NOT FOR PUBLICATION

CLM - M 46

SOME EXPERIMENTS RELATING TO DEGRADATION OF LARGE SUPERCONDUCTING COILS

by

D. N. CORNISH
J.E.C. WILLIAMS

A B S T R A C T

Having built a number of 8" bore pancake coils which exhibited the usual degradation experienced with coils of this size, some experiments have been carried out using these coils in order to try to understand the causes of this behaviour. Special windings and short samples of wire have been inserted between the main coils, and their characteristic H - I curves have been obtained.

U.K.A.E.A. Research Group,
Culham Laboratory,
Nr Abingdon,
Berks.

March, 1965 (C/7 IMG)

CONTENTS

MAIN COILS

The main coils, between which the special coils were inserted, are described in full in reference 1. The main parameters are as follows:

Each coil:

Bore	- 8"
Width	- 1.7/16"
Outside diameter	- 12"

The fields generated at the inside radius of the coils are as follows:

Two coils in series	- 20 amps, 17.6 kG
Four coils in series	- 12.3 amps, 14.4 kG .

Disc Coils

Some disc coils were made, clock spring fashion, with only one turn axially and 100 in the radial direction, having the same inside and outside dimensions as the main coils. The wire used was 0.010" dia Niobium 75%, Zirconium, copper-plated to 0.013" dia and insulated to 0.019" dia. It is similar to that used in the main coils and its normal H - I curve is shown as the reference curve in the accompanying figures. To obtain a coil occupying the minimum axial space, the winding was impregnated with epoxy resin together with a 1/32" thick backing washer. The total coil width was therefore 0.05".

Experiment No.1

Four main coils were assembled together and connected in series. A disc coil was then inserted between the two central coils and another was placed at the end of the main assembly. The two discs were arranged so that they could be energised from a separate supply.

Quenching curves for the discs were found by traversing different load lines, which were selected by choosing various ratios of disc to main coil current, thus carrying out a 'coil simulation' test[2]. The results are shown in Fig.1(a) on which the load line for four main coils has also been drawn. The test was repeated as shown in Fig.1(b), but this time the field was held constant and the current through the discs raised until quenching occurred.

It is to be noted that the reference curve for short sample performance shown in these figures was found to be the same by both the constant field and coil simulation method. The points were also extremely repeatable.

It should also be noted that in plotting the results, the field has been taken as the value existing at the inside radius in both cases; at the median plane for the centre disc, and at the end of the main assembly for the end disc.

Experiment No.2

Because the two discs behaved somewhat differently, particularly when energised in a constant field, experiment no.1 was repeated with the two discs interchanged. To reduce the helium consumption, however, and also the time taken to re-assemble the coils, the number of main coils was reduced from four to two.

Experiment No.3

There were two test samples for this experiment, both being inserted between two main coils.

Sample 1. This was a disc coil similar to those previously used but having a reduced number of turns such that the outside diameter was only 11". It was estimated that this would be just inside the zero field point in the main coils.

Sample 2. A single turn of wire in spiral form starting at the inner radius of the main coils, and finishing at the outer radius. Potential leads were attached to this turn at several points to enable the region from which normality propagated to be determined. This was found to be at or near the inner radius.

Coil simulation tests were carried out on both samples, together with a few spot checks at constant field which gave figures either on or above the reference curve.

Experiment No.4

In the final experiment to be reported here, a spiral turn of superconductor was screened by threading it through a copper tube 0.053"/0.125" dia. The turn was placed at the end of a pair of main coils and tested, using the coil simulation test.

Discussion of Results

During the course of manufacture of the main coils, many short samples of the wire used were tested by both the coil simulation and constant field method. There was extremely good agreement between the two methods and very little scatter of the points.

Similar tests carried out by sandwiching first 260 feet of wire in the form of a disc coil and then 2½ feet in the form of a single spiral turn between adjacent coils which themselves experience degradation, however, gives significantly different results. A degraded performance is now obtained, using the coil simulation method of test. Moreover, the amount of degradation tends towards that experienced by the main coils which is more severe when 4 coils are used than when there are only 2.

If the spiral turn is then screened with 0.02" thick copper normal short sample performance is restored to it.

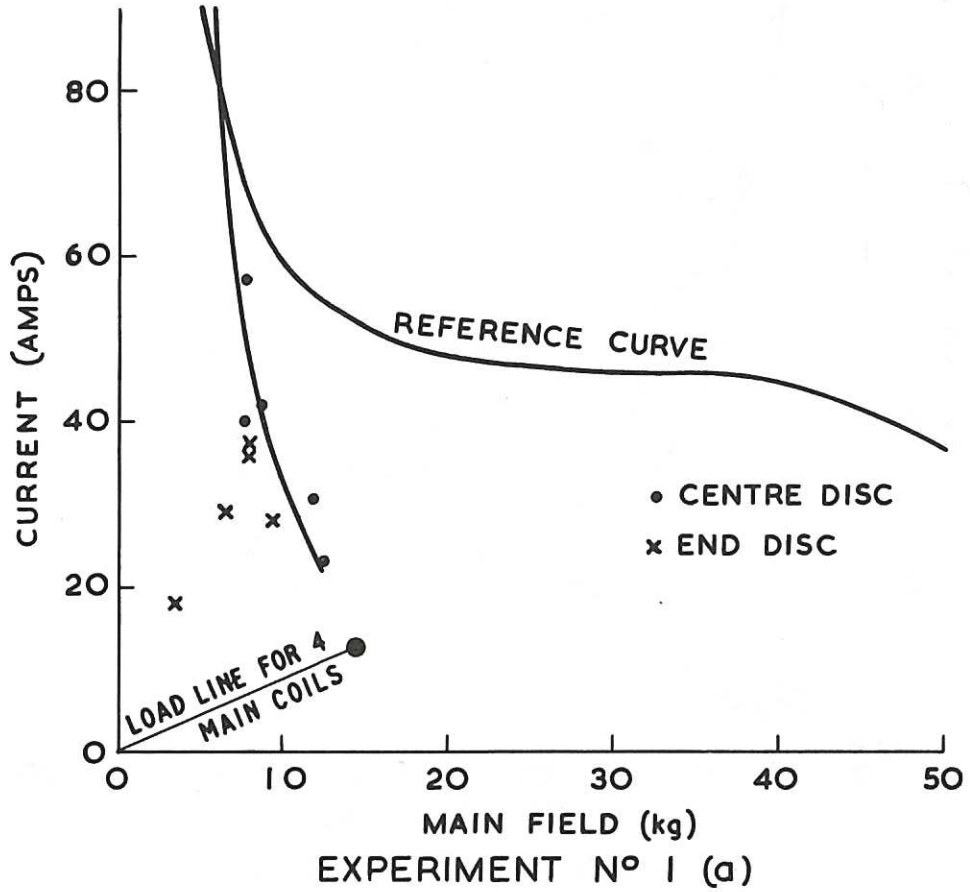
These results tend to suggest that degradation is caused by a combination of the quasi-steady field pattern and a flux transient which triggers the quench. So far it has not been found possible to identify the actual flux transient responsible for the quench but it is hoped to do so in the future.

A satisfactory explanation for the low points obtained on the end disc with a steady field in the first experiment cannot at this stage be given.

REFERENCES

1. CORNISH, D.N. and WILLIAMS, J.E.C. Eight-inch aperture superconducting coils. CLM-P 51, July 1964. (To be published in Cryogenics)

2. ROSNER, C.H. and SCHADLER, H.W. Relating measurements on short superconducting wires to solenoid performance (Letter). J. Appl. Phys., vol.24, no.7, July 1963. pp.2107 - 2108.



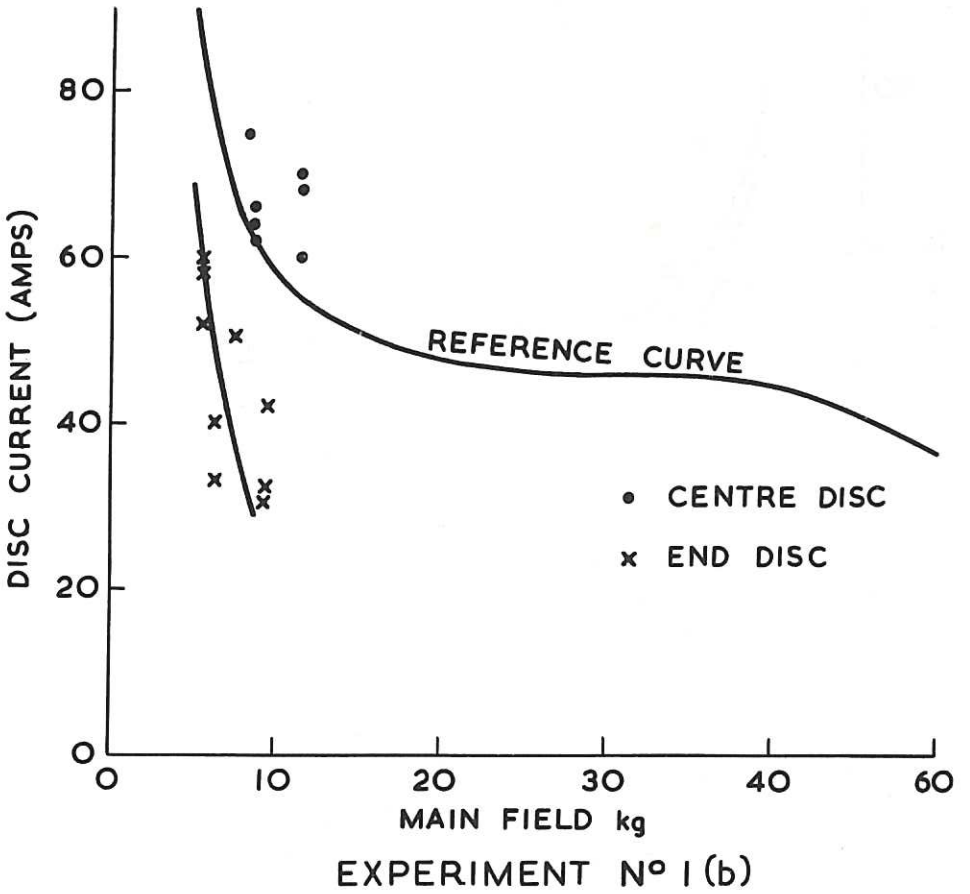


Fig. 1 (CLM-M46)
Quenching of disc coils inserted at centre and end of a 4 coil assembly
Top: coil simulation method. Bottom: steady field

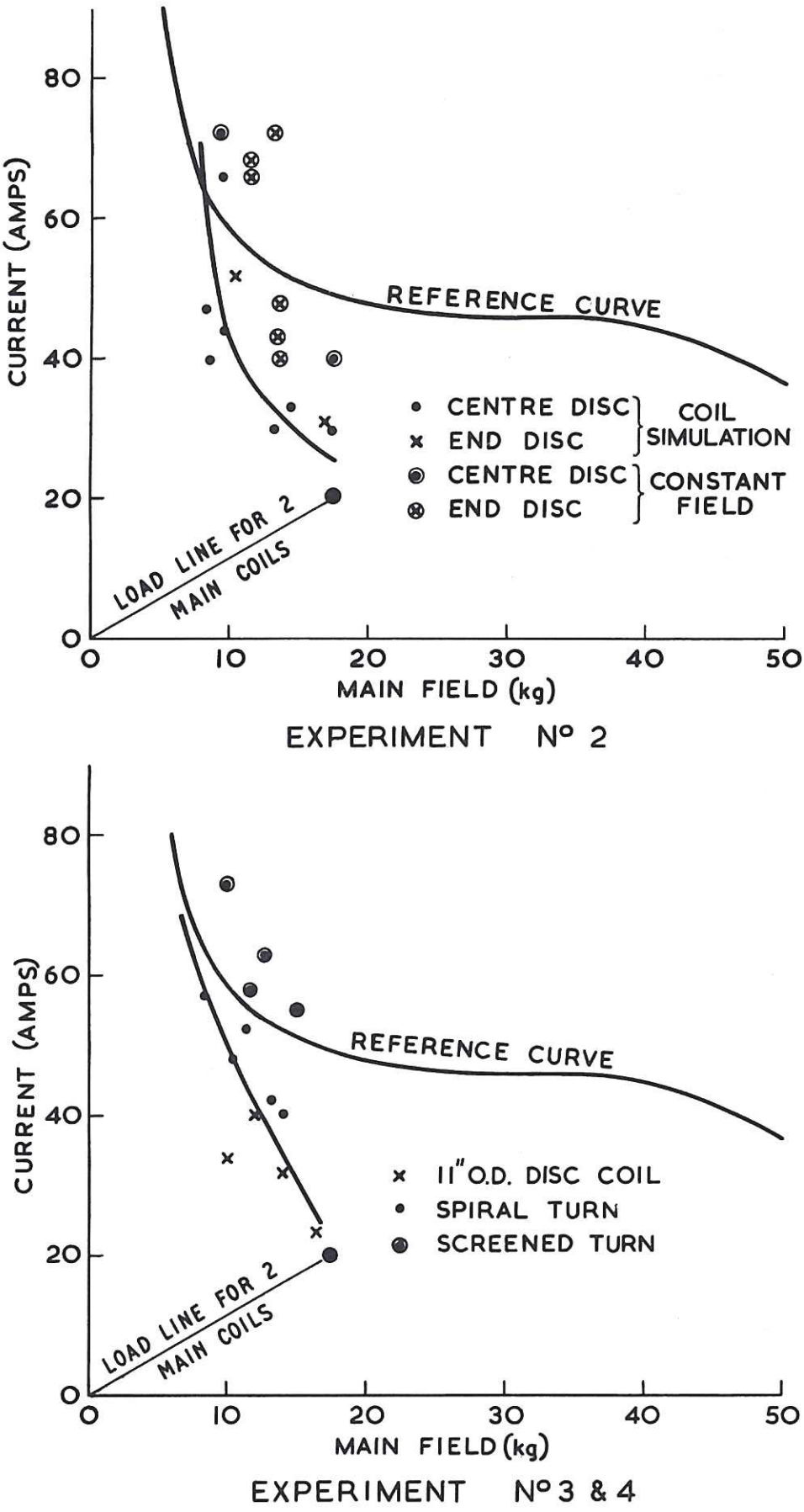


Fig. 2 (CLM-M46)

Top: quenching of disc coils inserted at centre and end of a 2 coil assembly. Bottom: quenching of a spiral turn and an 11 inch outside diameter disc at the centre, and of a screened spiral turn at the end of a 2 coil assembly

NOT FOR PUBLICATION