Fermilab

TS-SSC 92-044
3/23/92

DCA320 Turn-to-turn Short Located

DCA320 was disassembled following the determination that it had a turn-to-turn short. By electrical measurements the short had been localized to uninstrumented portion of the lower inner coil (15M-50-1022)[1]. The coil resistance was monitored and the short was observed to clear when the the keyss were removed from the last collar pack at the return end. The coils were separated and then the offending coil was compressed in the sizing fixture over the last 6 inches from the return end until the short reappeared. By resistance measurements made by piercing the insulation with a sharp probe, the short was found to be between turns 3 and 4, counting from the mid-plane, in quadrant I/III, 9.25" from the return end of the saddle, or 0.5" into the collared region. The conductors were carefully pried apart, but no obvious cause for the short could be observed. A 3 mil piece of Kapton was slipped between the turns and the offending spot was compressed by the sizing fixture. The short did not return. I measured the coil resistance, using an HP3457 DMM, to be 1.142 Ohms, and the resistance of the upper inner coil (15M-50-1021) to be 1.151 Ohms. This is approximately the original difference between the two coil resistance.

While it is disconcerting to have a short with no known cause, I believe that we should reassemble the magnet and re-key it. However, to limit the peak stress in the collaring press, I propose that the press be shimmed to limit the closure of the tooling. I will recommend a shim thickness shortly.

ACKNOWLEDGEMENTS

Essentially all the information noted above was given me by Denny Gaw and Dan Smith. Denny made the electrial measurements and Imre Gonczy made the coil repairs.

REFERENCE

[1] J. Strait, DCA320 Turn-to-turn Short, TS-SSC 92-039, 3/18/92.

Distribution:
R. Bossert, J. Carson, S. Delchamps, W. Koska, E.G. Pewitt, M. Wake,
DCA320 Traveler, Discrepancy Report#480

FNAL/SSC DISCREPANCY REPORT

1) Traveler Title:	2) Traveler No.:	3) Rev. No.:	4) DR No.:
Keying Procedure	ES-298280	H	480

5) Step No.:	6) Drawing/Revision No.:	7) Magnet/Coil Serial No.:	QA Assigned: Class: (1) or II
3.9		DCA-320	

8) Nonconformance Description by First Hand Observer:
The lower inner coil resistance (measured) was 1129 AT Post keyed. The coil resistance at Post collared was measured at 1142 AND the resistance Data Taken During Keying shows a coil to coil short at 7049 psi (See Attached sheets).

9) Name Al Forgety Title: QA Date: 3-18-92

10) Cause of Nonconformance:

11) Responsible Authority/Physicist Date:

12) Disposition:

11) Responsible Authority/Physicist Date:

13) Corrective Action to Prevent Recurrence:

14) Responsible Authority/ Physicist Title: Date:

15) Corrective Action/Disposition Verified By:

11) Responsible Authority/Physicist Date:
Class: I or II
Will Configuration be effected? [ ] Yes [ ] No

16) Approved By:

QA/QC Project Manager Date:

17) Reviewed By:

SSCL Q.A. Engineer Date:

RESISTANCE DATA TAKEN DURING KEYING

Magnet number: DCA320

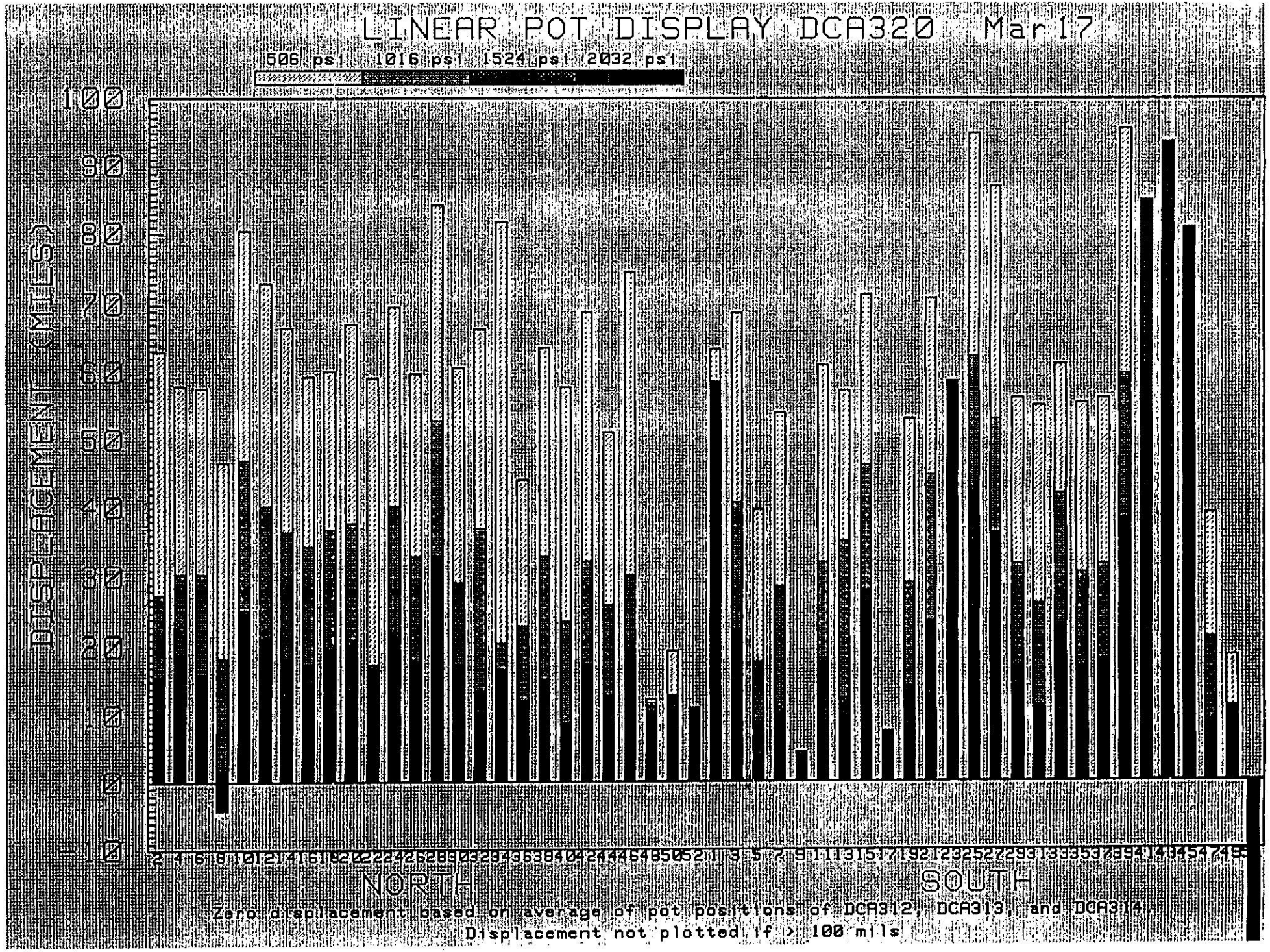
Date: 17 Mar 1992

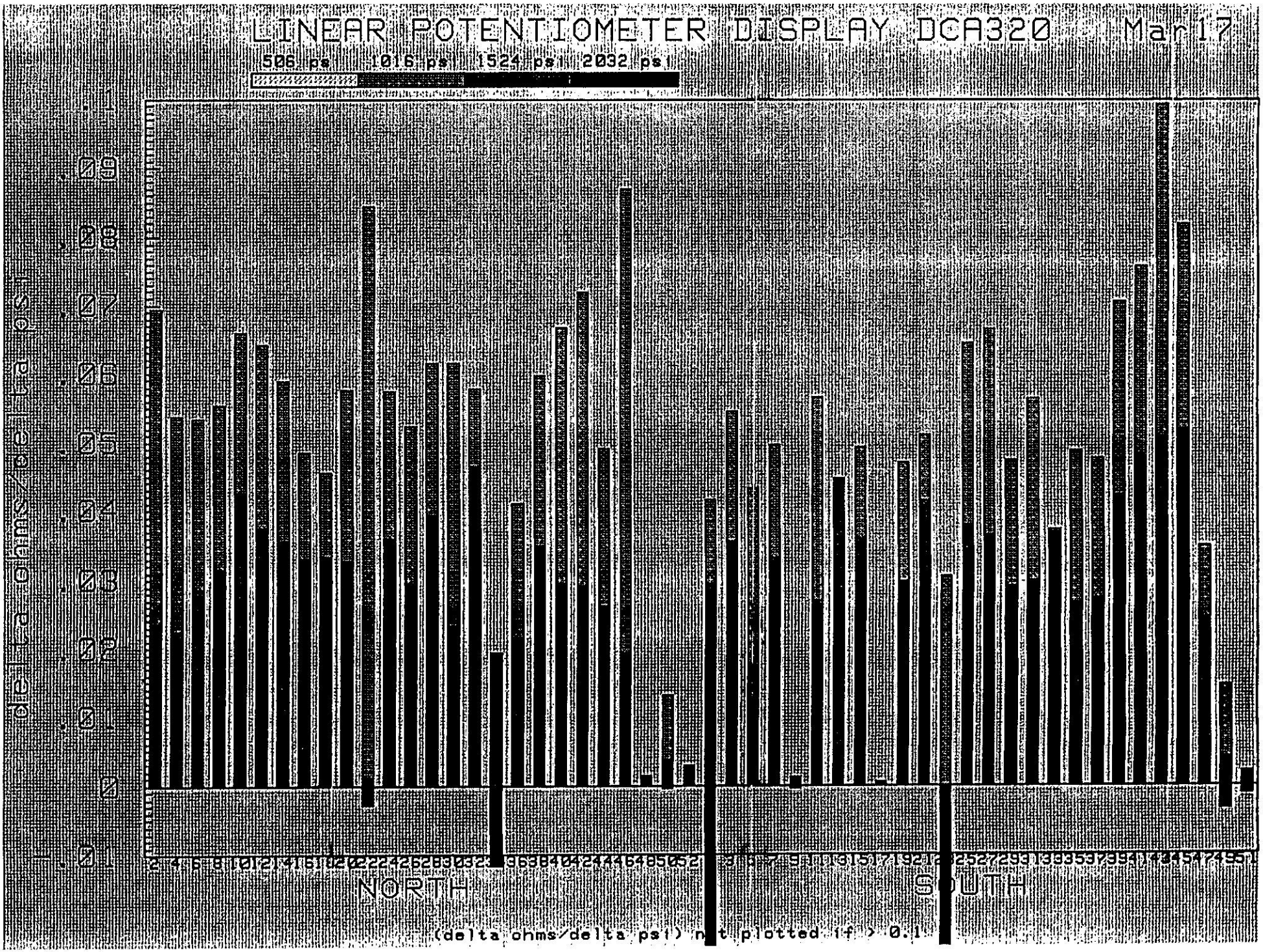
Time: 09:01:02

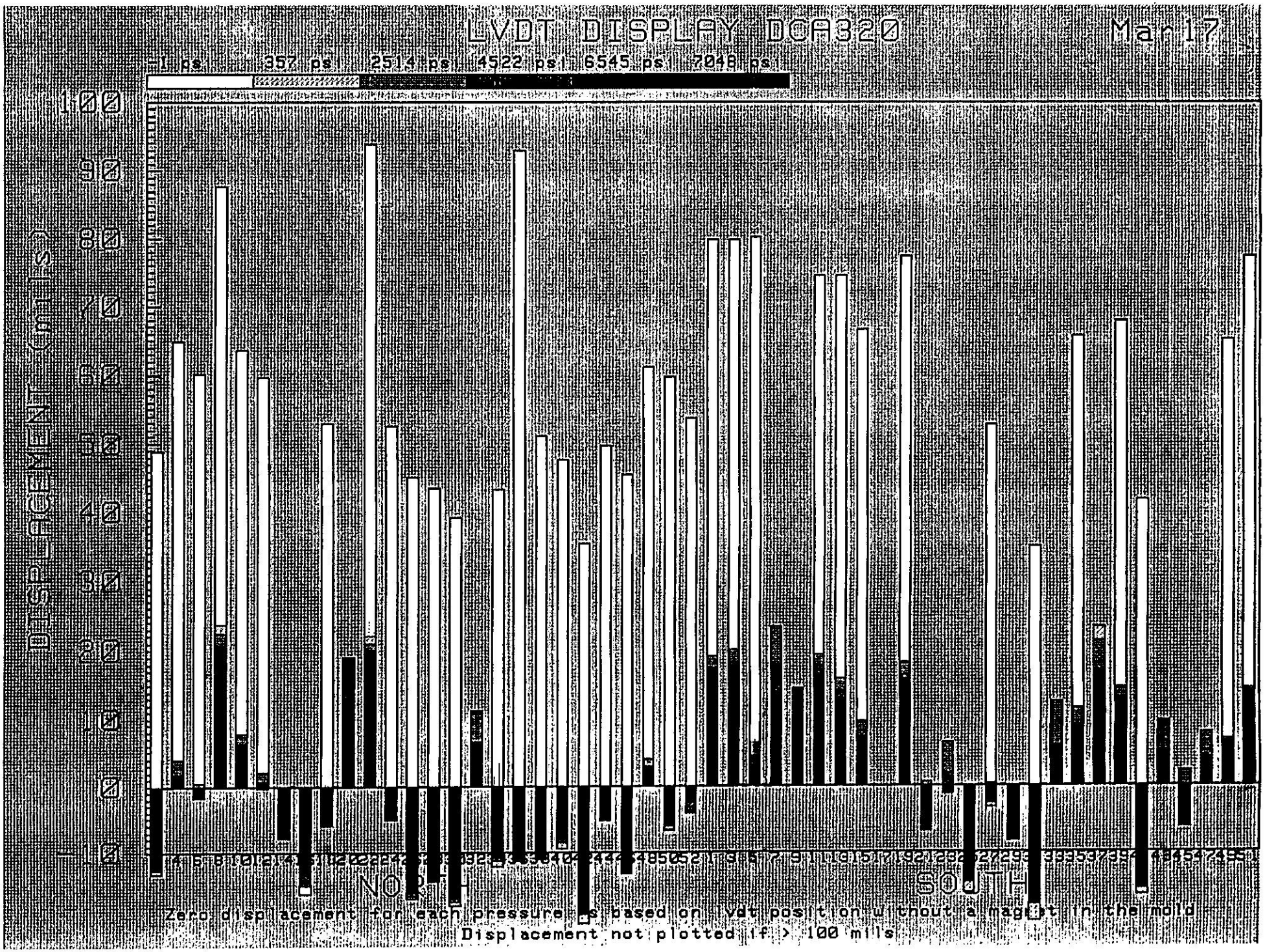
Operator's name: D.GAW

Comment: FIRST ATTEMPT THIS MAGNET HAS THE NEW CABLE INSULATION KAPTON WITHOUT FIBERGLASSTAPE

100-JACK	SIDE-JACK	UPPER COIL	LOWER COIL	% Difference	Coil-to-coil
-1 psi	-1 psi	2.974 ohms	2.960 ohms	.470%	OPEN
357 psi	8 psi	2.972 ohms	2.961 ohms	.370%	OPEN
2514 psi	7 psi	2.973 ohms	2.960 ohms	.440%	OPEN
4522 psi	7 psi	2.972 ohms	2.957 ohms	.500%	OPEN
6545 psi	7 psi	2.971 ohms	2.959 ohms	.400%	OPEN
7048 psi	7 psi	2.970 ohms	2.950 ohms	.670%	OPEN
7049 psi	6 psi	2.969 ohms	2.950 ohms	.640%	SHORT
7027 psi	506 psi	2.969 ohms	2.950 ohms	.640%	OPEN
7030 psi	1016 psi	2.969 ohms	2.950 ohms	.640%	OPEN
7042 psi	1524 psi	2.969 ohms	2.950 ohms	.640%	OPEN
7035 psi	2032 psi	2.968 ohms	2.952 ohms	.540%	OPEN
4078 psi	1976 psi	2.970 ohms	2.956 ohms	.470%	OPEN
14 psi	6 psi	2.969 ohms	2.955 ohms	.470%	OPEN


LINEAR POT DISPLAY DCA320 Mar 17
506 psi
1016 psi
1524 psi
2032 psi
DISPLACEMENT (MILS)
100
90
80
70
60
50
40
30
20
10
0
-10
NORTH
SOUTH
Zero displacement based on average of pot positions of DCA312, DCA313, and DCA314.
Displacement not plotted if > 100 mils


LINEAR POTENTIOMETER DISPLAY DCA320
Mar17
506 psi
1016 psi
1524 psi
2032 psi
delta ohms/delta psi
.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
NORTH
SOUTH
(delta ohms/delta psi) not plotted if > 0.1


LVDT DISPLAY DCA320
Mar 17
1 psi
357 psi
2514 psi
4522 psi
6545 psi
7048 psi
100
90
80
70
60
50
40
30
20
10
0
10
DISPLACEMENT (mils)
NORTH
SOUTH
Zero displacement for each pressure is based on lvdt position without a magnet in the mold
Displacement not plotted if > 100 mils

Fermilab

TS-SSC 92-039
3/18/92
J. Strait

DCA320 Turn-to-turn Short

DCA320 has developed a turn-to-turn short either during or immediately after the coller keying operation. The short is in the uninstrumented portion of the lower inner coil. Table I summarizes the inner coil resistance measurements recorded in the Traveler. From before to immediately after keying the lower inner coil resistance decreased 6 milliohms relative to the upper inner coil. This, however, is within the range of variation observed among earlier measurements and did not cause immediate alarm. By the next day, however, it had lost another 13 milliohms, and it became evident that there is a problem.

Table II and Figure 1 show the upper and lower half coil resistances during the keying operation. It is evident that the lower coil resistance dropped about 5 milliohms when the vertical press hydraulic pressure was brought from 6500 to 7000 psi. (No increase in coil stress was observed by the strain gauges at this step, however.) This represents only a 0.2% change in the lower-upper coil difference which is below the alarm threshold of 0.5%. As the press was opened, the lower-upper coil difference returned to its original value. In retrospect, of course, this change indicated the presence of a short; unfortunately no one was looking closely enough.

Table III gives the voltage tap series check data from the Traveler. Also indicated are 1) z, the estimated cable length, in inches, from tap 19B to each tap, 2) dz, the distance from the indicated tap the the previous one, and 3) $\langle z \rangle$, the average z of the cable segment defined by the indicated tap and the previous one. Vraw is the measured voltage from the Traveler. Vnorm is that voltage normalized to make the voltage at 13A match the "standard" voltage listed in the Traveler of 313.5 mV. dVnorm is the normalized voltage difference between the one tap and the previous tap. The data in the collared (pre-keyed) and keyed states are compared at the right. Within the instrumented portion, the normalized voltage at each tap differs between the two sets by at most 0.1 mV, which corresponds to the least significant digit recorded in the Traveler. However, the the normalized voltage across the uninstrumented portion is 17 mV lower after keying. This corresponds to a 19 milliohm decrease in resistance.

There is no further information about the location of the short that can be obtained without disassembling the magnet. Therefore we should begin disassembly as soon as the standard post-keying inspection has been completed. To aid in the location of the short, all 4 keys should be pryed out together down the length of the magnet and the upper inner and lower inner coil resistances should be monitored as the keys are pryed out. The resistances should be recorded after every 2 feet of the keys has been removed from the key slots.

Distribution:
R. Bossert, J. Carson, S. Delchamps, W. Koska, E.G. Pewitt, M. Wake,
DCA320 Traveler, Discrepancy Report, D. Smith

1022 Vtaps Keyed-Collared

Table I

		Inner Coils			
		Rupper	Rlower	Rl-Ru	Δ(Rl-Ru)
1/31/92	Post Cure	1148	1137	-11	0
2/7/92	Pre-Assembly	1147	1142	-5	6
2/18/92	Post-Assembly	1148	1139	-9	2
3/10/92	Pre-Collared	1148	1137	-11	0
3/12/92	Post-Collared	1153	1142	-11	0
3/17/92	Post Keyed	1146	1129	-17	-6
3/18/92	Post Keyed	1149	1119	-30	-19

TableI

Keying Sequence

Vert	Horiz	Rupper	Rlower	Rl-Ru	Δ(Rl-Ru)	Δ/R
-1.0	-1.0	2974	2960	-14	0	0.00%
357.0	8.0	2972	2961	-11	3	0.10%
2514.0	7.0	2973	2960	-13	1	0.03%
4522.0	7.0	2972	2957	-15	-1	-0.03%
6545.0	7.0	2971	2959	-12	2	0.07%
7048.0	7.0	2970	2950	-20	-6	-0.20%
7049.0	6.0	2969	2950	-19	-5	-0.17%
7027.0	506.0	2969	2950	-19	-5	-0.17%
7030.0	1016.0	2969	2950	-19	-5	-0.17%
7042.0	1524.0	2969	2950	-19	-5	-0.17%
7035.0	2032.0	2968	2952	-16	-2	-0.07%
4078.0	1976.0	2970	2956	-14	0	0.00%
14.0	6.0	2969	2955	-14	0	0.00%

Table III

1022 Vtaps Keyed-Collared

Coil 15M-50-1002 (DCA320 Lower Inner)

Vtap	Cable z (in)	dz	<z>(in)	Collared (3/12/92) Vraw (mV)	Vnorm (mV)	dVnorm (mV)	dV/dz (μV/in)	Vtap	Keyed (3/18/92) Vraw (mV)	Vnorm (mV)	dVnorm (mV)	dV/dz (μV/in)	Vtap	Keyed - Collared. Vnorm (mV)	dVnorm (mV)
19 B	0.0			0.0	0.0			19 B	0.0	0.0			19 B	0.0	
19 A	11.5	11.5	5.8	0.5	0.5	0.5	44.9	19 A	0.5	0.5	0.5	45.1	19 A	0.0	0.0
19 C	585.3	573.8	298.4	26.1	26.1	25.6	44.6	19 C	26.6	26.1	25.6	44.6	19 C	0.0	0.0
19 D	596.6	11.3	590.9	26.5	26.5	0.4	35.4	19 D	27.0	26.5	0.4	39.1	19 D	0.0	0.0
18 B	1171.1	574.5	883.8	52.1	52.1	25.6	44.6	18 B	53.0	52.1	25.6	44.5	18 B	0.0	-0.1
18 A	1182.4	11.3	1176.7	52.6	52.7	0.5	44.3	18 A	53.6	52.7	0.6	52.2	18 A	0.0	0.1
18 C	1757.6	575.3	1470.0	78.2	78.3	25.6	44.5	18 C	79.7	78.4	25.7	44.6	18 C	0.1	0.0
18 D	1767.4	9.8	1762.5	78.6	78.7	0.4	40.9	18 D	80.1	78.8	0.4	42.1	18 D	0.1	0.0
17 B	2343.4	576.0	2055.4	104.3	104.4	25.7	44.7	17 B	106.2	104.4	25.6	44.5	17 B	0.0	-0.1
17 A	2353.2	9.8	2348.3	104.7	104.8	0.4	40.9	17 A	106.7	104.9	0.5	50.2	17 A	0.1	0.1
17 C	2930.0	576.8	2641.6	130.4	130.5	25.7	44.6	17 C	132.7	130.5	25.6	44.3	17 C	-0.1	-0.2
17 D	2938.3	8.3	2934.1	130.7	130.8	0.3	36.2	17 D	133.1	130.9	0.4	52.1	17 D	0.1	0.1
16 B	3515.8	577.5	3227.0	156.3	156.4	25.6	44.4	16 B	159.2	156.5	25.6	44.4	16 B	0.1	0.0
16 A	3525.0	9.2	3520.4	156.8	157.0	0.5	54.4	16 A	159.7	157.0	0.5	53.4	16 A	0.0	0.0
16 C	4103.2	578.3	3814.1	182.5	182.7	25.7	44.5	16 C	185.8	182.6	25.6	44.3	16 C	0.0	-0.1
16 D	4111.8	8.6	4107.5	182.8	183.0	0.3	34.9	16 D	186.2	183.0	0.4	43.4	16 D	0.0	0.1
15 B	4690.8	579.0	4401.3	208.5	208.7	25.7	44.4	15 B	212.3	208.7	25.7	44.4	15 B	0.0	0.0
15 A	4699.4	8.6	4695.1	208.9	209.1	0.4	46.6	15 A	212.7	209.1	0.4	45.7	15 A	0.0	0.0
15 C	5276.2	576.8	4987.8	234.6	234.8	25.7	44.6	15 C	238.8	234.8	25.7	44.5	15 C	-0.1	-0.1
15 D	5289.3	13.1	5282.7	235.2	235.4	0.6	45.8	15 D	239.4	235.4	0.6	45.8	15 D	-0.1	0.0
14 B	5863.8	574.5	5576.5	260.7	260.9	25.5	44.4	14 B	265.4	260.9	25.6	44.5	14 B	0.0	0.0
14 A	5876.9	13.1	5870.3	261.3	261.6	0.6	45.8	14 A	266.0	261.5	0.6	46.5	14 A	0.0	0.0
14 C	6452.1	575.3	6164.5	286.9	287.2	25.6	44.5	14 C	292.1	287.1	25.6	44.5	14 C	-0.1	0.0
14 D	6463.7	11.6	6457.9	287.4	287.7	0.5	43.1	14 D	292.6	287.6	0.5	44.1	14 D	-0.1	0.0
13 B	7039.7	576.0	6751.7	313.0	313.3	25.6	44.5	13 B	318.6	313.2	25.6	44.4	13 B	-0.1	0.0
13 A	7051.3	11.6	7045.5	313.5	313.8	0.5	43.1	13 A	319.2	313.8	0.6	50.8	13 A	0.0	0.1
0 A	22476	15425	14764	999.7	1000.7	686.9	44.5	0 A	1000.2	983.3	669.5	43.4	0 A	-17.4	-17.4

584 Straight sect lgth
1.8 End lgth (turn 18)
3.6 End lgth (turn 15)

Vnorm = Vraw*313.8mV/V(13A)

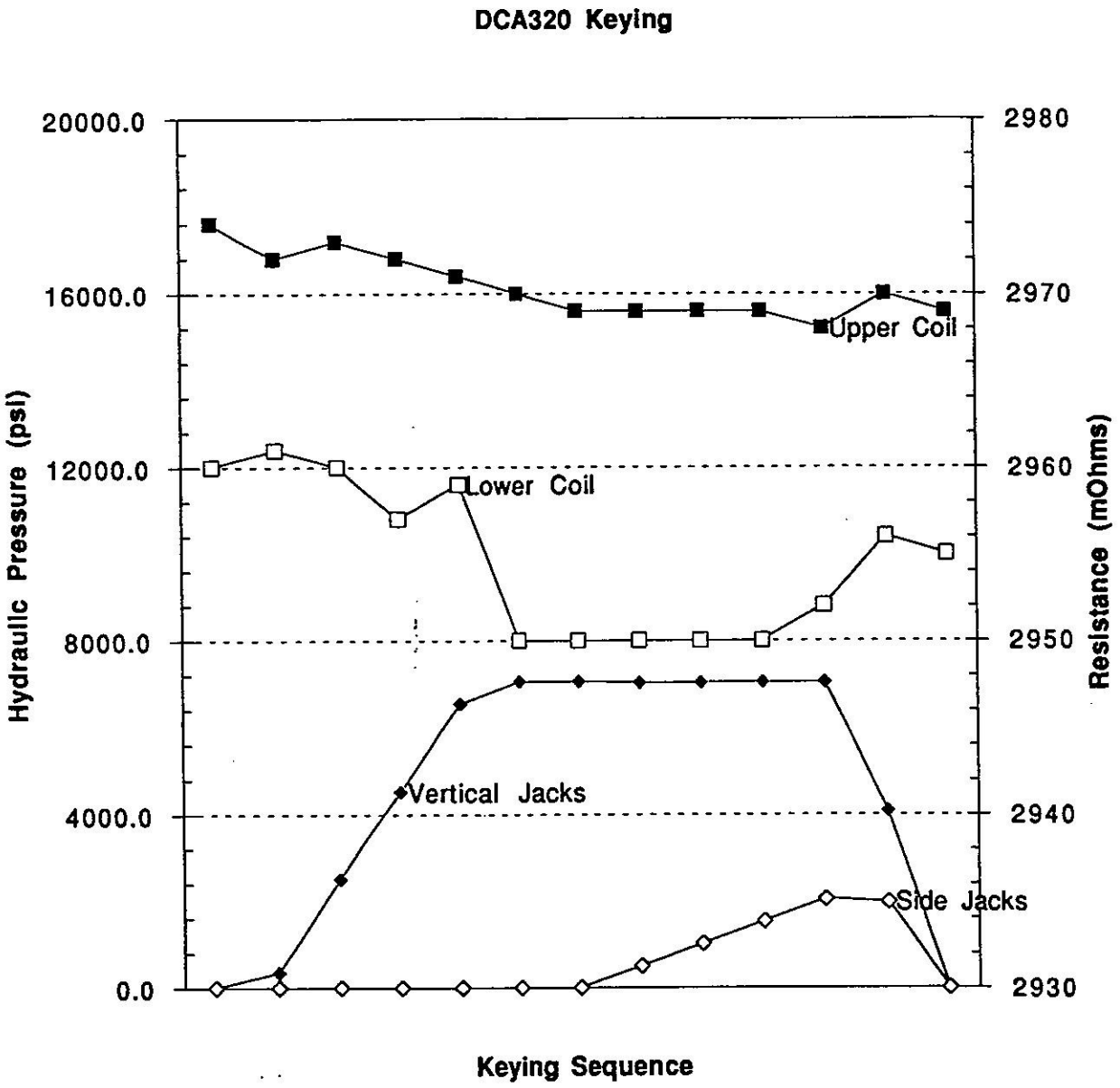

DCA320 Keying
20000.0
16000.0
12000.0
8000.0
4000.0
0.0
Hydraulic Pressure (psi)
2980
2970
2960
2950
2940
2930
Resistance (mOhms)
Upper Coil
Lower Coil
Vertical Jacks
Side Jacks
Keying Sequence

Figure 1