### xiii. Quench Protection System

The quench protection system is used to prevent damage to the superconducting cable or wire used in magnets or bus work. This damage will occur when there is sufficient energy deposited at the initial quenching location to cause the location to rise its temperature above safe operating limits. The current in the quenching magnet or bus must be reduced to zero before overheating occurs. They are three parts to this system. First, the cold bypass diodes are used to divert the current from the non-quenching magnets around the quenching magnet. Second, the quench detection system is used to determine when magnet or bus has quenched. The quench detection system will be used to trigger the energy extraction system. Third, the energy extraction system brings the current to zero in the quenching magnets and superconducting buses. This is mainly accomplished by switching in dump resistors in series with the magnet circuits.

**Cold Bypass Diode System**

Almost all of the collider main magnets are able to absorb their own energy during a quench. With these magnets a passive cold bypass diode system is used to prevent damage to the quenching magnet from current in the rest of the magnet circuit.

The cold bypass diode system is shown in Fig.2-23. 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. Current from the non-quenching magnets will not heat the quenching magnet because of the shunting action of the diode. During current ramping the diode must not shunt any significant current.

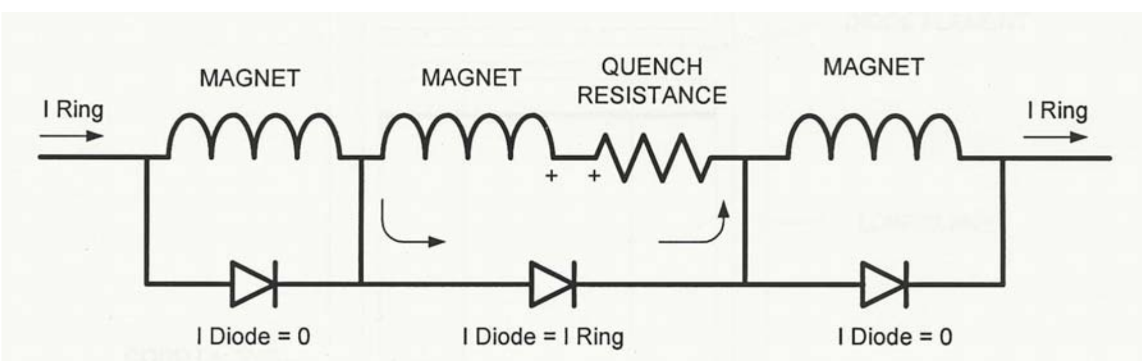


**Fig. 2-23** Simplified Circuit of a Quench Protection Diode Bypassing Current During a Magnet Quench

The cold diode assemblies (See Fig.2-24 ) have two 5 pound copper anvils compressing the diode element. A stainless-steel frame using disc spring washers maintain the large compressive force on the diode element under all operating conditions. This large force is needed for a good electrical and thermal contact between the diode element and copper anvils. Ceramic balls are used to provide electrical isolation between the copper anvils in a stainless-steel frame. The diode elements where specifically passivated for cryogenic temperatures. The large copper anvils are used to limit the maximum temperature of the diode element to below its maximum temperature rating.

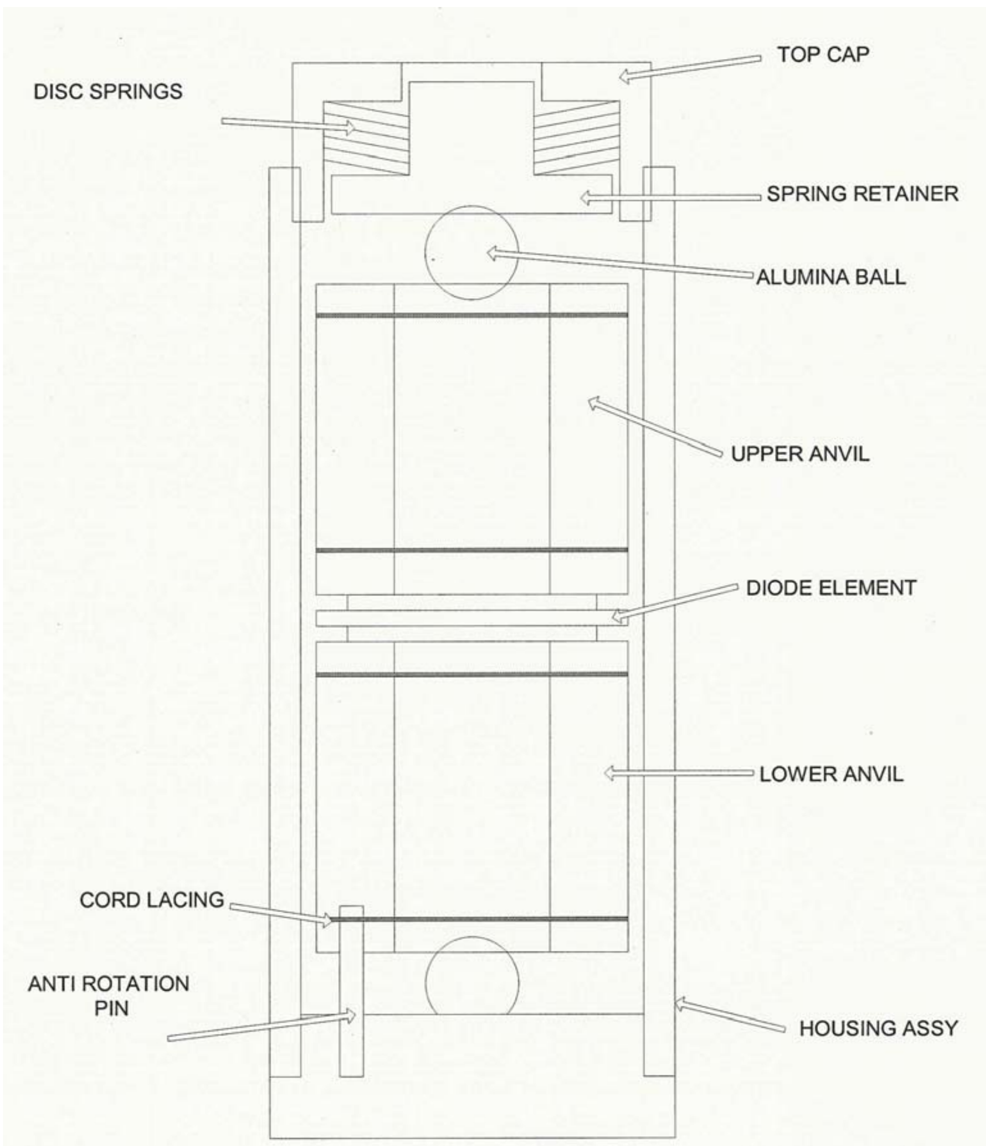


**Fig. 2-24** Cold Diode Assemblies

**DX Magnet**

The DX dipole magnet is different than the other main magnets in two ways. First, because of its higher inductances (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. 2-23. Second, since the DX magnet cannot absorb its own energy, an active quench protection system will be required. The active quench protection system consists of strip heaters placed along the outer diameter of the DX magnet coil and capacitor discharge power supplies that will pulse the heaters when a DX magnet quench is detected. These power supplies are located in each service building. When the strip heaters are pulsed it will cause a large area of the magnet coil to quench, this in turn will distribute the energy the magnet has to absorb to a much greater volume of the magnet coil thereby preventing any magnet damage due to overheating. To ensure high reliability of the active quench protection system for DX there are two strip heater circuits and two power supplies for every DX magnet.