ENHANCEMENT OF CRYOGENIC POOL BOILING BY SURFACE MODIFICATION
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Introduction
- Cryogenic liquids are used for propulsion and other space-based applications
- Pool boiling is known to be a stable and efficient method of producing vapor and transferring large quantities of heat
- In spite of the many studies of cryogenic boiling conducted to date, considerable experimental uncertainty in the results persists
- Altering the texture of the surface is used to increase the rates of boiling and heat transfer

Experimental Test Setup
- Liquid nitrogen is employed given its similarity to liquid oxygen and the large database of existing results
- The experimental configuration consists of an insulated vessel 13.5 inches (34.3 cm) in diameter fitted with horizontal or vertical test specimens
- The test specimens are cylinders with smooth surfaces and regular grooves
- Heating is provided by embedded electrical heaters
- Temperatures are measured using copper-constantan thermocouples mounted inside and near surface

Comparison with Previous Studies of LN$_2$ Nucleate Boiling
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Nucleate Boiling Results
- Heat Transfer Coefficient:
  \[ h = q / (T_s - T_\infty) \]

Vertical Cylinder Test Result

Corrected results
- Experiments were conducted to evaluate the effects of surface modifications on the nucleate pool boiling of liquid nitrogen.
- Temperature probes, combined with the variable thermal conductivity of the solid, were used to calculate the heat flux at the surface.
- A grooved surface provided an increase on heat flux, as indicated by the heat transfer coefficient, of as much as a factor of roughly 16.
- A greater enhancement in heat transfer was seen for the case of horizontal cylinders than vertical ones.
- For the vertical cylinder, both the rate of heat transfer and the augmentation due to surface modification were larger at the higher vs. lower measurement location.
- Applying a correction for fin effectiveness suggests a slighter greater enhancement in heat flux than indicated by the temperature measurements alone.

Summary and Conclusions
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Reference: