The Strength of Conductors at High Temperatures and High Strain Rates

J. R. J. Bennett

Introduction

High power targets for pulsed particle beams frequently have to dissipate high energy densities. This can produce temperature jumps in the target material that are so rapid that stress waves are produced which can exceed the strength of the material.

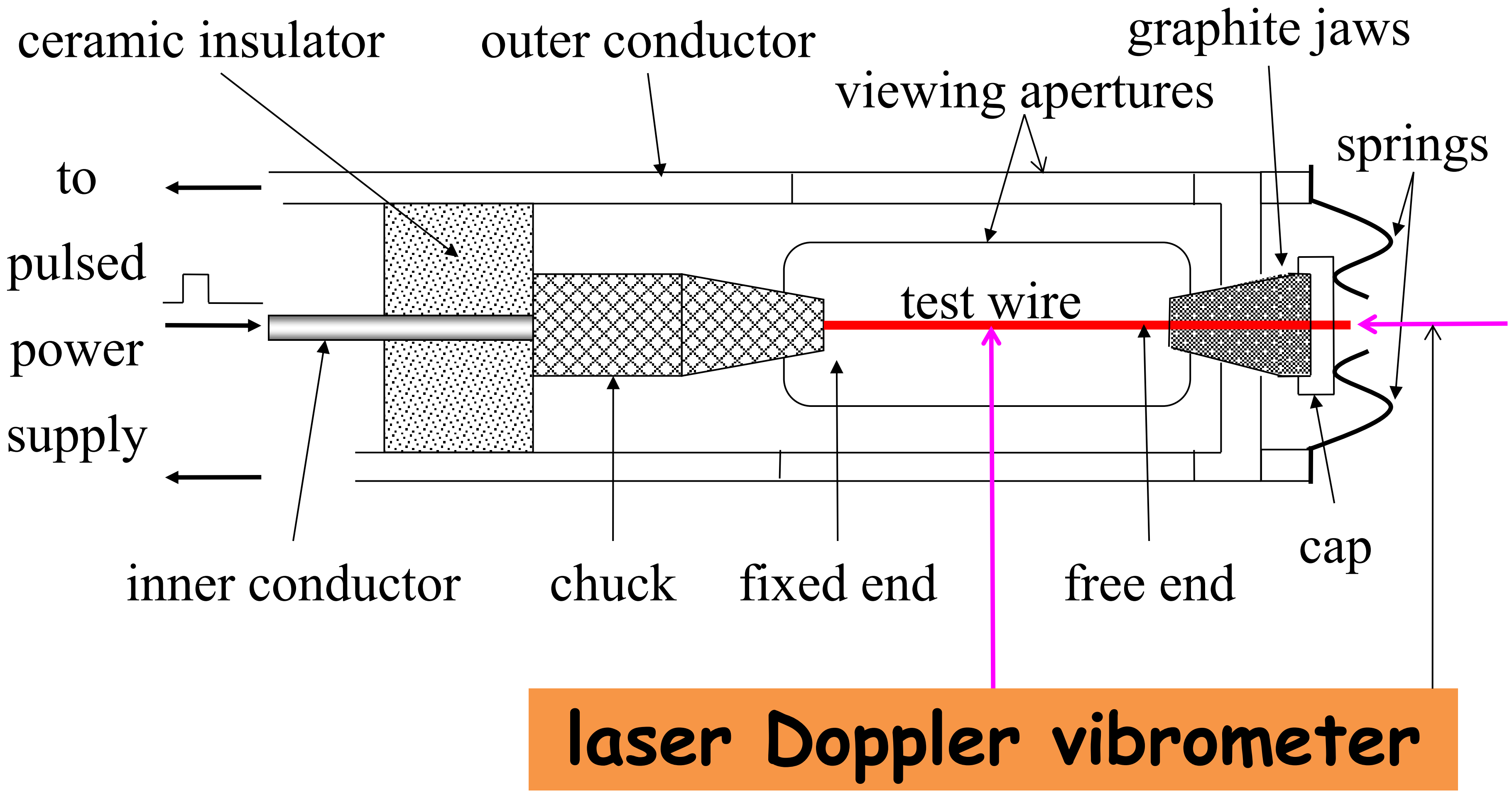
Because of the high strain rate (>10^3 s^{-1}) the breaking stress is enhanced above the value that is commonly measured using quasi-static or slow strain rate methods. Hence it is necessary to measure the breaking stress at high strain rates and temperatures.

The usual method of measuring at high strain rates is by Hopkinson bar. However this is limited for practical reasons to temperatures below ~1000°C.

The “Little Wire Method”

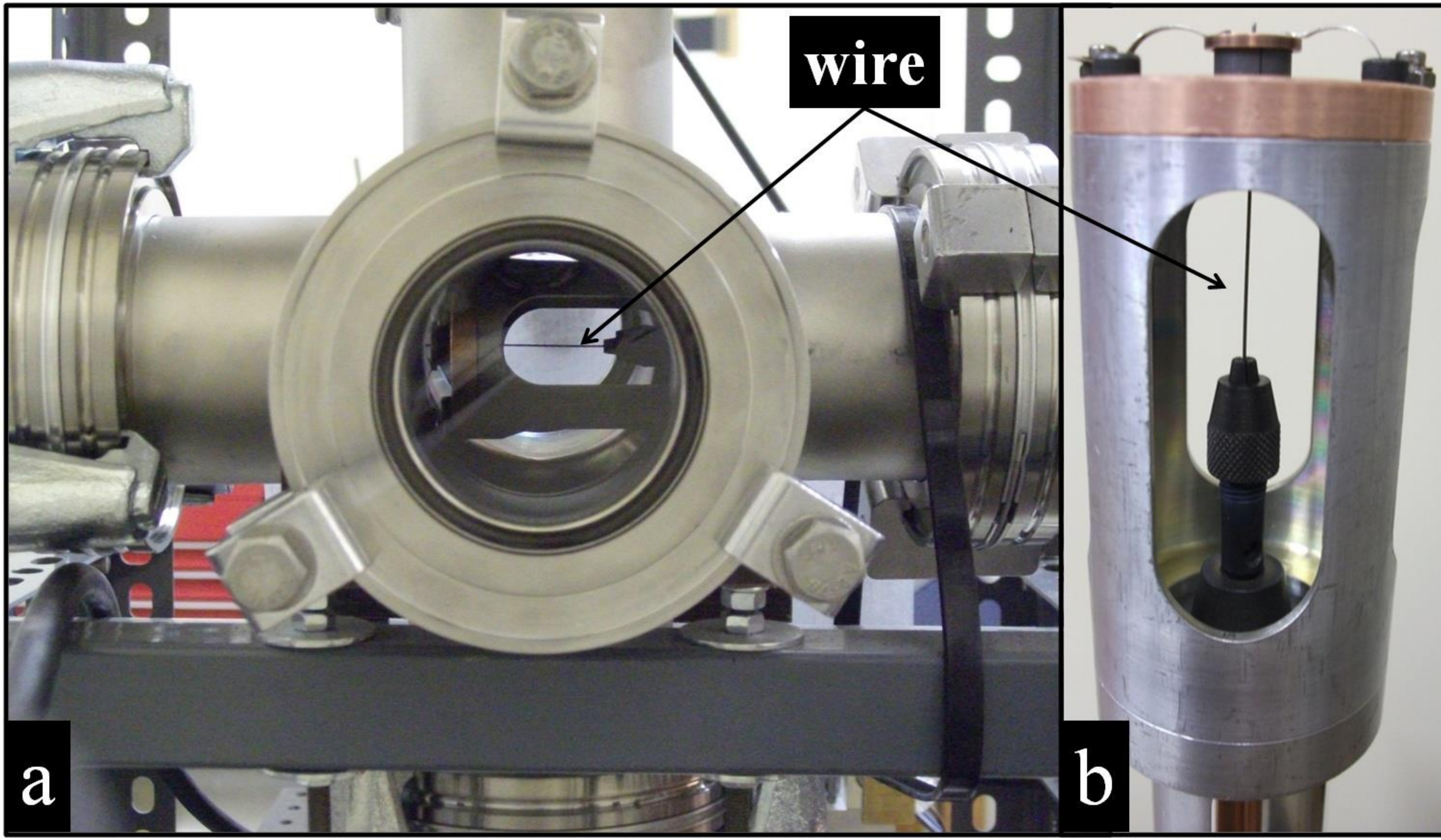
We (Bennett, Skoro et al) have developed a technique to measure the strength of materials by passing a short high current pulse (using the spare ISIS kicker magnet power supply) through a thin wire at high temperature.

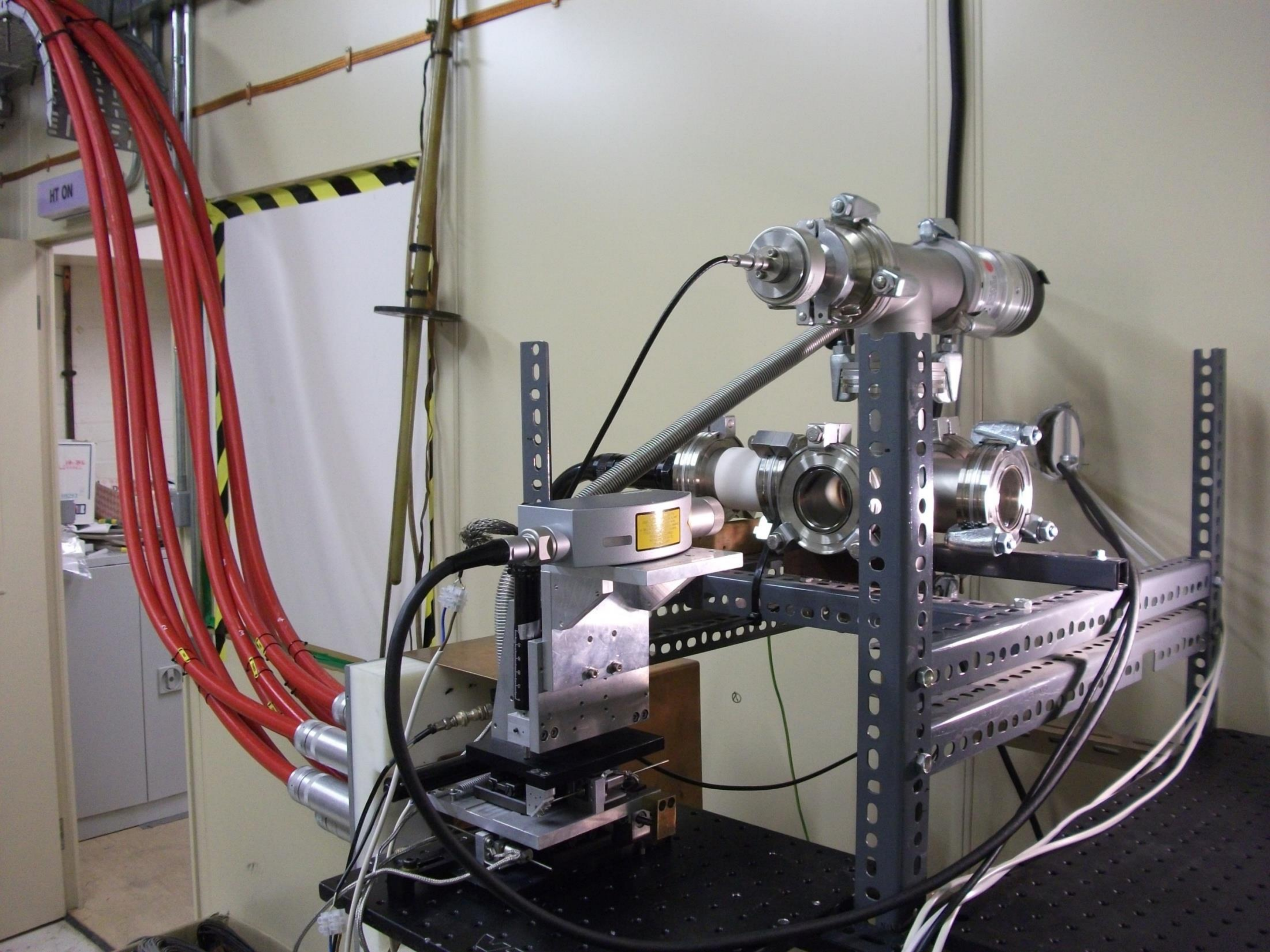
We have measured the strength of tungsten, tantalum and molybdenum at temperatures above ~1000°C.



Schematic diagram of “The Little Wire”

"The Little Wire" Equipment

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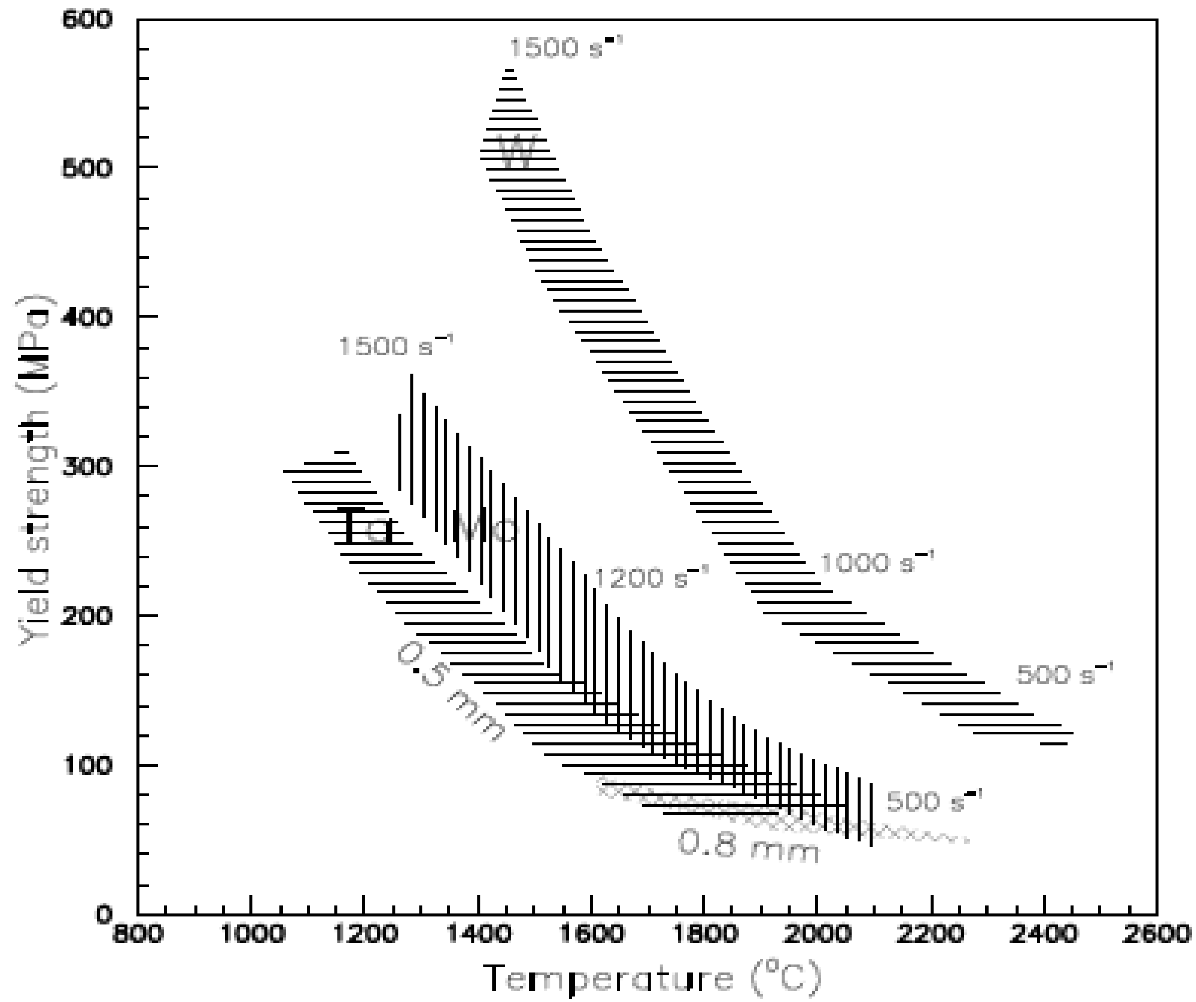


Figure 2. The yield strength versus peak temperature for tantalum wires of 0.5 and 0.8 mm diameter [5], for tungsten wires of 0.5 mm diameter [5] and for molybdenum wires of 0.5 mm diameter. The upper edge of the bands indicates the stress at which the wire started to bend and the lower edge indicates the stress where the wire was not deformed. The characteristic strain rate values are also shown.

Future Plans

1. Extend the measurements to other high temperature metals, including iridium and beryllium (not easy) for which there have been requests by CERN and FNAL.
2. Extend the temperature range to lower temperatures, for which a new power supply will be required to produce the required stress.

and now for something entirely different

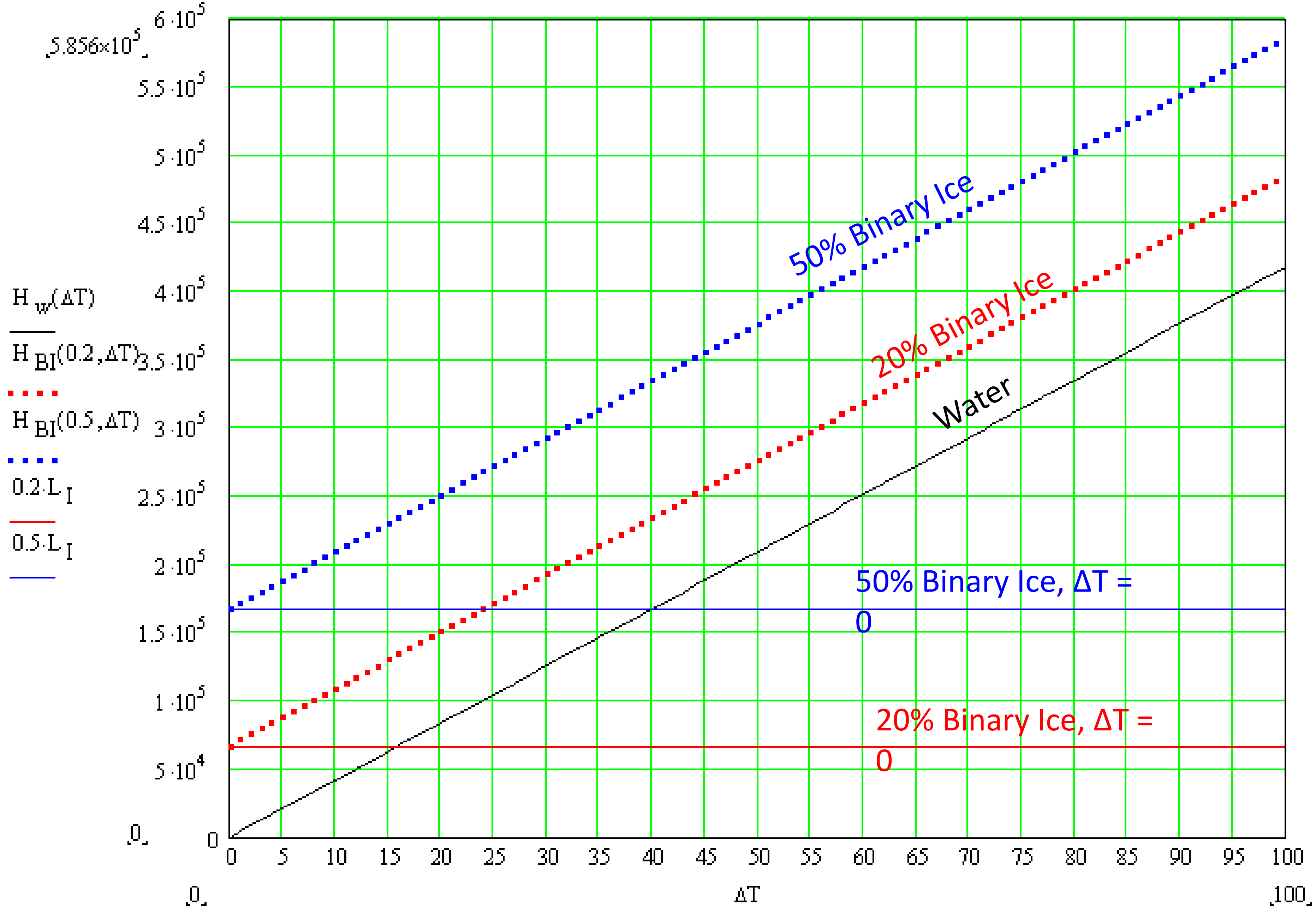
Binary Ice Cooling

J. R. J. Bennett and T. R. Edgecock

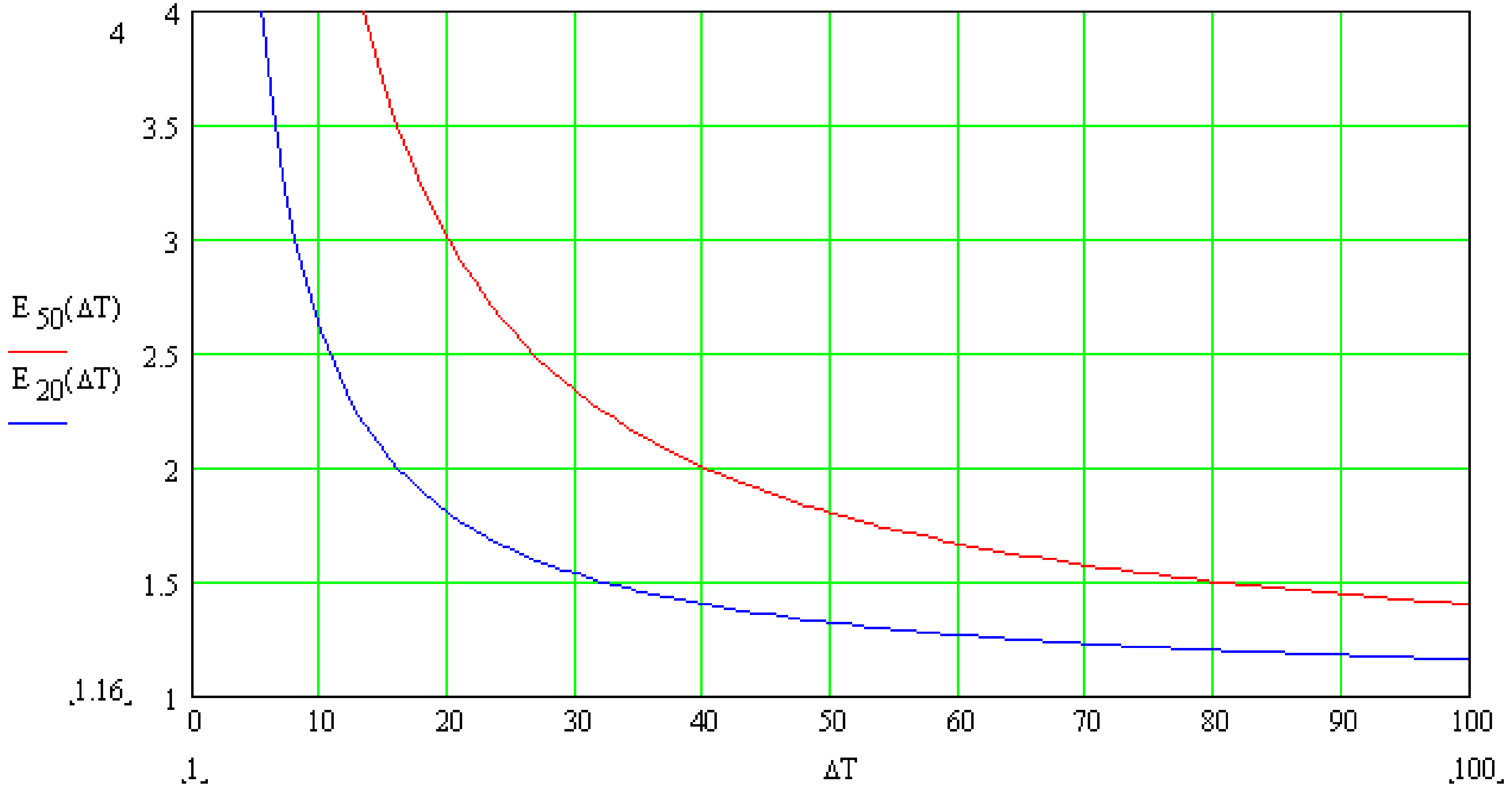
Slush Ice, Slurry Ice, Pumpable Ice or Binary Ice

-Is a mixture of fine ice particles in water (Bingham Plastic).
-A small amount of antifreeze is added to prevent the water from freezing.
-Usually the ice fraction is 20% of the mixture and the temperature is ~-2°C.
-It is used in the rapid cooling of foodstuffs, mainly fish, large refrigeration plants and many other uses.

The advantage of Binary Ice is the use of the Latent Heat of Melting, $L = 334\ kJ\ kg^{-1}$. This can be compare to the specific heat of water $S = 4.2\ kJ\ kg^{-1}\ K^{-1}$.
The next slides show the advantage of Binary Ice over water.



Heat Capacities (J) versus Temperature Rise, K.



The Ratio of Heat Capacity of Binary Ice to Water versus Temperature Rise, K.

We are in the process of purchasing a **Binary Ice Machine.**

It will be used to

- test the cooling of targets, particularly where the temperature rise is limited, e.g. lithium targets.
- Cooling of magnets which are near the limit with conventional water cooling.

In addition we want to understand the Binary Ice phase change rate. In a test with an immersed jet cooling system there appeared to be no advantage of Binary Ice over water (taking account of the relative temperatures).