iv. Quench Protection System

To prevent magnet damage in the event of a quench, the current in the quenching magnet must be reduced to zero before overheating occurs. There are two parts to this system. First, the energy from the non-quenching magnets is bypassed, through the natural switching action of a diode around the quenching magnet. Second, quench detectors "switch in" energy dump resistors that reduce the current, as they absorb the stored energy.

The single-diode bypass system is shown in Fig. 2-5. In this circuit, the current is forced out of the magnet and into the shunting diode by the natural action of the quench developed resistance of the magnet coil. Energy from the non-quenching magnets will not heat the quenching magnet because of the shunting action of the diode. The collider magnets, with the exception of the DX dipole, are able to absorb their own energy without overheating during the time that the current is being reduced by the energy dump resistors.

The DX dipole is different than the other main magnets in two ways. First, because of it's higher inductance (50 mH vs. 25 mH for an arc dipole), the induced voltage during a current ramp will be higher. This requires two series bypass diodes, instead of the single diode shown in Fig. 2-3. Second, since it cannot absorb its own energy, an active quench protection system will be required.

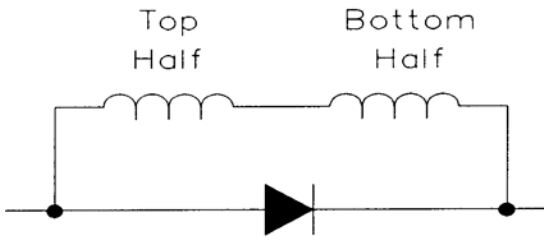

Fig. 2-5. Single diode protection circuit.

Even though the quench-inducing individual magnet is protected, it is necessary to remove the stored energy from the entire series-connected string as rapidly as possible to avoid quench propagation into neighboring magnets and to protect the bus and diodes from overheating. The thermal mass of these elements is large enough to permit a simple solution. Figs. 2-2 and 2-3 show this energy extraction system.

Current is reduced in the non-quenching magnets by a redundant set of switches. The primary switches are solid state silicon controlled rectifiers (SCR). Redundancy is provided by commercially designed dc interrupters commonly used to protect large power systems. When these switches open, the current is diverted into dump resistors which dissipate the stored energy and exponentially reduce the current to zero. The bus and the diodes together with their heat sink have been tested to withstand the rated current for the worst case "dump" period.