EXPERIENCE WITH TESTING AND APPLICATION OF CICC at JAERI

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at CICC meting
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CONTENTS

Outline of R&D for CICC at JAERI

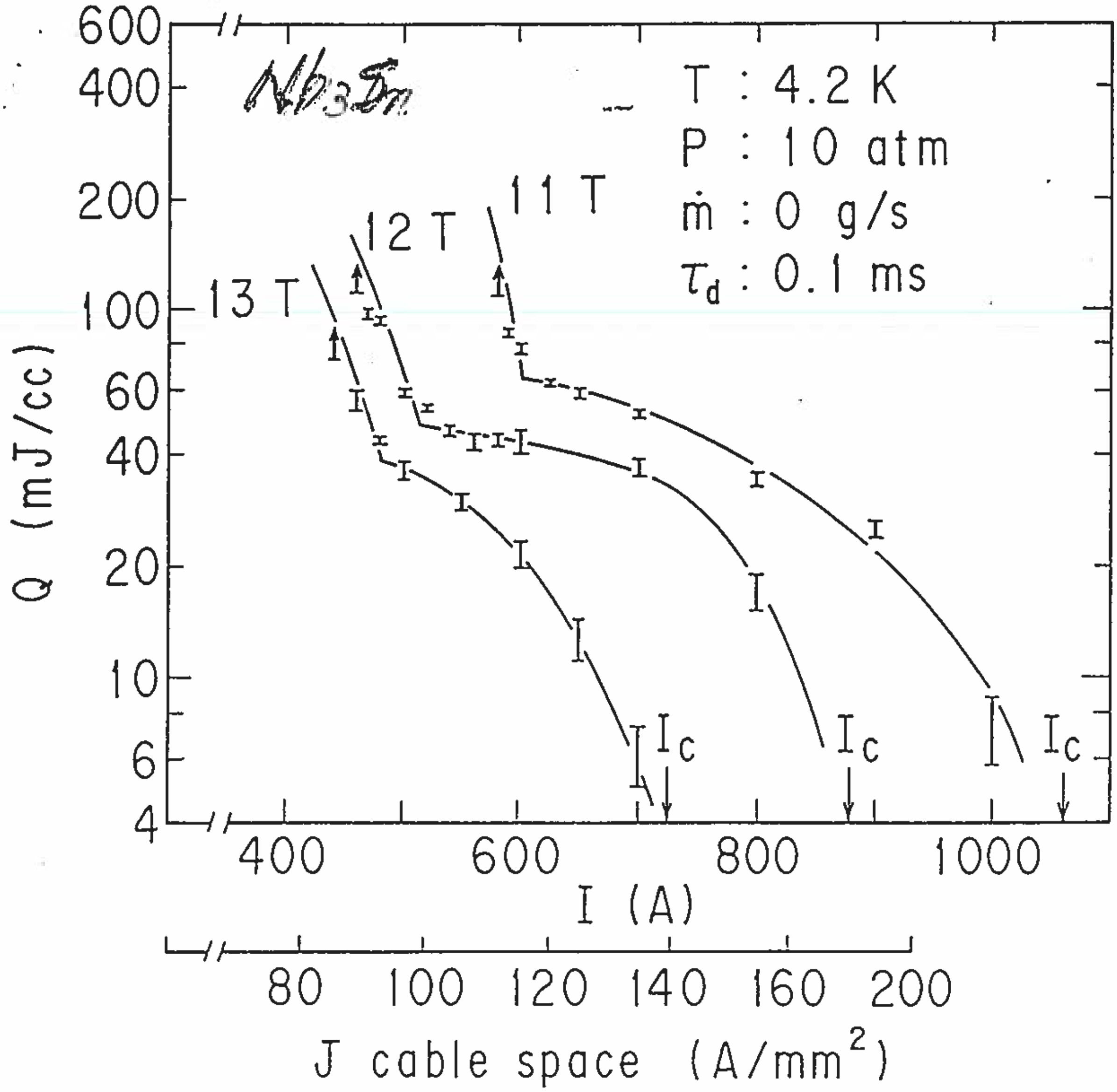
At JAERI, R&D works of CICC and its coil are being carried for tokomak fusion machines.

Stability
* stability margin
* limiting current
* lamp late limitation
* current sharing

AC losses
* inter-strand insulation
* cabling method

Ic degradation
* conduit material selection

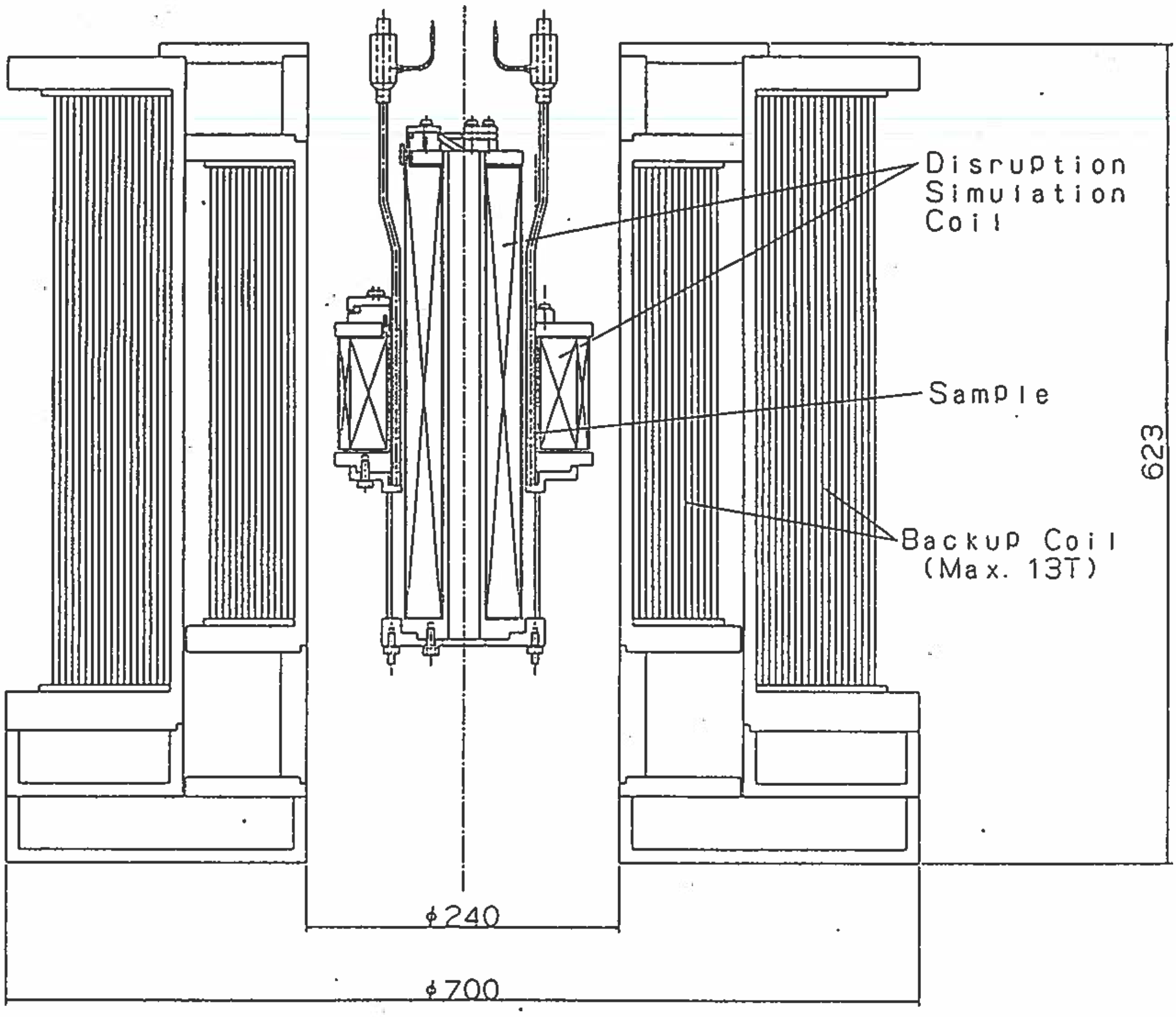
Quench phenomenon
* propagation velocity
* pressure rise
* temperature rise
* quench detection



$$I^2 = \frac{h \cdot S \cdot P}{\rho} (T_c - T_b)$$

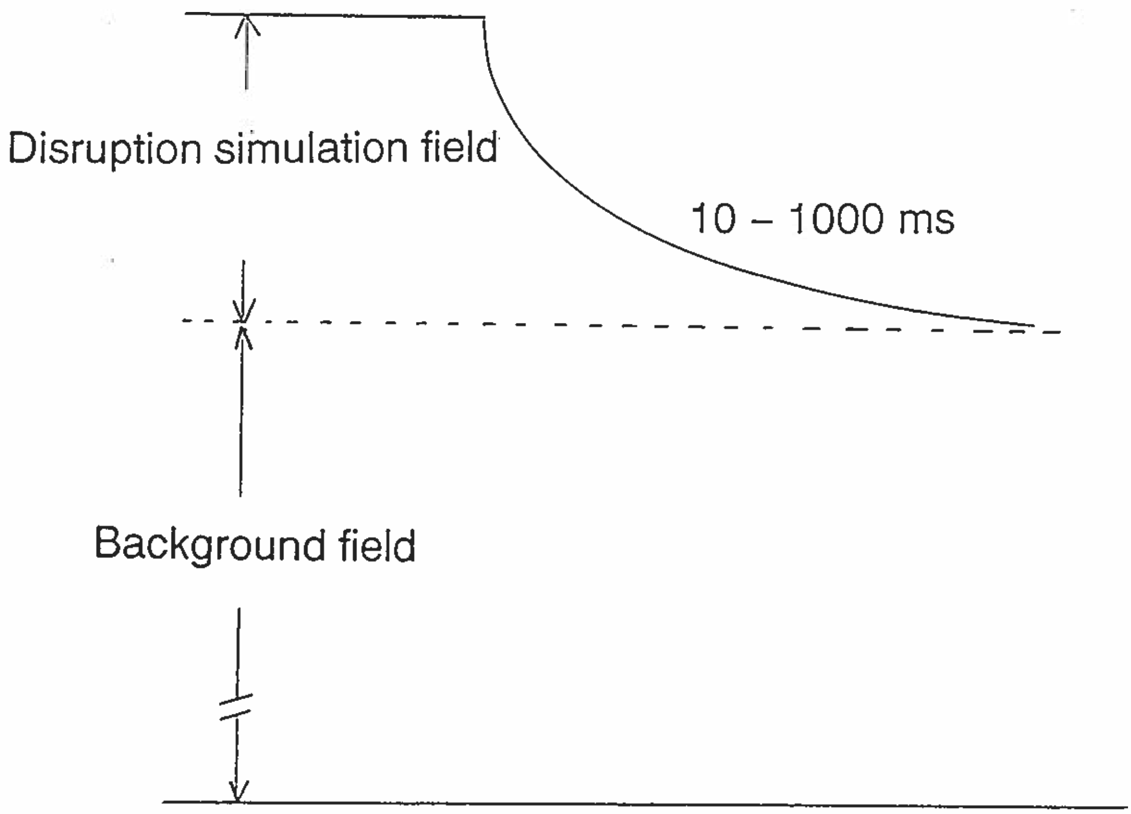
$$h = 1000 \ W/m^2 \cdot K$$

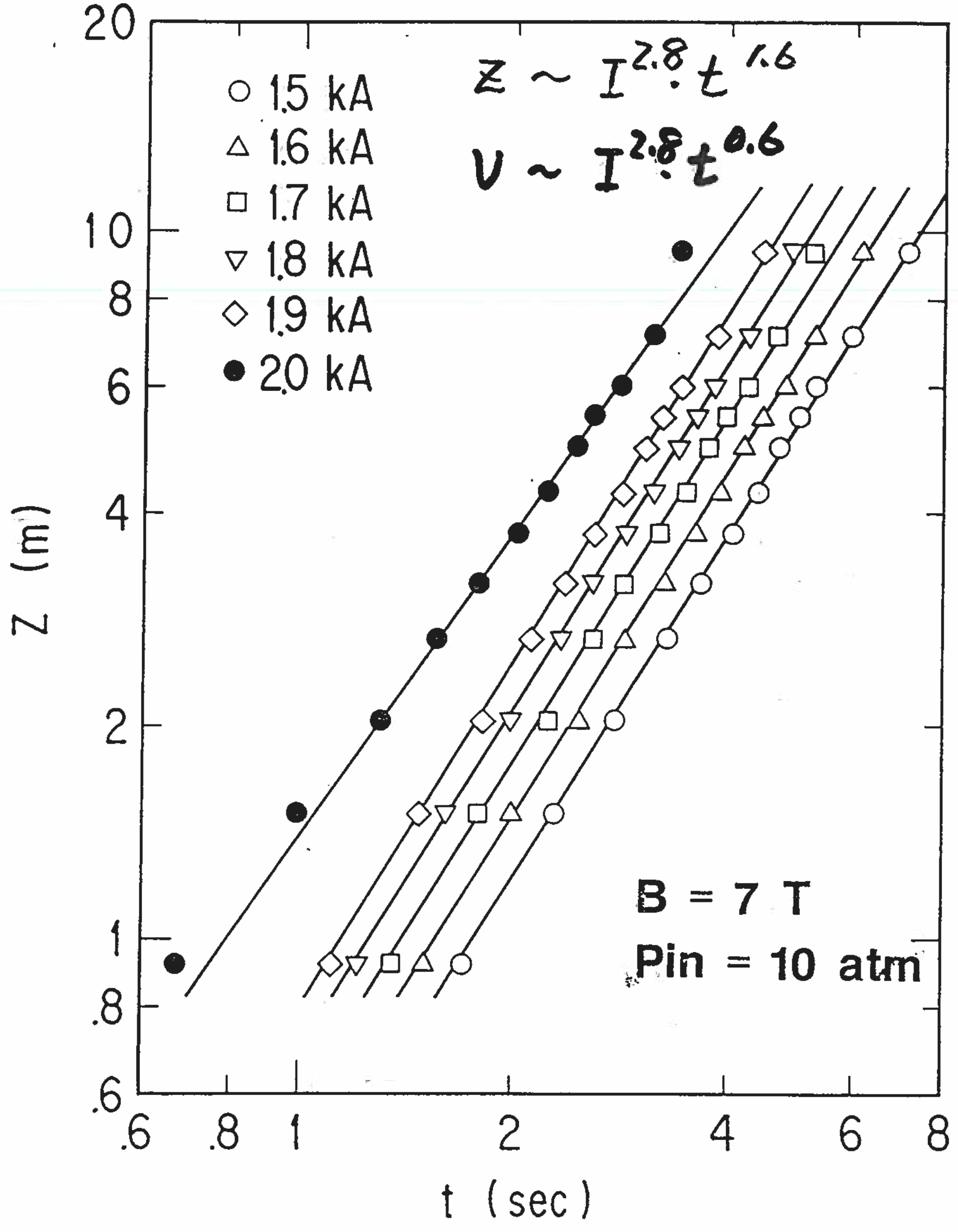
CONFIGURATION OF THE APPARATUS



TEST CONDITION

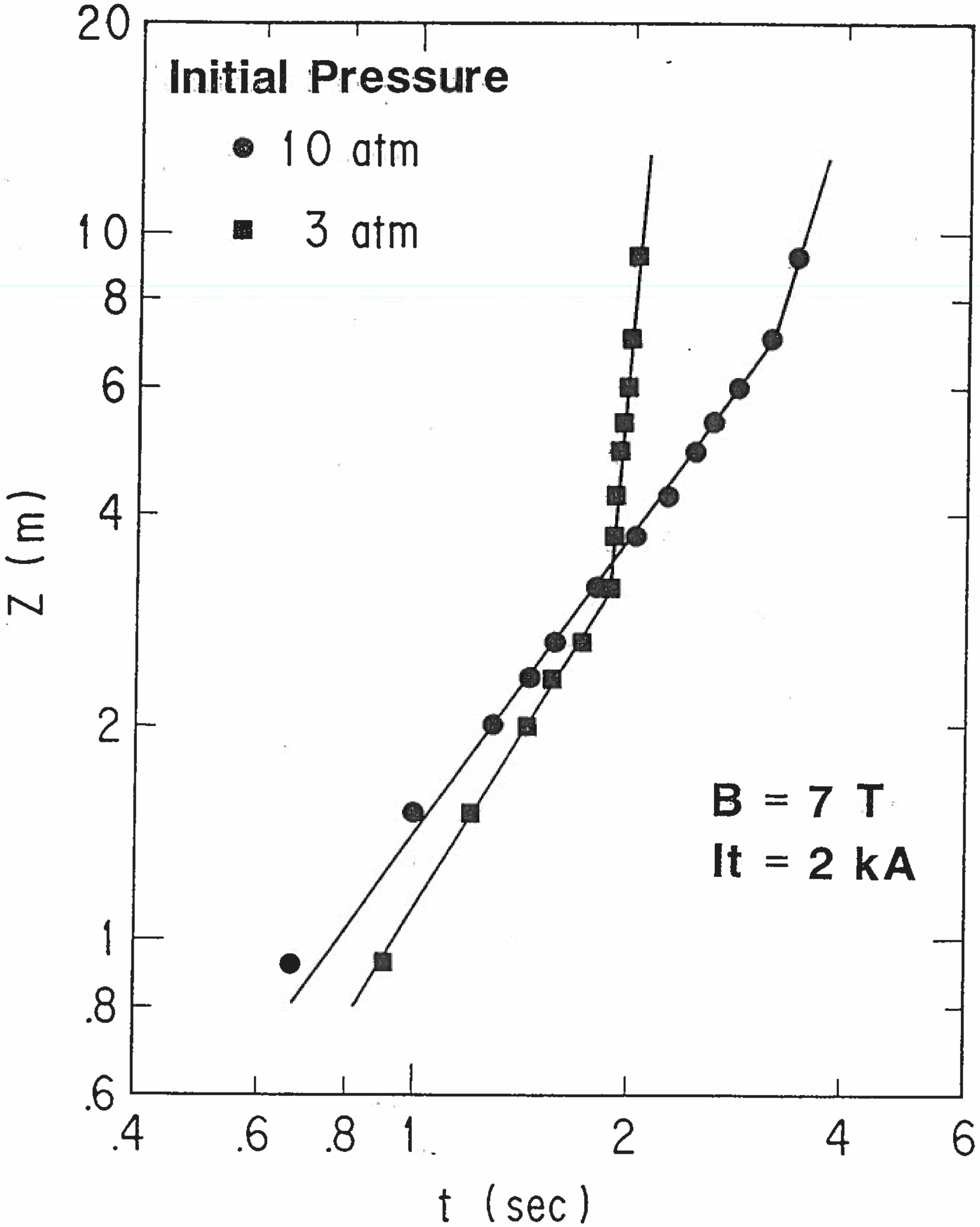
* Background field	:0 – 13 T
* Disruption simulation field	:0 – 2 T
* Disruption simulation changing time	:10 – 1000 ms
* Disruption simulation changing field	:20 – 2000 T/s





z ~ I^2.8 t^1.6
v ~ I^2.8 t^0.6
1.5 kA
1.6 kA
1.7 kA
1.8 kA
1.9 kA
2.0 kA
B = 7 T
Pin = 10 atm
Z (m)
t (sec)
20
10
8
6
4
2
1
.8
.6
.6
.8
1
2
4
6
8

$v \sim t^0$



Initial Pressure
10 atm
3 atm
B = 7 T
It = 2 kA
Z (m)
t (sec)
20
10
8
6
4
2
1
.8
.6
.4
.6
.8
1
2
4
6

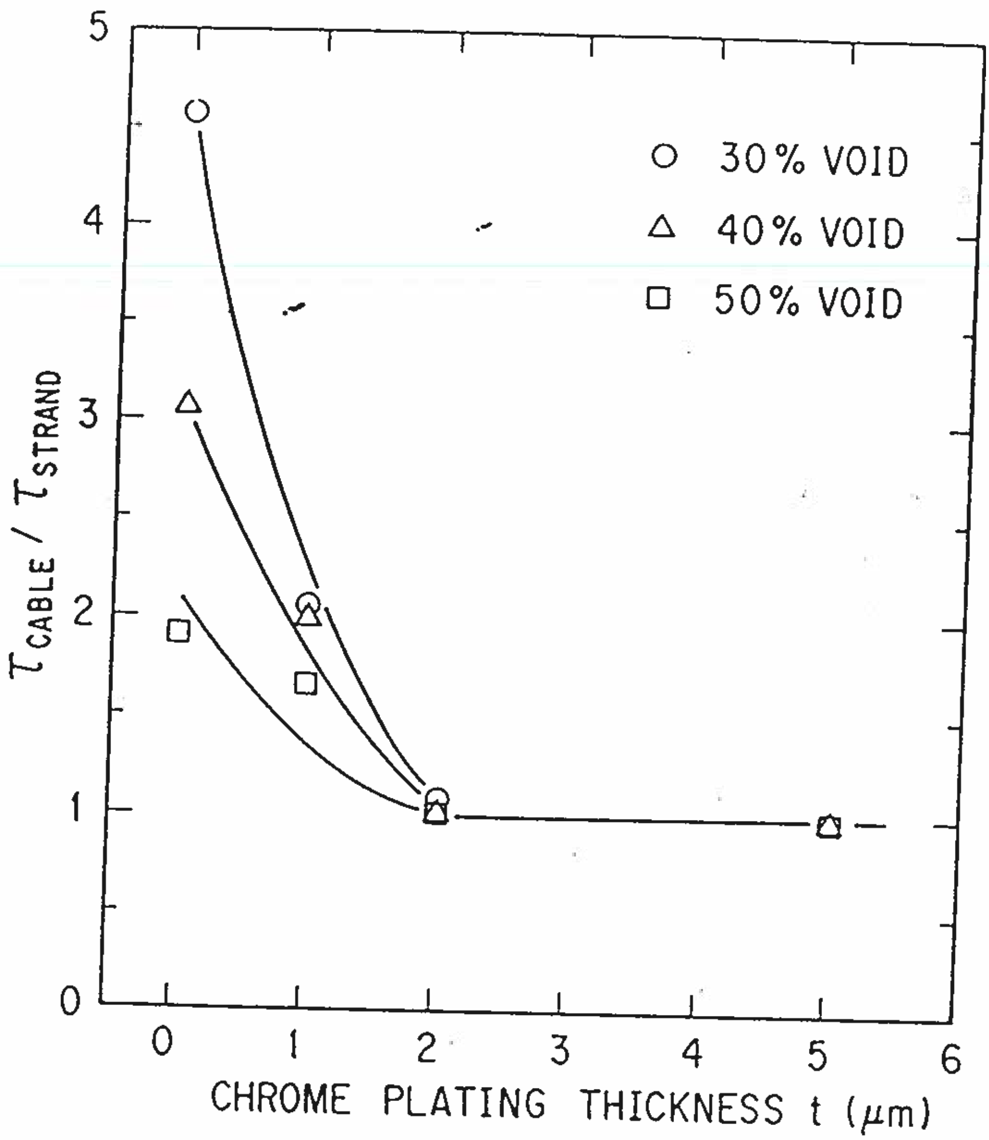
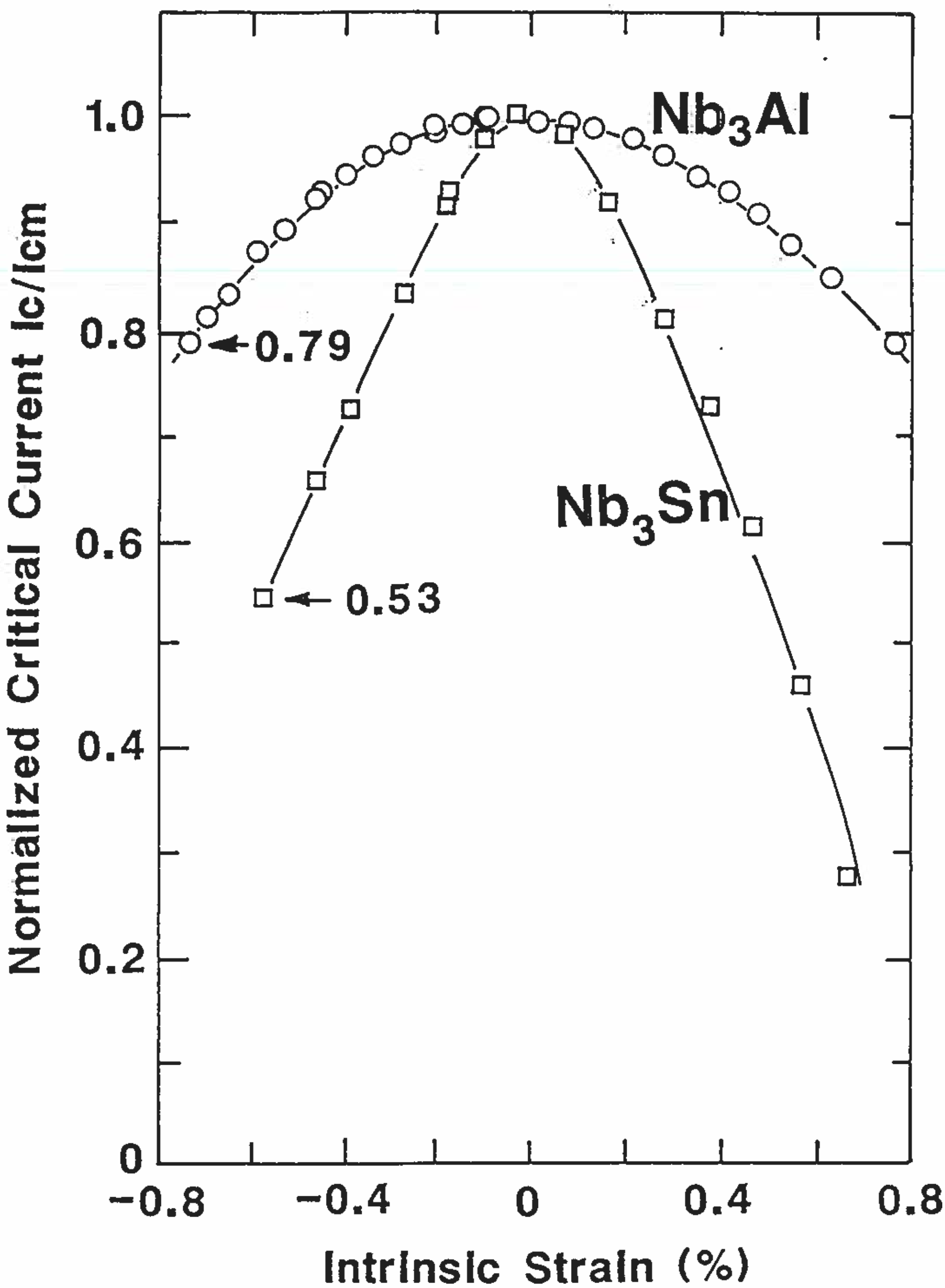


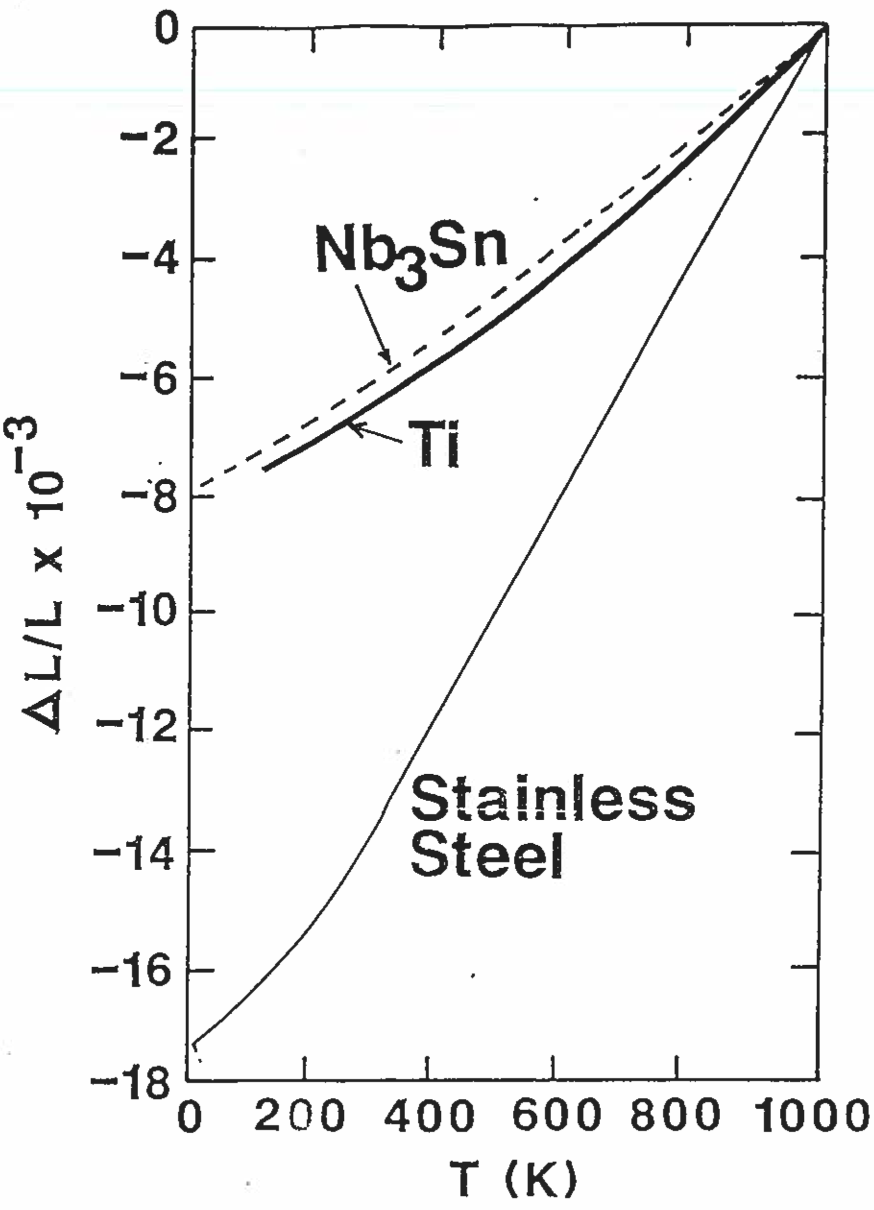
Fig. 6 Cable coupling time constant (τ_{cable}) normalized to the single strand coupling time constant (τ_{strand}) versus the chrome plating thickness.

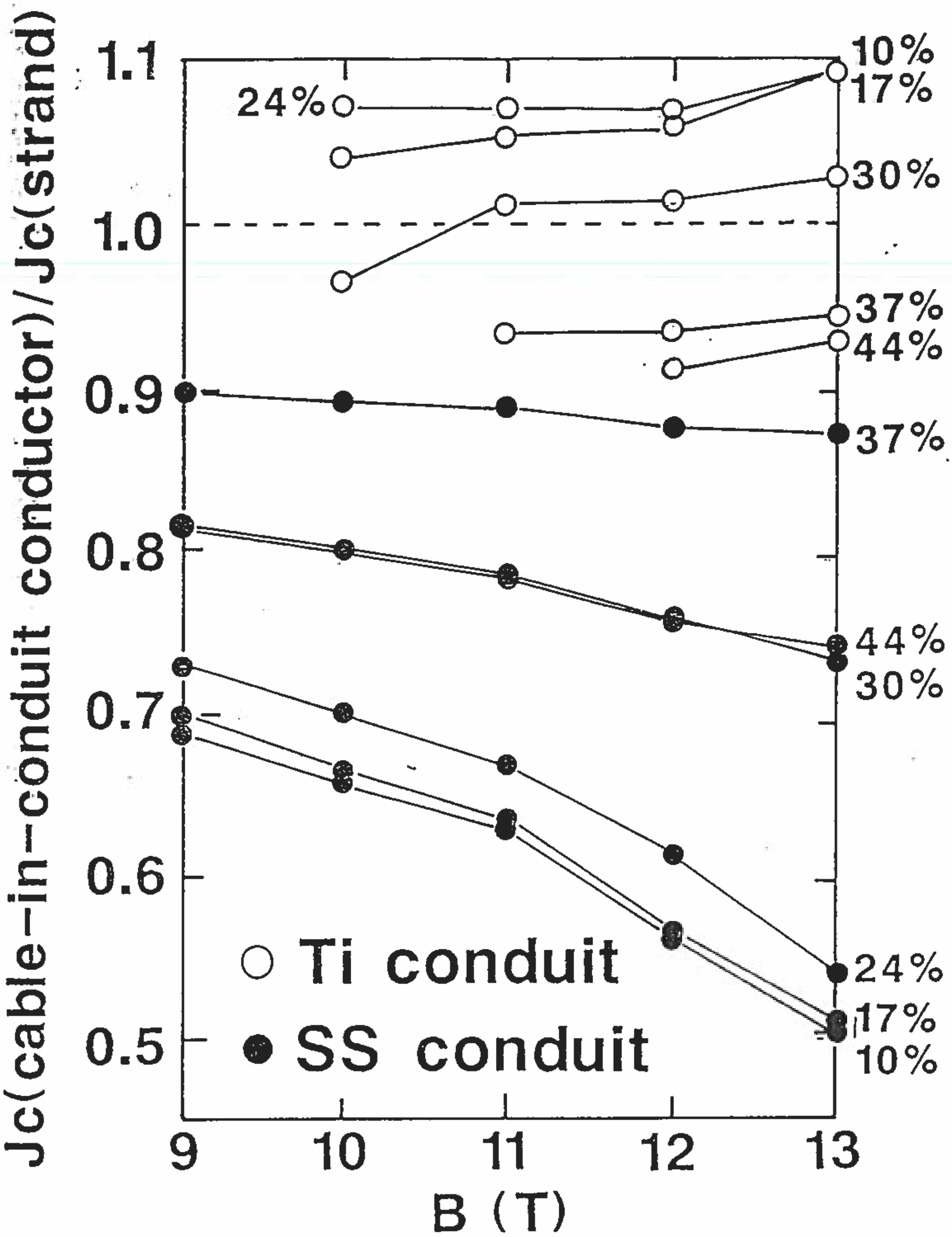


Nb3Al
Nb3Sn
0.79
0.53
1.0
0.8
0.6
0.4
0.2
0
−0.8
−0.4
0
0.4
0.8
Normalized Critical Current Ic/Icm
Intrinsic Strain (%)

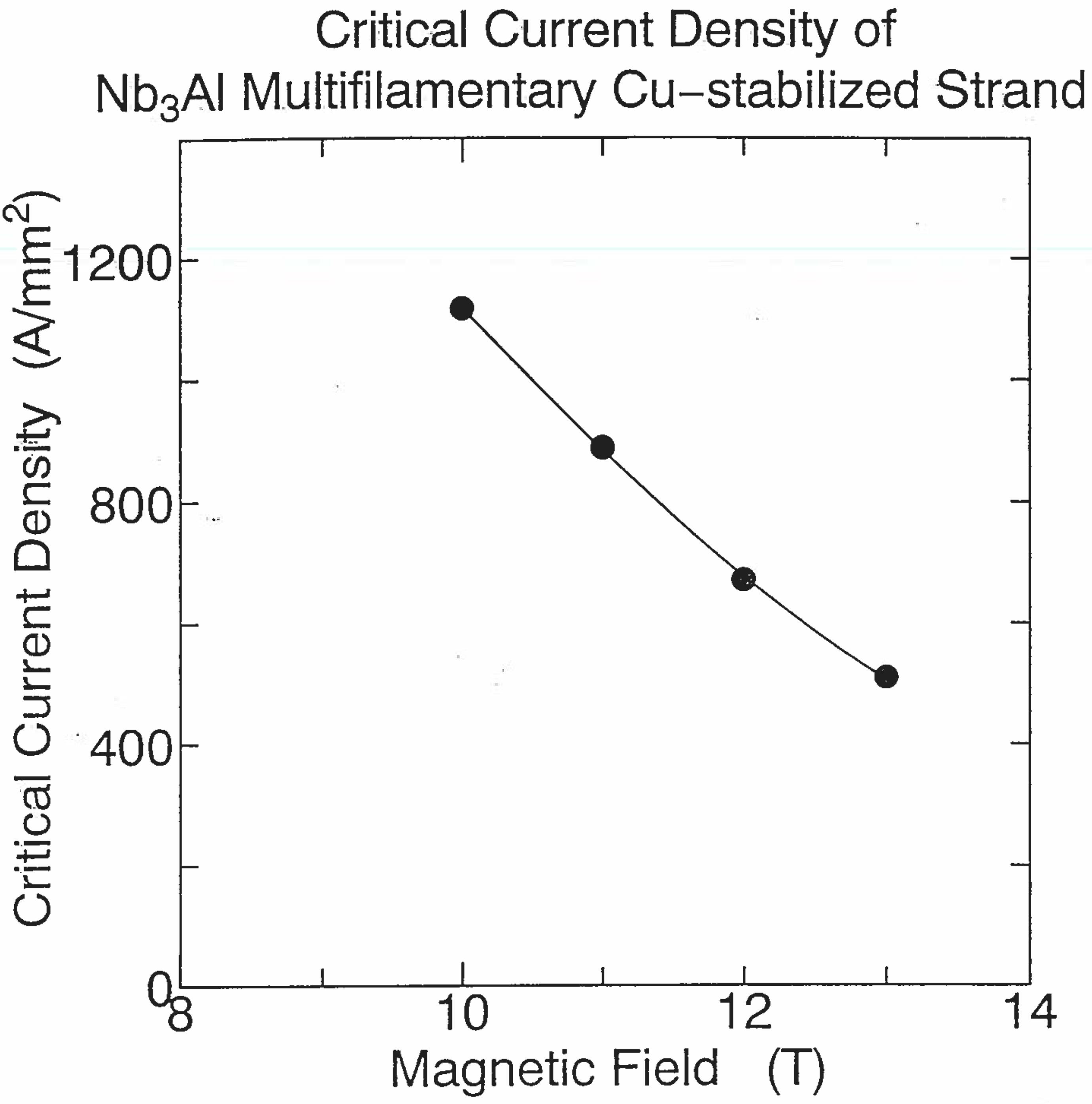
CONDUIT DEVELOPMENT

Thermal Expansion



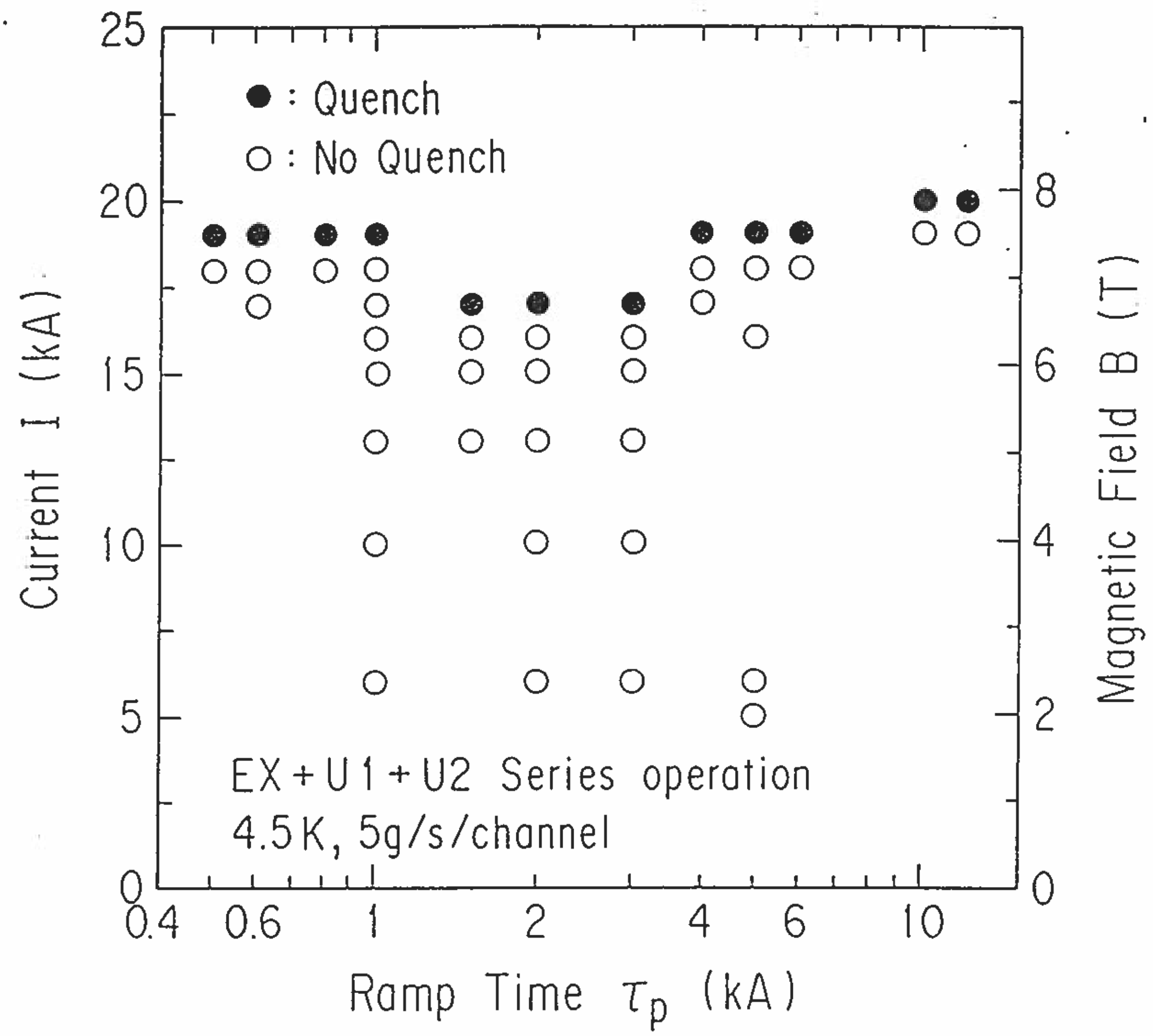


Jc(cable-in-conductor)/Jc(strand)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
9
10
11
12
13
B (T)
24%
10%
17%
30%
37%
44%
37%
44%
30%
24%
17%
10%
○ Ti conduit
● SS conduit

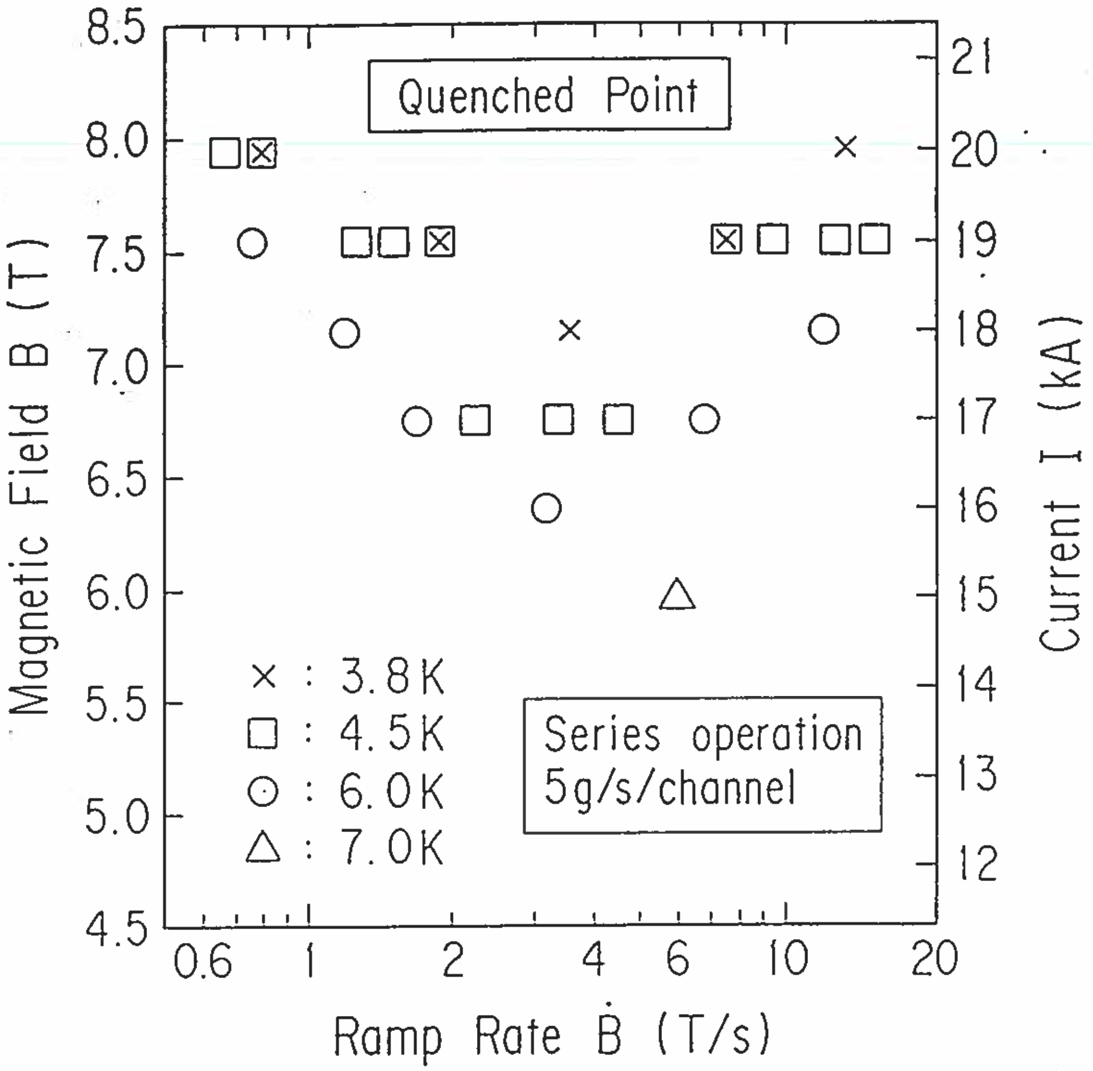

Critical Current Density of
Nb3Al Multifilamentary Cu-stabilized Strand
Critical Current Density (A/mm2)
1200
800
400
0
8
10
12
14
Magnetic Field (T)

2. LAMP LATE LIMITATION

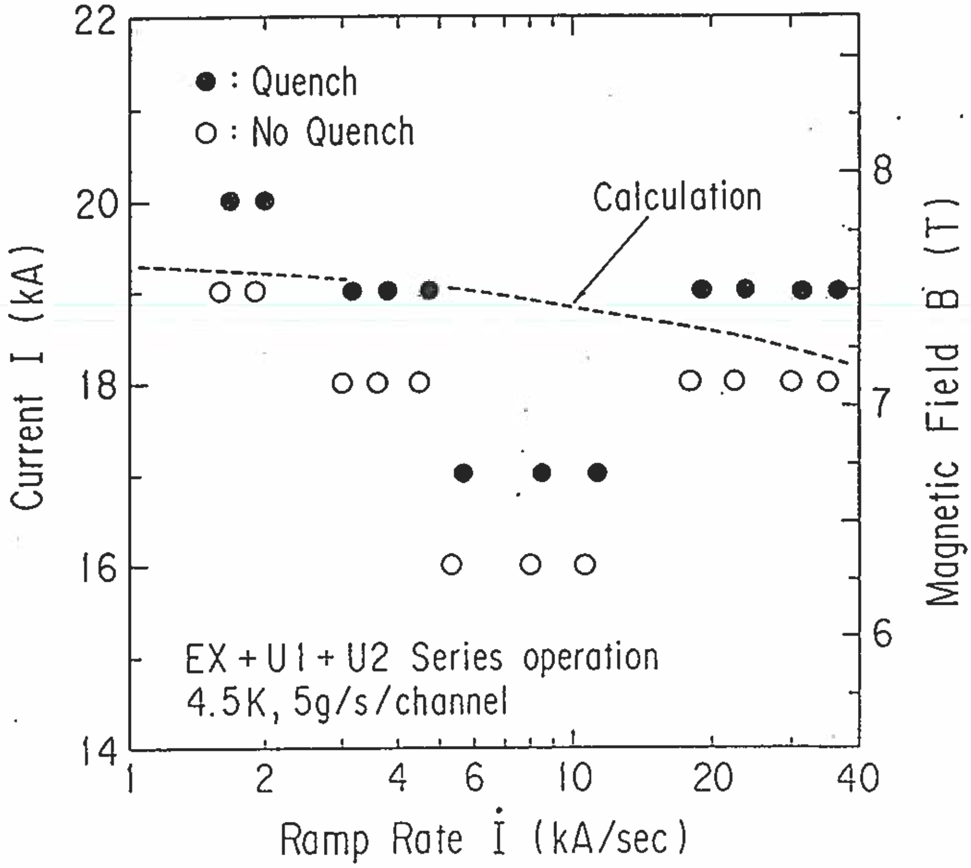
In the DPC–EX experiment, a lamp rate limitation has been measured.



LAMP RATE LIMITATION(continued)



LAMP RATE LIMITATION(continued)



$$I_{lim} \equiv \sqrt{I_o^2 + (\dot{I}+C_2)/4C_3^2} - (\dot{I}+C_2)/2C_3$$

$$B_{lim} \equiv \sqrt{c^2 I_o + (c\dot{B}+c\ C_2)/4C_3^2} - (\dot{B}+cC_2)/2C_3$$

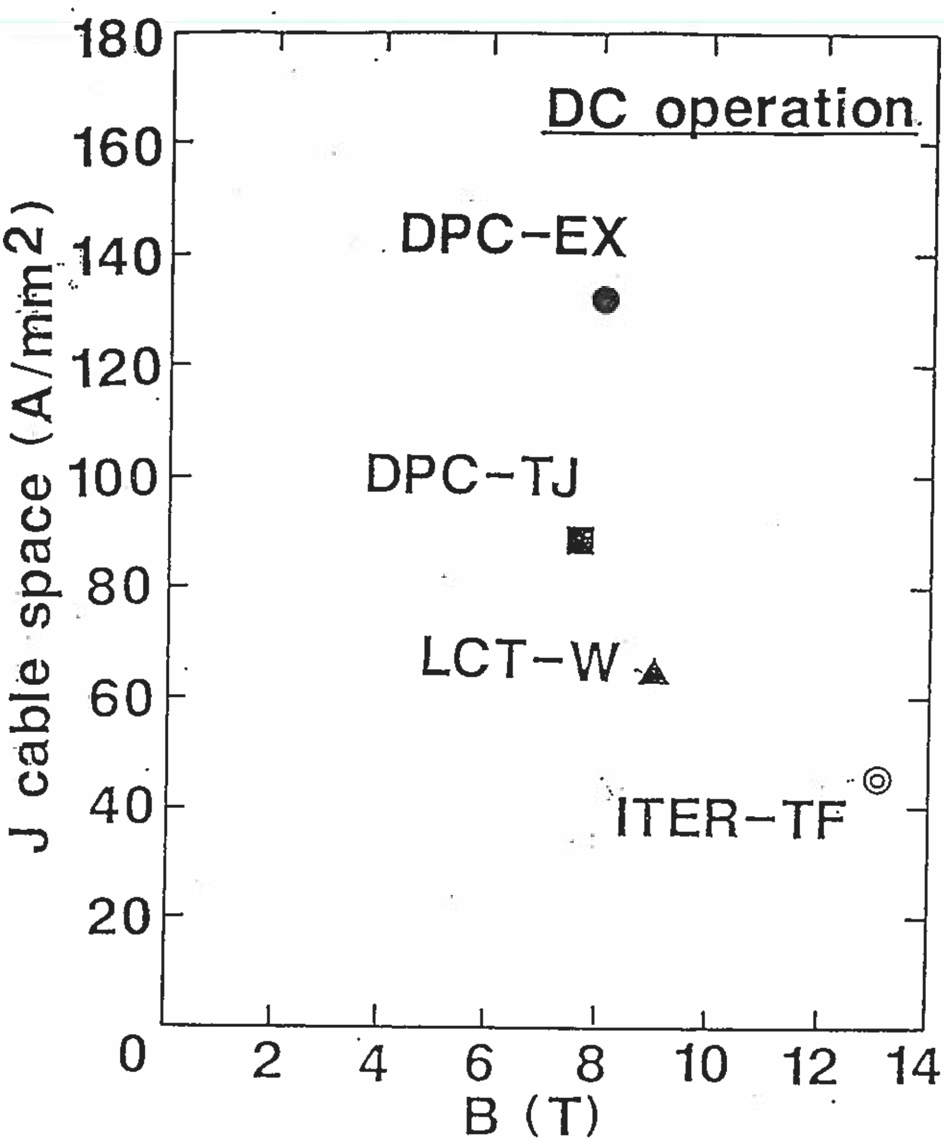
$$I_o^2 \equiv \frac{(T_{co}-T_{bo})hsp}{\rho}, \qquad C_1 \equiv \frac{1}{mb}(T_{co}-T_{bo})$$

$$C_2 \equiv \frac{cg + ma}{mb}$$

$$C_3 \equiv \frac{\rho}{mbhsp}$$

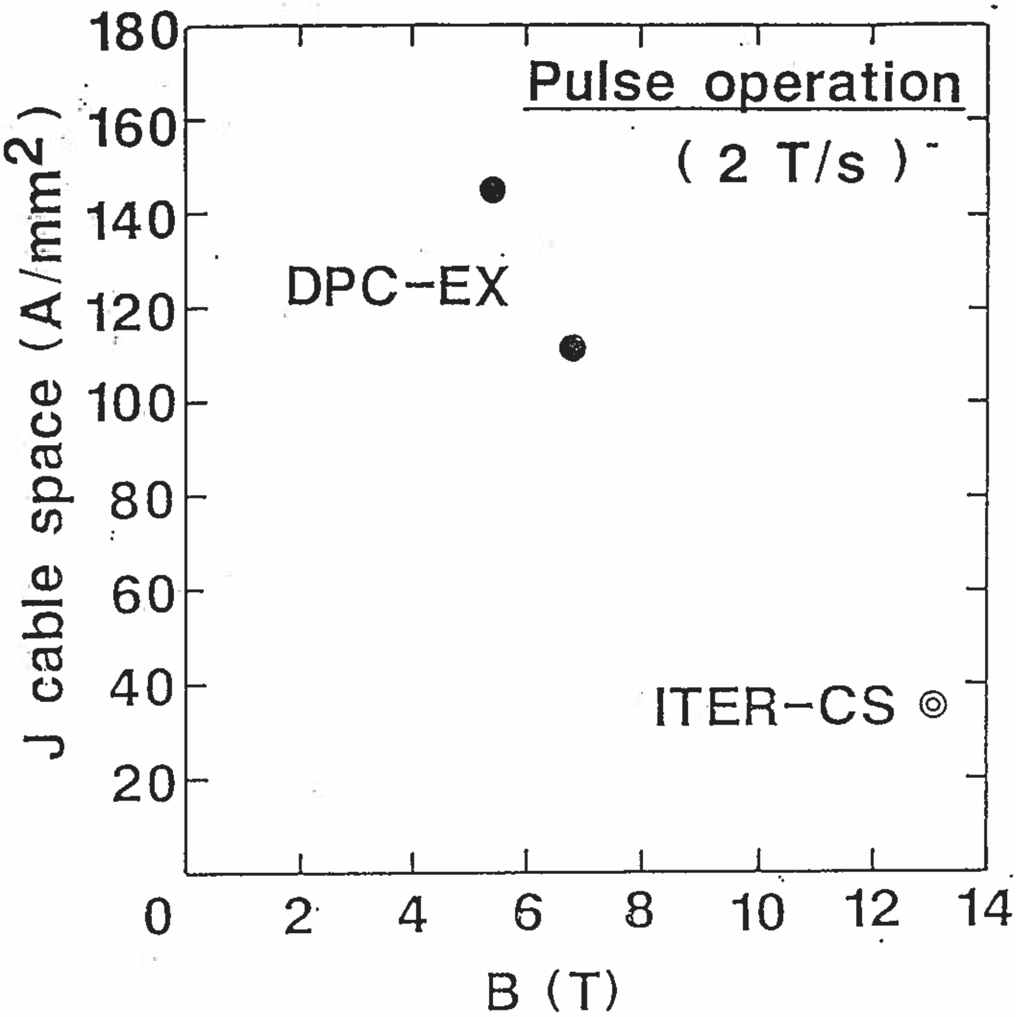
3. CURRENT DENSITY IN CABLE SPACE ACHIEVEDD IN COIL

DC Operation

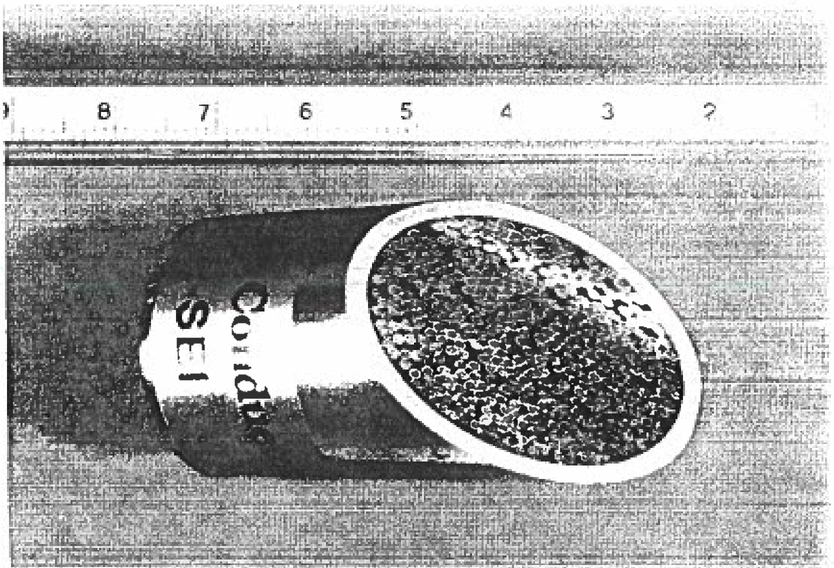


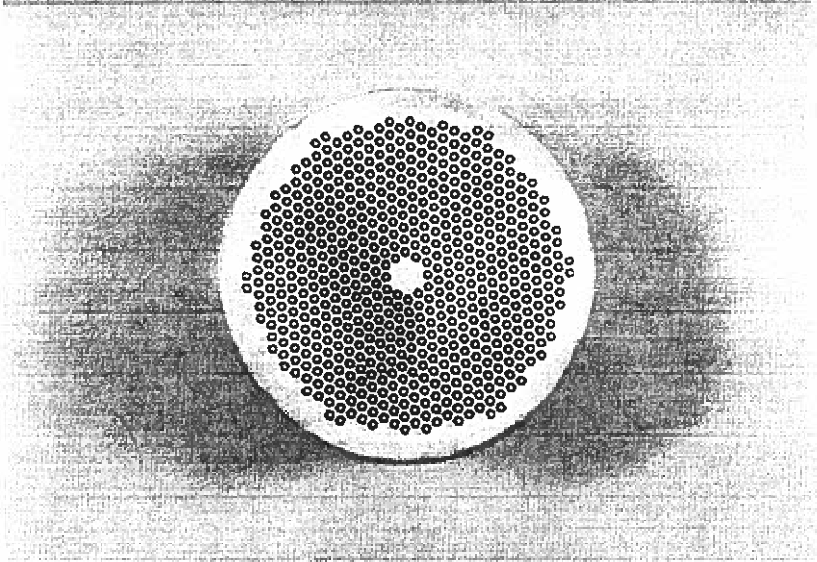
3. CURRENT DENSITY IN CABLE SPACE ACHIEVEDD IN COIL

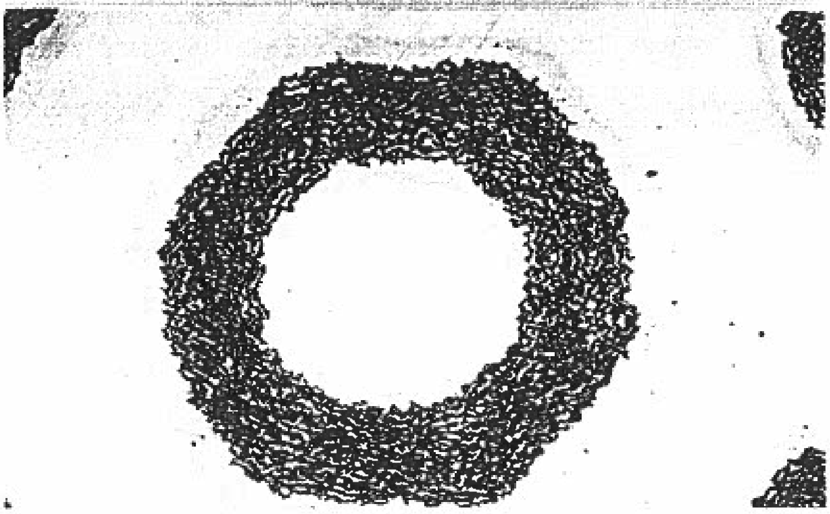
Pulse Operation



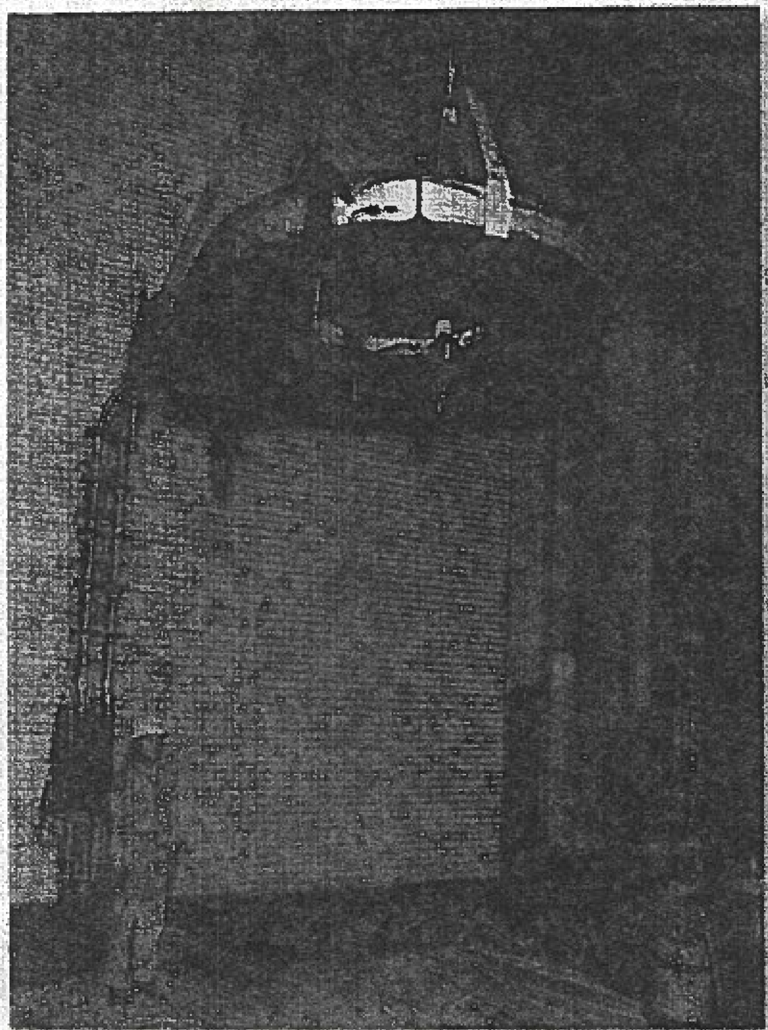
40 kA Nb_3Al CONDUCTOR







DPC-EX COIL



WINDING METHOD	2 DOUBLE PANCAKES (REACT and WIND)
COOLING METHOD	FORCED FLOW COOLING
WINDING INNER DIA.	1 m
WINDING OUTER DIA.	1.66 m
WINDINF WIDTH	0.17 m
No of TURNS	120
SELF-INDUCTANCE	22.6 mH
No of COOLING PATHS	4
TEST VOLTAGE	19.8 kV
TEST PRESSURE	30 bar