DSA322 Assembly Experiment Plan

J. Strait

Version 8.2
4/18/91

Objectives

DSA322 is a 1.5 m model 50 mm SSC collider dipole magnet which will be used for a series of assembly tests. The primary objectives are 1)to determine the correct collaring shims and the correct coil size to achieve simultaneously the correct harmonics and the correct preload, 2)to understand the proper use of the 50 mm collaring tooling in a series of exercises similar to those performed for the 40 mm tooling with DS0312 and 3)to understand coil preloads in the end clamp region and try to find correlations between the end preload and easily measured quantities. Because these three objectives are somewhat orthogonal, the plan for each is written separately and it is expected that the three sets of experiments will proceed more or less independently of each other. This plan is a working document and will evolve as the tests proceed.

Version 8.2 4/18/91
Modified 4th disassembly procedure: cutting of keys near the middle of the magnet is now done after the keys have been pried out of the return half of the coil, rather than before.

Version 8.1 4/15/91
Include procedures to determine the location of the inner coil short to ground.

Version 8 4/11/91
Added 4th disassembly procedure.
Changed specified current scale for mid-plane hipots from 2 mA (a "typo") to 2 μA.

Version 7 3/22/91
Added 4th assembly procedure.

Version 6 3/18/91
Added strain gauge readings to end can installation on 3rd assembly.
Added 3rd disassembly procedure

Version 5 3/5/91
Removed end clamp from 2nd assembly and disassembly. Added procedure for third assembly.

Version 4 3/4/91
Added a procedure for the second disassembly.

DSA322 Assembly Experiment Plan

Version 3.2 2/25/91
Include shims on the azimuthal alignment surfaces of the tooling. Added two more collar deflection measurements.

Version 3.1 2/11/91
Modified the specification of azimuthal positions for collar diameter measurements and added measurements of an undeflected collar pack.

Version 3 2/8/91
A complete procedure for the second assembly is included.

Version 3 2/8/91
A complete procedure for the second assembly is included.

Version 2 2/5/91
The procedure for the first disassembly is made more explicit.

Version 1 1/25/91
The procedure for setting the collaring shims and coil size to achieve the proper harmonics and prestress is "complete" only through the section that deals with harmonics. The section specifying the plan for the end clamp has not been completed and is not included in this version. (This procedure was written after the initial packaging of the coils was well under way and it was too late to begin the end clamp experiments. They will begin on the second assembly of DSA322.) The collaring tooling procedure is very rough.

DSA322 Assembly Experiment Plan

I. First assembly

1) Two inner and two outer coils have been molded using the nominal tooling dimensions (no tooling shims). For the outer coils the pole key is 5 mils smaller than is called for by the "final" cross section design, so the outer coils have been molded in a cavity that is 5 mils too large in azimuth. These coils have been used for experiments in the winding and curing of the ends and appear, for reasons not understood, to have somewhat larger size variations within the coils than other 50 mm coils wound so far.

2) Collar the coils using the nominal insulation system (no collaring shims).
   - See the collaring tooling experiment plan for detailed procedures.
   - Record coil prestresses during and after the collar keying operation.
   - Measure collar diameters and store data as usual in the traveller.
   - Measure the harmonics (center position only) with the mole. Compare measured b_2 and b_4 with values predicted for the collared coil without iron as shown in Table I (calculations courtesy of Ramesh Gupta). Compute inner and outer shims required to set b_2 and b_4 to their correct values using the shim sensitivities shown in Table I.

Table I
Expected Harmonics for W6733E Cross Section

	Harmonic Coefficients (units)		Shim Sensitivities (units/mil)		
	With Iron	Without Iron		Inner	Outer
B_o/I	1.047	0.795			
b_2	0.16	-4.0	db_2/dx	0.234	0.216
b_4	0.07	0.14	db_4/dx	-0.030	0.002
b_6	-0.021	-0.027	db_6/dx	0.004	-0.001
b_8	0.043	0.057	db_8/dx	-0.001	0.000
b_{10}	0.015	0.020			

DSA322 Assembly Experiment Plan

II. First Disassembly

1) Electrical inspection:
Measure coil resistances and record them in the traveller.
Perform coil-to-ground and upper-to-lower coil hi-pots; record results in the traveller.

2) Place collared coil in collaring press with a 10 mil shim between the upper tooling and the press platen.

3) Measure strain gauge resistances.

4) Close the press to 7000 pump psi. Verify that no gaps exist between the lower tooling and the upper platen.

5) Measure strain gauge resistances.

6) Remove the collar keys. (They should be loose at this point.)

7) Open the press.

8) Measure strain gauge resistances.

9) Remove the collared coil and keys from the tooling. Inspect the keys for any scoring on their surfaces or the presence of any chips. Record any finding in the space for comments at the end of the disassembly procedure.

10) Remove the collar packs from the coil and return the strain gauge packs to Marty and Ethel for inspection.

11) Remove all layers of ground insulation which can be removed without separating the inner from the outer coils. Compare the "as assembled" configuration with that specified in drawing MB-292047 and record any discrepancies in the comments section below. Note the quadrant and ends (lead vs. return) of each layer of insulation. Check for any foreign material within the collared coil assembly and record findings below.

12) Separate the upper from the lower coils but leave the inner and outer coils together and leave the remaining insulation on the coils. Place each coil half on insulating supports with the mid-plane up.

DSA322 Assembly Experiment Plan

II. First Disassembly

13) Perform mid-plane hi-pots on each half coil:
   a) Attach HV clip of hi-potter simultaneously to the inner and outer coils at the ramp-splice leads.
   b) Set voltage at 3.0 kV and current meter to the 2.5 mA scale.
   c) Run a grounded "wand" over the surface of the mid-plane separately on the left and right sides of the inner and outer coils. (Note that the grounded rod of this wand must be of a length equal to the width of the cable.) Record below the position of any breakdown as determined by observation of a spark, excessive current, or the appearance of breakdown marks on the insulation.
   d) Set HV = 0 and touch the grounded wand to the HV clip and the coil. Disconnect the hi-potter from the coil.
   e) If any breakdowns occurred, attempt to correlate them with foreign material or flaws in the insulation. Record any findings.

14) Remove the remaining insulation, noting the quadrant and end of each piece.

15) Give all insulation to Mike Winters for further inspection.

DSA322 Assembly Experiment Plan

II. First Disassembly

Record all findings and observations here. Include the date, time and procedure step number and initials with each comment. Duplicate this page if more space is needed.

III. Second assembly

1) Reinsulate the coils with the following modifications to the standard insulation scheme:
   a) Replace the 5 mils of Kapton that is normally applied to the outer coil return end keys to build them up to the design width with a layer of Fuji Prescale film (4 mils) plus 1 mil of Kapton. (The Fuji film can be obtained from Masayoshi Wake.)
   b) At the return end of the upper inner and upper outer coils replace the Kapton at the mid-plane (5 mils) with Fuji Prescale film plus 1 mil of Kapton from the end of the saddle to approximately 3 inches into the collared portion of the coil.

2) Collar pack installation.
   a) Assemble one collar pack (upper and lower) that is to be used in this magnet. Insert the keys and hold the upper and lower packs apart with a pair of tapered blocks. Measure the diameters specified on page 9 at a distance of 2 inches from each end and record the data at the bottom of the form on page 10.
   b) Assemble the collars over the coils.

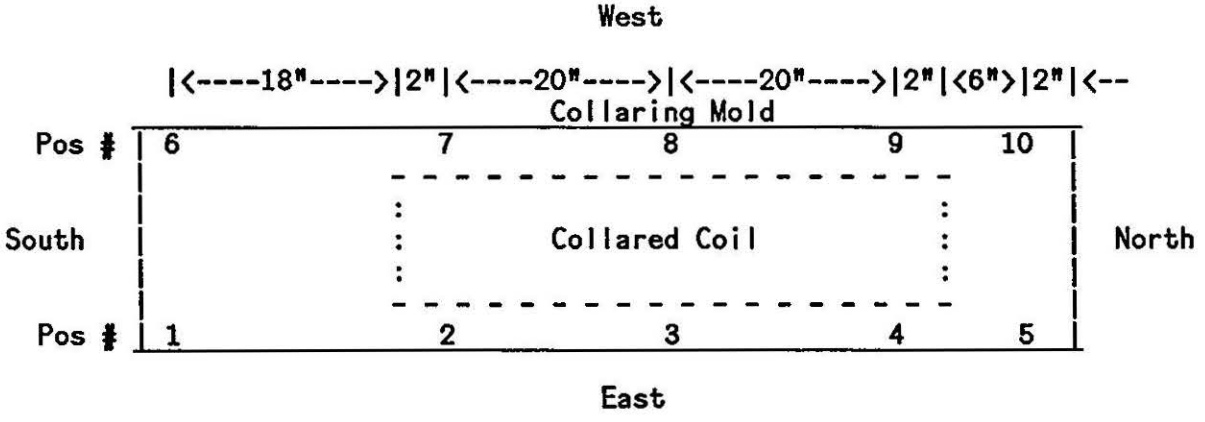
3) Collar keying
   a) Use the (new) laminated upper tooling.
   b) Place shims between the tooling flats and the collar pick-up tabs so as to fill the clearance (nominally 7 mils).
   c) Place the collared coil in the lower tooling with the lead end of the collared portion 8" from the north end of the tooling.
   d) Initially use a 5 mil shim between the upper tooling and the press platen.
   e) Place the tooling in the press so that the north end of the tooling is 6" from the north end of the press platen. This centers the tooling in the press and centers the coil over press columns 2-5 (counting from the north end).
   f) Disconnect the hydraulic cylinders at columns 1, 6, and 7. This gives the press a total capacity of 100 T per pump kpsi. If this load is balanced uniformly by the collared region of the coil (44" x 1.95" area), this corresponds to 2.56 coil psi per pump psi.
   g) Compress the coil until the press closes completely or to a pump pressure of 9000 psi, whichever occurs first. Coil resistance, strain gauge and press gap data should be recorded at pressures given in the table below. For the coil resistance measurements, the inner-outer coils splices should be temporarily connected and the upper and lower half coils resistances should be recorded. Press gap measurements should be made at the locations shown on the next page. Enter the resistance and gap data in the form on the next page at the press pressures indicated and record strain gauge resistance at each pressure. If either the upper or lower coil resitance changes by more than 3 mΩ, stop (leave the press energized at the level at which the change was noted) and contact Jim Strait.

DSA322 Assembly Experiment Plan

III. Second assembly

3) Collar keying

	Press pump pressure (psi) 0	750	2000	4000	6000	7000	8000	9000
R(upper)								
R(lower)								
Press Gaps:								
Pos 1	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 2	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 3	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 4	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 5	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 6	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 7	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 8	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 9	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 10	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						



DSA322 Assembly Experiment Plan

III. Second assembly

3) Collar keying

h) With the press closed attempt to insert a tapered key into the collars by hand at the lead end on both sides. If the key cannot be inserted at least 3/4 of the way, open the press and increase the tooling shim, otherwise to to step 5. If in the worst case the key can be inserted less than half way, increase the shim by 5 mils, otherwise increase it by 3 mils. Then repeat step 3 and 4.

i) Perform coil-to-ground hi-pot at 5 kV. Measure upper-to-lower coil resistance but do not do an upper-to-lower hi-pot. If the hi-pot fails or the upper-to-lower resistance is non-infinite, stop and contact Jim Strait.

Hi-Pot Current _____ R(upper-lower) _____

j) Energize the side cylinders to 500 psi; measure the strain gage resistances. Set the vertical hydraulic system pressure to zero; measure the strain gage resistance. Set the size cylinders to 0 psi; measure the strain gage resistances.

k) Measure the amount by which the keys protrude above the surface of the collars. If the keys protruded by more than 10 mils, increase the tooling shim by 2 mils and recompress the coils until the press fully closes. Energize the side cylinders to 500 psi, then remove the vertical, then the horizontal loads. Record strain gauge resistances at the following points:

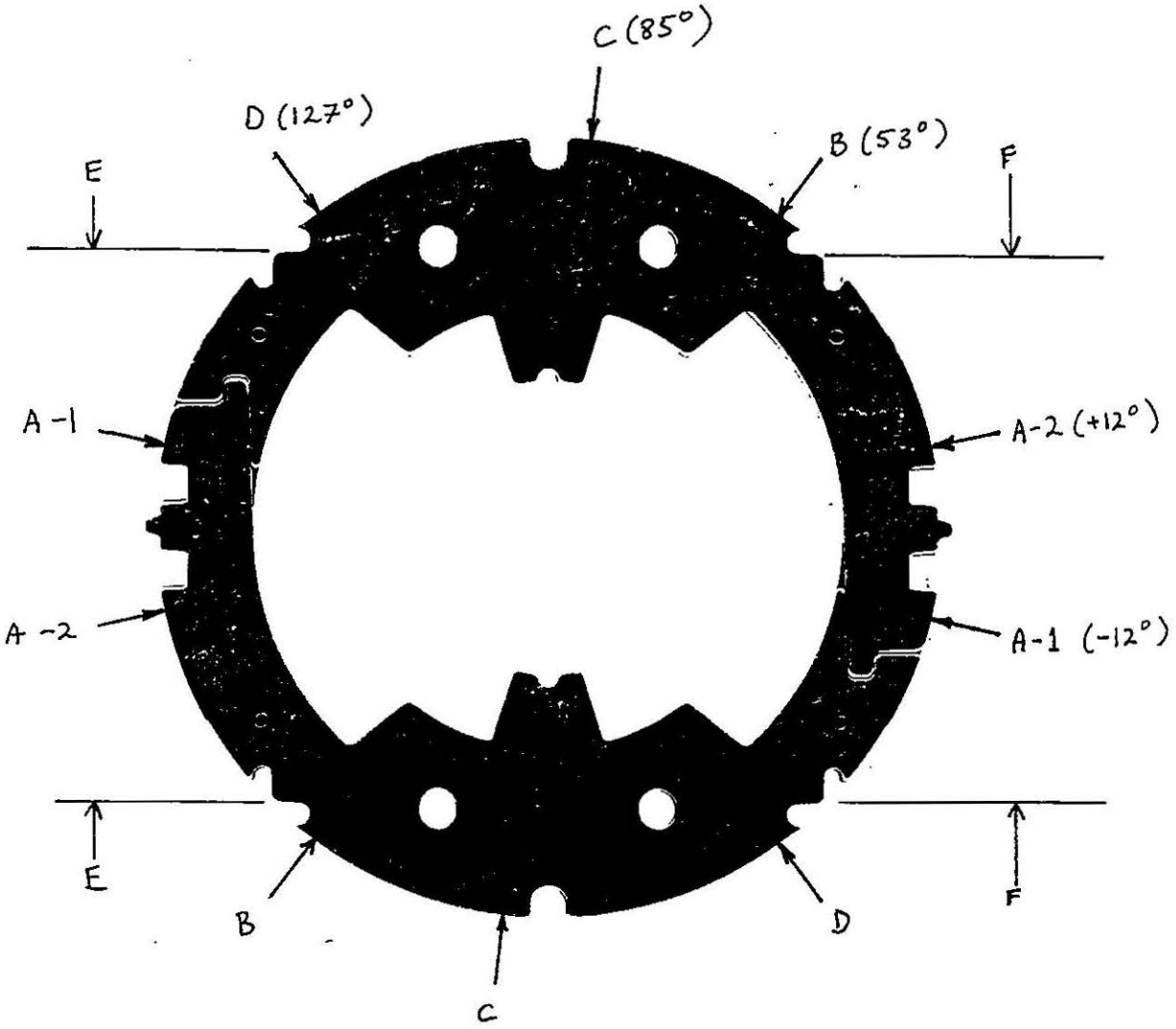
Pump psi	
Vertical	Horizontal
0	0
Full*	0
Full*	500
0	500
0	0

*Pressure at which press closes fully.

If the keys still protrude by >10 mils, stop and contact Jim Strait.

III. Second assembly

4) Measure collared coil diameters at the angular locations specified on the figure below. Measure the coil at the positions along the length of the coil specified on the table on the next page and recored the data there. (These correspond to two sets of measurements per standard collar pack, two sets on the strain gauge pack and one set each on the two end packs.)



Collared Coil Viewed From the Lead End

Measurements are to be made approximately 1/8 inch from the nearest feature that breaks the circular outer surface: the key slots for dimensions A-1 and A-2, the lifting fixture features for dimensions B and D and the instrumentation wire slot for dimension C.

DSA322 Assembly Experiment Plan

III. Second assembly

Collared Coil Diameter Measurements

Dist.frm Lead End (inches)	Dimension A-1 -12°	Dimension A-2 12°	Dimension B 53°	Dimension C 85°	Dimension D 127°	Dimension E Left	Dimension F Right
2							
5.5							
8.5							
11.5*							
14.5*							
17.5							
20.5							
23.5							
26.5							
29.5							
32.5							
35.5							
38.5							
42							

Undeflected Collar

Dist.frm end							
2							
4							

*Strain Gauge Pack

DSA322 Assembly Experiment Plan

III. Second assembly

*** STEP 5 IS POSTPONED TO THE NEXT ASSEMBLY DUE TO LACK OF PARTS *******

5) Install the return end clamp.
   a) Measure end can diameters at the standard points during the assembly.
   b) Record the hydraulic pressure required to install the end can.
   c) Do not weld the ring onto the end can.

*** STEP 5 IS POSTPONED TO THE NEXT ASSEMBLY DUE TO LACK OF PARTS *******

6) Measure the harmonics with the mole in IB1.
   a) Perform standard measurements with the coil right-side-up.
   b) Repeat the measurements with the coil up-side-down.

IV. Second disassembly

1) Place the collared coil in the collaring press with the same shims on the alignment features as used in the second assembly and with a 5 mil vertical shim on the upper tooling.

2) Measure the strain gauge resistances.

3) Close the press to 8000 pump psi. Verify that no gaps exist between the lower tooling and the upper platen.

4) Measure strain gauge resistances.

5) Remove the collar keys. (They should be loose at this point.)

6) Open the press.

7) Measure strain gauge resistances.

8) Remove the collared coil and keys from the tooling. Inspect the keys for any scoring on their surfaces or the presence of any chips. Record any finding in the space for comments on page 14.

9) Remove the collar packs from the coil and return the strain gauge packs to Marty Whitson and Ethel Gonczy for inspection.

10) Remove all layers of ground insulation which can be removed without separating the inner from the outer coils. Compare the "as assembled" configuration with that specified in drawing MB-292047 and record any discrepancies in the comments section below. Note the quadrant and ends (lead vs. return) of each layer of insulation. Check for any foreign material within the collared coil assembly and record findings below.

11) Separate the upper from the lower coils but leave the inner and outer coils together and leave the remaining insulation on the coils. Place each coil half on insulating supports with the mid-plane up.

12) Remove the Fuji film from the mid-plane at the return end. Tape each piece of film to a piece of white paper and record the location of each piece of film. Give the Fuji film to Masayoshi Wake for measurement.

IV. Second Disassembly

13) Perform mid-plane hi-pots on each half coil:
   a) Attach HV clip of hi-potter simultaneously to the inner and outer coils at the ramp-splice leads.
   b) Set voltage at 3.0 kV and current meter to the 2.5 mA scale.
   c) Run a grounded "wand" over the surface of the mid-plane separately on the left and right sides of the inner and outer coils. (Note that the grounded rod of this wand must be of a length equal to the width of the cable.) Record below the position of any breakdown as determined by observation of a spark, excessive current, or the appearance of breakdown marks on the insulation.
   d) Set HV = 0 and touch the grounded wand to the HV clip and the coil. Disconnect the hi-potter from the coil.
   e) If any breakdowns occurred, attempt to correlate them with foreign material or flaws in the insulation. Record any findings on page 14.

14) Remove the remaining insulation, noting the quadrant and end of each piece.

15) Give the pole caps to Mike Winters and the mid-plane caps to Dick Sims for further inspection.

16) Leave the Fuji film at the pole of the outer coil return end for use on the next assembly.

DSA322 Assembly Experiment Plan

IV. Second Disassembly

Record all findings and observations here. Include the date, time and procedure step number and initials with each comment. Duplicate this page if more space is needed.

DSA322 Assembly Experiment Plan

V. Third assembly

1) Reinsulate the coils with the following modifications to the standard insulation scheme:
   a) Replace the 5 mils of Kapton that is normally applied to the outer coil return end keys to build them up to the design width with a layer of Fuji Prescale film (4 mils) plus 1 mil of Kapton. (The Fuji film can be obtained from Masayoshi Wake.) (This film may be left over from the previous assembly.)
   b) At the return end of the upper inner and upper outer coils replace the Kapton at the mid-plane (5 mils) with Fuji Prescale film plus 1 mil of Kapton from the end of the saddle to approximately 3 inches into the collared portion of the coil.
   c) Trim one layer of outer coil ground wrap to remove that part that covers the outer coil pole. This layer may be held in place by taping it to the layer below it with 0.5 mil adhesive Kapton tape. (This is to be done in all four quadrants.)
   d) Place a layer of 5 mil thick non-adhesive Kapton between the inner coil pole turn and the pole cap. (This is to be done in all four quadrants.)

2) Collar pack installation.
   a) Assemble one collar pack (upper and lower) that is to be used in this magnet. Insert the keys and hold the upper and lower packs apart with a pair of tapered blocks. Measure the diameters specified on page 9 at a distance of 2 inches from each end and record the data at the bottom of the form on page 19.
   b) Assemble the collars over the coils.

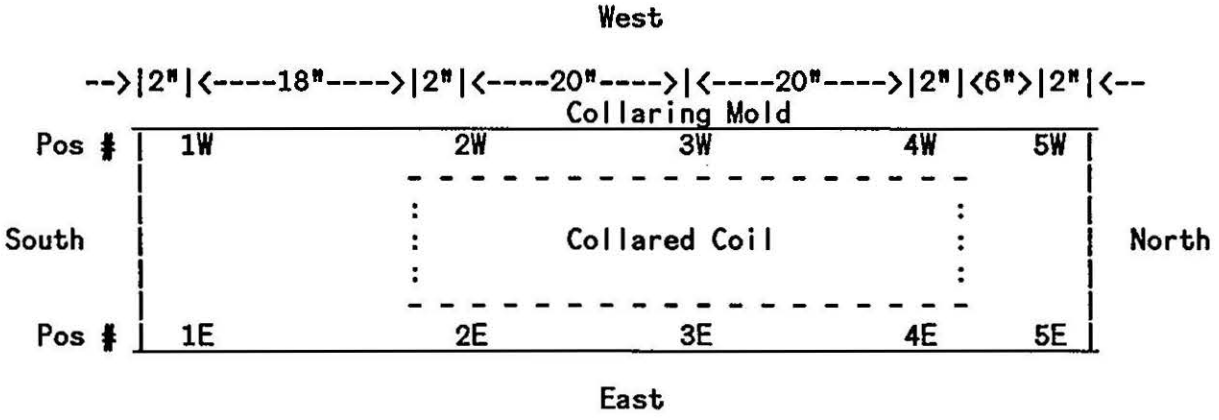
3) Collar keying
   a) Use the (new) laminated upper tooling.
   b) Place shims between the tooling flats and the collar pick-up tabs so as to fill the clearance (nominally 7 mils).
   c) Place the collared coil in the lower tooling with the lead end of the collared portion 8" from the north end of the tooling.
   d) Initially use NO shim between the upper tooling and the press platen.
   e) Place the tooling in the press so that the north end of the tooling is 6" from the north end of the press platen.
   f) Disconnect the hydraulic cylinders at columns 1, 6, and 7.
   g) Compress the coil until the press closes completely or to a pump pressure of 9000 psi, whichever occurs first. Coil resistance, strain gauge and press gap data should be recorded at pressures given in the table below. The inner-outer coils splices should be temporarily connected and the upper and lower half coils resistances should be recorded. Press gap measurements should be made at the locations shown on page 16. Enter the resistance and gap data in the form on the page 16 at the press pressures indicated and record strain gauge resistance at each pressure. If either the upper or lower coil resitance changes by more than 3 mΩ, stop (leave the press energized at the level at which the change was noted) and contact Jim Strait.

DSA322 Assembly Experiment Plan

V. Third assembly

3) Collar keying

	Press pump pressure (psi) 0	750	2000	4000	6000	7000	8000	9000
R(upper)								
R(lower)								
Press Gaps:								
South Pos 1E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 2E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 3E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 4E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
North Pos 5E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
South Pos 1W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 2W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 3W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 4W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
North Pos 5W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						



V. Third assembly

3) Collar keying

h) With the press closed attempt to insert a tapered key into the collars by hand at the lead end on both sides. If the key cannot be inserted all of the way, estimate the amount by which the keys protrude. Open the press and increase the tooling shim by one-tenth the key protrusion and repeat steps 3g and 3h. Otherwise go to the next step.

i) Perform coil-to-ground hi-pot at 5 kV. Measure upper-to-lower coil resistance but do not do an upper-to-lower hi-pot. If the hi-pot fails or the upper-to-lower resistance is non-infinite, stop and contact Jim Strait.

Hi-Pot Current _____ R(upper-lower) _____

j) Sequence for side cylinders and press opening:
- Energize the side cylinders to 500 psi; measure the strain gauge resistances.
- Set the vertical hydraulic system pressure to zero; measure the strain gage resistance.
- Set the size cylinders to 0 psi; measure the strain gage resistances.

k) Measure the amount by which the keys protrude above the surface of the collars. If the keys protruded by more than 10 mils, increase the tooling shim by 2 mils and recompress the coils until the press fully closes. Energize the side cylinders to 500 psi, then remove the vertical, then the horizontal loads. Record strain gauge resistances at the following points:

Pump psi	
Vertical	Horizontal
0	0
Full*	0
Full*	500
0	500
0	0

*Pressure at which press closes fully.

If the keys still protrude by >10 mils, stop and contact Jim Strait.

V. Third assembly

4) Measure collared coil diameters at the angular locations specified on the figure on page 9. Measure the coil at the positions along the length of the coil specified on the table on the next page and record the data there. (These correspond to two sets of measurements per standard collar pack, two sets on the strain gauge pack and one set each on the two end packs.)

DSA322 Assembly Experiment Plan

V. Third assembly

Collared Coil Diameter Measurements

Dist.frm Lead End (inches)	Dimension A-1 -12°	Dimension A-2 12°	Dimension B 53°	Dimension C 85°	Dimension D 127°	Dimension E Left	Dimension F Right
2							
5.5							
8.5							
11.5*							
14.5*							
17.5							
20.5							
23.5							
26.5							
29.5							
32.5							
35.5							
38.5							
42							

Undeflected Collar

Dist.frm end							
2							
4							

*Strain Gauge Pack

V. Third assembly

5) Install the return end clamp.
   a) Measure end can strain gauge resistances before installation.
   b) Measure end can diameters at the standard points during the assembly.
   c) Record the hydraulic pressure required to install the end can.
   d) Do not weld the ring onto the end can.
   e) Measure end can strain gauge resistances after installation.

6) Measure the harmonics with the mole in IB1.
   a) Perform standard measurements with the coil right-side-up.
   b) Repeat the measurements with the coil up-side-down.

VI. Third Disassembly

1) Remove the return end clamp.
   a) Record the hydraulic pressure required to remove the can.
   b) Measure the end can strain gauge resistances after removal.
   c) Measure the end can diameters after removal.

2) Place the collared coil in the collaring press with shims on the alignment features and with a 4 mil vertical shim on the upper tooling.

3) Measure the strain gauge resistances.

4) Close the press to 8000 pump psi. Verify that no gaps exist between the lower tooling and the upper platen.

5) Measure strain gauge resistances.

6) Remove the collar keys. (They should be loose at this point.) If the keys are not loose, open the press, increase the vertical shim by 2 mils, and repeat steps 3-6.

7) Open the press.

8) Measure strain gauge resistances.

9) If the vertical shim thickness required for key extraction was >4 mils, then
   a) Remove 2 mils of vertical shim.
   b) Close the press to 8000 pump psi. Verify that no gaps exist between the lower tooling and the upper platen.
   c) Measure strain gauge resistances.
   d) Attempt to insert a key by hand at the lead end of the magnet. If they key can be fully inserted into all 4 key slots, repeat steps 7-9.

10) Remove the collared coil and keys from the tooling. Inspect the keys for any scoring on their surfaces or the presence of any chips. Record any finding in the space for comments on page 23.

11) Remove the collar packs from the coil and return the strain gauge packs to Marty Whitson and Ethel Gonczy for inspection.

VI. Third Disassembly

12) Remove all layers of ground insulation which can be removed without separating the inner from the outer coils. Compare the "as assembled" configuration with that specified in drawing MB-292047 as modified for this assembly (see page 23) and record any discrepancies in the comments section below. Note especially whether the modified outer coil piece that was taped to the layer below it is in its correct place. Note the quadrant and ends (lead vs. return) of each layer of insulation. Check for any foreign material within the collared coil assembly and record findings on page 23.

13) Separate the upper from the lower coils but leave the inner and outer coils together and leave the remaining insulation on the coils. Place each coil half on insulating supports with the mid-plane up.

14) Remove the Fuji film from the mid-plane at the return end. Tape each piece of film to a piece of white paper and record the location of each piece of film. Give the Fuji film to Masayoshi Wake for measurement.

15) Perform mid-plane hi-pots on each half coil:
   a) Attach HV clip of hi-potter simultaneously to the inner and outer coils at the ramp-splice leads.
   b) Set voltage at 3.0 kV and current meter to the 2 mA scale.
   c) Run a grounded "wand" over the surface of the mid-plane separately on the left and right sides of the inner and outer coils. (Note that the grounded rod of this wand must be of a length equal to the width of the cable.) Record on page 23 the position of any breakdown as determined by observation of a spark, excessive current, or the appearance of breakdown marks on the insulation.
   d) Set HV = 0 and touch the grounded wand to the HV clip and the coil. Disconnect the hi-potter from the coil.
   e) If any breakdowns occurred, attempt to correlate them with foreign material or flaws in the insulation. Record any findings on page 23.

16) Remove the remaining insulation, noting the quadrant and end of each piece. Verify that the additional 5 mil Kapton pieces placed at the inner coil poles remained in their correct places.

17) Save the pole and mid-plane caps for possible further inspection.

18) Remove the Fuji film from the pole of the outer coil return end. Tape each piece of film to a piece of white paper and record the location of each piece of film. Give the Fuji film to Masayoshi Wake for measurement.

DSA322 Assembly Experiment Plan

VI. Third Disassembly

Record all findings and observations here. Include the date, time and procedure step number and initials with each comment. Duplicate this page if more space is needed.

VII. Fourth assembly

1) Measure the azimuthal size of all four coils. The Excel data files made from these measurements should have the same name as the original measurements with a suffix of "RESIZE 1."

2) Reinsulate the coils with the following modifications to the standard insulation scheme (this is the same as was done on the previous assembly):
   a) Replace the 5 mils of Kapton that is normally applied to the outer coil return end keys to build them up to the design width with a layer of Fuji Prescale film (4 mils) plus 1 mil of Kapton. (The Fuji film can be obtained from Masayoshi Wake.)
   b) At the return end of the upper inner and upper outer coils replace the Kapton at the mid-plane (5 mils) with Fuji Prescale film plus 1 mil of Kapton from the end of the saddle to approximately 3 inches into the collared portion of the coil.
   c) Trim one layer of outer coil ground wrap to remove that part that covers the outer coil pole. This layer may be held in place by using a small amount of adhesive to "tack" to the layer below it. (This is to be done in all four quadrants.)
   d) Place a layer of 5 mil thick non-adhesive Kapton between the inner coil pole turn and the pole cap. (This is to be done in all four quadrants.)

3) Collar pack installation.
   a) Assemble one collar pack (upper and lower) that is to be used in this magnet. Insert the keys and hold the upper and lower packs apart with a pair of tapered blocks. Measure the diameters specified on page 9 at a distance of 2 inches from each end and record the data at the bottom of the form on page 29.
   b) Assemble the collars over the coils.

DSA322 Assembly Experiment Plan

VII. Fourth assembly

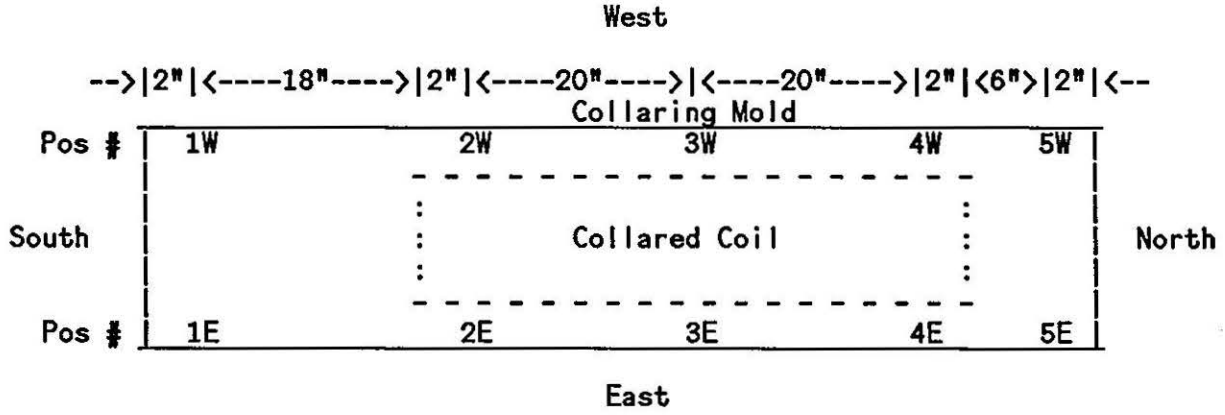
4) Collar keying
   a) Using a sample collar and a sample lower tooling lamination, determine the amount of clearance between the azimuthal alignment features and the collar flats.
   b) Place shims between the tooling flats and the collar pick-up tabs so as to fill the clearance.
   c) Lubricate the tapered keys with Colloidal Graphite & Isopropyl Key Lubricant (Acheson Collids Co., Mil Spec. L24131B) as supplied by Jim Strait. Apply the lubricant with a brush or roller only to the surfaces which will contact the collars. Insert the keys into the holding clips in the tooling.
   d) Place the collared coil in the lower tooling with the lead end of the collared portion 8" from the north end of the tooling.
   e) Place 12 mil shims between the LOWER tooling and the upper platen.
   f) Place the tooling in the press so that the north end of the tooling is 6" from the north end of the press platen.
   g) Disconnect the hydraulic cylinders at columns 1, 6, and 7.
   h) Compress the coil until the press closes completely or to a pump pressure of 9000 psi, whichever occurs first. Coil resistance, strain gauge and press gap data should be recorded at pressures given in the table below. The inner-outer coils splices should be temporarily connected and the upper and lower half coils resistances should be recorded. Press gap measurements should be made at the locations shown on page 26. Enter the resistance and gap data in the form on the page 26 at the press pressures indicated and record strain gauge resistance at each pressure. If either the upper or lower coil resitance changes by more than 3 mΩ, stop (leave the press energized at the level at which the change was noted) and contact Jim Strait.

DSA322 Assembly Experiment Plan

VII. Fourth assembly

4) Collar keying

	Press pump pressure (psi) 0	750	2000	4000	6000	7000	8000	9000
R(upper)								
R(lower)								
Press Gaps:								
South Pos 1E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 2E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 3E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 4E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
North Pos 5E	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
South Pos 1W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 2W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 3W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
Pos 4W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						
North Pos 5W	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX						



VII. Fourth assembly

4) Collar keying

i) With the press closed attempt to insert a tapered key into the collars by hand at the lead end on both sides. The target amount of insertion is 50±10 mils. If the keys can be inserted this far or farther, record the amount of insertion and proceed with the next step. If the keys can be inserted less than the target amount, open the press, decrease the tooling shim by one-tenth the amount by which the keys protrude beyond 50 mils, and repeat steps 4h and 4i.

Key insertion: Upper Left _____ Upper Right _____

Lower Left _____ Lower Right _____

k) Perform coil-to-ground hi-pot at 5 kV. Measure upper-to-lower coil resistance but <u>do not</u> do an upper-to-lower hi-pot. If the hi-pot fails or the upper-to-lower resistance is non-infinite, stop and contact Jim Strait.

Hi-Pot Current _____ R(upper-lower) _____

l) Energize the side cylinders in 500 psi steps until full key insertion is achieved or 5000 psi has been reached. Record the strain gauge resistance at each step. Record the peak side pressure used:

Peak side hydraulic pressure _____

m) Reduce the vertical pressure to 2000 psi. Record strain gauge resistances.

n) Set both vertical and horizontal pressures to zero. Record strain gauge pressures.

o) Measure the amount by which the keys protrude above the surface of the collars.

VII. Fourth assembly

4) Collar keying

p) If the keys protruded by more than 10 mils, and if less than 5000 pump psi side cylinder pressure was used, then
- Replace the coil in the collaring press.
- Close the press to the same vertical pressure as used in step 4h. Record strain gauge resistance.
- Energize the side cylinders to the peak pressure used in step 4l. Record strain gauge resistances.
- Increase the side cylinder pressure in 500 psi steps to 5000 psi. Record strain gauge resistances after each step.
- Repeat steps 4m - 4p.

If the keys protrude by more than 10 mils and 5000 pump psi side cylinder pressure was used, then
- Decrease the shim between the upper platen and lower tooling by 2 mils.
- Replace the coil in the collaring press.
- Energize the vertical cylinders until the press fully closes. Record strain gauge resistances.
- Energize the side cylinders in 1000 psi steps to 5000 psi. Record strain gauge resistances after each step.
- Repeat steps 4m - 4p.

q) If the keys still protrude by >10 mils after decreasing the vertical shim by 2 mils, stop and contact Jim Strait.

5) Measure collared coil diameters at the angular locations specified on the figure on page 9. Measure the coil at the positions along the length of the coil specified on the table on the next page and record the data there. (These correspond to two sets of measurements per standard collar pack, two sets on the strain gauge pack and one set each on the two end packs.)

DSA322 Assembly Experiment Plan

VII. Fourth assembly

Collared Coil Diameter Measurements

Dist.frm Lead End (inches)	Dimension A-1 -12°	Dimension A-2 12°	Dimension B 53°	Dimension C 85°	Dimension D 127°	Dimension E Left	Dimension F Right
2							
5.5							
8.5							
11.5*							
14.5*							
17.5							
20.5							
23.5							
26.5							
29.5							
32.5							
35.5							
38.5							
42							

Undeflected Collar

Dist.frm end							
2							
4							

*Strain Gauge Pack

VII. Fourth assembly

NOTE: Steps 6 and 7 can be done in either order as the mole and end clamp parts schedules dictate.

6) Install the return end clamp.
   a) Use end insulators and instrumented aluminum cylinder supplied by Steve Delchamps. Apply extra layers of Kapton between the coil and insulators as specified by Steve.
   b) Measure end can strain gauge resistances before installation.
   c) Measure end can diameters at the standard points during the assembly.
   d) Record the hydraulic pressure required to install the end can.
   e) Do not weld the ring onto the end can.
   f) Measure end can strain gauge resistances after installation.

7) Measure the harmonics with the mole in IB1.
   a) Perform standard measurements with the coil right-side-up.
   b) Repeat the measurements with the coil up-side-down.

VIII. Fourth Disassembly

1) Remove the return end clamp.
   a) Record the hydraulic pressure required to remove the can.
   b) Measure the end can strain gauge resistances after removal.
   c) Measure the end can diameters after removal.

2) Measure collared coil diameters at the angular locations specified on the figure on page 9. Measure the coil at the positions along the length of the coil specified on the table on page 32 and record the data there.

   NOTE: Jim Strait must be present for steps 3-8

3) Measure the resistance of each of the quarter coils to the collars:

   Upper Inner_____ Upper Outer_____

   Lower Inner_____ Lower Outer_____

4) Pry out the tapered keys from the return half of the collared coil, starting from the return end. Be careful not to disturb the keys beyond the boundary between collar packs #4 and #5 at the magnet center-line. Monitor the upper inner coil resistance to the return end collar pack as the keys are removed and record changes in the comment section on page 35.

5) Cut off the portion of the keys that have been pried out and discard the removed sections.

6) Remove the collar packs from this half of the magnet. However, leave one or more lower half collar packs attached to the coil with, for example, tie-wraps or velcro strips to support the coil.

7) Visually inspect the inner coil ground insulation in the neighborhood of the third turn from the pole near the end of the collared region on both sides. If no unambiguous damage to the insulation is found, perform a "wand" hipot on this region at 3 kV. Note any findings on page 35.

8) Place the collared coil in the collaring press with 5 mil brass or aluminum shims on the alignment features and with an 8 mil shim between the upper tooling and the upper press platen. The return half of the coil should be supported by one or more lower collar packs. However, it is very important that this half of the coil not be compressed in the press.

DSA322 Assembly Experiment Plan

VIII. Fourth Disassembly

Collared Coil Diameter Measurements

Dist.frm Lead End (inches)	Dimension A-1 -12°	Dimension A-2 12°	Dimension B 52°	Dimension C 84°	Dimension D 128°	Dimension E Left	Dimension F Right
2							
5.5							
8.5							
11.5*							
14.5*							
17.5							
20.5							
23.5							
26.5							
29.5							
32.5							
35.5							
38.5							
42							

Undeflected Collar (after disassembly)

Dist.frm end							
2							
4							

*Strain Gauge Pack

VIII. Fourth Disassembly

9) Measure the strain gauge resistances.

10) Close the press to 8500 pump psi. Verify that no gaps exist between the lower tooling and the upper platen.

11) Measure strain gauge resistances.

12) Remove the collar keys. (They should be loose at this point.)

13) If the keys are not loose, open the press, increase the vertical shim by 2 mils, and repeat steps 6-9. If the keys cannot be removed on the second try, stop and contact Jim Strait.

14) Open the press.

15) Measure strain gauge resistances.

16) Remove the collared coil and keys from the tooling. Inspect the keys for any scoring on their surfaces or the presence of any chips. Record any finding in the space for comments on page 35. Mark and save the keys for further inspection and evaluation.

17) Remove the collar packs from the coil. Inspect the key slots for any signs of damage and record any findings on page 35. Mark and save the collar packs for further inspection and evaluation. Return the strain gauge packs to Marty Whitson and Ethel Gonczy for inspection.

18) Reassemble collar pack #2 using virgin keys and hold the upper and lower packs apart with a pair of tapered blocks. Be careful to assure that the parallel surfaces of the two tapered blocks contact the pole posts of the upper and lower packs along their full length. Tap the two tapered blocks to ensure that the packs are held firmly apart. Tap the tapered keys into place to be sure that they are fully seated. Measure the diameters at the azimuthal locations specified on page 9 and record the data at the bottom of page 32.

19) Remove all layers of ground insulation which can be removed without separating the inner from the outer coils. Compare the "as assembled" configuration with that specified in drawing MB-292047 as modified for this assembly (see page 24) and record any discrepancies in the comments section on page 35. Note especially whether the modified outer coil piece that was glued to the layer below it is in its correct place. Note the quadrant and ends (lead vs. return) of each layer of insulation. Check for any foreign material within the collared coil assembly and record findings on page 35.

20) Separate the upper from the lower coils but leave the inner and outer coils together and leave the remaining insulation on the coils. Place each coil half on insulating supports with the mid-plane up.

VIII. Fourth Disassembly

21) Remove the Fuji film from the mid-plane at the return end. Tape each piece of film to a piece of white paper and record the location of each piece of film. Give the Fuji film to Masayoshi Wake for measurement.

22) Perform mid-plane hi-pots on each half coil:
   a) Attach HV clip of hi-potter simultaneously to the inner and outer coils at the ramp-splice leads.
   b) Set voltage at 3.0 kV and current meter to the 2 μA scale.
   c) Run a grounded "wand" over the surface of the mid-plane separately on the left and right sides of the inner and outer coils. (Note that the grounded rod of this wand must be of a length equal to the width of the cable.) Record on page 35 the position of any breakdown as determined by observation of a spark, excessive current, or the appearance of breakdown marks on the insulation.
   d) Set HV = 0 and touch the grounded wand to the HV clip and the coil. Disconnect the hi-potter from the coil.
   e) If any breakdowns occurred, attempt to correlate them with foreign material or flaws in the insulation. Record any findings on page 35.

23) Remove the remaining insulation, noting the quadrant and end of each piece. Verify that the additional 5 mil Kapton pieces placed at the inner coil poles remained in their correct places.

24) Save the pole and mid-plane caps for possible further inspection.

25) Remove the Fuji film from the pole of the outer coil return end. Tape each piece of film to a piece of white paper and record the location of each piece of film. Give the Fuji film to Masayoshi Wake for measurement.

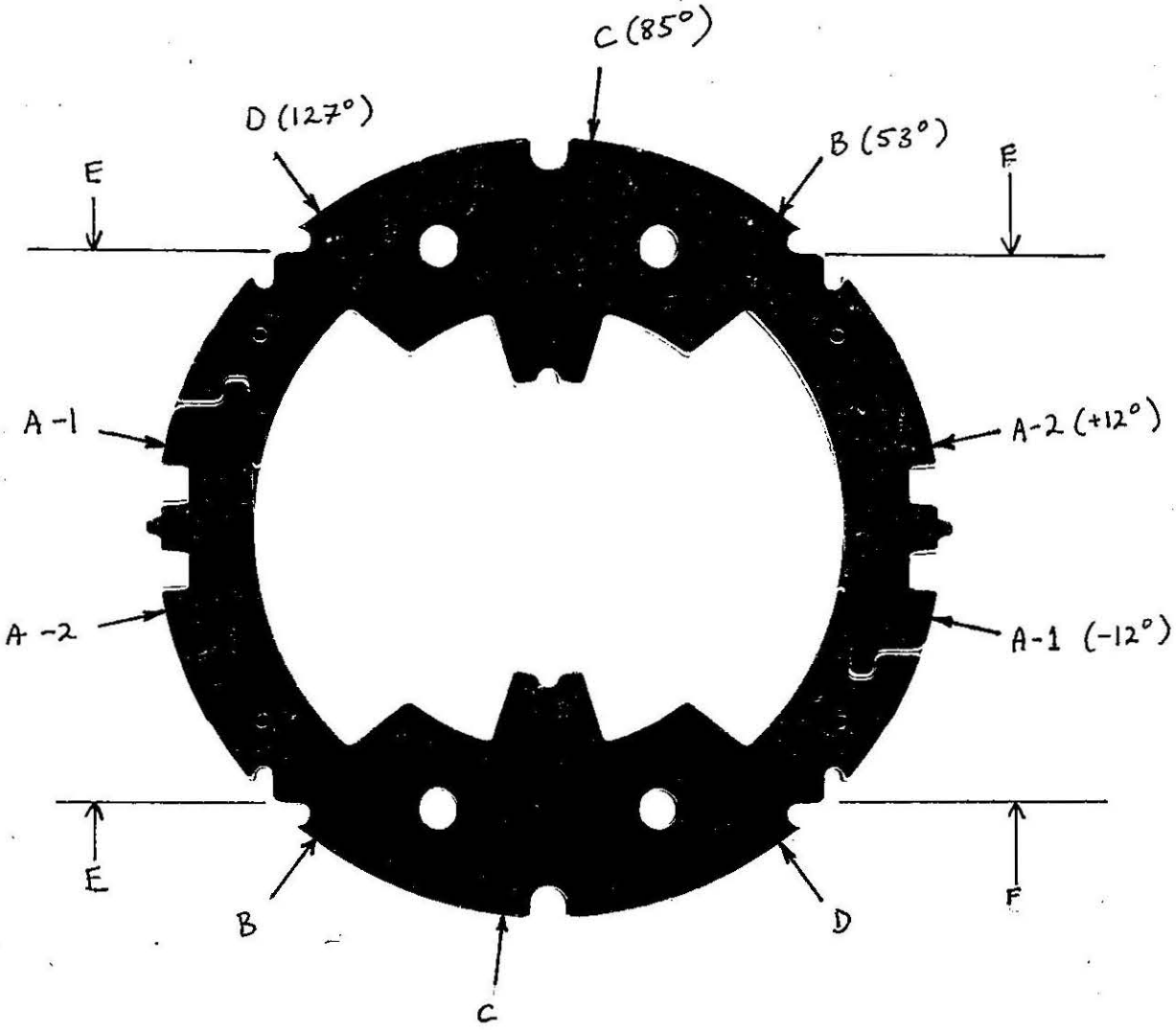
DSA322 Assembly Experiment Plan

VIII. Fourth Disassembly

Record all findings and observations here. Include the date, time and procedure step number and initials with each comment. Duplicate this page if more space is needed.

III. Second assembly

4) Measure collared coil diameters at the angular locations specified on the figure below. Measure the coil at the positions along the length of the coil specified on the table on the next page and recored the data there. (These correspond to two sets of measurements per standard collar pack, two sets on the strain gauge pack and one set each on the two end packs.)



Collared Coil Viewed From the Lead End

Measurements are to be made approximately 1/8 inch from the nearest feature that breaks the circular outer surface: the key slots for dimensions A-1 and A-2, the lifting fixture features for dimensions B and D and the instrumentation wire slot for dimension C.