Fermilab

TS-SSC 91-234
11/27/91
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Location of turn-to-turn short in DCA318

SUMMARY

A turn-to-turn short has developed in the upper inner coil of DCA318 (coil 15M-50-1017) during installation of the lead end clamp. Resistance measurements indicate that the short is between turns 19 (the pole turn) and 18, 2.5+/-1.0 inches from tap 18A towards tap 18B. This is 0.7+/-1.0 inches into the end clamp. The cable in turn 19 begins to move away from turn 18 and into the inner-outer splice preform 0.5 inches into the end clamp. Thus the short must be 0.7 +0.0/-1.0 inches into the end clamp. "Anomolous" voltages readings at tap 19A, which is 2.5 inches into the collared portion of the coil, could be interpreted to put the short at tap 19A instead. However, since the short only appeared when the end clamp was being installed, this interpretation of the data appears to be a less likely to be correct.

VOLTAGE TAP DATA

A turn-to-turn short has developed in the upper inner coil of DCA318 (coil 15M-50-1017) during installation of the lead end clamp. Voltage tap measurements were taken to try to locate the short. A voltage of 1.002 V was placed across the offending coil and the voltages relative to tap 19B (at the inner-outer splice) were measured at taps 19A through 17D. The data are displayed in Table I in the column labeled "V (mV)." The voltage at tap 19A is expected to be about 0.5 mV, yet it is measured to be 17 mV, almost equal to the voltage one turn away. This leads us to suspect that the short may be related to damage to tap 19A or an incorrect installation of it. A possible circuit that would explain the observed pattern of voltages is shown in Figure 1. In the analysis below the voltage at this tap is ignored, however.

The length of cable corresponding to each voltage tap segment was determined from the voltage tap installation drawing, a portion of which is attaced as Figure 2. The length of the end segment, from the end of the straight section on one side to the beginning of the straight section on the other side was measured to be about 1.8 inches for turn 18. This value was applied to all three turns in Table I, although there is an estimated 0.2 inch difference from one turn to the next. The distance from tab 19A to 19B was set to 10 inches in the Table as a pure guess. (This length does not enter into the determination of the short location.)

DATA ANALYSIS

The derivative dV/dz (z is the coordinate along the cable) is displayed in Table I. The first entry corresponds to taps 19B-19C, and the rest correspond to adjacent pairs. Between taps 18A and 18B the derivative changes by about a factor of three. The lower derivative between 18A and 19B results from the fact that about 2/3 of the current is flowing through the short and only 1/3 through the coil. Because the derivative in the 18A-18B segment is intermediate between that in the segments on either side, the short must be within that segment. Figure 3 is a plot of the voltage and derivative data versus length along the cable. Shown also are two linear least squares fits done to the data on either side of the short. In order not to bias the determination as to which side of tap 18A the short is located, the data from tap 18A has not been used in either fit. The voltages at each tap predicted by the two fits are shown in Table I. In the region of each fit, the measured values deviate from the fit by at most 0.02 mV. Although 18A was not included in the fit, it lies "perfectly" on the fit done to 18C-17D.

At the location of the short the slope dV/dz changes; therefore the location can be determined from the intersection of the two fit lines. The data and the fits in Figure 3 are plotted on an expanded scale around the intersection point in Figure 4. Note again that tap 18A is NOT included in the fit. The lines intersect at z = 1168.3 inches, which is 2.5 inches from tap 18A towards tap 18B. Two main factors enter into the uncertainty in this estimate: the knowledge of the cable length between the end taps and noise in the voltage readings. The uncertainty in the cable length at the ends is on the order of +/-0.25 inch, which gives rise to an uncertainty in the short location relative to tap 18A of about +/-0.1 inch. Both from the deviations of the measured voltages from the fits and from observed fluctuations in the voltmeter readings, the estimated uncertainty in the voltages is around +/-0.02 mV. The location of the intersection point is most sensitive to the data points nearest to it. Varying the voltages at 18B, 18C and 18D by +/-0.02 mV gives rise an uncertainty in the location of the short of +/-1.5 inches, where the contributions from the three taps have been added linearly. Since the short is clearly between taps 18A and 18B, the data from 18A can be included in the fit with those from 18C-17D. This does not change the estimate of the short location, but it does reduce the uncertainty to +/-1.0 inch. Thus the location of the short is determined to be 2.5+/-1.0 inches from tap 18A towards 18B.

The short location is near the point where turn 19 moves away from turn 18 and into the inner-outer splice preform. This takes place 0.5 inches into the lead end key (Figure 5) or 2.25 inches from tap 18A. This limits the possible short location to between 1.5 and 2.3 inches from 18A towards 18B.

Unfortunately this contradicts the picture in Figure 1, which was based on the fact that tap 19A shows a voltage close to that at 18A. Tap 19A is 0.75 inches from 18A in the opposite direction from 18B. That is, the resistance measurements, ignoring 19A, indicate that the short is 3.3+/-1.0 inches from tap 19A, while the value of the voltage at 19A can "only" be explained if the short is at 19A. The location determined ignoring 19A is the more likely, however, because the short appeared when the end clamp was being installed. The collared portion of the coil ends 1.8 inches from 18A towards the coil end. The short location from the resistance measurements is therefore 0.7+/-1.0 inches into the end clamp, but 19A is 2.5 inches into the collared portion.

DISTRIBUTION:

R.Bossert, J.Carson, S.Delchamps, W.Koska, E.G.Pewitt, G.Tassotto, M.Wake

Table I

Vtap	Cable z (in)	V (mV)	z(in)	dV/dz(μV/in)
19 B	-10.0	0		
19 A	0.0	17.14		
19 C	573.8	8.82	281.9	15.1
19 D	585.1	8.98	579.4	14.2
18 B	1159.6	17.48	872.3	14.8
18 A	1170.9	17.73	1165.2	22.1
18 C	1746.1	44.37	1458.5	46.3
18 D	1755.9	44.81	1751.0	44.9
17 B	2331.9	71.50	2043.9	46.3
17 A	2341.7	71.97	2336.8	48.0
17 C	2918.5	98.66	2630.1	46.3
17 D	2926.8	99.04	2922.6	45.8

		Fit 19C-18B		Fit 18C-17D	
Vtap	z(in)	Fit V	V-Fit	Fit V	V-Fit
19 B	-10.0	0.18	0.18	-36.96	-36.96
19 A	0.0	0.33	-16.81	-36.50	-53.64
19 C	573.8	8.82	0.00	-9.93	-18.75
19 D	585.1	8.98	0.00	-9.40	-18.38
	1150.0	17.34		16.76	
18 B	1159.6	17.48	0.00	17.20	-0.28
18 A	1170.9	17.65	-0.08	17.73	0.00
	1190.0	17.93		18.61	
18 C	1746.1	26.15	-18.22	44.37	0.00
18 D	1755.9	26.30	-18.51	44.82	0.01
17 B	2331.9	34.82	-36.68	71.50	0.00
17 A	2341.7	34.96	-37.01	71.95	-0.02
17 C	2918.5	43.49	-55.17	98.66	0.00
17 D	2926.8	43.62	-55.42	99.05	0.01

Fit 19C-18B		Fit 18C-17D	
slope	intercept	slope	intercept
0.0148	0.3312	0.0463	-36.5

Point of intersection

z	V	z-z(18A)
1168.3	17.61	-2.5

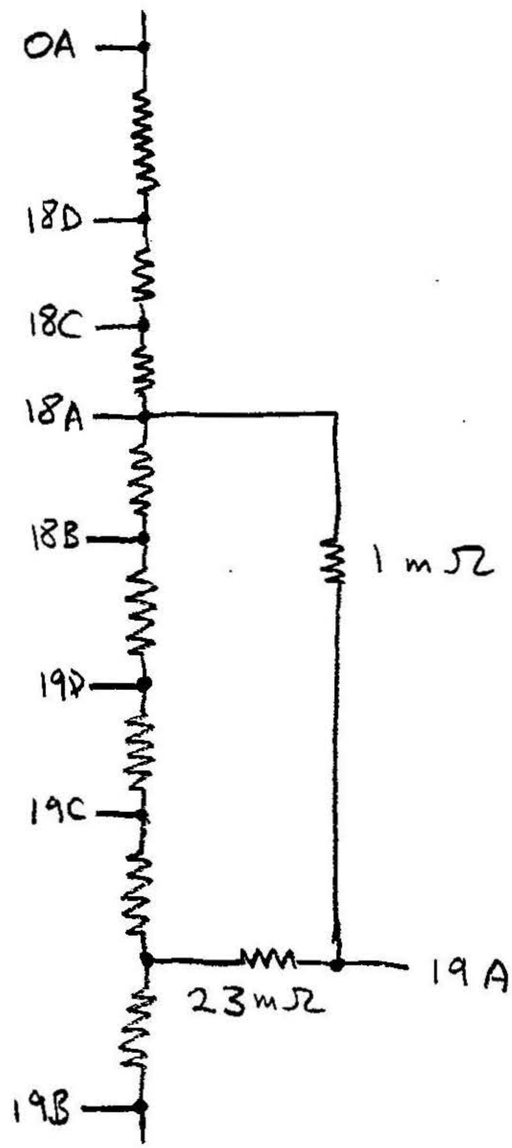


Figure 1

REV.	DESCRIPTION
A	CHANGED NOTE 2 FORM 32 AW AND ADDED NOTES 5

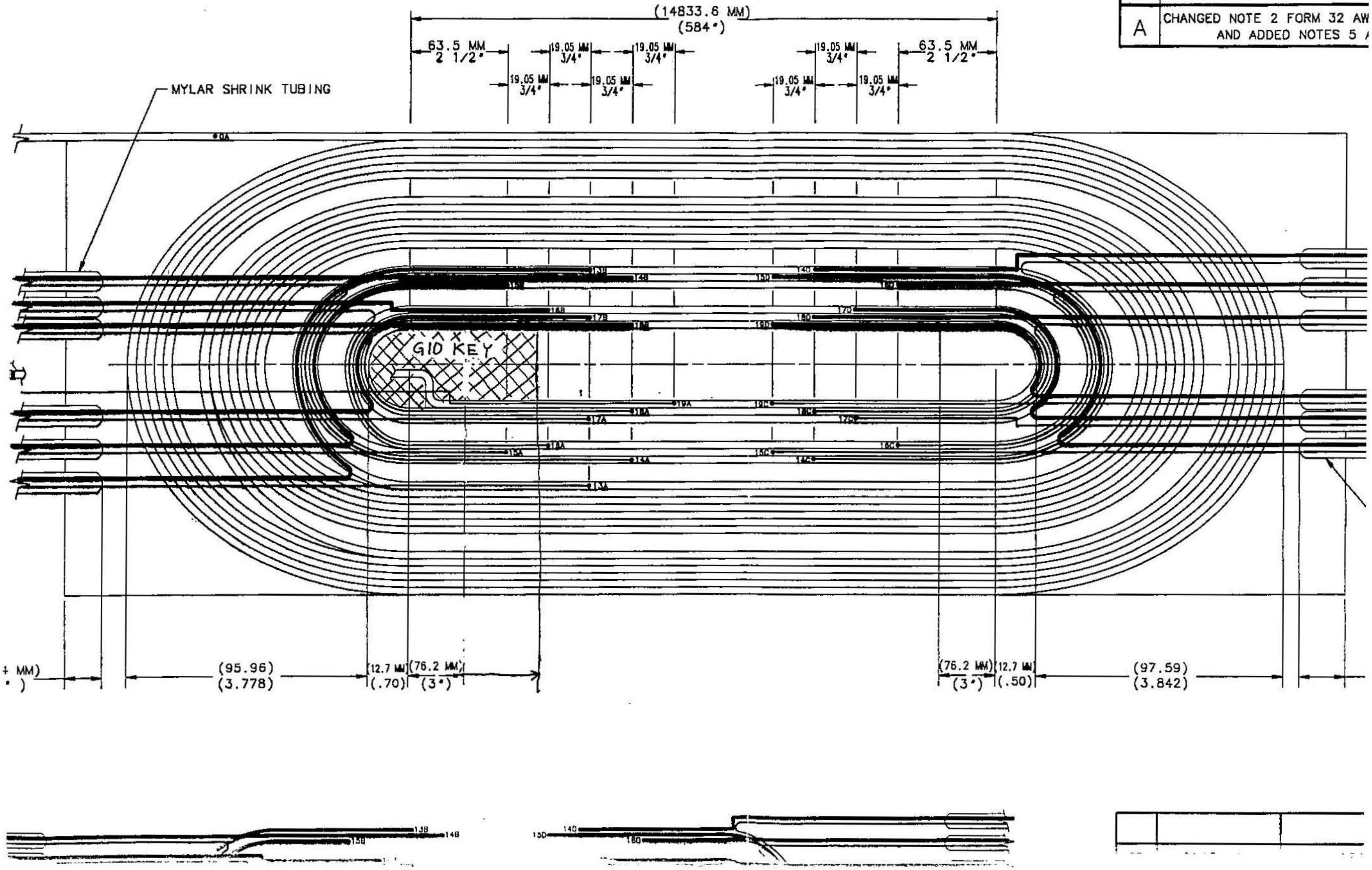


Figure 2

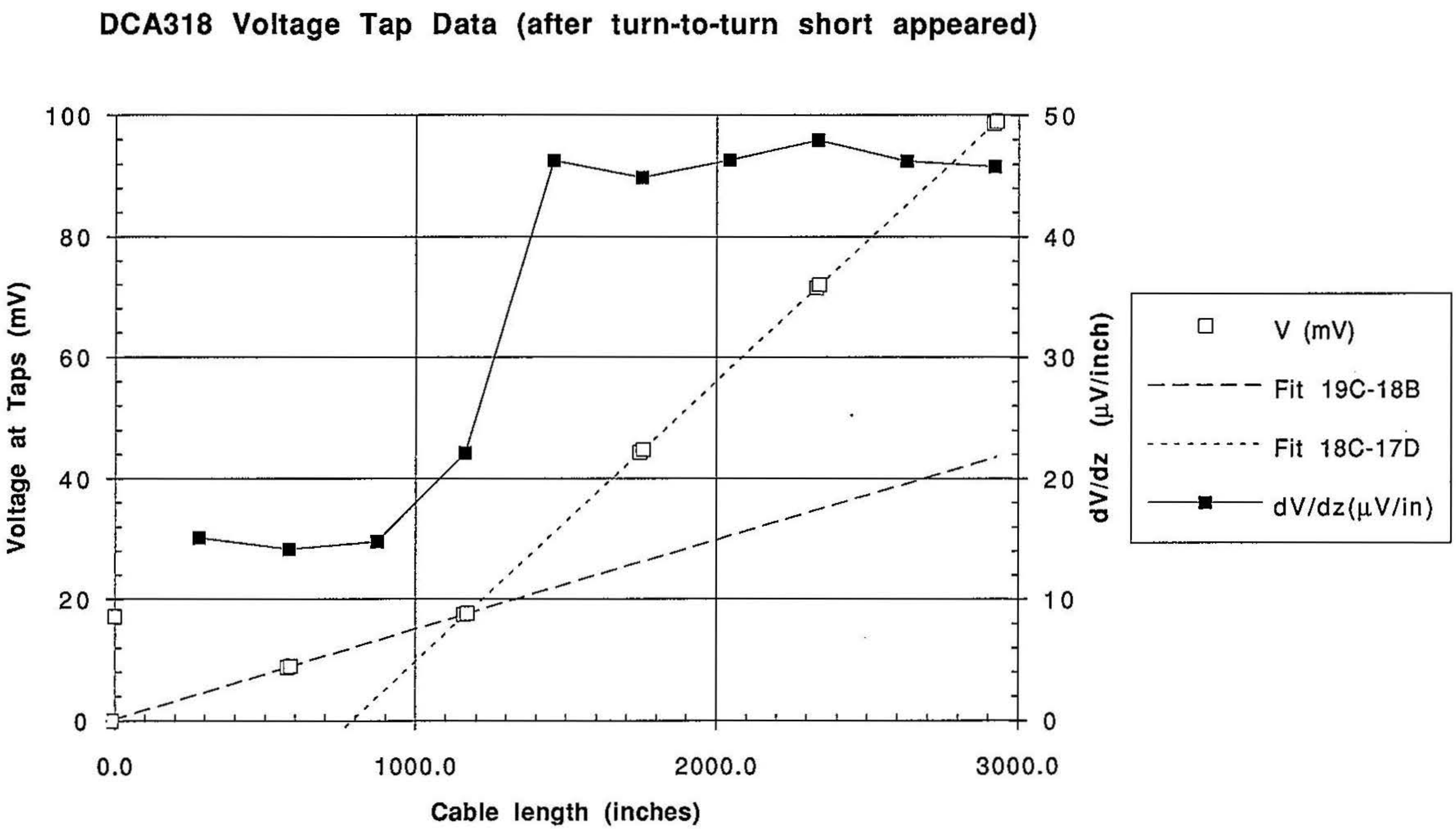

DCA318 Voltage Tap Data (after turn-to-turn short appeared)
Voltage at Taps (mV)
dV/dz (µV/inch)
Cable length (inches)
0.0
1000.0
2000.0
3000.0
0
20
40
60
80
100
0
10
20
30
40
50
V (mV)
Fit 19C-18B
Fit 18C-17D
dV/dz(µV/in)

Figure 3

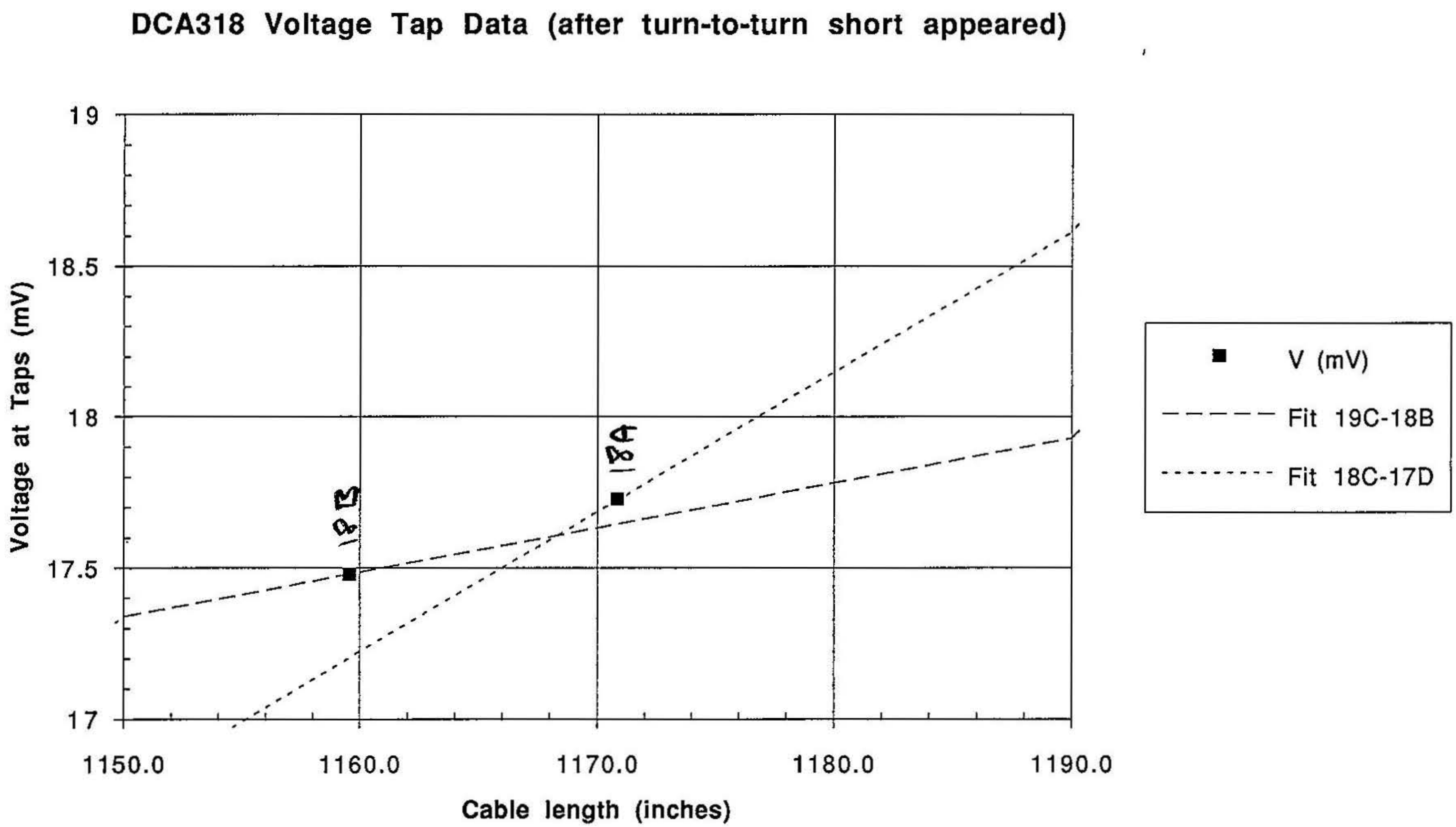
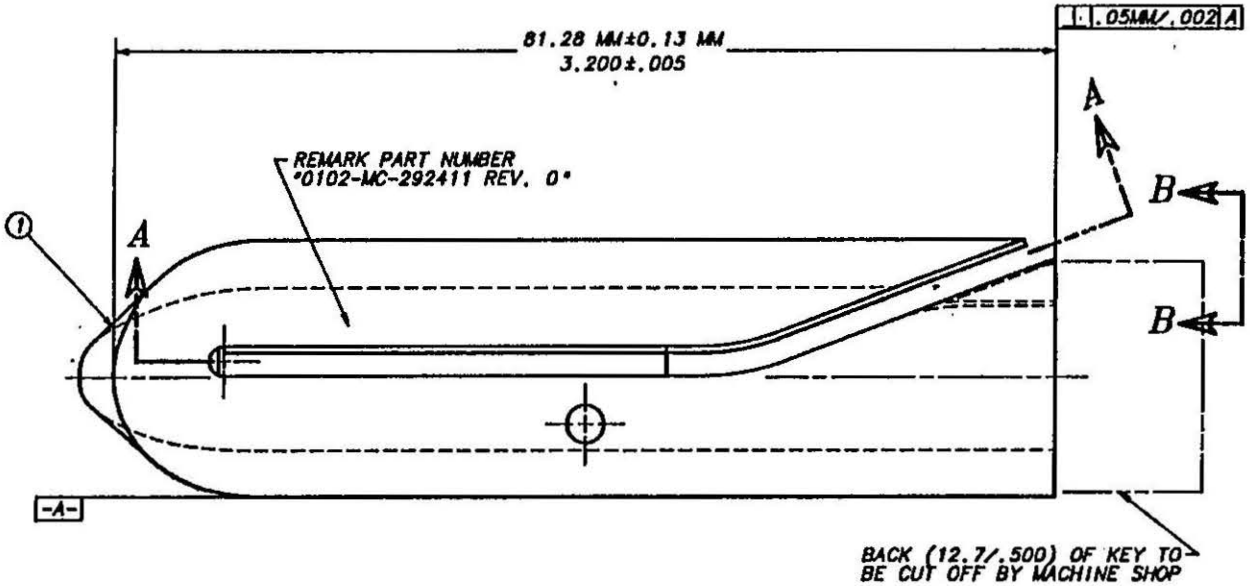
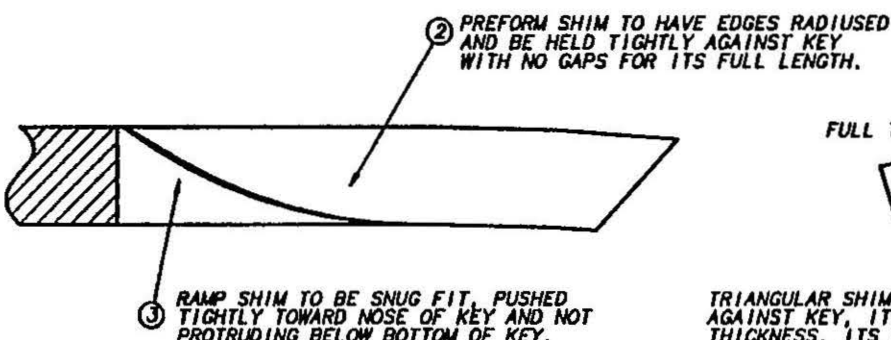

DCA318 Voltage Tap Data (after turn-to-turn short appeared)
Voltage at Taps (mV)
19
18.5
18
17.5
17
1150.0
1160.0
1170.0
1180.0
1190.0
Cable length (inches)
V (mV)
Fit 19C-18B
Fit 18C-17D
18B
18A

Figure 4

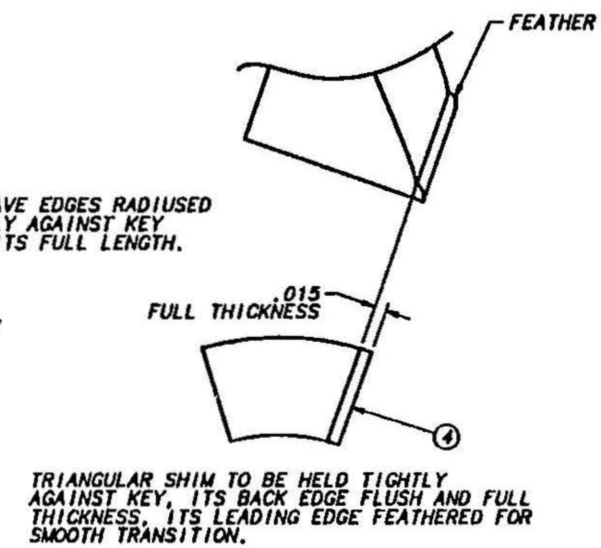
Figure 5



NOTE:
G-10 SHIMS #2, #3 AND #4 TO BE GLUED TO CUT-OFF KEY #1 WITH CYANOACRYLATE OR TWO-PART EPOXY. SHIMS MUST BE TIGHTLY PUSHED AGAINST KEY WHILE GLUE SETS TO PREVENT GAPS OR EXCESSIVE GLUE BOND THICKNESS.



VIEW A-A
SCALE 2:1



VIEW B-B
SCALE 2:1

ITEM	PART NUMBER	DESCRIPTION	QTY
4	0102-MB-292406	SHIM- TRIANGULAR	1
3	0102-MB-292374	SHIM- RAMP	1
2	0102-MB-292372	SHIM- PREFORM	1
1	0102-MC-292028	KEY- INNER COIL LEAD END	1

UNLESS OTHERWISE SPECIFIED:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. TOLERANCES: SEE NOTE 3
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982.
4. INCH DIMENSIONS ARE FOR REFERENCE ONLY.
5. BREAK ALL SHARP EDGES.
6. DO NOT SCALE DRAWING.
7. MAX. ALL MACH. SURFACES 125
8. DIMENSION IDENTIFICATION: MILLIMETER / INCH MILLIMETER/INCH

ORIGINATOR	J. BRANDT	
DRAWN	NWBARTLETT	6/28/91
CHECKED	J. BRANDT	7-9-91
APPROVED	Rodger Bossert	7-9-91
USED ON	0102-MA-292020	
MATERIAL		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
SSC

SSC 50mm DIPOLE COLD MASS
INNER COIL ASSEMBLY
MODIFIED LEAD END KEY- G-10

SCALE	DRAWING NUMBER	SHEET	REV.
3:1	0102-MC-292411	1 OF 1	

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