Laboratori Nazionali di Frascati

LNF-63/25 (1963)

G. C. Sacerdoti: RECENT ADVANCES IN NEW HIGH MAGNETIC FIELD TECHNIQUES AT NATIONAL LABORATORIES OF FRASCATI, ITALY.

Estratto da: Nucl. Instr. and Meth. 20, 503 (1963).

NUCLEAR INSTRUMENTS AND METHODS **20** (1963) 503—504; NORTH-HOLLAND PUBLISHING CO.

RECENT ADVANCES IN NEW HIGH MAGNETIC FIELD TECHNIQUES AT NATIONAL LABORATORIES OF FRASCATI, ITALY

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1. Introduction

As is well known, the actual techniques to obtain high magnetic fields are the following:

a) pulsed magnets (discharging a bank of condensers into a coil, which may be either of copper or of unconstrained mercury),

b) cryogenic magnets (copper or sodium),

c) superconducting magnets.

The main direction of our work during the last years has been the pulsed and superconducting magnets.

2. Pulsed Magnets

First of all we have built a heavy stainless steel frame to clamp the different coils to be tested. For these coils we used several materials and techniques: Cu and Cu–Cr as conductors; fiberglass mixed with silicon, epoxy, acrilic and phenolic resins as insulators. We have built coils with a single spiral, and two concentric spirals with a different number of turns (the inner a greater number of turns than the outer). On a single spiral coil of Cu, with insulator 0.5 mm thick, we succeeded in obtaining 320 kG for a few pulses: after these pulses we had about 400 pulses more at 250 kG, without breaking the coil. The length of the pulses was $\sim$ 5 msec.

At fields near 220 kG a Cu coil of the same kind has had $\sim$ 2200 pulses without definite damage; only the effect of the tremendous stresses suffered was visible, i.e. the inner diameter and the height of the coil was changed by about 5 %. Radial deformation was not observed in the insulator.

The critical point of this type of coil is the insulation between successive turns; what we have done to improve this point is to select insulators by mechanical tests simulating the real conditions of work. We saw that by doubling the thickness of the material its life was increased by a factor 3 or 4, so we built two coils (Cu and Cu–Cr, respectively) with insulator 1 mm thick; both of these have been tested with $\sim$ 500 pulses at 220 kG without damage: in the Cu coil we noted a deformation not observed in the Cu–Cr one. These coils are now used for emulsion experiment by the University of Bern group (Dr. Winzeler). We also prepared three coils for the Milan group (Dr. Vegni) to be used in the antiproton beam.

3. Superconducting Magnets

After some preliminary trials we have built a superconducting coil working in liquid He by

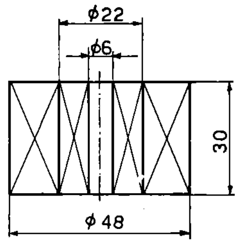

Fig. 1. Scheme of the superconducting coil.

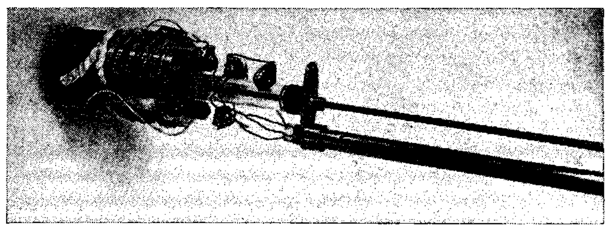

Fig. 2. Photo of the superconducting coil.

which we obtained more than 36 kG. This coil is shown in figs. 1 and 2: it consists of two concentric sections with the following characteristics:

wire: $\overline{Nb}$–Zr 25 %; diameter: 0.25 mm (Wah Chang Inc.),

contacts: Nb–Zr pressed between copper plates (fig. 3) (between the bars that bring from outside the dewar the current to the coils and the Nb–Zr wire),

insulation: no axial insulator between the turns; Cu sheet 0.05 mm thick radially,

length of the wire: outer section 450 m; inner section 110 m,

number of turns: external section: 4020; internal section: 2665.

Our first results are summarized in table 1.

TABLE 1

$I_{int} = 26$ A	$I_{ext} = 0$	$B_{meas} = 27$ kG
$I_{int} = 0$	$I_{ext} = 11.6$ A	$B_{meas} = 11.6$ kG
$I_{int} = 24$ A	$I_{ext} = 11$ A	$B_{meas} = 36$ kG

Concerning the contacts, we had many trials (Cu mechanically pressed against Nb–Zr, Ag against Nb–Zr, Nb plate against Nb–Zr, In plus Cu contact); we succeeded in having a d.c. current of about 140 A in a wire of 0.25 mm diameter with a Cu pressed contact. We could also have a current of 180 A passing in a wire of Nb–Zr of diameter 0.5 mm by a Cu–In contact. This contact has been obtained by melting In around a wire wound on a Cu cylinder.

We also built and tested a thermoswitch to short-circuit the coil. This device allows us to cut off the Cu bars after the magnet is excited and avoid thermal dissipation in liquid He due to the Cu bars. This thermoswitch enclosed in a lucite box consists of a carbon resistor whose aim is to measure the temperature; on this resistor lies the Nb–Zr wire. Around the whole a costantan resistor can warm the Nb–Zr and so destroy the super-

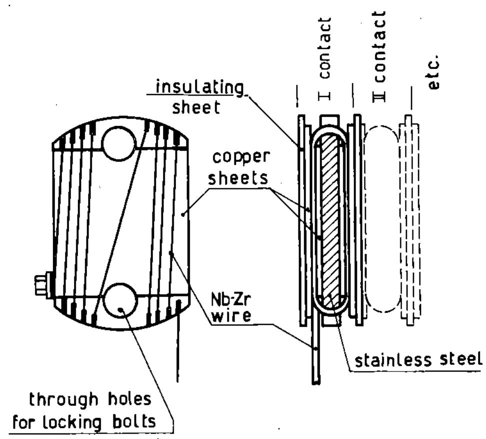

Fig. 3. Contacts between Cu and Nb Zr.

conductivity interrupting the short circuit, if crossed by a current of ~ 20 mA. With this device we were able to short-circuit a superconductive coil with current ~ 20 A, by a superconducting bridge so having the magnetic field without connections between the coil and the current generator outside the dewar.

4. Unconstrained Hg Coils

In collaboration with Milan group we have tested some multi-turn Hg coils. The first trials at fields of 20 — 40 kG led us to the conclusion that it was necessary to work in vacuum to avoid together the oxidation of Hg and the shock waves in the gas that damage the coils.