

Fermilab

TS-SSC 91-044

3/6/91

REVISED 3/8/91

To: DSA323 Traveler
From: Jim Strait
Subject: Location of coil-to-ground short

On 3/5/91, just before it was to be compressed for shell welding, DSA323 failed coil-to-ground hi-pot. The coil held 5 kV to ground briefly before arcing. Shortly after the failure the coil-to-ground resistance was measured to be approximately 250 K Ω . Over the course of the next several hours the resistance drifted up to 5 M Ω . The next morning it had decreased to about 40 K Ω and went later to about 25 K Ω at the time the resistance measurements described below were made. After the coil was removed from the yoke it was determined that the short is to the collars and not to the end clamps.

To determine the location of the short the magnet was powered with a current source which had no reference to ground and the voltages to ground at various points in the coil were measured via voltage taps. Because of the high and fluctuating resistance to ground, an extremely well isolated current source was needed; a 12 V storage battery with a 20 Ω resistor were used to deliver about 0.6 A to the coil. The current was measured with a hand-held multimeter (battery operated and "perfectly" isolated from ground) and the coil voltages to ground were measured with an HP 3457A DVM which has an input impedance of 10 G Ω on the scale used. The circuit is shown in Fig. 1.

The measurements are shown in Table I. The measured voltages fluctuated by less than ± 0.1 mV and the average voltages were reproducible to better than this level over the approximately 15 minutes that it took to make the measurements. The current drifted down by about 0.1 mA over the course of the measurements, presumably because the resistance of the 20 Ω resistor increased as it heated. (The current was on for at least 15 minutes before any measurements were taken and the resistor was quite hot to the touch.) The quarter coil resistances deduced from the measured voltages are shown in Table II. They agree well with the values noted in the Traveler during the post-cure inspection and the two inner and two outer coils agree with each other extremely well. This supports the model that there is a single short to ground.

The ground short is in the lower outer coil, 9.4 ± 0.1 m Ω from the inner-outer splice. (The ± 0.1 m Ω uncertainty estimate comes from the stability of the 0.1 mV digit in the voltage measurement.) The cable has a resistance of 2.320 m Ω /m, so the short is 4.05 m from the splice. Alternatively, the Traveler lists the total length of cable in the coil as 78.0 m. The short is 5.24% of the length or 4.09 m from the splice. The best estimate of the distance is the average of the two calculations and the uncertainty is taken to be half the

difference between them added linearly to the uncertainty from the voltage measurement, yielding a result of 4070 ± 60 mm.

To determine the location that corresponds to this distance we add up the lengths of various cable segments as shown in Figure 2. From the middle of the splice joint to the point where the preform enters the pole turn is about 200 mm; to the return end of the straight section is 1200 mm; the return end cable length is about 130 mm; the straight section, lead end and next straight section (2nd turn from the pole) are 1270 mm, 130 mm and 1270 mm respectively. The total distance up to this point (the return end of the straight section of the 2nd turn from the pole) is 4200 mm. The uncertainty in this calculated distance is estimated to be ± 50 mm coming from the uncertainty in the end and preform lengths.

The short is $4200 - 4070 = 130 \pm 110$ mm from the return end to the straight section of the 2nd turn from the pole of the lower outer coil (quadrant III). The collars end 76.2 mm from the end of the straight section. Therefore the short is between 0 and 155 mm from the return end of the collars.

Distribution:

J. Carson
S. Delchamps
M. Gordon
R. Pace
E.G. Pewitt

Table I
Measured Voltages to Ground

Location	I(mA)	V-ground(mV)	V/I(m Ω)
LI Lead	574.6	66.7	116.1
LI-LO Splice	574.5	5.4	9.4
LO-UO Splice	574.5	-97.6	-169.9
UO-UI Splice	574.5	-200.5	-349.0
UI Lead	574.5	-261.9	-455.9

Table II
Coil Resistances

Coil Segment	This Measurement	Traveler
Lower Inner	106.7 m Ω	105.1 m Ω
Upper Inner	106.9 m Ω	106.2 m Ω
Lower Outer	179.5 m Ω	178.1 m Ω
Upper Outer	179.1 m Ω	178.3 m Ω
LI-LO splice-to-short	9.4 m Ω	

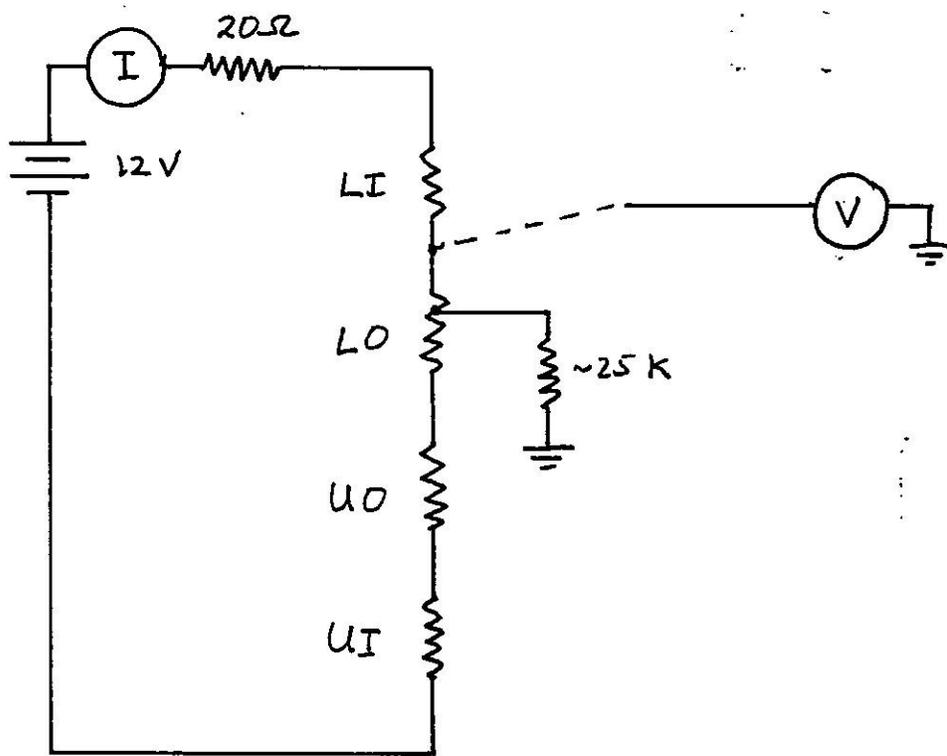
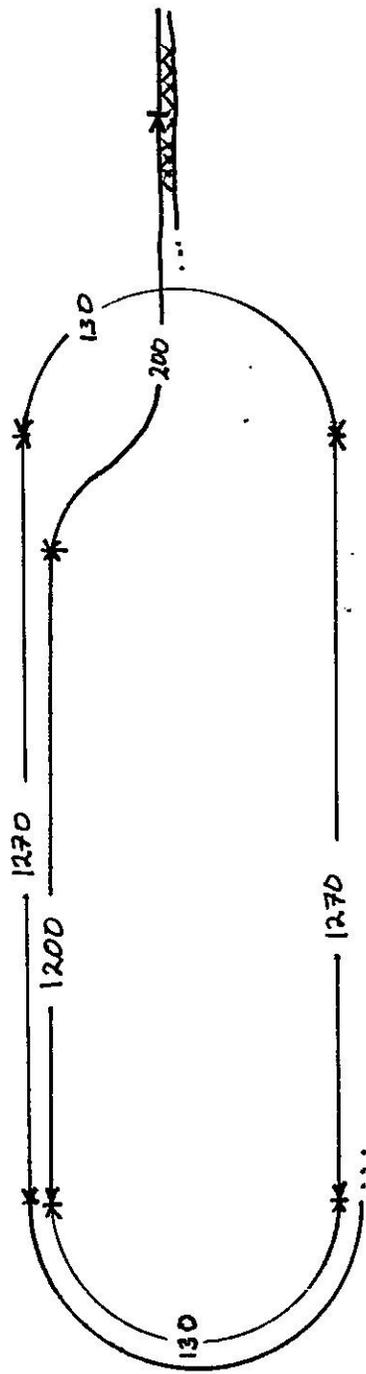
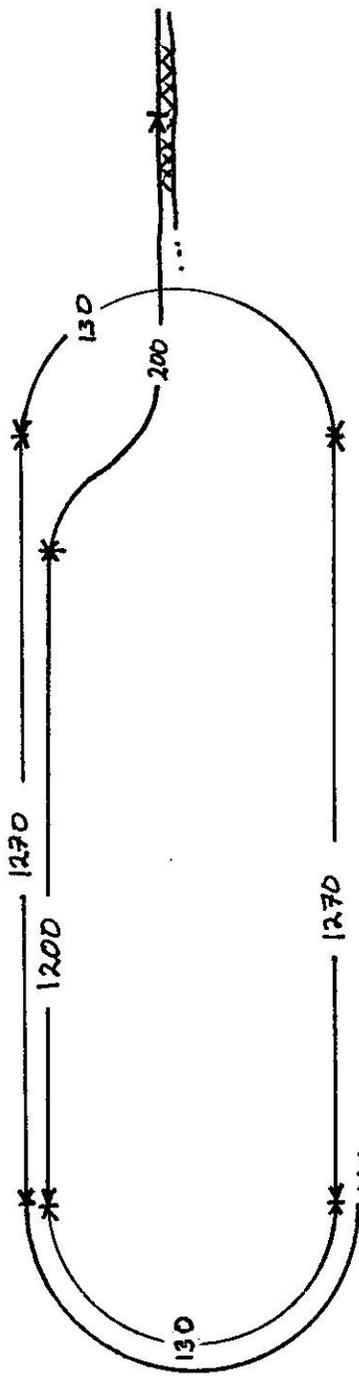


Figure 1



all dimensions mm

Figure 2



all dimensions mm

Figure 2