§10. Cryogenic Control System for the Large Helical Device

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We have been constructing the cryogenic control system for the Large Helical Device (LHD). The cryogenic system for the LHD consists of the helium refrigerator/liquefier, the superconducting helical and poloidal coils and the peripheral equipment, such as superconducting bus-lines, control-valve-boxes and cryogenic transfer-lines. The helium refrigerator/liquefier has cooling capacities of 5.65 kW at 4.4 K, 20.6 kW from 40 K to 80 K and 650 L/h liquefaction. Three different cooling schemes are utilized for each cooling object; a pool boiling for the helical coils (cold mass of 240 tons), a forced flow of supercritical helium for the poloidal coils (182 tons), a forced flow of two phase helium for the coil supporting structure (390 tons) and the superconducting bus-lines (total length of 463 m).

The development of a new control system, which is highly flexible and expandable concerning both hardware and software, is crucial for the LHD because of fairly complicated cooling schemes. The cryogenic control system consists of workstations, VME (Versa Module Europe) controllers, Local Area Networks (LAN), operating graphic consoles, peripherals and signal terminals as shown in Fig.1. The control system is composed as a duplex system which significantly improves the reliable operation with fault diagnoses of each component. The operating system of workstations and VME controllers are the UNIX and the Vxworks, respectively. Primarily, the overall control system can be expandable, using standard hardware and operating software. Furthermore the software tool packages are being developed based upon them, which provide us more flexible and easy construction of a control program. These software tool packages have the function of system configuration, easy making of graphic control panels, reporting and programming sequence and loop control.

The control system is composed as a duplex system which significantly improves the reliable operation with fault diagnoses of each component. The fault diagnoses of the VME controllers are now limited to the CPU and communication boards. However we will extend them to every board including analogue input/output boards and digital input/output boards. Based on above cryogenic control system, the overall operating scenario of the cryogenic control system; such as, a cool-down, a steady-state operation, a warm-up, a power failure and a coil quench, are being considered to develop a fully automatic control program for the LHD cryogenic system.

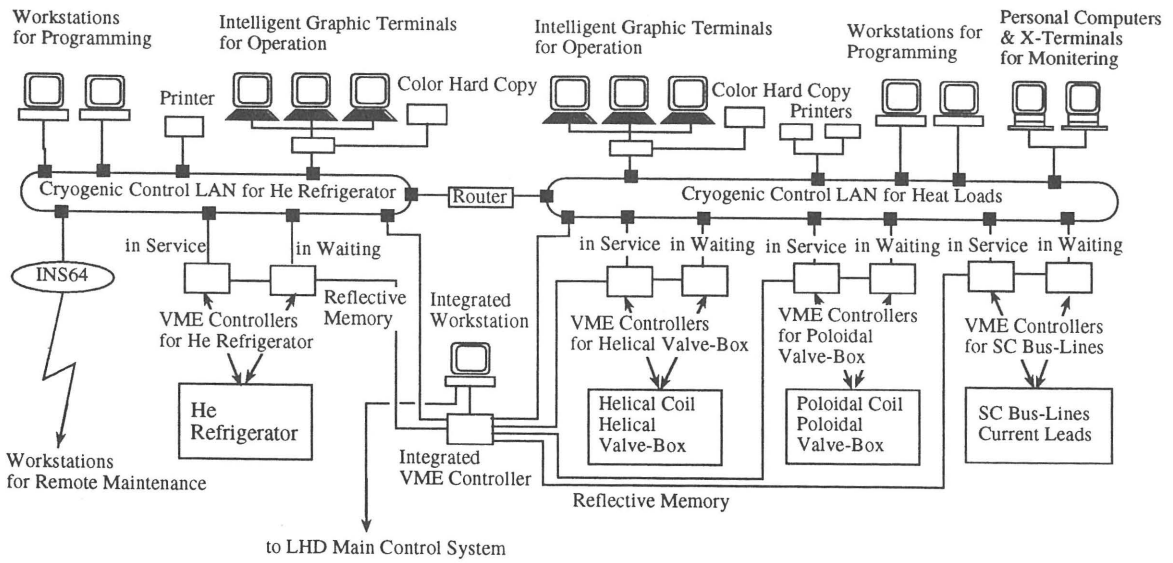

Fig. 1. Cryogenic Control System for the Large Helical Device.