

# ICONE-12

Washington, DC April 2004

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A follow-up to the author's ICONE-11 2003 paper  
*Fretting In Nuclear Steam Generators –A New Approach*

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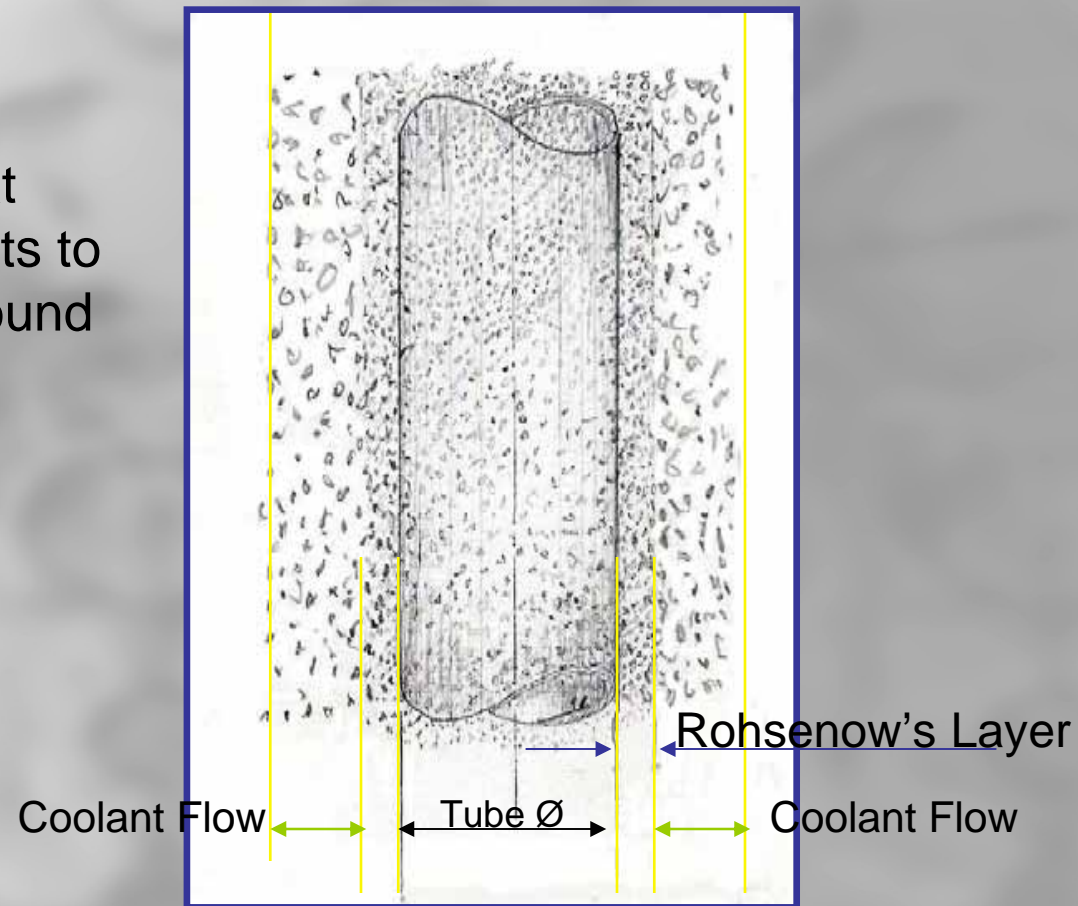
2003 paper #36443

2004 paper #49059

# The Role of Two-Phase Coolant Flow in Moderating Fretting in Nuclear Steam Generators

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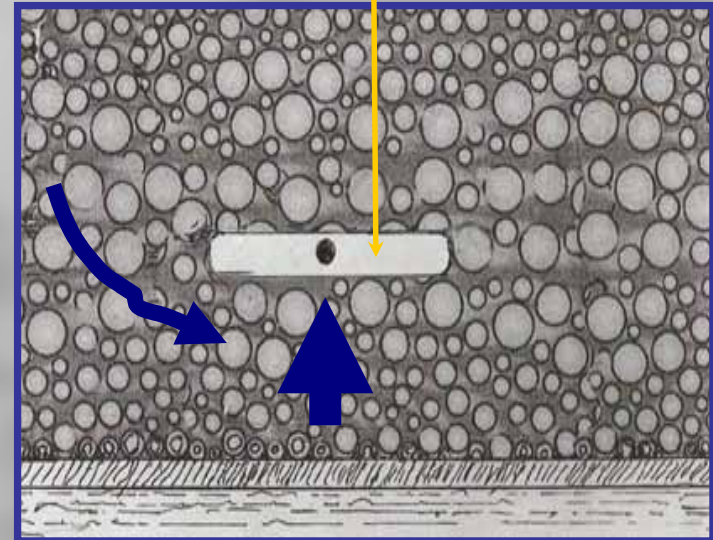
- A new theory suggesting that Rohsenow's Bubble layer acts to form a protective blanket around every tube as a 'spoiler'.
- It prevents the ABV from breaking through the bubble layer to cause tube failures.



# AVB Design with Wide Bar

- AVB should be wide enough to develop ample cushioning force between the parts
- AVB tube gap should be wide enough to allow  $T_{SAT}$  fluid to operate
- AVB should be thin to absorb some vibration energy.

Anti Vibration Bar

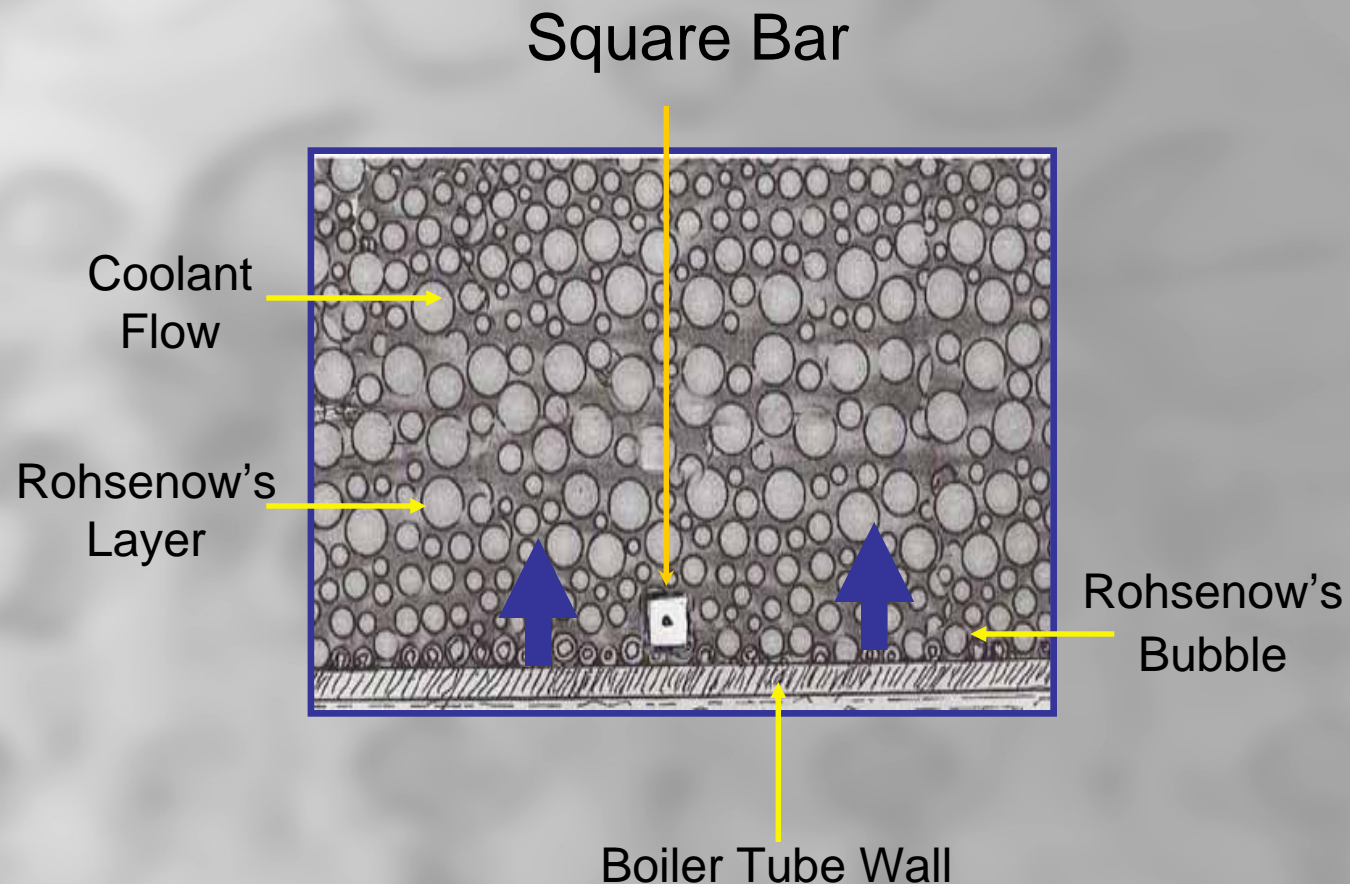




# Bubbles and their Effect on AVB Design

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- The square bar 'slips' through the bubble layer.
- A square AVB will penetrate Rohsenow's layer.

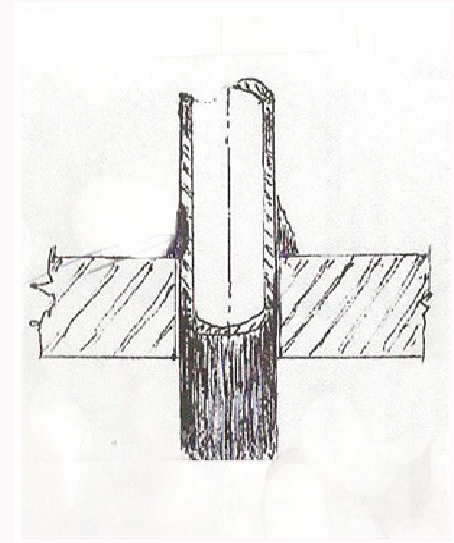


# Water Treatment caused changes in Design of AVB's

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Using co-ordinated phosphates additions caused:

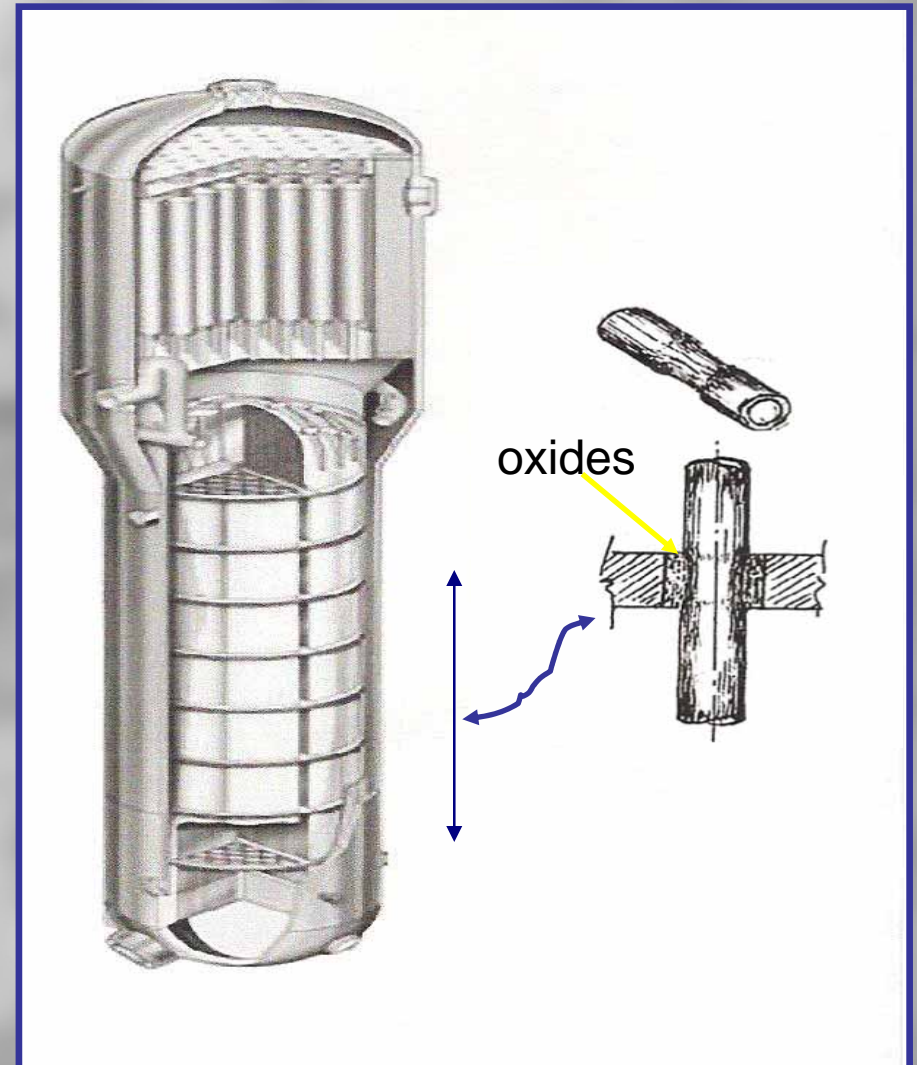
- Acid attack of the tube walls adjacent to sludge piles on the tube sheet plates.
- Because the water flows in Nuclear is so much higher than in Fossil Boilers, chemical cleaning became necessary earlier than expected.



# Changing to AVT changed the design requirements once more

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- The use of all volatile treatment (no solid additions) set up conditions where the carbon steel parts became unprotected.
- Slow growth oxides formed in the crevice of the TSP's.
- Tube crushed into an hour glass shape.
- This affected most N.A. Boilers.

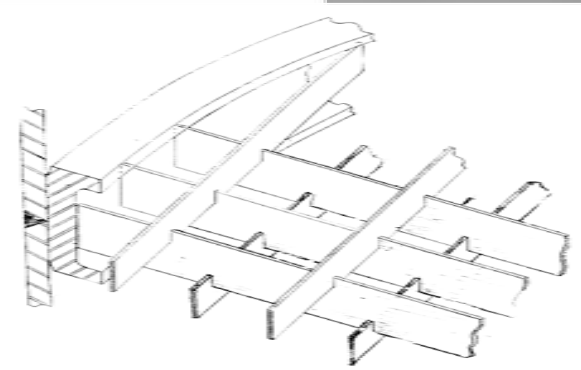
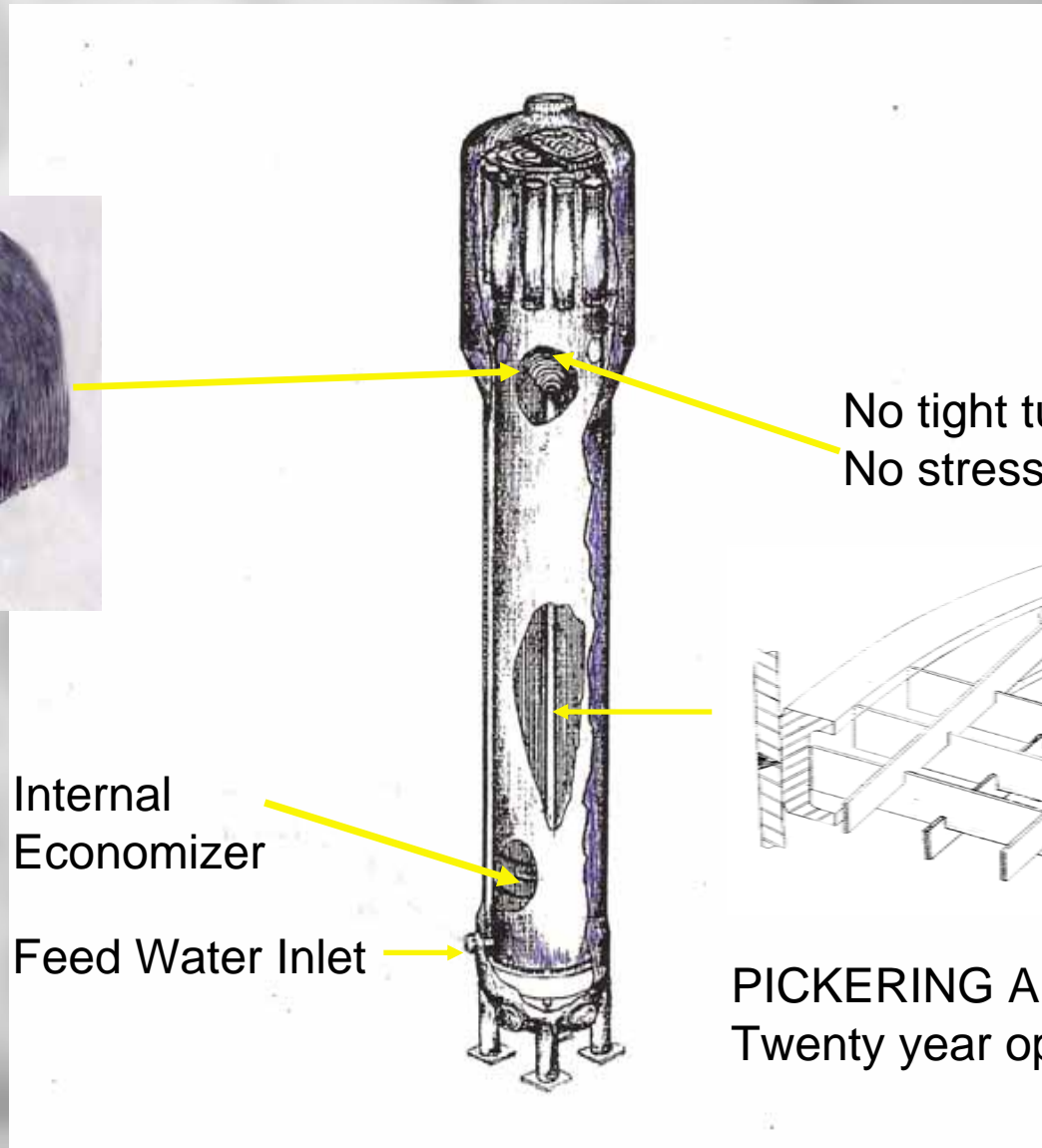
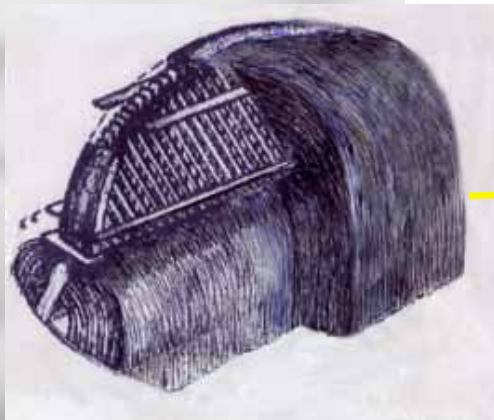




# Pickering A Nuclear Steam Generator

## B&W Ltd. Vertical Recirculating Boiler with Internal Economizer & Lattice Bars

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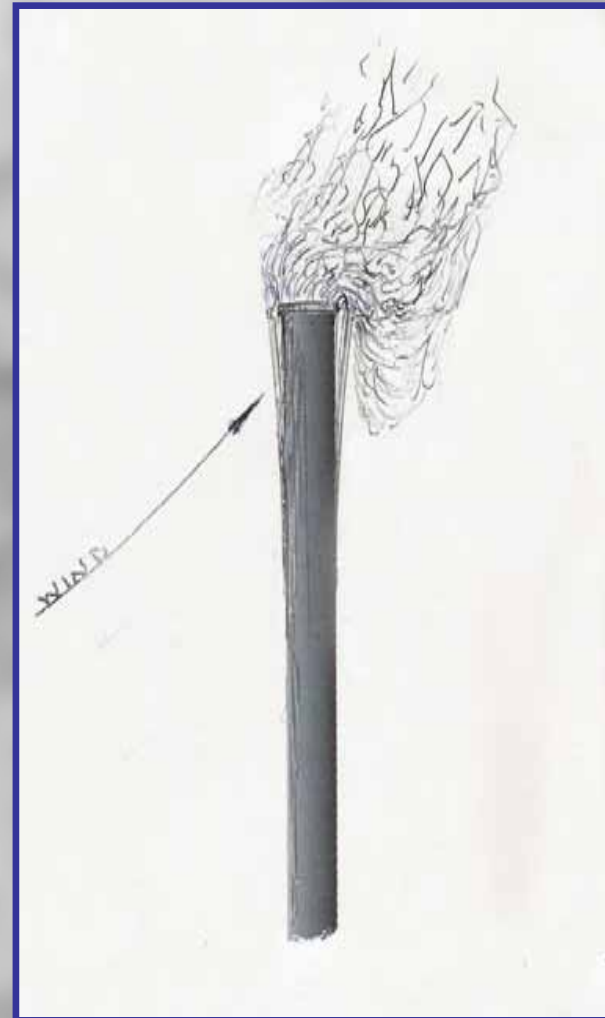


PICKERING A Straight Support  
Twenty year operation longevity

# Looking at Ideas from other Equipment - Smoke Stacks

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- Will vibrate to destruction in high winds if unsupported

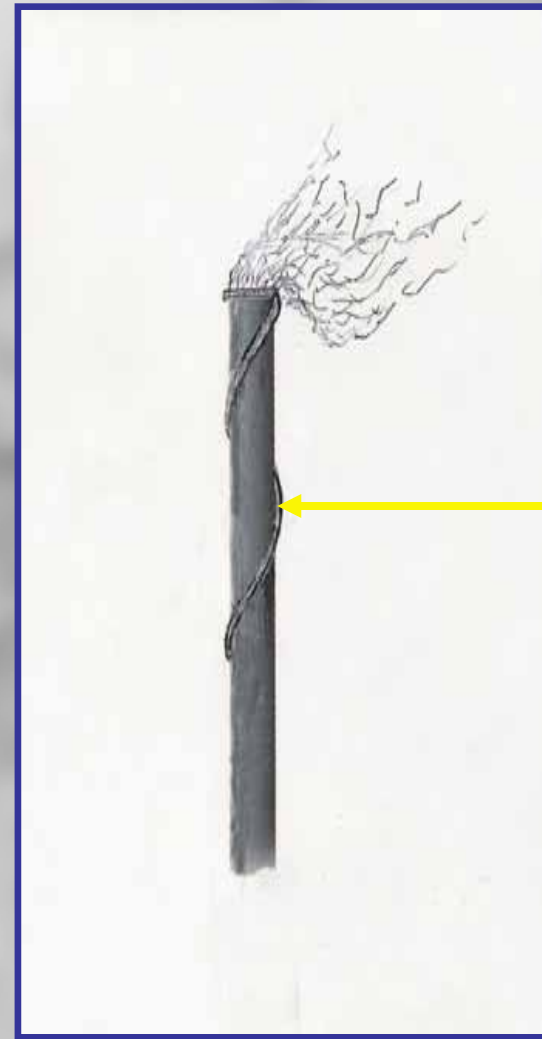




# Spoilers

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- 3" x 5/8" bar welded to the circumference of the stack, spiral shape.
- Spoilers break up the wind into two opposite and equal forces.
- Stack does not vibrate.

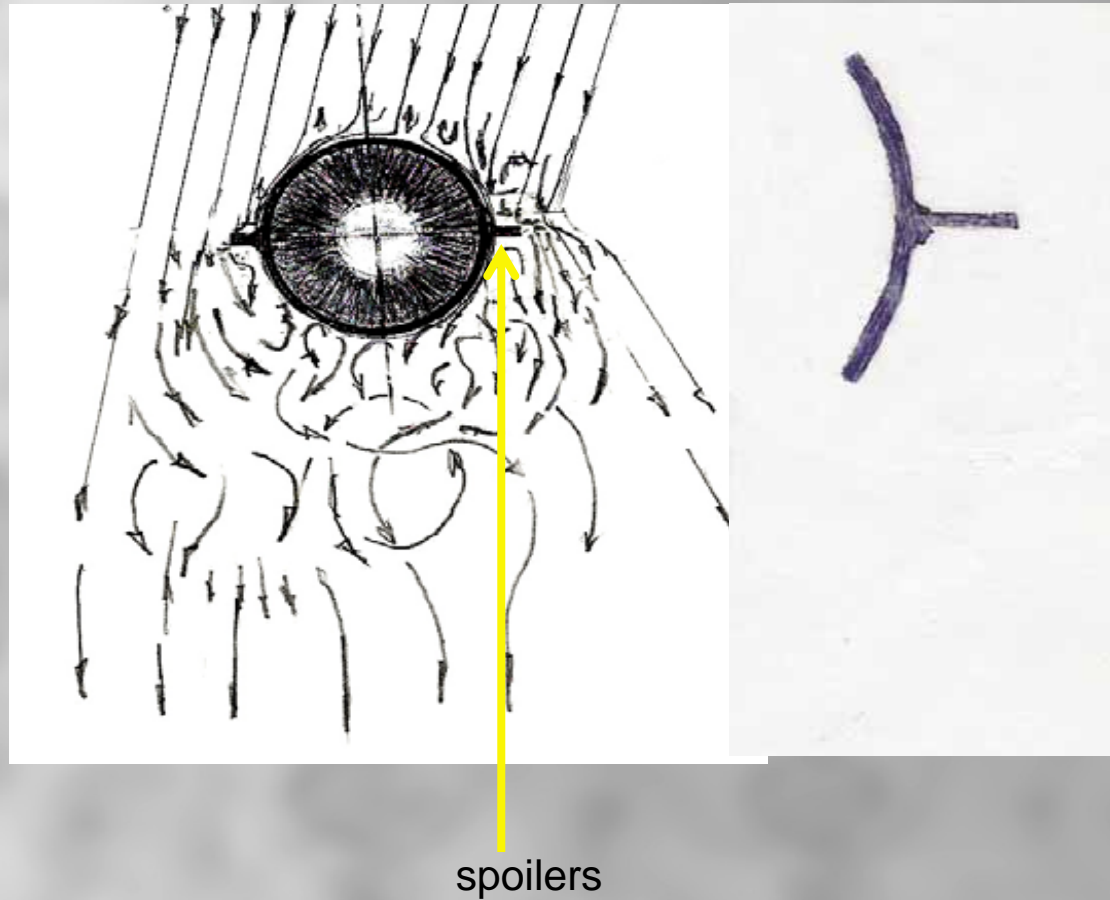


Spiral spoilers

# Top View of Steel Stack

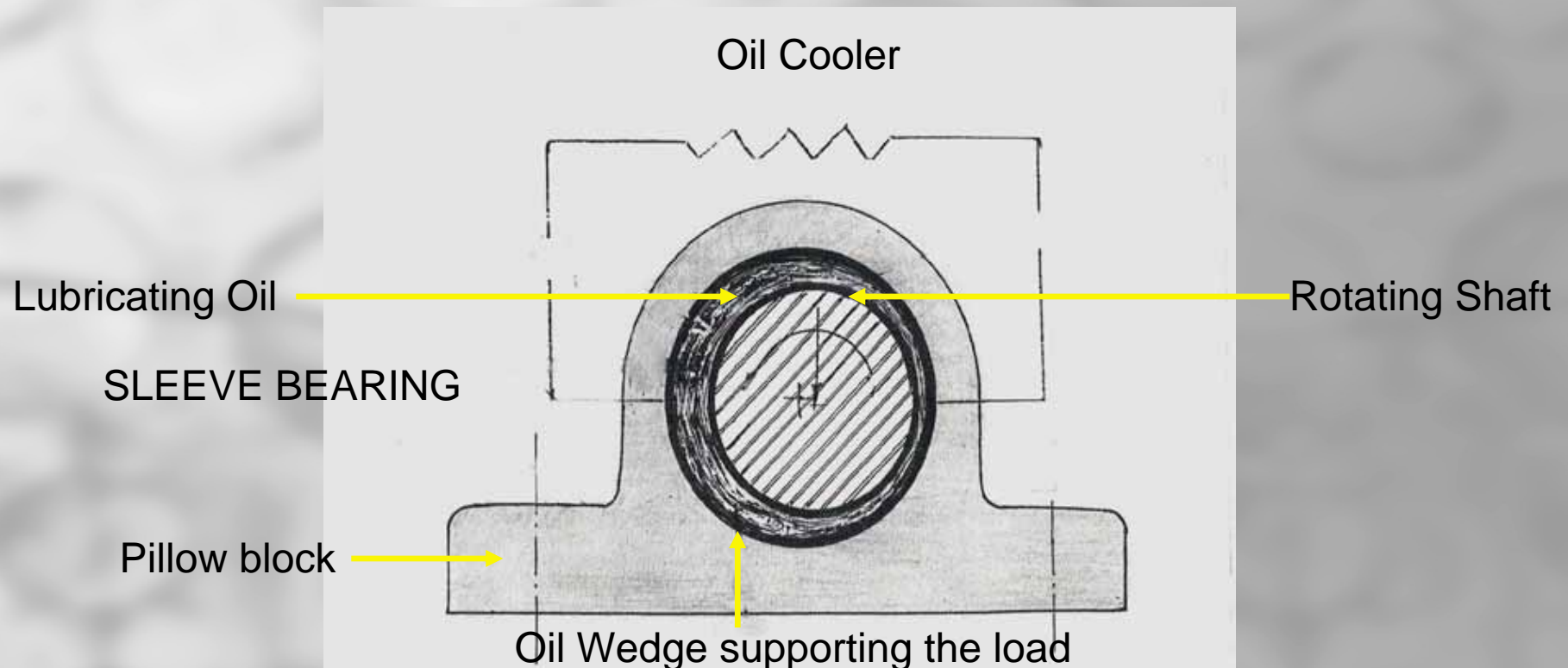
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- Effect of spoilers to stop vibrations from the wind's effects.



# The Importance of Proper Lubrication in Sleeve Bearings

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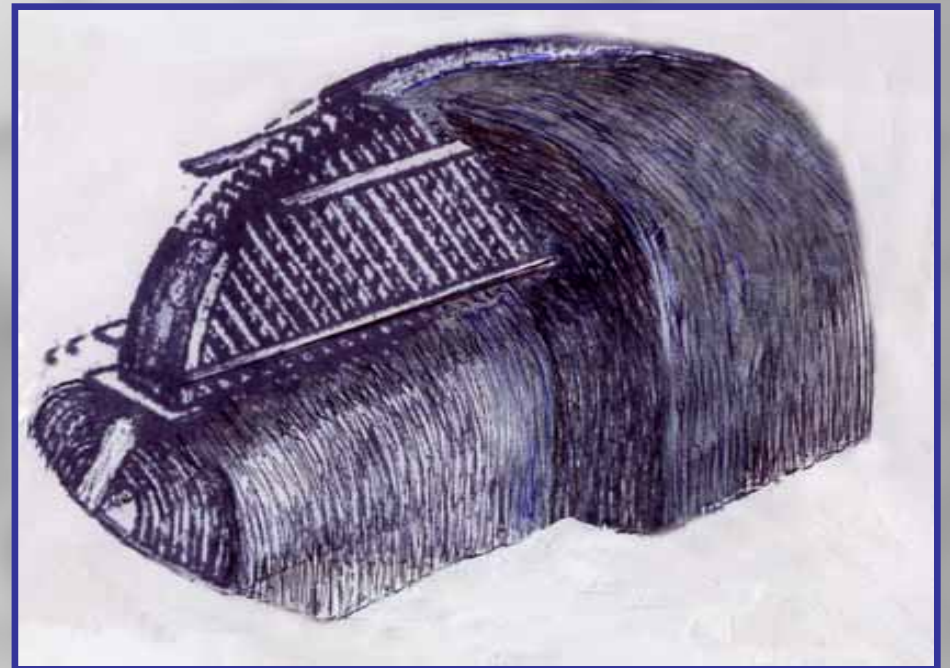
Oil wedge formed by the rotating shaft dragging the oil under the shaft supports the load.



# In Conclusion - 1

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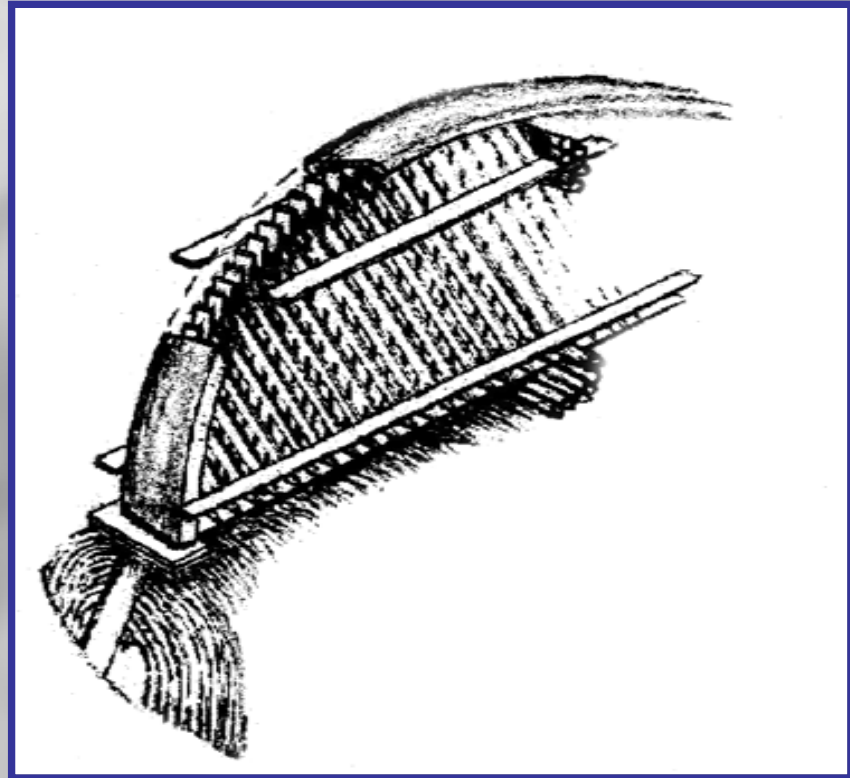
- This theory requires verification by an accredited laboratory.
- Pickering A design worked for 20 years.



# U Bend Design 2

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- The lattice bars freely float in the bubble streams and therefore do not fret.
- Operated for 20 years without fretting.

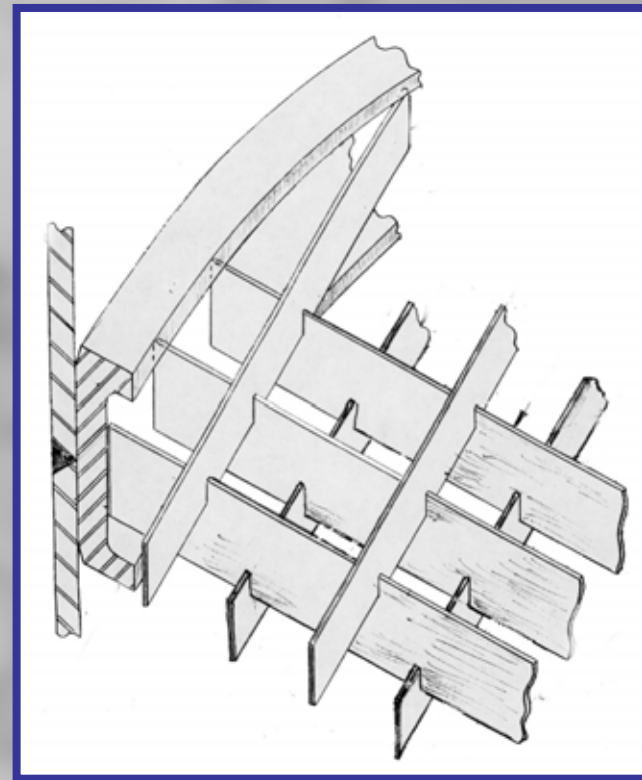


# Pickering A Tube Supports

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## Lattice Bar Design

- A new theory suggesting that Rohsenow's Bubble Layer acts to form a protective blanket around every tube as a 'spoiler'.
- It prevents the ABV from breaking through the bubble layer to react with the tubes wall and causes fretting.



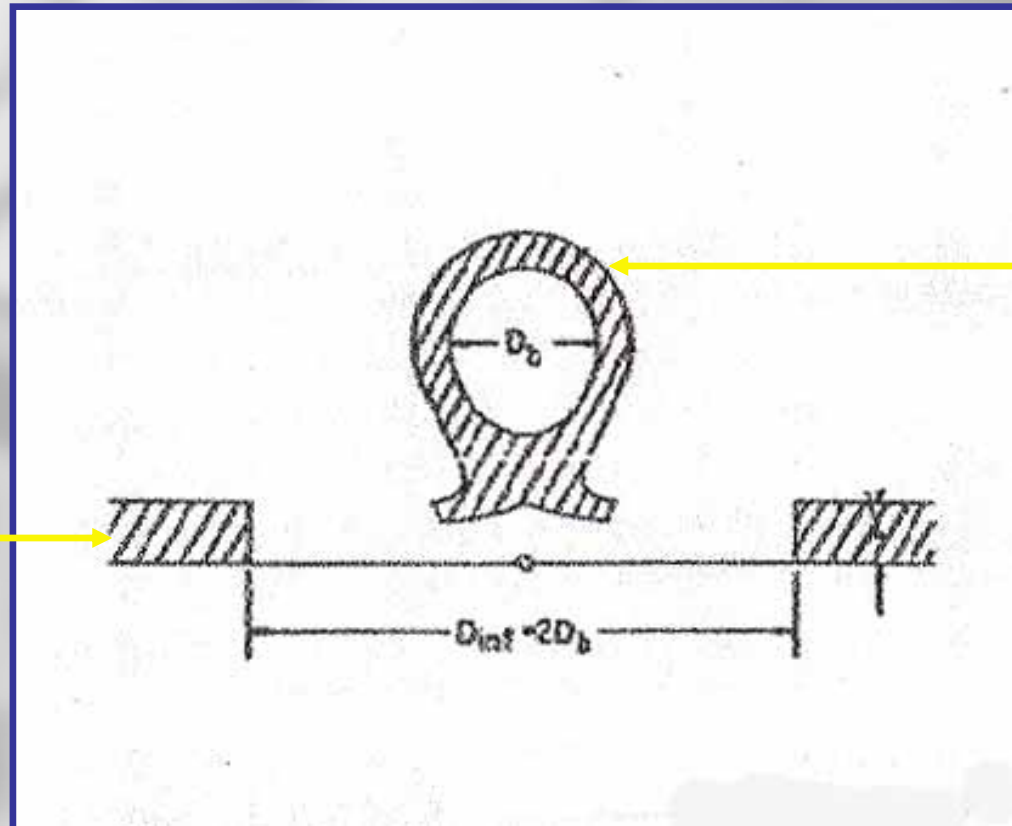
Pickering A Straight Tube Support  
Twenty year operation longevity



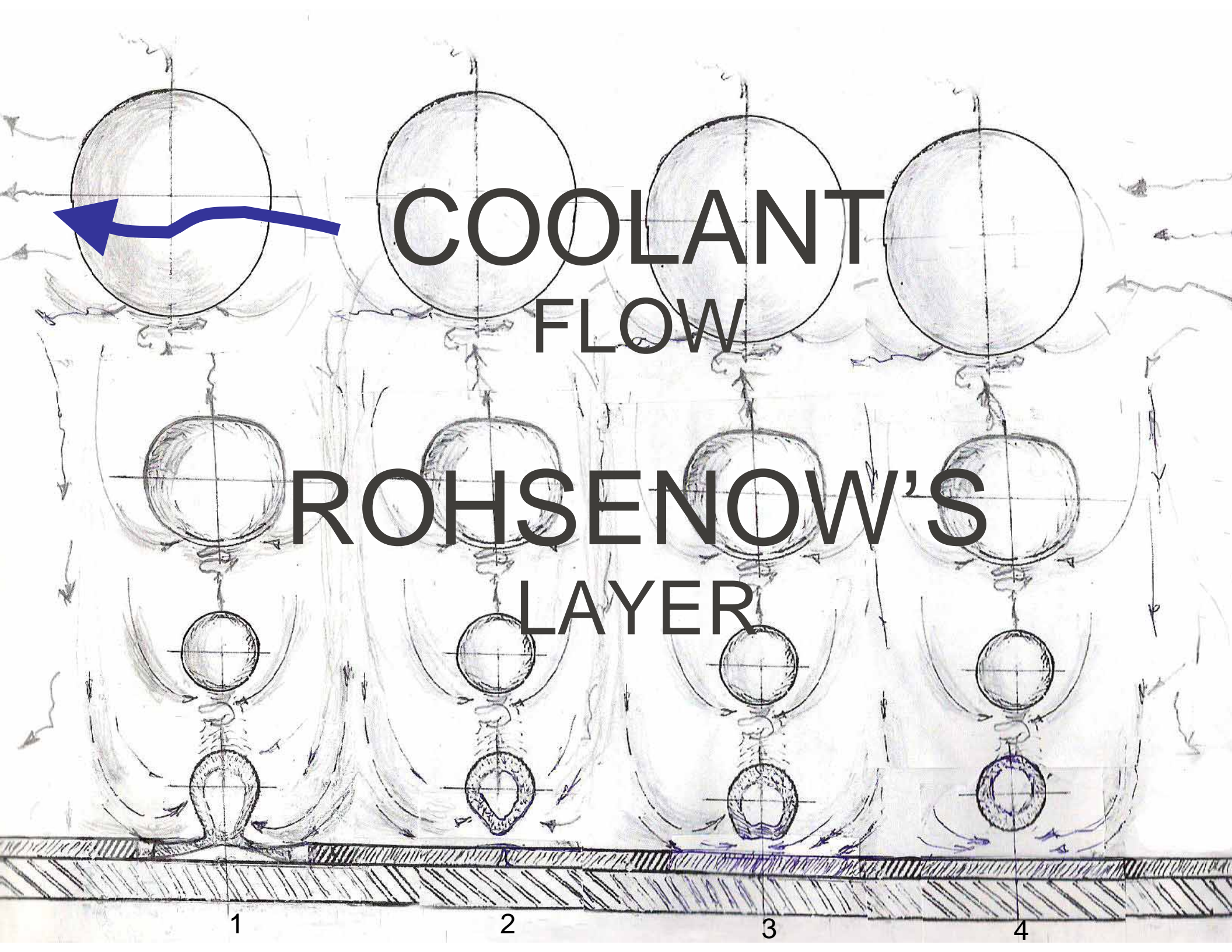
# Rohsenow's Bubble

## The Basis of the Theory

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Physical model of transient conduction mechanism



COOLANT  
FLOW

ROHSENOW'S  
LAYER