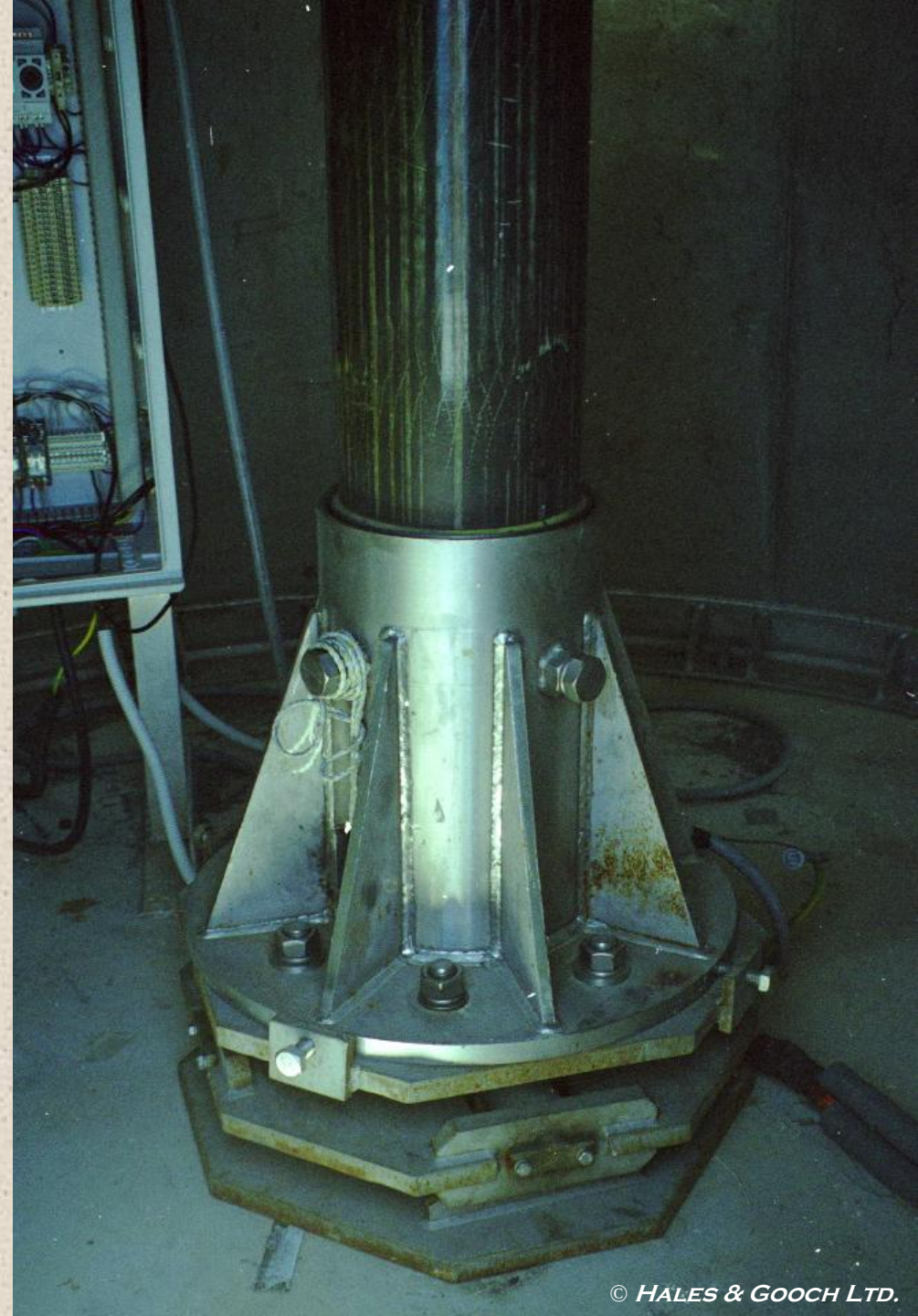
The Wind Wand is a carbon fiber reinforced tube, cylindrical on the outside and tapered on the inside, to meet the artist's demand for a uniform outside diameter and the engineering requirement for strength and weight optimization.

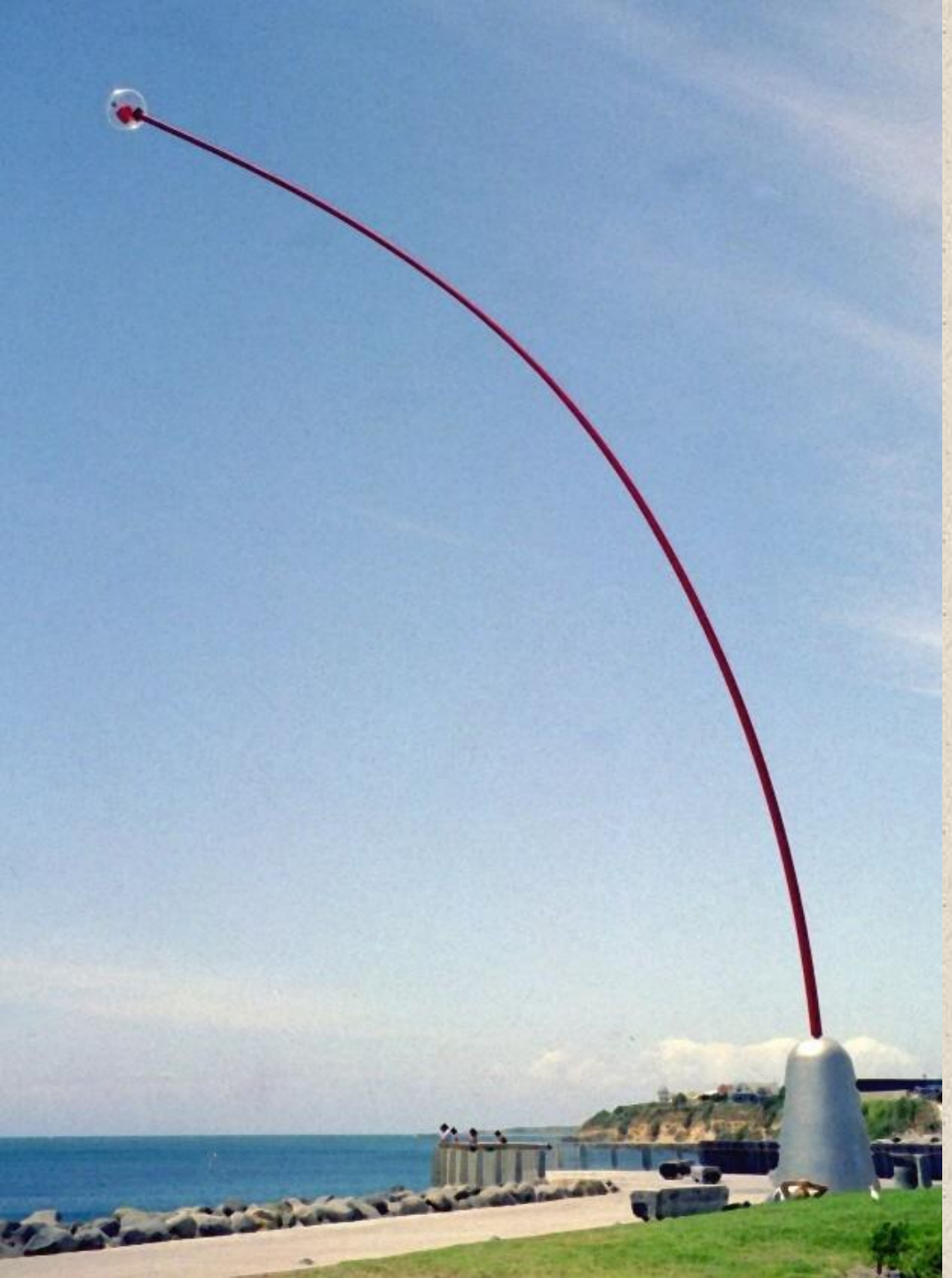
MODIFICATIONS AND REPAIRS INCLUDED:

- Strengthened tube.
- More constrained lighting system at top.
- Re-designed globe.
- Re-designed gland and bearing assembly.
- Changes to base plate and support assembly.



ADJUSTABLE SUPPORT AND BASE PLATE ASSEMBLY





New Plymouth now happy!

"A narrow red fibre glass tube, 200mm in diameter, the Wind Wand stands 45 metres high on the foreshore of New Plymouth. Weighing approximately 900kg, the Wind Wand can bend at least 20 metres. At night, a light at the top of the Wand emits a soft red glow."

www.windwand.co.nz

SOME ENGINEERING DESIGN TIPS FOR USE OF PLASTICS

- Visualize “flow lines” of force involved
- Think in terms of strength and bending
- Think about stresses and deflections
- Consider effect of distortion over time
- Consider aging effects of heat and light
- Consider embrittlement effects in winter
- Match materials to engineering needs
- Don’t use “nibs” for hinges and spindles!

THE LAST WORD

When in doubt
Make it stout
Out of stuff
You know about.

Quote from:
Profs. Emeritus Geza Kardos and Charles Smith
Rose-Hulman Institute of Technology/Carleton University Engineering Case Studies
http://civeng.carleton.ca/ECL/