ix. Cryogenic Control System

A stand-alone process control system is required for the Cryogenic System. When desired this will permit operation of the Cryogenic System independent of the main RHIC control system. This may occur quite frequently during periods of cooldown and warmup.

The refrigerator and compressor control sub-system was designed, installed and in operation since 1984. It originally consisted of 3 PDP11® computers and Crisp® software running the refrigerator and compressors via an input/output (I/O) system. The I/O system interfaces a total of about 1700 points consisting of analog and digital input/output points, temperatures and PID loops. Through these points, the I/O system controls the cryogenic vacuum system, purifiers, compressors, refrigerator and gas management.

The current Cryogenic Control System design which also includes the Ring Control Sub-System, replaces the three PDP11® computers with two VAX® 4000/400 computers connected in a hot back-up configuration (Fig. 3-7). The system runs an updated version of the Crisp® Process Control Software in conjunction with a new PLC based I/O system. Included in the current design are multiple operator workstations in various locations running Crisp® Process Control Software. Any workstation can be used to generate or modify databases and programs or perform other functions such as historical trending and analysis and creating reports from the Crisp® system database.

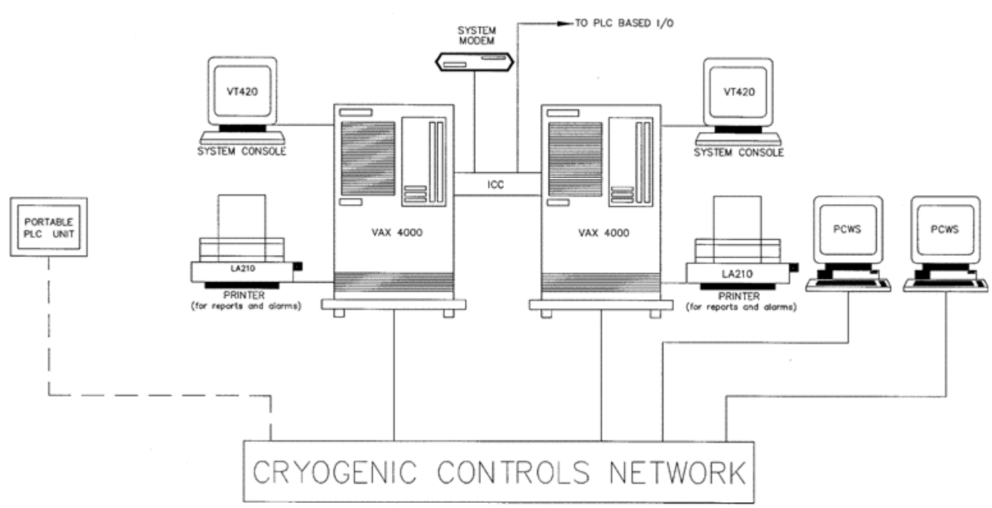

Fig. 3-7. Cryogenic Control System Layout

One of the most powerful tools of Crisp® software is the graphic system which provides the opportunity to create and modify standard and custom process graphic displays on-line without any programming required. Thus, hundreds of pages of graphic display of all cryogenic variables can be generated and linked to the database on the fly, without a glitch or interruption of operation of the process control system.

The dual VAX® computers are connected in a hot-backup configuration. While only one computer is in control, the other one is always updated of the activity of the first one. If the active computer fails, the inter computer communications (ICC) network (Fig. 3-7) which connects the two VAX® together automatically switches control to the backup computer. Since the backup system was continuously updated, the transition is totally smooth with no loss of information and no human intervention.

The Ring Control Sub-System consists of programmable logic controllers (PLC), located at each of the six experimental areas. They are connected to the cryogenic control room via the RHIC Cryogenic Controls network shown in Fig. 3-8. The 10/100 Ethernet switch in the 1005 Communications Hub room distributes the network to the six experimental areas and the B Alcoves. This switch is connected to a similar switch in the Cryogenic Control room that feeds three other switches. The four switches in the control room provide network connections for the dual VAX® 's, local workstations, the Refrigerator room and the Compressor room. Network monitoring and diagnostics are done on a dedicated PC. At each experimental area, the PLC processor manages all cryogenic signals via input/output (I/O) modules located in crates distributed along the RHIC tunnel, connected to the PLC via a local data highway running at a speed of 250 kbaud. There are about 8300 points around the ring to be monitored and controlled for a system total (including refrigerator and compressors) of almost 10000 points.

The ring remote I/O crate consists of a 19 inch rack mountable chassis with its own power supply, I/O scanner and as many I/O modules as needed. Some of the points to be controlled are: Mass flow controllers (MFC) used to control the flow of helium gas, which cools the superconducting magnet power leads. The MFC are located at the room temperature end of the power leads. Magnet current information is received by the VAX® via data transfer with the Main Control Room. The control program running on the VAX® determines the proper control point and this information is passed to the MFC through the PLC analog output module. Flow readback from the MFC is sent back to the VAX® via analog input module.

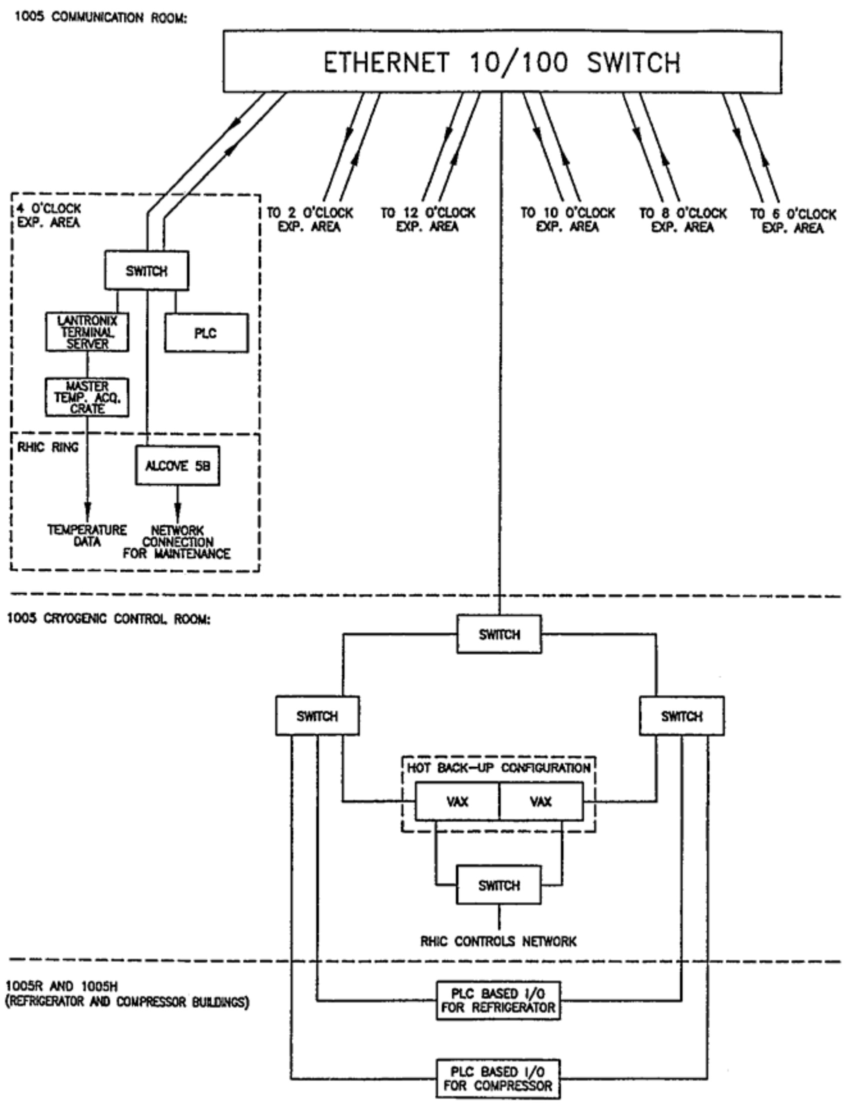

Fig. 3-8. Cryogenic Controls Network

The PLC is also programmed to control the helium liquid level in the recooler at a fixed level. This is achieved by reading the liquid level via analog input module and positioning the opening of the valve via analog output module to keep the liquid level constant.

The rest of the cryogenic signals controlled by the PLC via the I/O crates are pressure sensors and low flow indicators using thermistor resistors in the self-heating mode and cooled by the flow of helium gas.

The ring temperature acquisition crate[1] consists of a 19 inch rack mountable EUROCARD® chassis located in the same cabinet as the remote I/O crate. It is an in house designed multiplexed data acquisition system with an overall accuracy of ± 20 PPM, which translates into a temperature accuracy reading of less than 1mK for temperatures below 10 K. The system reads temperature of pre-calibrated transducers such as germanium, silicon diode, thermistor or platinum temperature sensors. Inside the temperature acquisition system, the raw data associated with these transducers is linearized by use of corresponding polynomial coefficients. The final result (a digitized analog reading) is shipped to the VAX® via a Lantronix terminal server over the RHIC Cryogenic Controls network as shown in Fig. 3-9.

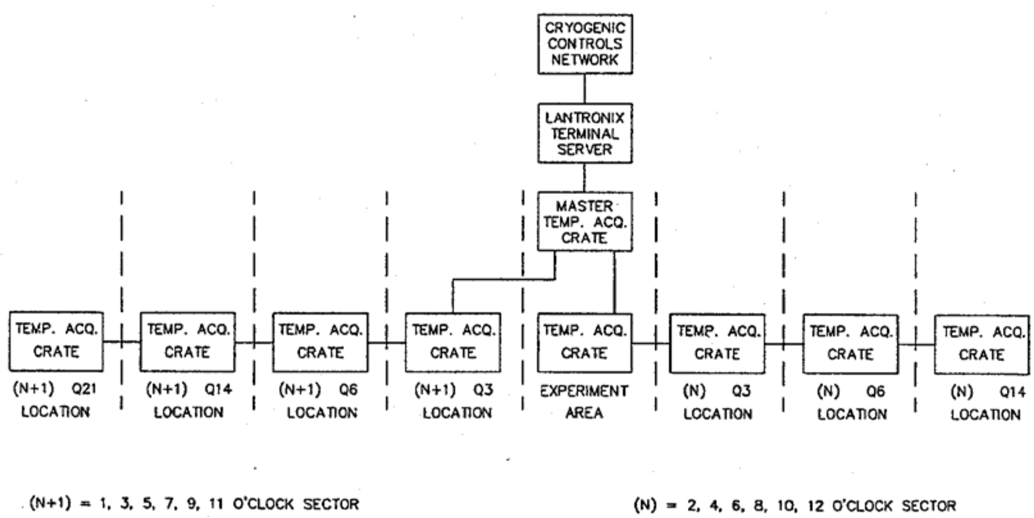

Fig. 3-9. Ring Temperature Acquisition System Layout

[1] Y. Farah, J. H. Sondericker, "A Precision Cryogenic Temperature Data Acquisition System", Advances in Cryogenic Engineering. Vol. 31 (Plenum Press, New York, 1985).

The temperature acquisition system used for the refrigerator and compressors is slightly different from that used in the ring. The temperature devices are wired to a LakeShore Model 218 temperature monitor, where the information can be read locally. Like the ring temperature acquisition system, a Lantronix terminal server is used to take information from the LakeShore device to the VAX® over the RHIC Cryogenic Controls network.

In the design of this system, a clear choice was made in favor of using many remote I/O crates (up to a maximum of 32) distributed along two tunnel sectors, thus minimizing the length of cables between transducers (points) and the electronics. This choice was driven by the low cost of the remote I/O crates in comparison to the cost of fire-retardant cables.

The PLC software is developed at the PC workstation in the Cryogenic Control room. A portable PLC unit complete with a remote I/O and temperature acquisition crates is attached to the PC workstation via the Ethernet hub (Fig. 3-7). This unit located next to the workstation is used to test the PLC software. Once the software is bug free, it is downloaded to the individual PLC in the experimental areas via the RHIC Cryogenic Controls network.

Communication between the CRISP® database in the VAX® computers and the PLC is done via CRISP® intelligent device interface (IDI) over the RHIC Cryogenic Controls network.

The state of the cryogenic system is needed for the operation of some of the components of the collider such as the power supply and the vacuum systems. Therefore, a communication link between the cryogenic and RHIC main computers is necessary. On the cryogenic side, a directory is created under VMS® operating system in which an ASCII input/output file is written. This file will contain all the necessary data to be shared between the two computers over the RHIC controls network. Under VMS® authorize utility, access to variables in the directory by either the main or cryogenic control systems is limited to predetermined status, control and interlock functions.