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LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA ENGINEERING NOTE		CODE MD1141	SERIAL M5563	PAGE 1 of 2
AUTHOR R Warren	DEPARTMENT Mechanical	LOCATION Berkeley	DATE 14 Aug 80	
PROGRAM — PROJECT — JOB HIGH Field Magnet Development				
TESTING FACILITIES				
TITLE 1.8 K MAGNET TEST FACILITY - MODIFICATION FOR 7000 A				

SUMMARY

The magnet current leads in the helium II cryostat are sealed in a teflon gland in the region between the two reservoirs. The length of this gland is approximately 2 inches. Since this length of conductor is not in contact with the helium it must be cooled by conduction along it's length. Furthermore, we require that the leads in this region be cryogenically stable, ie, that the leads not exceed the superconductor transition temperature while carrying all of the current in the copper. It is found that by inserting a Nb_3Sn ribbon in the sealed region along with four 18-C conductors that this criteria is satisfied with 7000 A carried in the copper. Under this condition the temperature at the center of the sealed region rises to 13 K. Fins are required at either end of the sealed length to transfer the I^2R heating into the helium. One circular fin of 1.6 inch diameter or two of 1.2" dia. are required each end.

References

1. R Warren, M5395
2. "Handbook on Materials for Superconducting Machinery", Metals and Ceramics Information Center, Battelle, Columbus Laboratories, MCIC-HB-04

AUTHOR	DEPARTMENT	LOCATION	DATE
R Warren	Mechanical	Berkeley	14 Aug 80

ANALYSIS

The analysis follows the derivation in Ref 1 pg 17. It is shown there that the temperature rise in the center of an insulated conductor of length 2L and which is conduction cooled (temperature prescribed at the ends) is given by

$$\Delta T = \left(\frac{IL}{A}\right)^2 \frac{\rho}{2K}$$

ρ resistivity
K thermal conductivity
A area

The 18-C conductor measures 0.052"×0.127" and has a copper to superconductor ratio of 6.9. Therefore the copper area is 0.0372 cm^2 for a single conductor.
For 4 conductors, $A = .1488\ cm^2$

For the Nb_3Sn tape there is a total thickness of 0.002" and we will assume a width of 0.5 inch which gives a copper area of 0.0065 cm^2.
The total copper area is then 0.1553 cm^2
We will assume the following properties for the copper

$\rho = 1.7 \times 10^{-8}\ \Omega cm$ $L = 1"$
$K = 13\ W/cmK$

The temperature rise is then

$$\Delta T = \frac{(7000)^2 \frac{W}{\Omega} (1 \times 2.54)^2 cm^2}{(.1553)^2 cm^4} \frac{1.7 \times 10^{-8} \Omega cm}{2 \times 15 \frac{W}{cmK}} = 8.6\ K$$

If the temperature at the ends is 4.5 K then the center temperature is 13.1K and the mean temperature (from which to evaluate properties) is 8.8K

From Ref 2 for a residual resistance ratio of 100
$\bar{\rho} = 1.7 \times 10^{-8}\ \Omega cm$ $\bar{K} = 13\ W/cmK$

The I^2R heating in each end is

$$\frac{(7000)^2 (1.7 \times 10^{-8})(2.54)}{0.1553} = 13.6\ W$$

at $\frac{1}{2}$ W/cm^2 heat rejection rate we require 27.2 cm^2 fin area at each end of the insulated length. This would be provided by a circular fin of 1.6" diameter or two fins of 1.2" diameter.

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720