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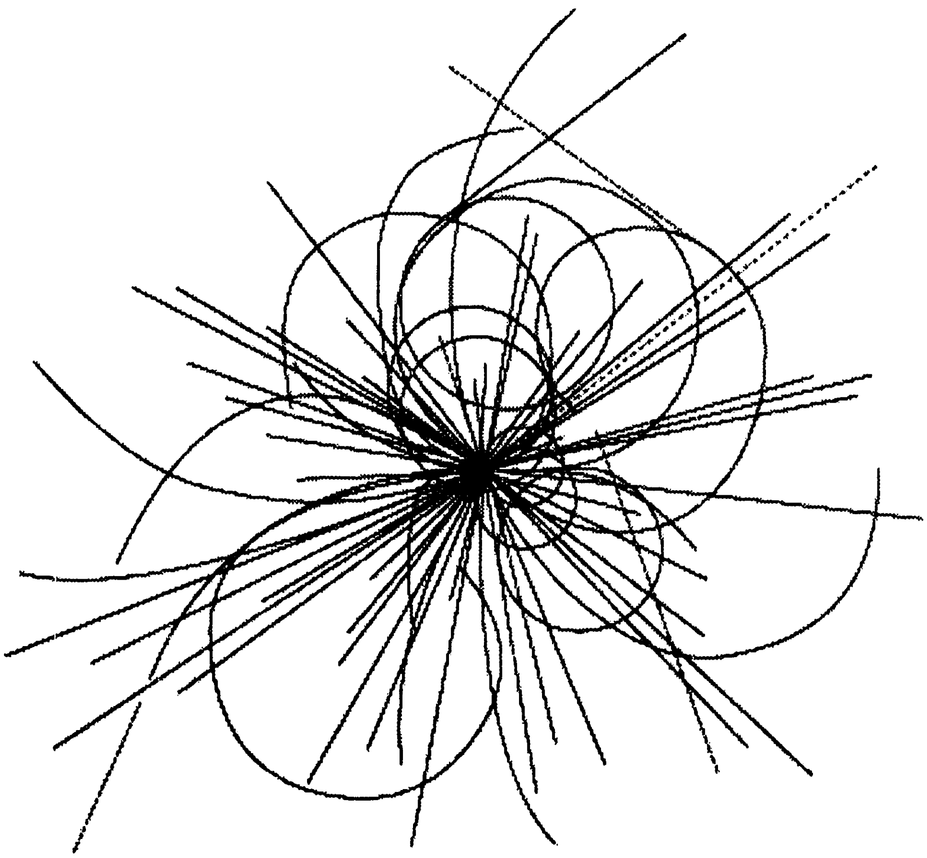

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DEVELOPMENT OF CRYOGENIC INSTRUMENTS AND EQUIPMENT FOR SSC MAGNET CRYOGENIC TESTS AT THE MTL

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INTRODUCTION

The Magnet Test Laboratory (MTL) will test a considerable portion of the total SSC superconducting magnet production in order to control the manufacturing process and verify magnet performance requirements. With ten cryogenic test stands, MTL is capable of housing tests for 30 dipoles and 5 quadrupoles per month. For further understanding and improving the performance of the SSC magnets, there will be two R&D test stands for extensively instrumented magnets, and there will also be three-magnet string test facilities.[1] A large number of instruments were allocated and installed inside the prototype and first production magnets, as well as in the feed and end cans. A data acquisition and control system is developed. A comprehensive cryogenic system (including refrigerator, cryogenic distribution box and, feed/end cans), vapor-cooled power leads, anti-cryostats (warm bore), and other associated systems, have been designed, developed and tested. This paper will briefly discuss the progress to date.

THE CRYOGENIC INSTRUMENTATION SYSTEM

The cryogenic instrumentation to be placed in the MTL Cold Test Stand provides cryogenic parameters – temperature, pressure, flow, cold mass stress (strain gauges) and voltage taps – monitoring and feedback information for the control systems during test operations. The location of gauges on the MTL Test Stand is shown on Figure 1.[2]

Electrical heaters, shown on the Figure 1, together with temperature controllers, will be used used for fine temperature control of helium and nitrogen flow (1, 2), warming up part of single-phase helium flow to operate the 20 K shield (3), heating helium gas up to 300 K before returning to the compressor, and the remainder (5, 6) will be used for calibration purposes. All heating elements must be installed in stream.

CRYOGENIC DATA ACQUISITION SYSTEM

The front-end part of the cryogenic data acquisition and control system, shown in Figure 2, has a VME-based architecture, driven by a Motorola MV147 card, containing a 25 MHz 68030 microprocessor. A real time operation system, VxWorks, runs the acquisition and control software as a set of separate tasks, serving different types of instrumentation (temperature, pressure, etc.), that run independently and asynchronous. The necessary timing is provided by the test specific application software. This approach provides the necessary flexibility for the whole system to accommodate various types of tests.

Digital Voltmeters (DVMs) HP 3458A together with 16-channel multiplexer cards form scanning voltmeters used for monitoring signals from temperature, pressure, strain gauges and voltage taps. Using one power line cycle, the voltmeter integration time (which provides 7.5 digit resolution) gives a practical

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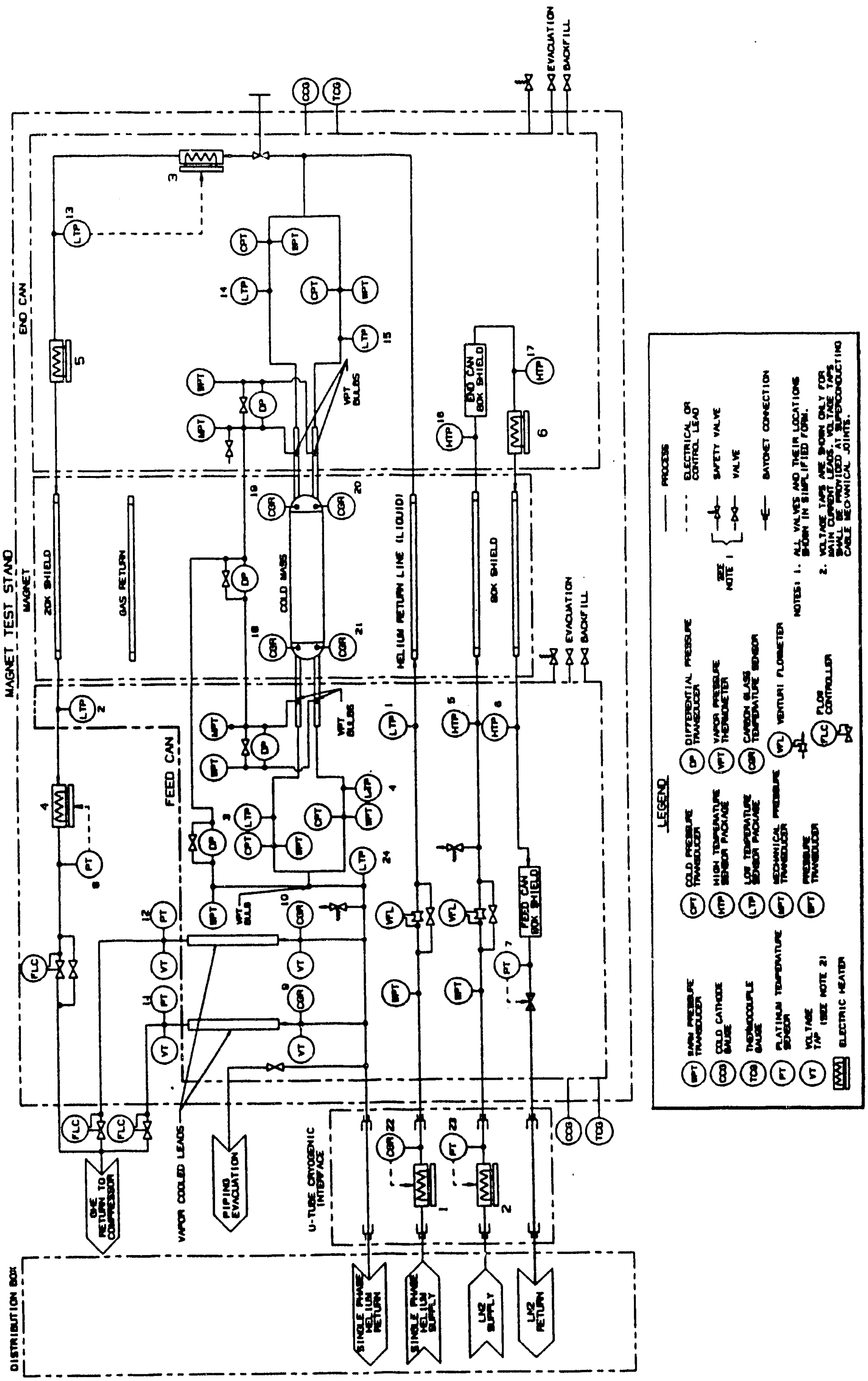

Figure 1. The flow chart of the cryogenic instruments for the MTL Superconducting Magnet Test Stand.

scanning rate of 25 ch/sec. Solid-state FET multiplexers in a HP 1351A provide virtually an unlimited number of switches that increases system reliability. Programmable current sources are used for gauge excitation.

The electrical heater temperature controllers and flow controllers are used as stand-alone devices, with set points downloaded via RS232 and GPIB lines to off-load the VME computer.

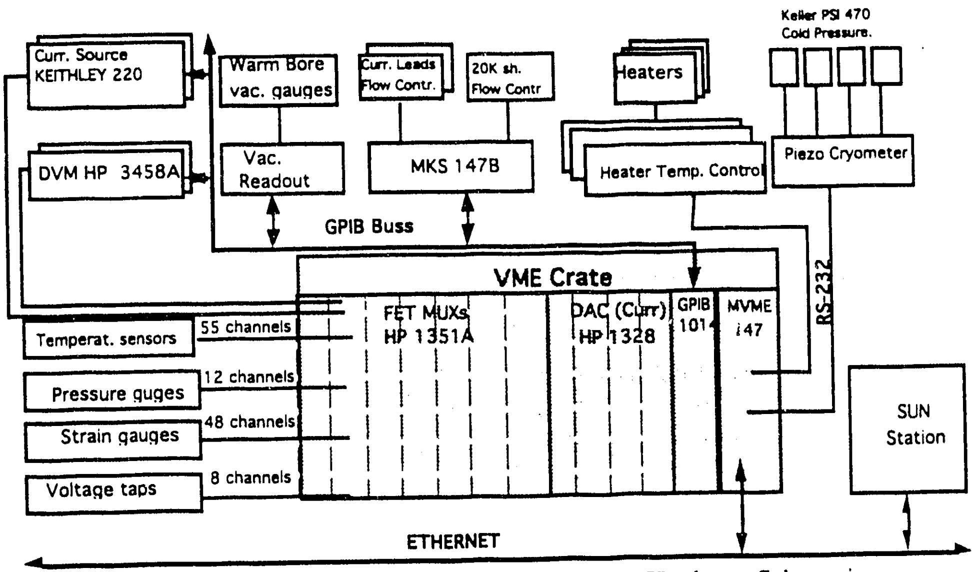

Figure 2. MTL Cold Test Stand Instrumentation Hardware Schematic.

THE FEED AND END CAN STATUS

The concurrent design effort with Meyer Tool for the feed and end can is now complete. The fabrication of the first pair of feed and end cans is nearing completion. SSCL confidence in the design has enabled the placement of an option for four additional pairs of feed and end cans from Meyer Tool. Delivery of the first pair of feed and end cans is scheduled to allow cold testing of ASST dipole magnet DCA-207 in August of this year. The end cans are fully instrumented to be able to accurately measure temperature, pressure, and flow rate of helium through the cold mass, 20 K shield and 80 K shield lines. The 20 K shield can be operated from 2.5 to 40 K at a flow rate of 0 to 10 g/s. The flow path for the cold test stand takes the helium through the feed can and into the magnet liquid helium return line to the end can. From the end can the helium flows through the magnet cold mass and into the feed can. As the helium flows through the feed can, it passes through the vapor cooled power lead pot where a portion of the helium is taken through the leads for cooling. The remainder of the helium returns from the feed can back to the distribution box.

THE REFRIGERATION SYSTEM AND DISTRIBUTION BOXES

The refrigeration system for the MTL is in the early stages of commissioning. The compressors will be tested first, followed by the refrigerator liquefier. Figure 3 shows the first cold test stand with the distribution box skid behind. The cans shown on the ends of the magnet are for vacuum system testing which is currently taking place. Cryogenic transfer lines will connect the distribution box to the feed can that will be mounted on the cold test stand. The transfer lines will provide helium and nitrogen supply and return to the feed can. A small heater is included in the helium supply line to provide fine temperature control to the test stand. The nitrogen supply line includes a heater for heat leak testing purposes. The distribution box functions as the interface to the main and CCWP (clean-up, cooldown, warm-up, and purification) cold boxes. It also contains the subcooler required for operating temperatures below 4.5 K. Magnet quench process flow is handled by the distribution box valves. The normal supply and return valves are closed and a quench return valve opens allowing the quench flow to return to the liquid helium dewar and/or the refrigerator cold box.

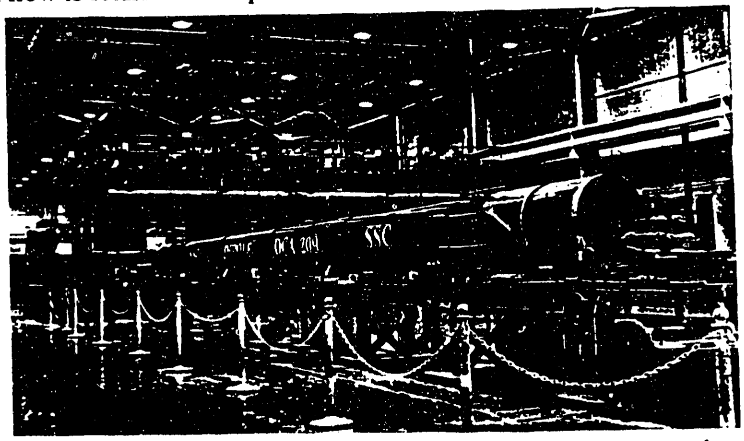

Figure 3. Cryogenic distribution boxes and magnet test stand.

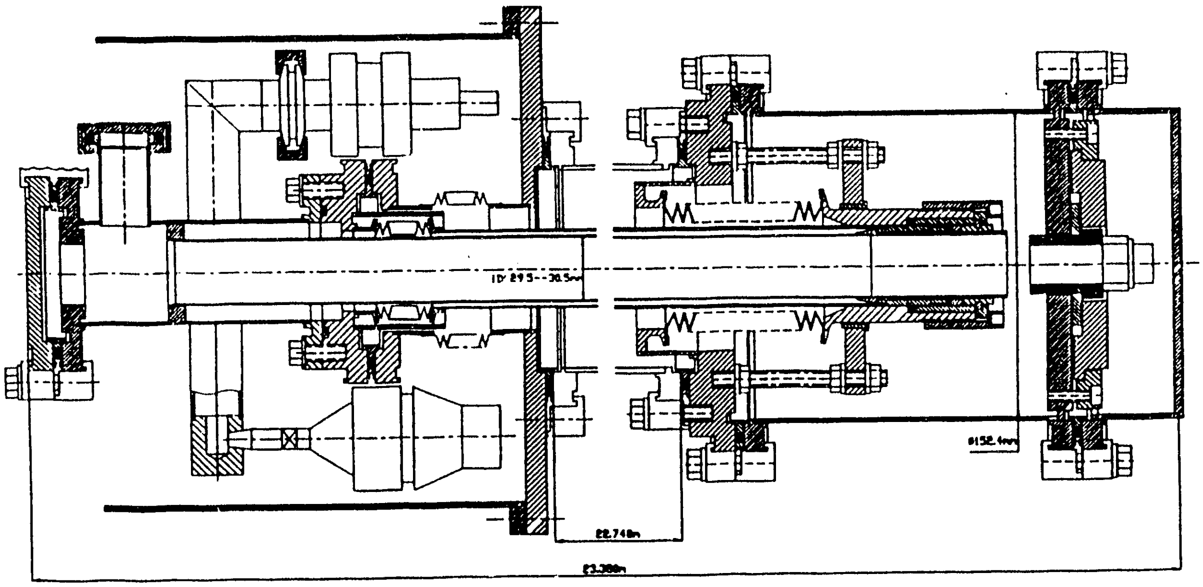

Figure 4. One of the warm bore designs.

DESIGN AND TEST OF THE WARM BORE AND FINGER

The anti-cryostats, so called warm bore and warm fingers, for the magnetic field measurements during magnet cryogenic testing have been designed and tested. The warm bore inserts into the magnet beam tube, which is at a temperature around 4.2 K, and accommodates a magnetic measuring field rotating coil, NMR probe and Hall probe within its warm space. Contrary to a normal dewar, the temperature of the outer wall of the warm bore is 4.2 K, whereas the inner space of the bore is maintained above 273 K. Several short warm fingers (3–4 m) have been successfully tested and used in SSC short magnet vertical tests. The thermal performance agrees with design specifications of 2.5 W. A warm bore for SSC full size dipole cryogenic tests has been designed as shown in Figure 4.

DESIGN AND TEST OF 10 kA VAPOR COOLED POWER LEADS

The spiral fin 10 kA helium vapor cooled power leads have been designed for SSC superconducting magnet tests at the Magnet Test Laboratory (MTL). Two different fin geometries and three RRR lead material values were developed to thermally optimize the power lead parameters, including lead diameters, that minimize Carnot work for different lead lengths. In the design, a new thermal barrier device to reduce heat conduction from the vacuum and gas seal area was employed. Therefore, the electric insulation assembly, which isolates the ground potential parts of the lead from the high power parts, was moved into a warm region in order to prevent vacuum and helium leakage in the o-ring seals due to transient cold temperature. The first pair of the power leads were cryogenically tested up to 10 kA.

ACKNOWLEDGEMENTS

The author wishes to thank all colleagues involved in the MTL development.

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