ULTRA-PRECISE ATTITUDE TEST FACILITY FOR FLIGHT SPACECRAFT

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To date, it has not been possible to test the stabilization and control systems of large spacecraft in the complete flight-ready configuration. Attempts to conduct systems tests using air-bearing facilities have failed because of the difficulty of maintaining torque-free conditions in the face of convection currents, mass imbalance, and hard wire cable connections. It remains a highly desirable goal to conduct systems tests of the flight spacecraft to assure proper interaction of the various subsystems, the integrity of the flight cable harness and the proposed control system-spacecraft operations procedures.

A facility has been designed and built for conducting complete dynamic systems tests of the OAO spacecraft. The operating principle of the facility is illustrated for a single control axis in Figure 1. In orbit, the spacecraft position θ_s is a function of momentum wheel position θ_w multiplied by the ratio of wheel inertia to the spacecraft inertia. In the facility, the spacecraft is suspended on a gimbaled platform. The wheel position is monitored by means of a synchrotransmitter, and a high gain servo tracks the wheel position. A mechanical gear reduction factors in the ratio of inertias. The result is that the spacecraft motion in the facility simulates precisely that which will occur in the external, torque-free space. The gain of the servo overpowers the extraneous disturbance torques which defeat air-bearing type facilities.

Although simple in theory, implementation of this approach for OAO, where ultra-accurate pointing was desired, placed very stringent requirements on the mechanical design of the facility. Specifically, very low friction suspension, zero backlash, extreme structural stiffness and dimensional stability, and maximum attenuation of building vibration inputs were essential.

Figure 2 shows the complete facility in schematic form. The spacecraft is suspended in the cradle as shown. The cradle is gimbaled about two orthogonal horizontal axes. The base, which supports the gimbal ring, also supports a superstructure for mounting stellar simulators. To complete the capability for testing the spacecraft control system, a precision coelostat provides an inertially fixed optical beam for stimulation of the fine guidance error sensor in the observatory telescope. Thus it is possible to test the inertial reference unit and to conduct realistic transfers of control between the inertial package and the stellar guidance sensor.

Figure 3 shows the test facility which was built and employed successfully to test the stabilization and control system of the OAO B flight spacecraft. Fine pointing of the spacecraft, under the control of the GSFC experiment package was demonstrated to better than 0.5 seconds of arc. Other spacecraft functions tested included

Gimbaled star tracker operation,

Boresight star tracker operation,

Coarse slew maneuvers,

Fine slew maneuvers,

Operation of the inertial guidance package including demonstration of the proposed in-orbit drift correction,

Settling time of the spacecraft control system, and

Transfers between all modes of control (automatic and/or commanded as appropriate).

The facility is presently being upgraded, with the goal of testing the OAO C spacecraft with a pointing stability approaching 0.1 seconds of arc. The facility concept demonstrated here could also be employed for preflight testing of any spacecraft employing momentum exchange devices for control muscles.

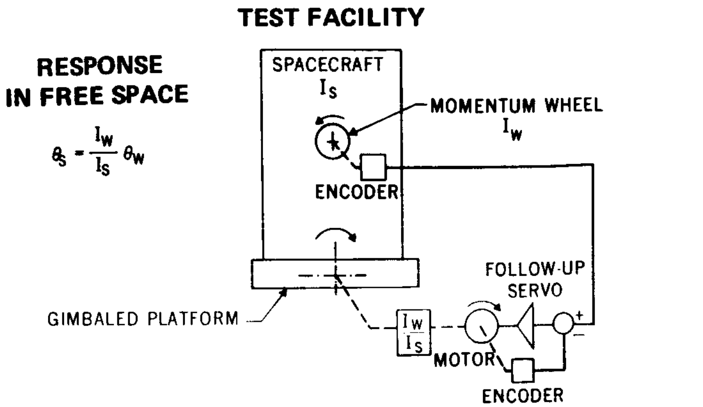

Figure 1–Operating principle of the OAO fine pointing test facility.

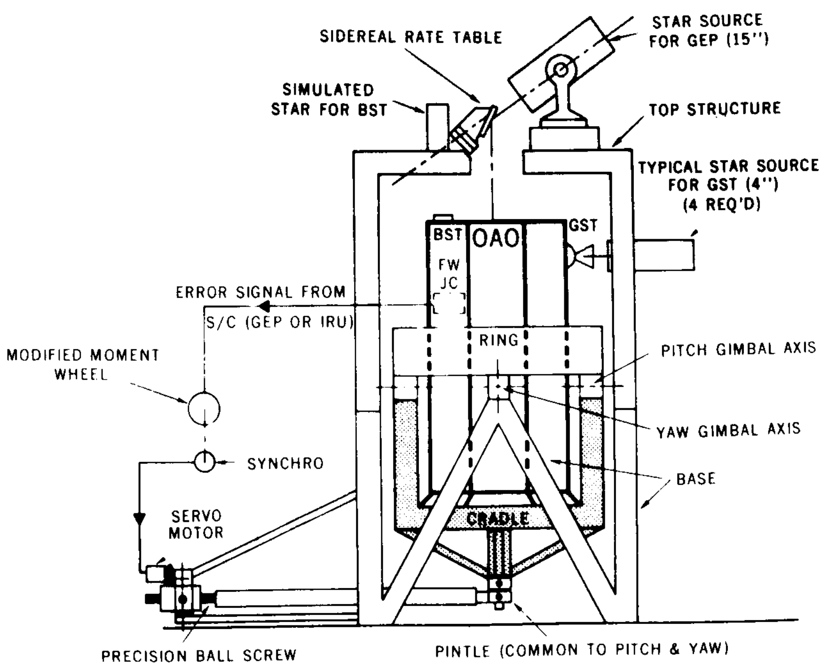

Figure 2–OAO fine pointing test facility (schematic).

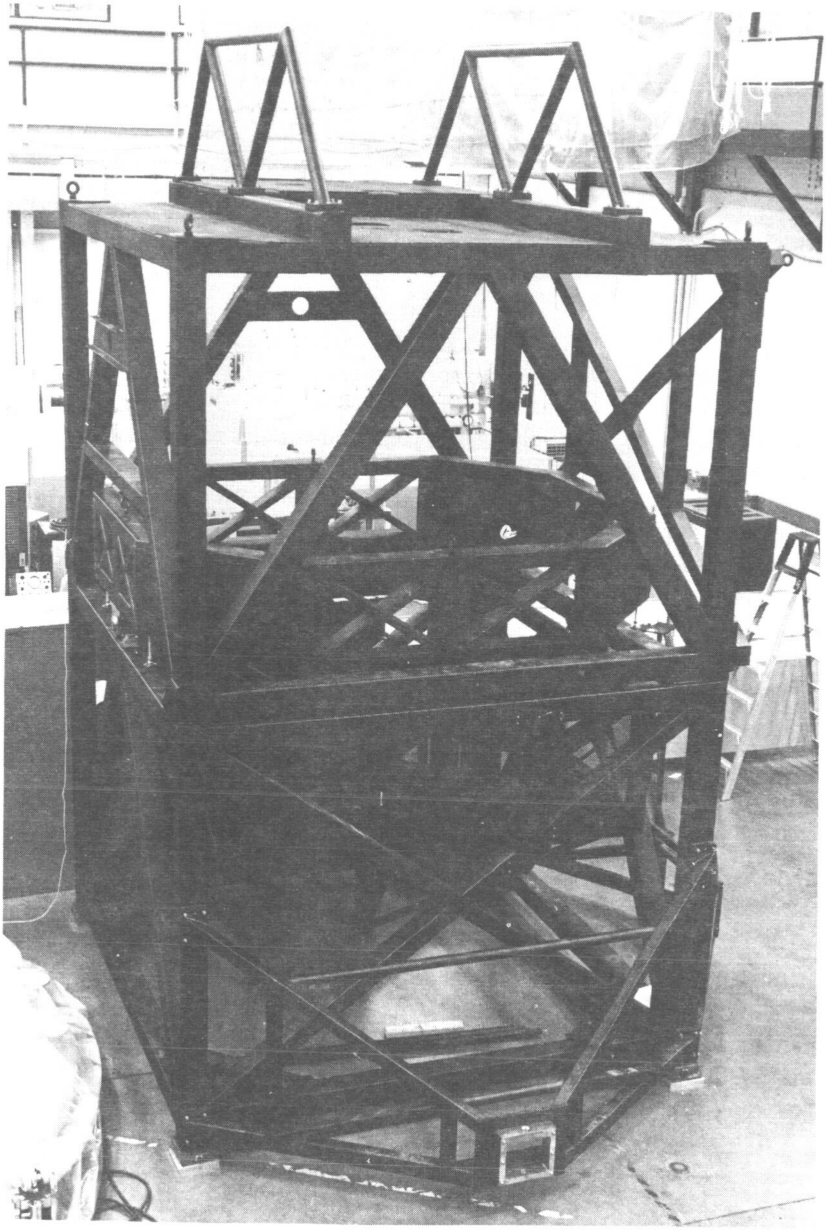

Figure 3–OAO fine pointing test facility.