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ASSEMBLY AND INSTALLATION OF THE LARGE COIL TEST FACILITY TEST STAND*

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Abstract

The Large Coil Test Facility (LCTF) was built to test six tokamak-type superconducting coils, with three to be designed and built by U.S. industrial teams and three provided by Japan, Switzerland, and Euratom under an international agreement. The facility is designed to test these coils in an environment which simulates that of a tokamak. The heart of this facility is the test stand, which is made up of four major assemblies [1]: the Gravity Base Assembly, the Bucking Post Assembly, the Torque Ring Assembly, and the Pulse Coil Assembly [2] (see Figure 1). This paper provides a detailed review of the assembly and installation of the test stand components and the handling and installation of the first coil into the test stand.

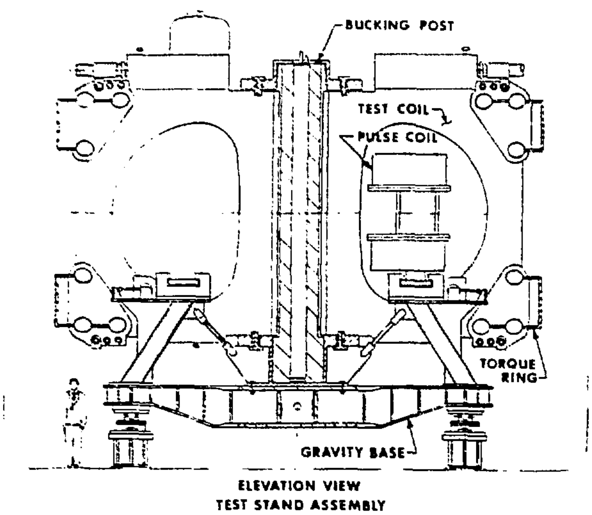

Figure 1

Gravity Base Installation

The Gravity Base Assembly is made up of five basic components: the column feet weldment, the liquid-nitrogen-cooled track assemblies, the roller assemblies, the pivot assemblies, and the spider frame.

In preparation for installation, all these components were thoroughly cleaned with a TP-35 Freon solvent. The initial step in the installation sequence was to accurately establish scribed centerlines for each of the six column feet. This was done by establishing a reference bench mark on the side of the vacuum vessel wall and a center punch mark in the center of the vessel floor. A transit was set up 10 in. east of this punch mark in accordance with engineering drawings. The radial centerlines were established using a transit; the radial distance was established within ±1/16 in. using a steel tape. Once these centerlines were enscribed on the vessel floor, the column feet weldments were lowered into place. Each weldment had centering index lines machined into them which were aligned with the scribe mark on the vessel floor. Each assembly was checked to ensure that it was level. Those that were not level were shimmed with 304L stainless steel shim stock. The column feet were welded in place with a TIG fillet around the base. Figure 2 shows two of these feet in place.

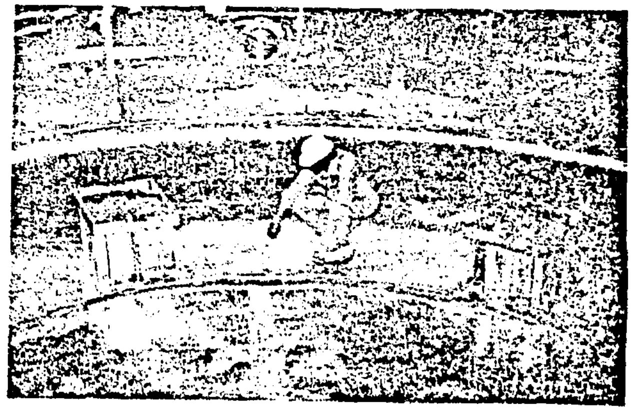

Figure 2

MASTER

Once the column feet were in place, the G-10 thermal insulation which isolates the liquid nitrogen cooled tracks was installed, with one large piece in the top recess of the column feet and four strips around the inside edge. The track assemblies were set into the recess formed by the G-10 strips. Additional G-10 strips and 304L stainless steel retaining plates were added to the outside edges. The entire assembly was then tied together by bolts that penetrated the retaining strips and G-10 pieces without contacting the track assemblies. Since these bolts tied materials of different coefficients of thermal expansion together, Belleville spring washers were inserted under the head and under the nuts at all locations. Upon tightening these bolts, all 300 of the Belleville washers failed. An investigation revealed that the supplier had used the wrong heat treat procedure to precipitation harden these washers. Once the washers were replaced, the track assemblies were checked to ensure that they were level, and the guide rollers were adjusted to be centered on the centerlines of the column feet. One such completed assembly is shown in Figure 3.

Next, the roller and pivot assemblies were installed onto the track assemblies. With the pivots locked so that the top surface was parallel with the lower surface, each assembly was checked for levelness and to ensure that the top surfaces of all assemblies were in the same plane. Due to tolerance stackup on the assemblies at this point, the top surfaces were not in a horizontal plane. Special shims were made to bring the top surfaces coplanar in a horizontal plane.

When the shims had been installed, the test facility was ready for the installation of the spider frame. The spider frame had to be brought from the first floor of the LCTF building to the second floor through a narrow hatchway that necessitated tilting the spider frame. Once it was on the second floor the spider frame rigging had to be changed to allow the assembly to be lowered into the vacuum vessel level (Figure 4). Once in place the spider frame was attached to the pivots with 300 series stainless steel bolts. All bolt threads and

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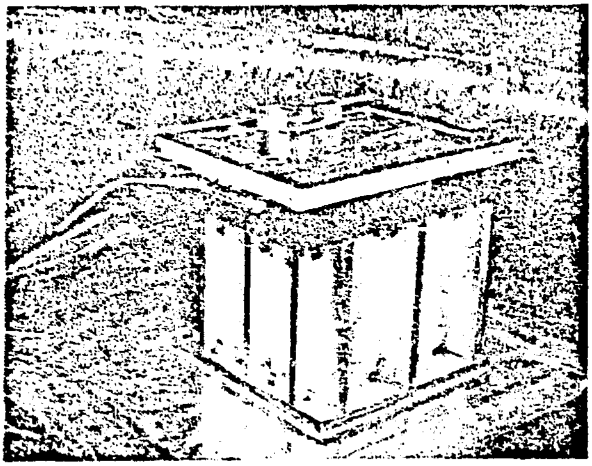

Figure 3

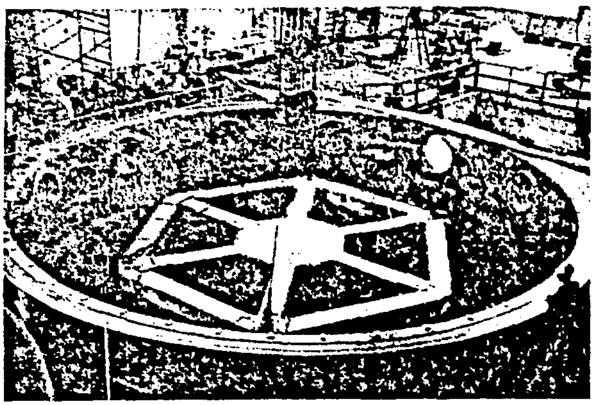

Figure 4

pivot pin surfaces had been lubricated using a dry film molydisulfide lubricant "Molykote 321."* The central surface of the spider frame where the bucking post attaches was checked for levelness. It was well within the allowable limits.

Bucking Post Installation

The bucking post assembly is made up of the bucking post subassembly, the lower collar, the upper collar, the bucking post shims, and the coil keeper hardware. Some of these components interface with the coils and cannot be installed until the installation of the coils.

The lower collar was heat shrunk onto the bucking post subassembly to provide an interference fit. This operation was done at Japan Steel Works, the manufacturer of the post and two collars. Once the post arrived in Oak Ridge it was uncrated, inspected, and given a final cleaning; then, the upper collar was temporarily installed. The spoke attachment lugs on the upper collar were used to attach uprighting slings. The post was uprighted, and the sling configuration was changed to allow the post to be lifted in a vertical orientation. Figure 5 shows the post being bolted to the spider frame.

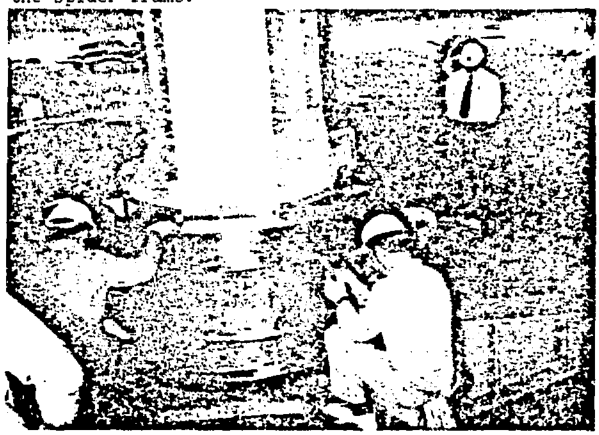

Figure 5

At this point the upper collar was removed so that instrumentation sensors could be attached and the torque ring spoke bearings could be installed in the spoke attachment lugs.

The coil attachment hardware that installs in the lower collar was pre-assembled in a retracted position. This hardware consists of a "T"-shaped keeper, a wedge block, and several shims, bolts, etc., which secure the coils to the bucking post.

During this same period other components and systems were being installed in the vacuum vessel. Installation of large components such as the liquid-nitrogen-cooled cold wall assemblies required careful scheduling and coordination in order to permit the smooth flow of work. Much of the installation of the smaller components occurred simultaneously where the availability of craft personnel permitted.

After the installation of the cold wall floor, which provided a thermal intercept between the vacuum vessel floor and the test stand, a personnel work platform grating was put into place. The assembled grating has an outside diameter concentric with the vessel which extends to within 30 in. of the cold wall assembly. The grating is made in six sections which bolt together and are supported off the spider frame. This grating provides a means for personnel access, support for instrumentation cable trays, and a means for transferring the coil support jack loads into the spider frame. Once the grating was installed, access to the bucking post assembly was made easier. Additional special scaffolding was needed to allow installation of instrumentation sensors up the height of the bucking post. This scaffolding was designed so that it could be relocated to any of the six sides of the post.

Torque Ring Installation

The next major component to be installed was the torque ring system. The torque rings are designed to be supported by a system of 3 in. diameter spokes and the test coils themselves. Once all six coils are installed, the coils alone support the torque ring assemblies. In the absence of the test coils, temporary support stands were built to aid the spokes in providing support and stability. Since the spokes for the upper assembly attach to the upper bucking post collar, which must be removed during the installation of the coils, a set of three support assemblies provides support from

*Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not necessarily imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof.

the lower torque ring to the upper torque ring. These supports are only intended to take the gravity loads of the upper torque ring and are not designed to carry any magnetically induced load. The design is such that once the coils and spokes are installed a spacer can be removed to isolate the two torque rings.

The lower torque ring was lowered into the vessel and set on the temporary support stands. Three of the six spokes were installed. The torque ring was aligned with the faces of the bucking post in both the radial and the azimuthal directions. Next, the supports for the upper torque ring were attached to the lower assembly. The upper torque ring was then placed on these supports. Figure 6 shows the [illegible]TF test stand with the torque rings installed.

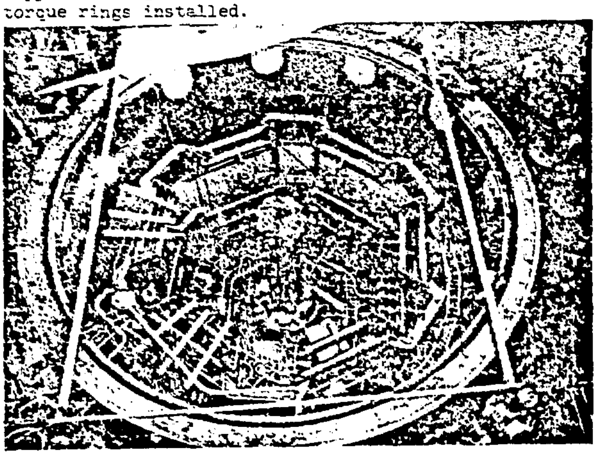

Figure 6

The two torque ring assemblies provided convenient structure for supporting temporary work platforms needed to install the many liquid helium piping assemblies and the multitude of instrumentation cable assemblies.

Final preparations to the test stand structure were made so that the first coil could be installed. Final instrumentation sensors were installed on the torque rings. The 3 in. diameter tension rods that span the coil slots in the torque rings were installed on the lower torque ring. Those for the upper torque ring cannot be installed until after the insertion of the coil into the slot. Final preparation of the bucking post involved welding sheet metal shim guide/instrumentation wire covers into the bucking post slots. These guides provided a positive means of centering the bucking post shims.

Coil Installation

The first coil to be installed was that furnished by the Japan Atomic Energy Research Institute. The final preparations of the coil were made with the coil in a horizontal orientation. In order to move the coil into the vertical orientation, a special set of upending shoes (Figure 7) and brackets was fitted to the coil. These upending shoes provided a pivot point about which the coil was rotated. The shoes and brackets interfaced with an upending cart which provided a means to move the bottom of the coil during the upending process. With the coil positioned on the cart, the lifting fixture was attached to the lifting brackets on the top of the coil (Figure 8). As the top of the coil was lifted, the cart was moved by means of a tow truck to enable the lifting fixture to remain in a vertical line under the crane. Once the coil was vertical, the rigging on the lifting fixture was changed to allow the coil to be lifted vertically in a plumb condition (Figure 9).

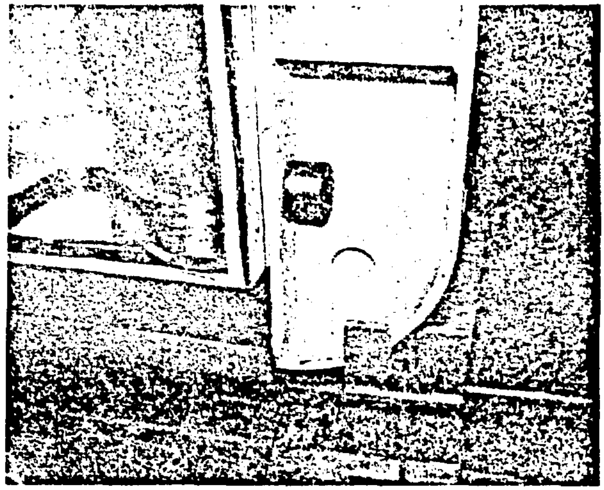

Figure 7

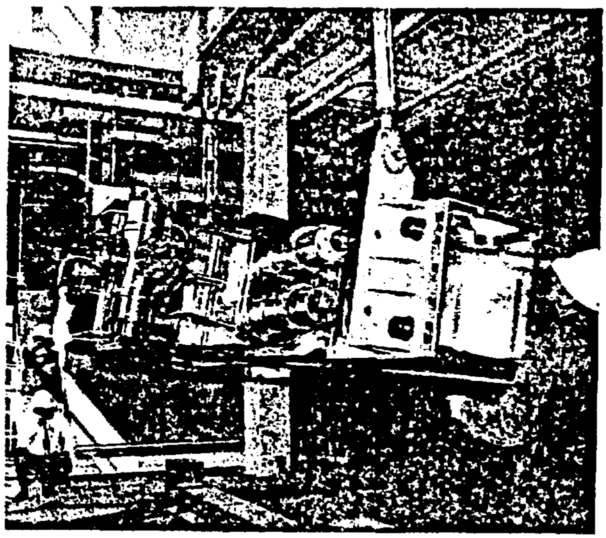

Figure 8

After the coil was put in the vertical position, but prior to installing into the test stand, the upending shoes were removed and the lower torque ring bearing plates were installed.

The coil support jack was installed on the aluminum bearing pad on the spider frame grating. The height of the jack was adjusted to the same height as the support surface of the lower collar. The coil was lifted into a position just above the test stand. Final alignment adjustments were made. Then the coil was very slowly lowered into place. As the weight of the coil was shared by the support jack and the lower collar, the support jack had a greater deflection than the much larger collar so the support jack was cranked upward until the coil was level.

The lower coil attachment hardware was put into

Figure 9

place securing the coil against the post. Next, the torque ring shims were installed between the lower torque ring and the coil. These shims were attached to the torque rings and adjusted by mechanical wedges until they bear on the bearing plates attached to the coil. The upper shim bearing plates were installed on the coil and the upper shims installed.

The bucking post shims are mechanical wedges capable of being expanded or retracted by turning a threaded rod. The bucking post shims were installed in the space between the coil key and the post key way by lowering from the top of the coil to the bottom of the slot. The bucking post shims provide a zero gap method of transferring loads from the coil to the bucking post. Each shim was stacked upon the previously installed shim. Once each shim was lowered into position, it was mechanically expanded into place.

At this time, the tasks of installing the superconducting leads, the helium piping, and the instrumentation lead conduit were initiated. The final installation of the upper collar could not be completed until the installation of the coil built by General Dynamics Convair.

Pulse Coil Installation

The pulse coil system [2] is not scheduled for installation until the completion of the two-coil test.

References

[1] C. C. Queen, Jr., P. S. Litherland, "Large Coil Test Facility Test Stand Design Description," The Eighth Symposium on Engineering Problems of Fusion Research, 1979, pp. 1183-1186.

[2] C. C. Queen, Jr., "Design Description of the Large Coil Test Facility," The Ninth Symposium on Engineering Problems on Fusion Research, 1981, pp. 265-267.

This last ref. was changed.