Title
MECHANICAL TEST RESULTS ON DIPOLE MODEL C-l 25 mm ALUMINUM COLLARS

Author
Peters, C.

Publication Date
1985-02-01

LBL-19182

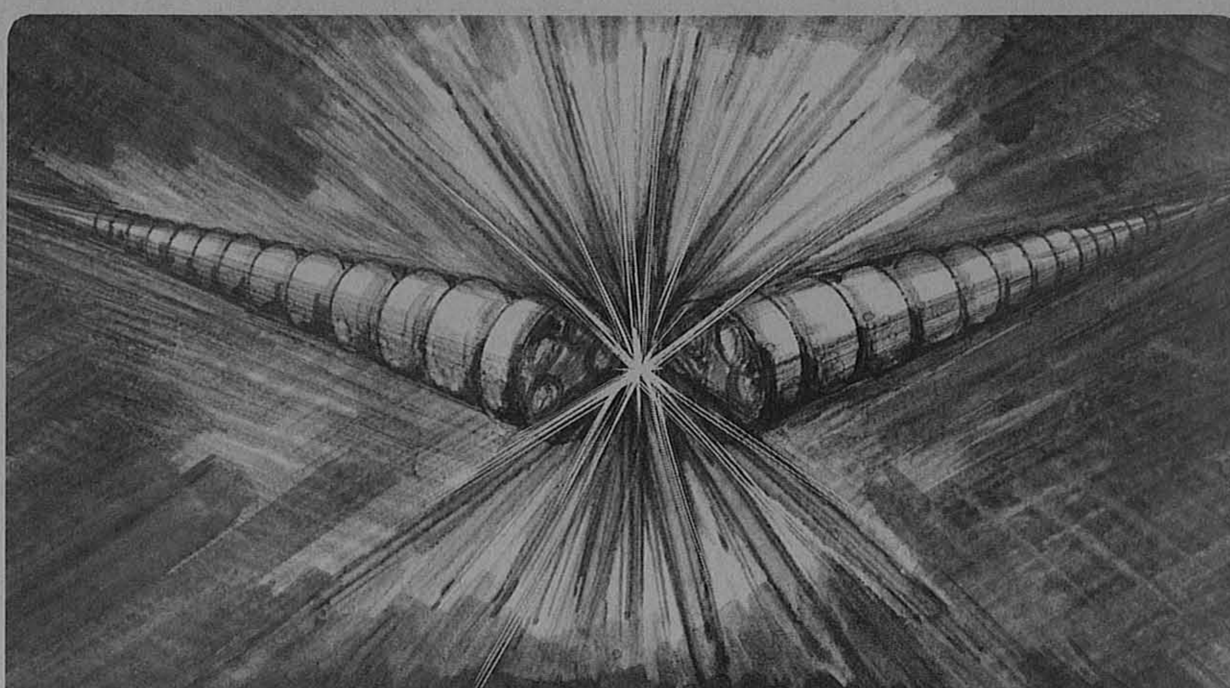
Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Accelerator & Fusion Research Division

MECHANICAL TEST RESULTS ON DIPOLE MODEL C-1 25 mm ALUMINUM COLLARS

C. Peters

February 1985



Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price Code: A02

SSC-MAG-33
LBL-19182

MECHANICAL TEST RESULTS ON DIPOLE MODEL C-1 25 mm ALUMINUM COLLARS*

Craig Peters

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

February 1985

* This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, High Energy Physics Division, U.S. Dept. of Energy, under Contract No. DE-AC03-76SF00098.

MECHANICAL TEST RESULTS ON DIPOLE MODEL C-1 25 mm ALUMINUM COLLARS

Craig Peters

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Introduction

This report is a summary of procedures used in collaring the SSC Dipole model C-1. Included are descriptions of the collars, instrumentation, collar pack preparation, collaring procedures, and collar dimension and coil pressure data measurements taken during collaring and testing of the magnet.

Collars

Individual collar plates are machined from 0.125 inch thick 7075-T6 aluminum alloy plate. Fabrication included N.C. machining and EDM. Figure 1 shows the basic collar dimensions.

Review of Mechanical Tests

A series of mechanical load deflection tests were formerly completed and are summarized in Table I. Tests were conducted with a stack of collars pinned and keyed together. A more complete description is given in SSC-MAG Note #25.

TABLE I.

Review of Collar Mechanical Test Results

Test Description	Diameter Deflections (in.)	
	Horizontal	Vertical
1. 6000 lb. pull on 1 inch stack		
a. Horizontal Pull	+0.014	-0.007
b. Vertical Pull	-0.006	+0.011
2. 5600 psi Hydraulic load on 6 inch stack	+0.002	+0.012

Collaring Setup

During fabrication of the collar plates, a 6 inch stack was clamped in a fixture and the external "ears" and keyways were machined. Each plate was marked to permit reassembly into 6 inch collar packs in the same order. A short shoulder screw was used in the end of each 0.250 inch diameter pin to hold each pack together. The collar plates were found to have grown in thickness by 0.0005 to 0.0008 inch in the area of the machined keyways. This required individually sanding the face of each collar plate in this area prior to assembling into packs. This permitted easy assembly of the assembled mating packs.

The C-2 cross section design permitted the use of a 0.030 inch thick stainless steel shoe between the outer coil and the collars. This shoe was used to protect the kapton insulation layers over the coils from the sliding of the collars. A film of anti-galling lubricant was used between this shoe and the collars.

A hydraulic press, see Figure 2, was used to press together and permit key installation in each pair of collar packs. The press length was 8.5 inches to allow each new collar pack to be aligned to the collar pack assembled before it. The press was also designed to minimize collar deflections during collaring which would aggravate key installation.

Collaring

Prior to assembly, each of the four coils were measured in a compression fixture. These measurements were used to predict dimensions of pole shims to be used during assembly. It became necessary during collaring to modify these shim thicknesses. Each coil layer was separately compressed to 10,000 psi (by using an undersized shim in the layer not of interest) to determine its "real" size in the collared coil assembly. Coil pressure was known from the hydraulic force applied. The final shim thicknesses were within 0.005 inch of the predicted. This difference reflects the slight inaccuracy in the measured dimensions of many components.

One problem that came up was that of keeping these tapered pole shims from getting radically out of position during collaring. They tended to migrate radically inward causing excessive pressure in the coils. The next model will have pole spacers glued to the collar poles. A second problem is the sausage effect. The coil package experiences a significant bulging or flaring at the ends of the collar pack due to the coil sponginess (relative to a glass/epoxy insulated cable). This effect was attenuated by the stainless steel shoe over the outer coils as mentioned above. The effect will be less pronounced in future models whose assembled coil pressures will probably be less than in this C-1 model.

To install any particular key, it was necessary to vary the coil pressure over a range of about 6,000 psi. Typically, a key would fit well at one end of the collar pack but the keyway at the other would be visibly smaller (0.002-0.003 inch).

This technique worked well, requiring, at worst, tapping the key in with a plastic mallet. This required manipulation of coil pressure reflects the sausage effect, the pole wedge locational errors (both mentioned above), the lack of any feature in our press design which would guarantee symmetry of the mating collar packs, and no doubt some variation of our coil size with axial position. Despite these considerations, the collaring went well. It took about 8 hours to get the correct shim sizes and 16 hours to assemble the remaining four 6 inch collar packs.

Instrumentation

Coil pressure data was obtained using strain gauges. A stainless steel holder containing a block mounted with strain gauges was installed in the pole area of each layer immediately adjacent to the conductor. This arrangement consisting of a total of 4 gauges mounted in the center of the magnet is shown in Figure 3. The gauges were calibrated with dummy coils prior to collaring the real magnet coils. During calibration each collar pack, containing two gauges, was held in a fixture that simulates its boundary conditions in a collared magnet and a known load was applied to the dummy coil of the gauge being calibrated. The gauges were found to be insensitive to diameter changes and load applied to the other layer.

Coil position indicators (CPI's) were installed on the iron yoke assembly as a means of measuring collar diameter within the yoke during operation. The CPI's actually measure the collar position relative to the inside of the iron yoke. Each CPI uses a cantilevered beam with 4 strain gauges. Four CPI's were installed as shown in Figure 4. The iron yoke with the 4 CPI's was set up and cooled to 77K for calibration. A second test found that the CPI's accurately predict the thermal contraction of a mock aluminum collar installed in the yoke.

Test Results

The test results are presented in Figures 5 through 9. Figures 5 and 6 show only 3 pressure gauge channels due to a malfunction of the layer 2, top gauge.

Figure 5 shows a post assembly coil pressure decrease, a cooldown repressurization from the aluminum collars, a decrease of pole pressure in each layer after each training quench, and a warm-up relaxation of pressure in each layer.

Figure 6 is an expansion of the operation portion of Figure 5 and shows coil pressure to magnet current relationship. It can be seen that coil pressures at the pole were reduced by up to 45 percent after the seventh transition as compared to the pressures measured prior to any training quenches. This reduction of pressure reflects both friction on the coils and also the somewhat plastic nature of the coils. After sufficient training quenches, the pressure curves became fixed and unchanged with subsequent current ramps.

Figure 7 shows the pressure history of layer one, top gauge. This includes the data on Figures 5 and 6 and additionally by a warm-up to 300K and then operation in HeII. The coil pressure after warm-up was about 2000 psi below its level immediately prior to cooldown which shows that the coil had taken a set or compaction after being operated at high fields. After recooling to 4K, it was found that the pressure level was very close to its level after the first cooldown. This indicates, assuming a similar degree of repressurizing from the collar contraction, that the pressure during the 5 day warm-up period had increased. The coil apparently experienced negative compaction or reverse creep. In agreement with this, the magnet went through several training quenches to attain current levels it had formerly been operated at.

Figure 8 shows the change in collar diameter with decreasing temperature. The total collar diameter change is the sum of the calculated iron change and the collar to iron relative change as measured by the CPI's. The vertical and horizontal diameters decrease by 0.021 inch and .0215 inch, respectively, which corresponds well with the 5.1 inch outside dimension of the collar. After warm-up the vertical and horizontal dimensions return to their precooldown values within 0.0005 inch and 0.0025 inch, respectively.

Figure 9 shows the change in collar diameter during operation in HeI and II after training. The magnet was warmed up in between. The collars behave elastically, that is, they exhibit very little deflection hysteresis for current ramp data available. The vertical and horizontal deflections at 7500 amps were 0.0021 inch and 0.0018 inch, respectively.

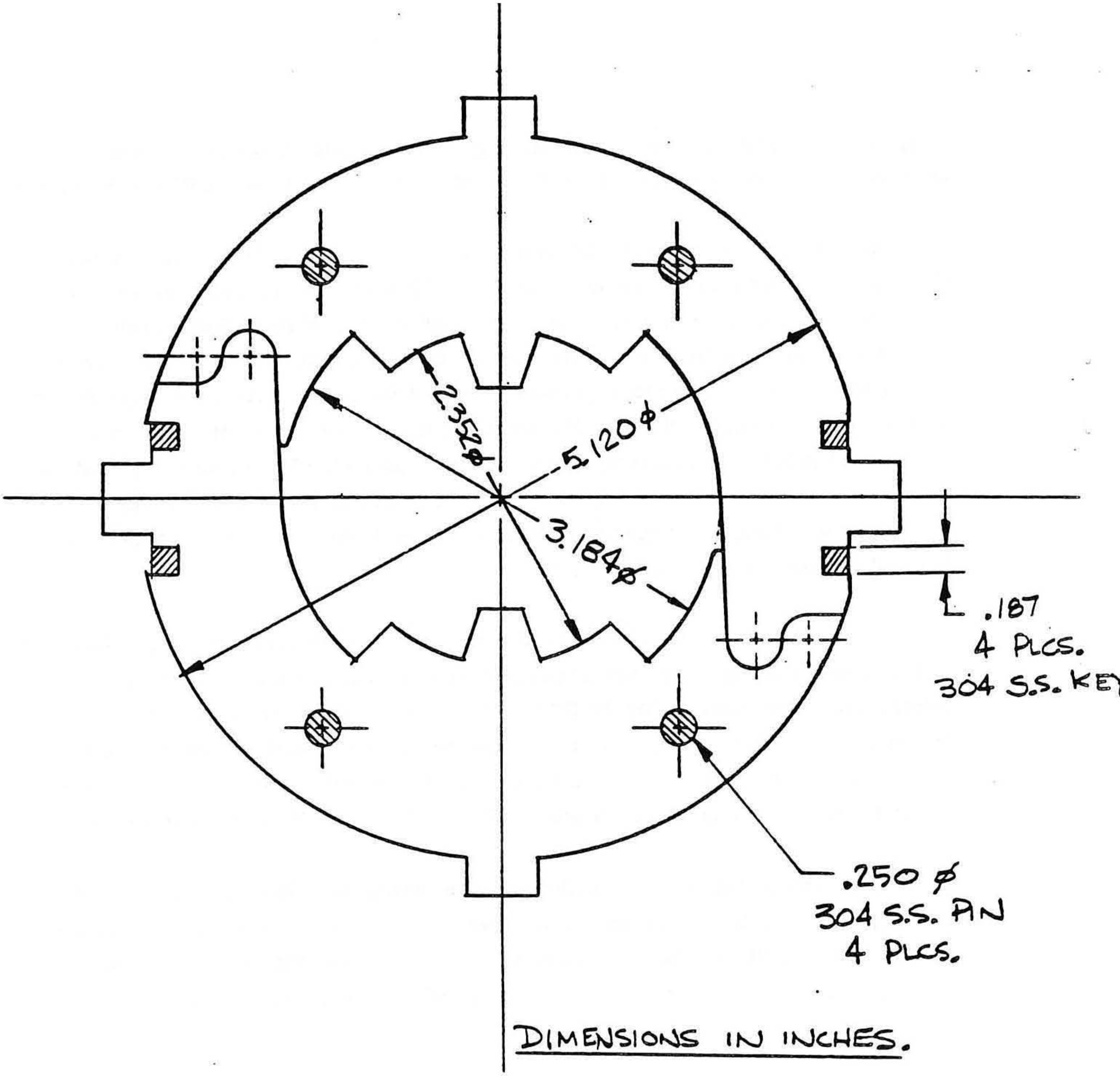


FIG. 1 25 mm 7075-T6 ALUMINUM COLLAR

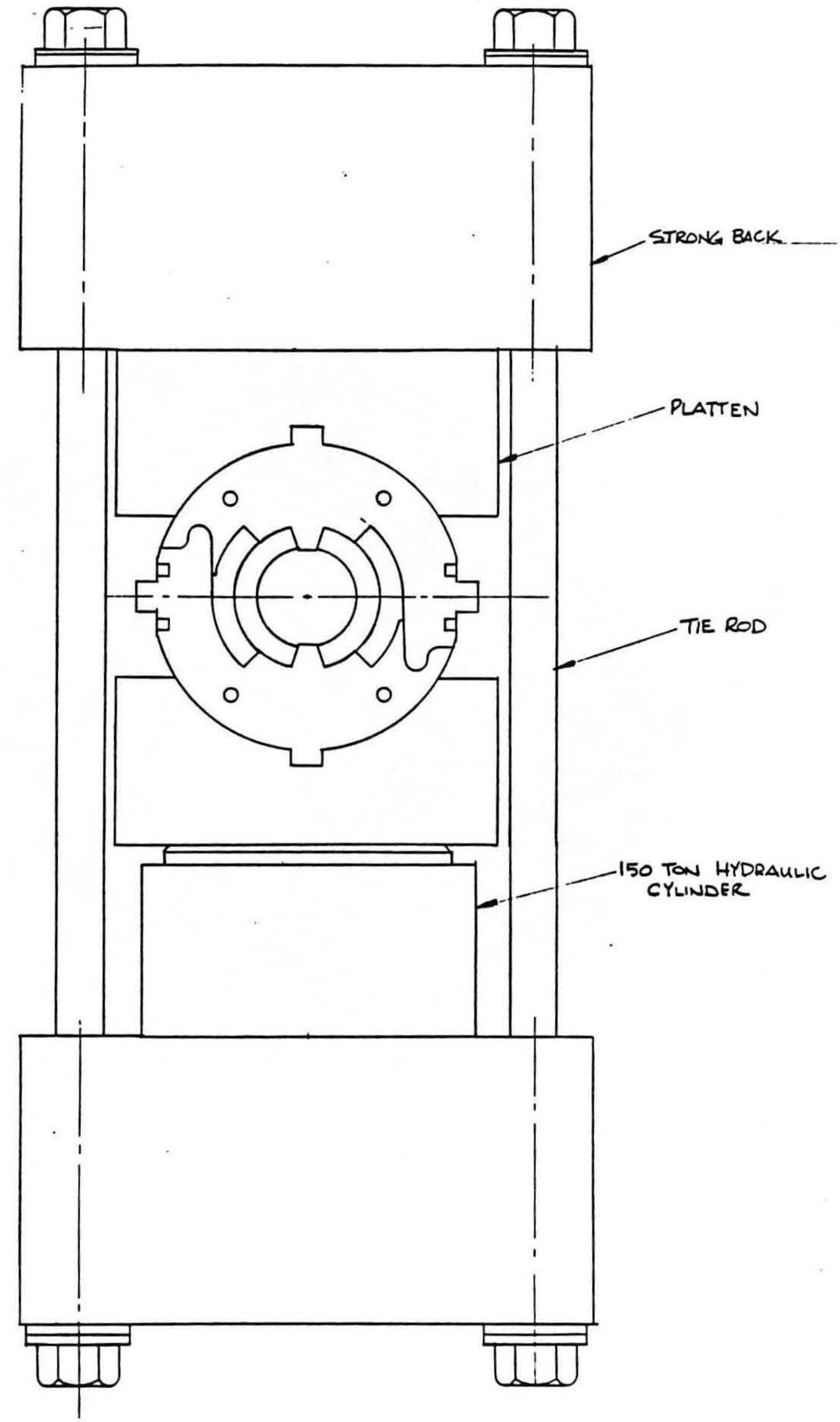


FIG. 2 COLLARING PRESS ARRANGEMENT

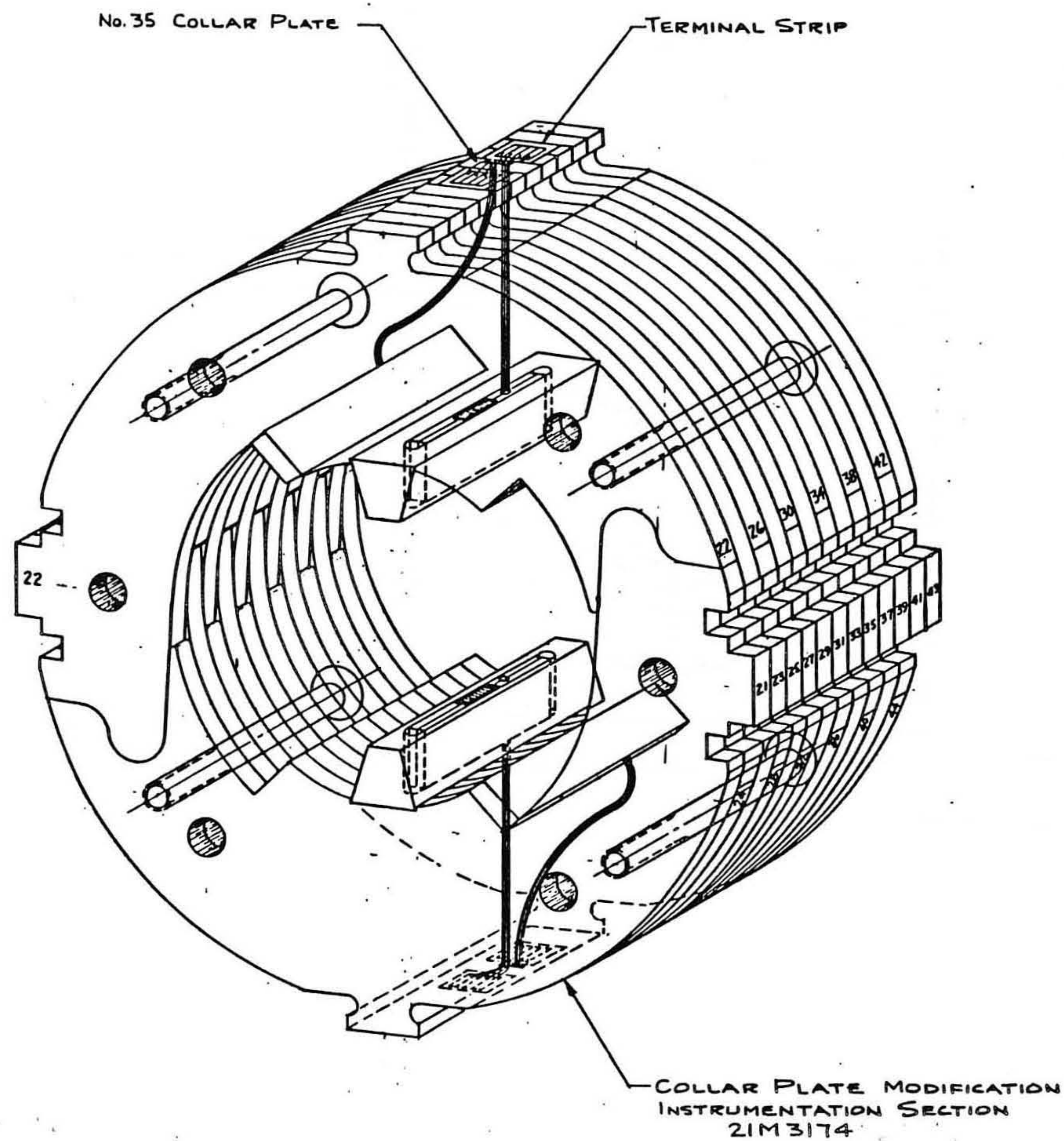
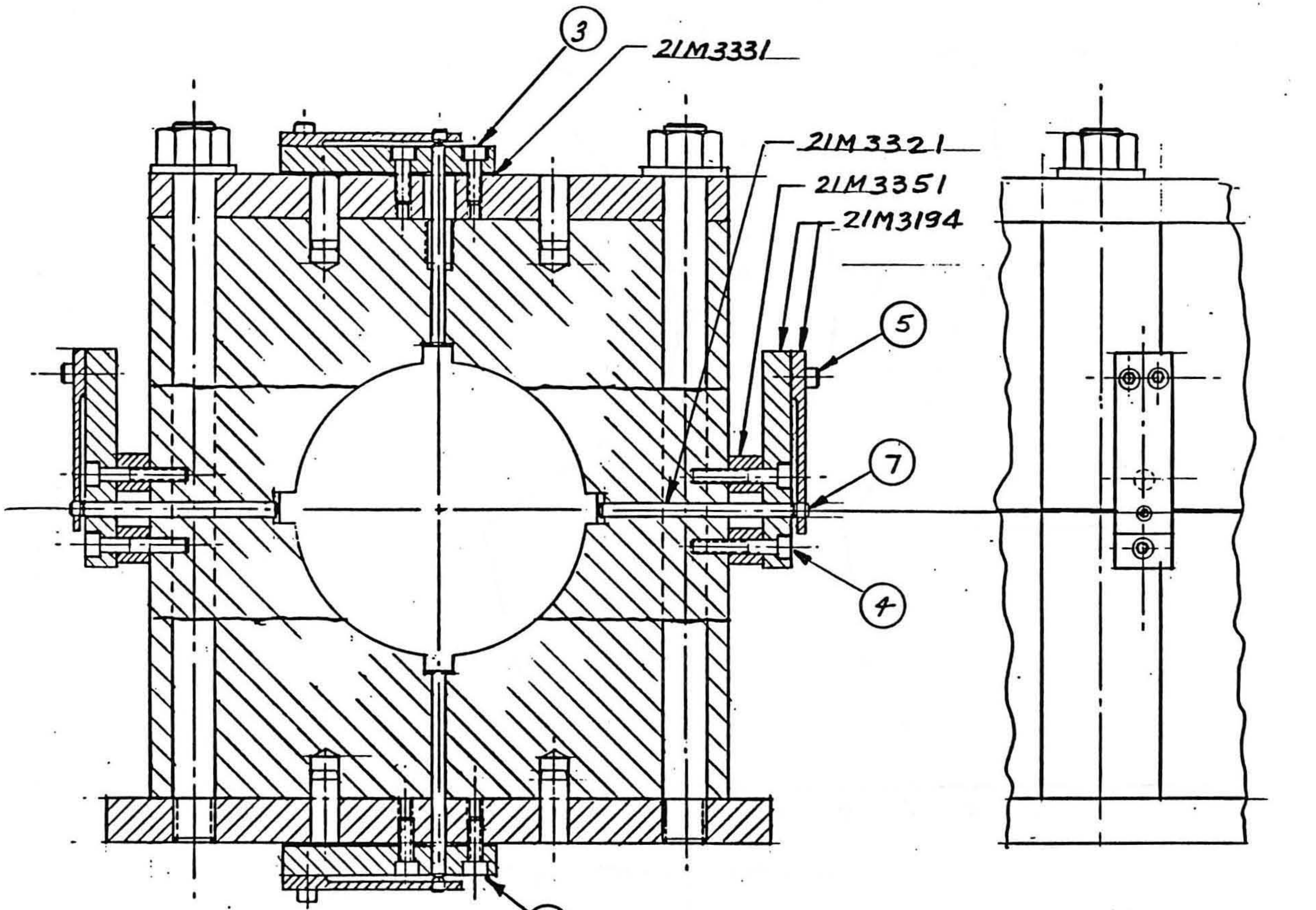


FIG. 3 PRESSURE GAGE ARRANGEMENT

Gage Block Assemblies And Fasteners



E-E

FIG. 4 SECTION AT POSITION SENSORS

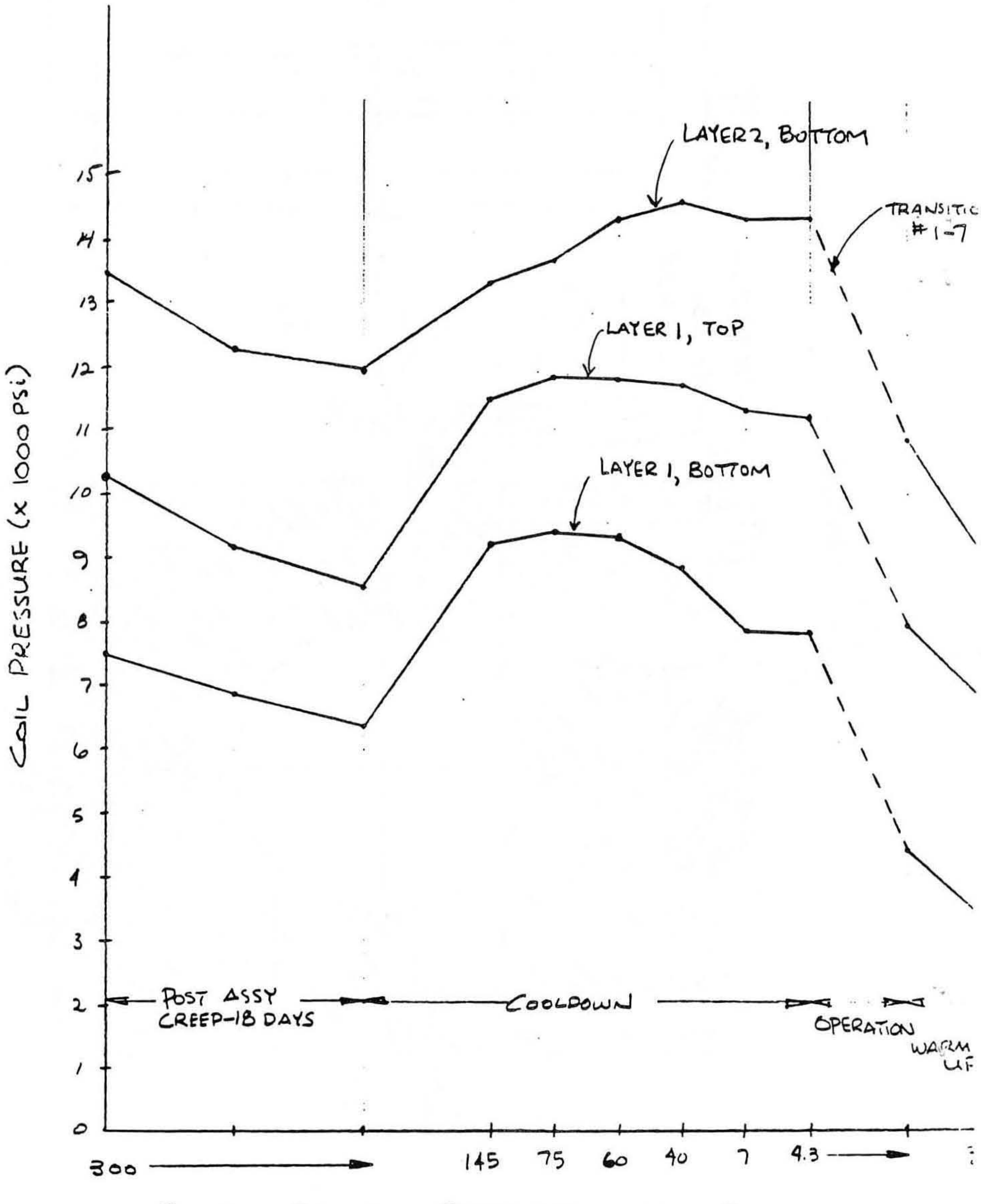


FIG. 5 C-1 COIL PRESSURES AT POLE DURING FIRST COOLDOWN AND WARM-UP

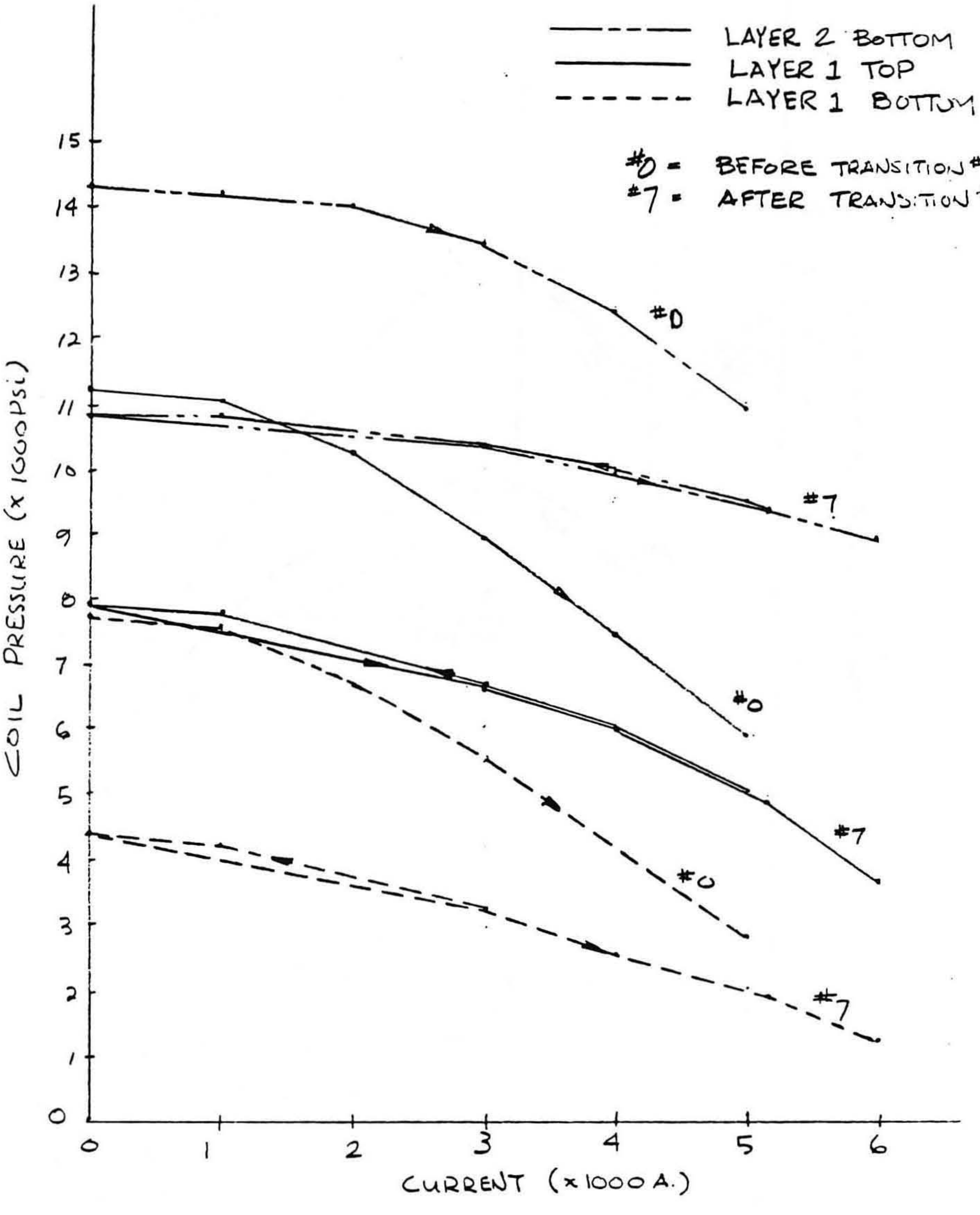


FIG. 6 C-1 COIL PRESSURE AT POLE DURING TESTING.

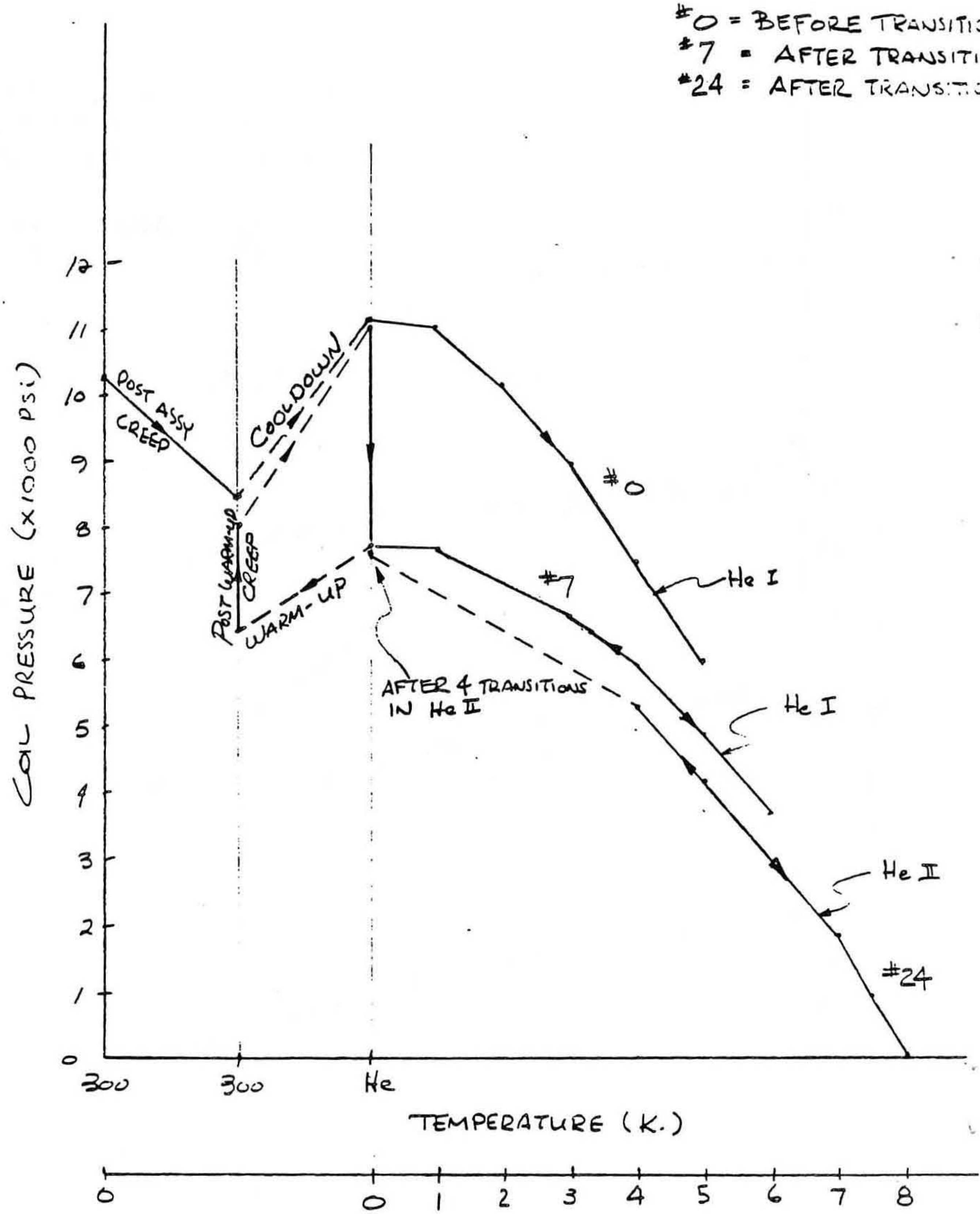


FIG. 7 C-1 LAYER 1, TOP, COIL PRESSURE AT POLE

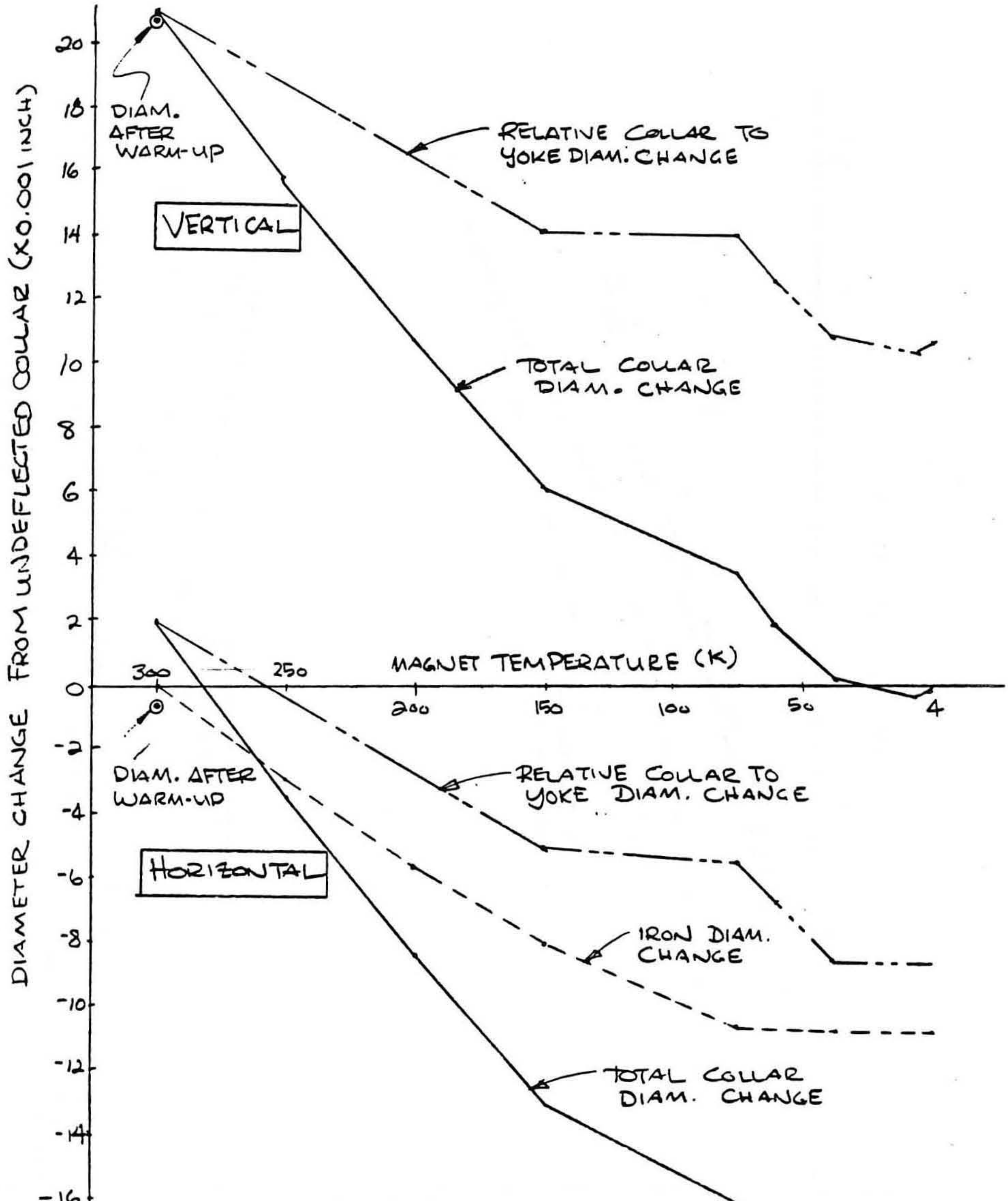


FIG. 8 C-1 COLLAR DEFLECTIONS DURING COOLDOWN

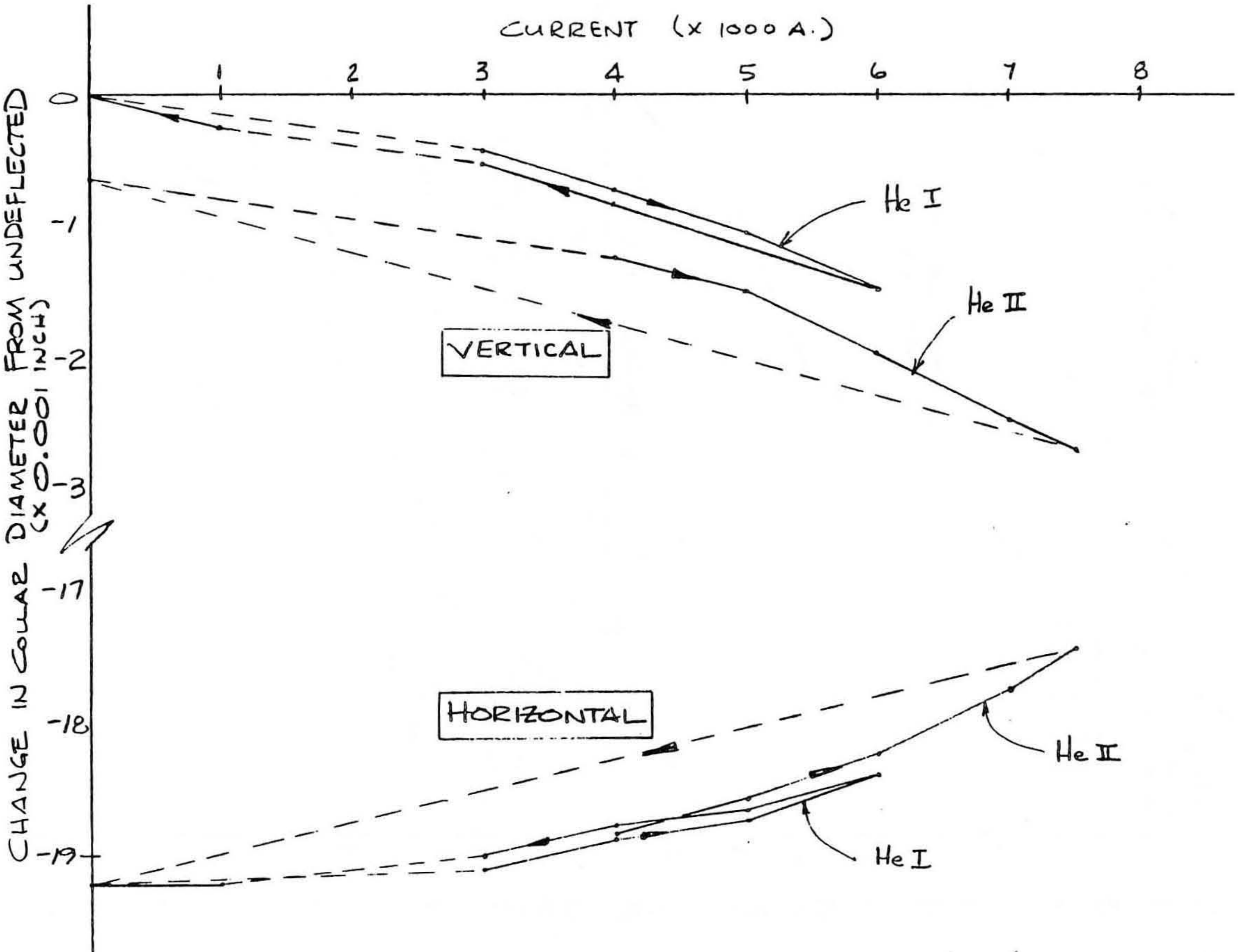


FIG. 9 C-1 COLLAR DEFLECTIONS DURING OPERATION