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A SURVEY OF NbTi CONDUCTOR STATUS

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INTRODUCTION

As part of the European Collaboration for the Development of High-Field Superconducting Magnets, a preliminary survey has been made of currently available Niobium Titanium materials. The purpose of this survey was to examine the present (early 1985) situation with respect to conductors which approach that needed for a 10 Tesla LHC Dipole Magnet operating at 1.8° K.

LHC REQUIREMNTS

The overall requirements for LHC Dipole Magnets are detailed in the feasibility study (ref. 1) and we here recall only those aspects which are particularly relevant to this survey.

The LHC Dipole Magnets would be wound from a superconducting cable whose basic constituents are strands of 0.4 to 0.8 mm diameter. Each strand consists of a large number of filaments of superconducting material inbedded in copper. No definitive design of the cable exists as yet and different possible solutions are being considered. Thus, in order to have a common basis for comparisons, it was decided that the survey should focus on critical current density of single wires with diameters in the above range.

As a result of preliminary estimates, the required superconductor critical current density, as defined at a specific resistivity of 10^{-14} Ohm m, has been set at 1300 A/mm^2 at a magnetic induction of 11 Tesla. Also, to limit the effects of persistent currents at the injection field level of 0.5 Tesla, an upper limit of 10 microns effective filament diameter is assumed. However, since the main effect of the persistent currents is to add a sextupole component to the required dipole field in the bending magnets, which could in principle be counteracted by correction elments, the absolute filament diameter may prove to be less of a limitation than its variation during a large production process.

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TABLE 1

Details of three industrial scale NbTi wires

Reference	# 1	# 2	# 3
Composition	Nb-49 W/oTi	Nb-50 W/oTi	Nb-46.5 W/oTi
Diameter of wire(mm)	0.50	0.72	0.5 - 0.6
Diameter of filaments (μ)	44	8.9	20
Number of filaments	~ 50	~ 2600	~ 400
Copper/s.c. ratio	1.4:1	1.5:1	1.3:1
Origin of material	Europe	Japan	USA

TABLE 2

Details of two laboratory scale NbTi wires

Reference	# 4	# 5
Composition	Nb-50 W/oTi	Nb-46.5 W/oTi
Diameter of wire(mm)	0.306	0.44
Diameter of filaments (μ)	8.5	9.8
Number of filaments	~ 600	~ 1000
Copper/s.c. ratio	1.23:1	0.94:1
Origin of material	Japan	Japan

TABLE 3

Details of four laboratory scale NbTi ternary alloy wires

Reference	# 6	# 7	# 8	# 9
Composition	Nb-41 W/oTi-14 W/oTa	Nb-44 W/oTi-8 W/oHf	Nb-44 W/oTi-19 W/oTa	Nb-62.8 a/oTi-5 a/oTa
Diameter of wire (mm)	0.6807	0.50	0.65	0.306
Diameter of filaments (μ)	~ 13	18.8	24.0	8.5
Number of filaments	1700	~ 300	~ 300	~ 560
Copper/s.c. ratio	1.5:1	1.4:1	1.4:1	1.3:1
Origin	USA	Japan	Japan	Japan

THE SUPERCONDUCTOR CRITICAL CURRENT DENSITY VERSUS FIELD ($\rho = 10^{-14}\ \Omega m$)

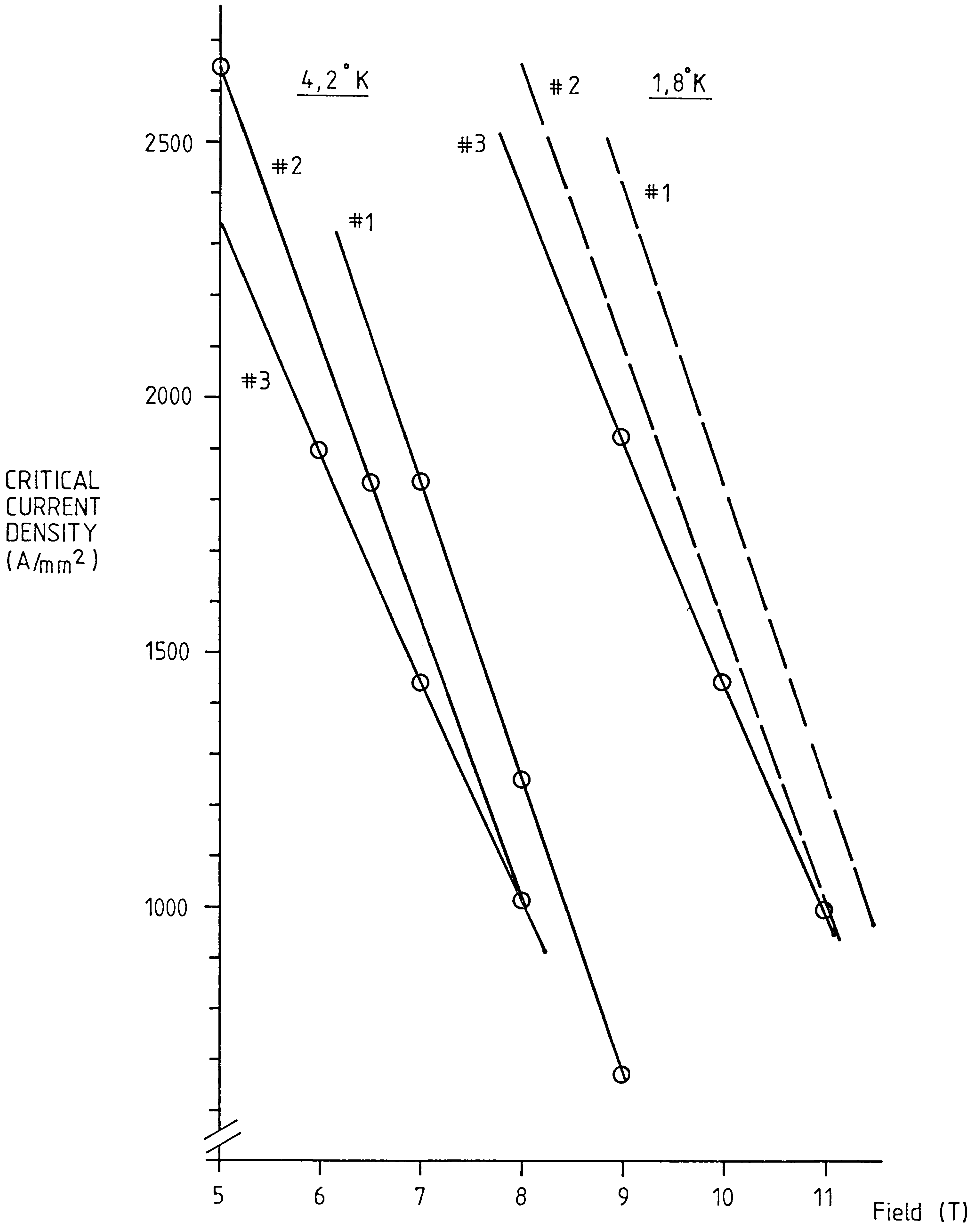

Fig. 1 Three industrial scale Nb Ti Wires

—o— measured curve

— — estimated curve. (see Methodology)

THE SUPERCONDUCTOR CRITICAL CURRENT DENSITY VERSUS FIELD ($\rho = 10^{-14}\,\Omega m$)

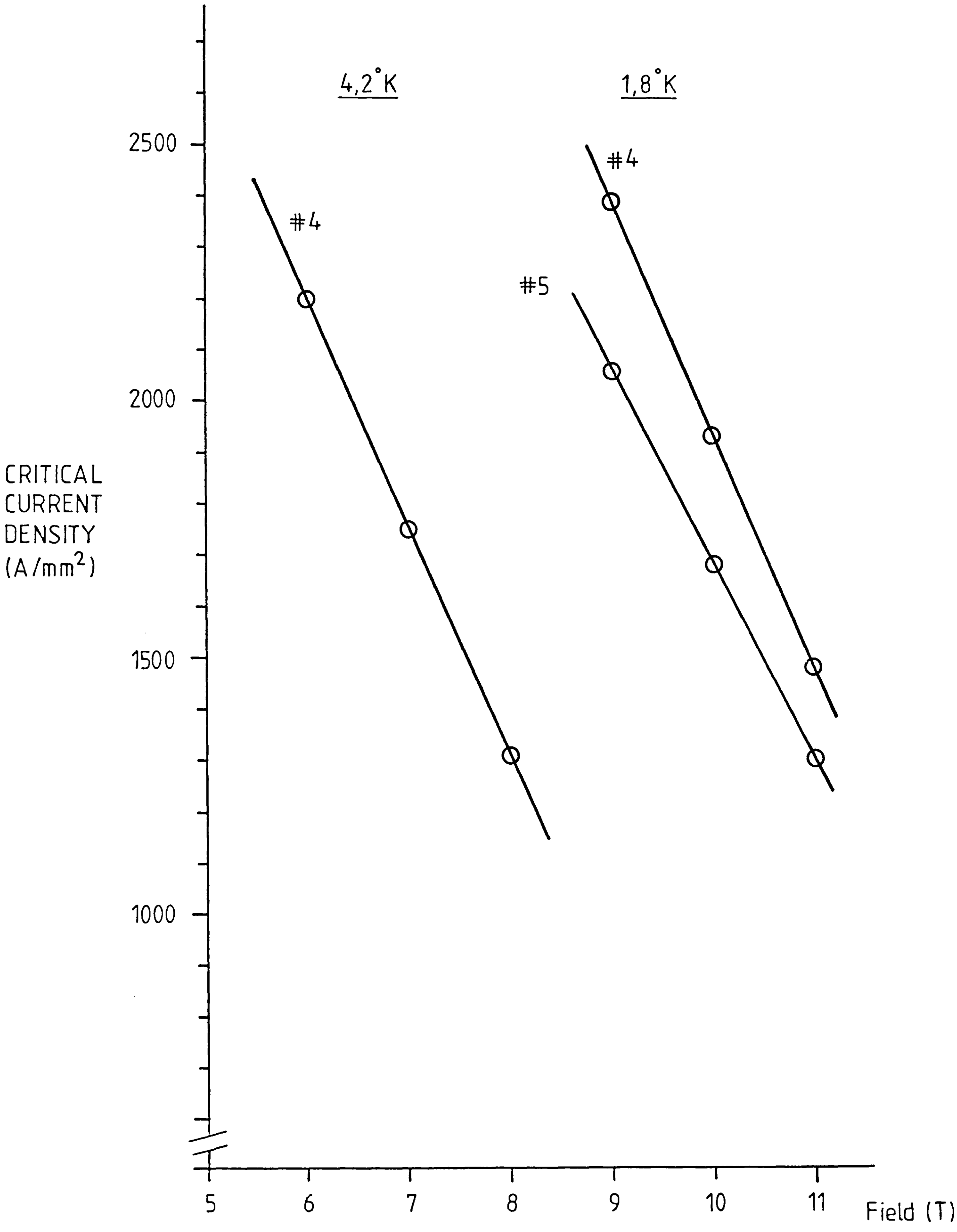

Fig. 2 Two laboratory scale Nb Ti wires
(all curves are measured)

THE SUPERCONDUCTOR CRITICAL CURRENT DENSITY VERSUS FIELD ($\rho = 10^{-14} \Omega m$)

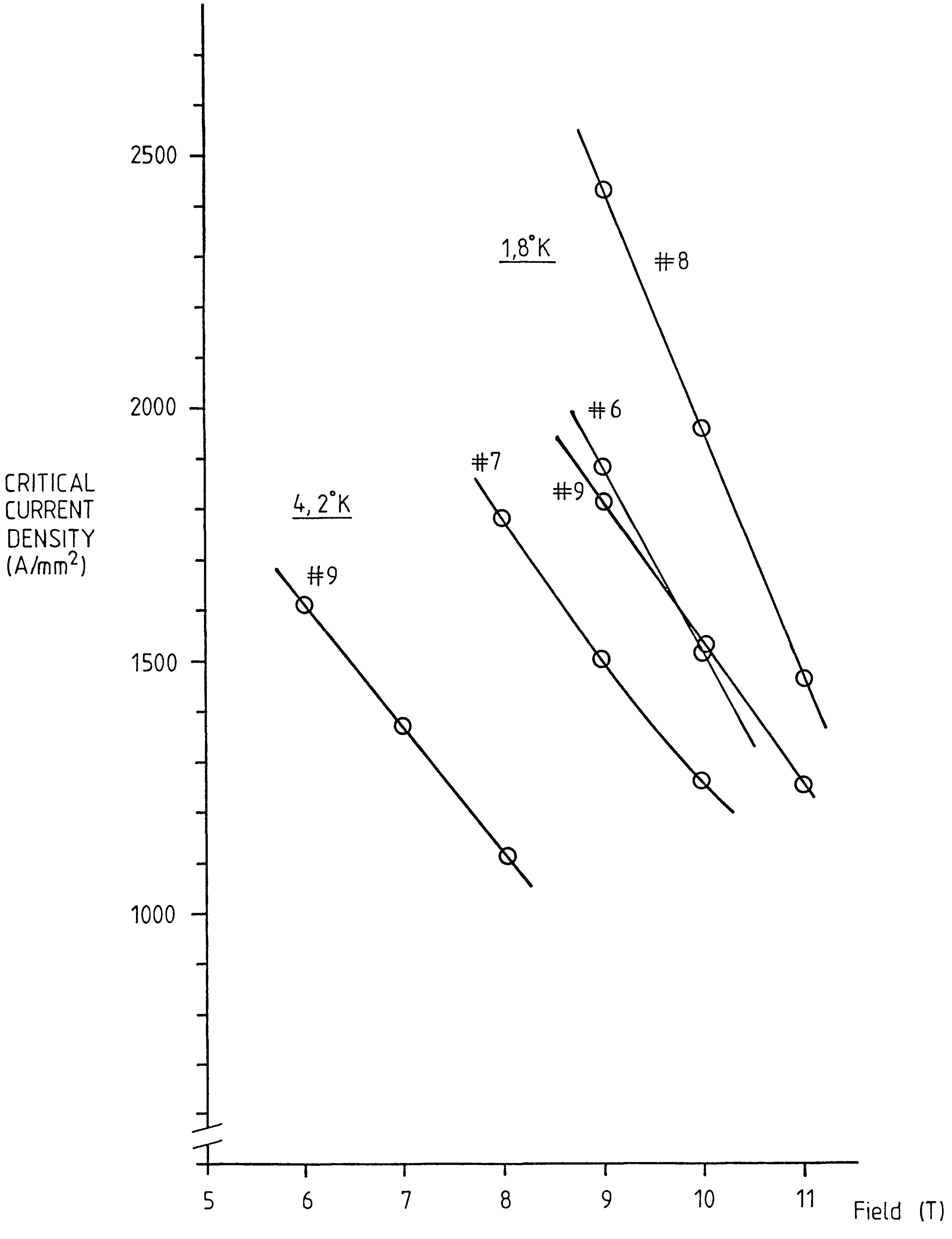

Fig. 3 Four laboratory scale Nb Ti ternary alloy wires
All curves are measured; #6 : 23 strand cable at $2.10^{-14} \Omega$ m ;
#7 – #9 single wires at $10^{-14} \Omega$ m