DRAFT
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RETURN BUS QUENCH PROTECTION

Tevatron Inductances: Table I is a summary of dipole inductance measurements. The cold measurements were made in the Awning on four magnets in series. The 53 Hz measurements were made at 1.5A with a lock-in amplifier. The total tevatron inductance should be:

$L_{bus} = 15 \pm 5mH$

$M = 160 \pm 30mH$

$L_{coil} = 36 \pm 1H$

Quench Detection: The voltage across the bus in each sector (±10V during regular ramping, 72V during dumping) will be monitored by an IBM differential voltage channel. In addition, the IBM at the fold will monitor the total voltage of the entire bus (±60V during regular ramping, -1.5V during dumping). The IBM should be able to detect .2V of normal resistance in the bus.

Active Bus Dumping: When a quench is detected, all "hole in the wall" by-pass SCR's will be gated on, including the by-pass SCR located at the fold. This enables the coil current to be by-passed around the entire bus as shown in Figure 1. At the same time all other SCR's in Figure 1 are turned off. The return bus is dumped through the .1Ω resistor. The bus current falls rapidly at first with a $\tau_{buss} = \frac{L_{bus}}{R_{bus}} = .15s$ and then slowly with a $\tau_{coil} = \frac{L_{coil}}{R_{coil}} = 12s$ at $\beta = \frac{M}{\tau_{coil} R_{bus}} = 13\%$ of the coil current as shown in the numerical integration, Figure 2. The total quench load in the bus is $\int I^2 dt = 3.4MA^2s$, well below its capacity of $7MA^2s$. This corresponds to a maximum temperature rise of 100°K.

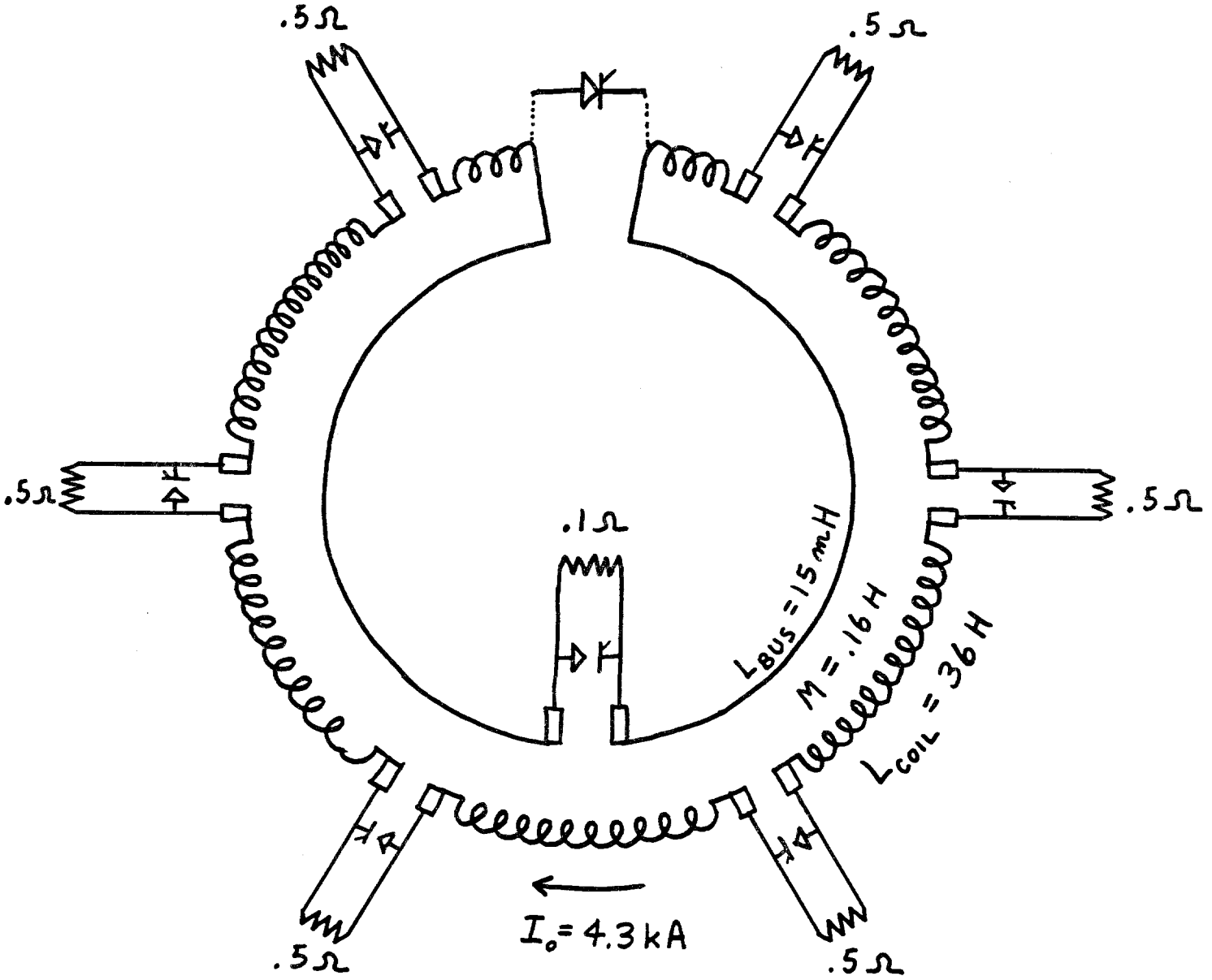
Voltage Distribution: The additional voltage stress due to the bus dump is only 200V if the dump is placed more or less opposite the fold, as shown in Figure 3. Exact placement is a matter of convenience.

Bus Dump (Energy Bush): The dump must absorb $W = R_{bus}\int I^2 dt = .34MJ$ at most. If it is made of stainless steel and a temperature rise of 350°F is tolerable, it would be 25 feet long and .087 $inch^2$ in cross section.

TABLE I

22' DOUBLER DIPOLE

Measurement Condition / Inductance	4.2°K		300°K		Summary
	Ramp	Sine Wave			
	329 A/s	53Hz	400Hz	1kHz	
L_{bus}		14μH	18μH	13μH	15±3μH
M_{BC}	190μH	216μH			200±20μH
M_{CB}	171μH	215μH			
L_{coil}	45mH	43mH			44±1mH



SCR	DURING DUMP
ON	
OFF	

LEAD PENETRATION	
D.C. POWER	
TRANSIENT SAFETY	(100 MA²s)

Figure 1

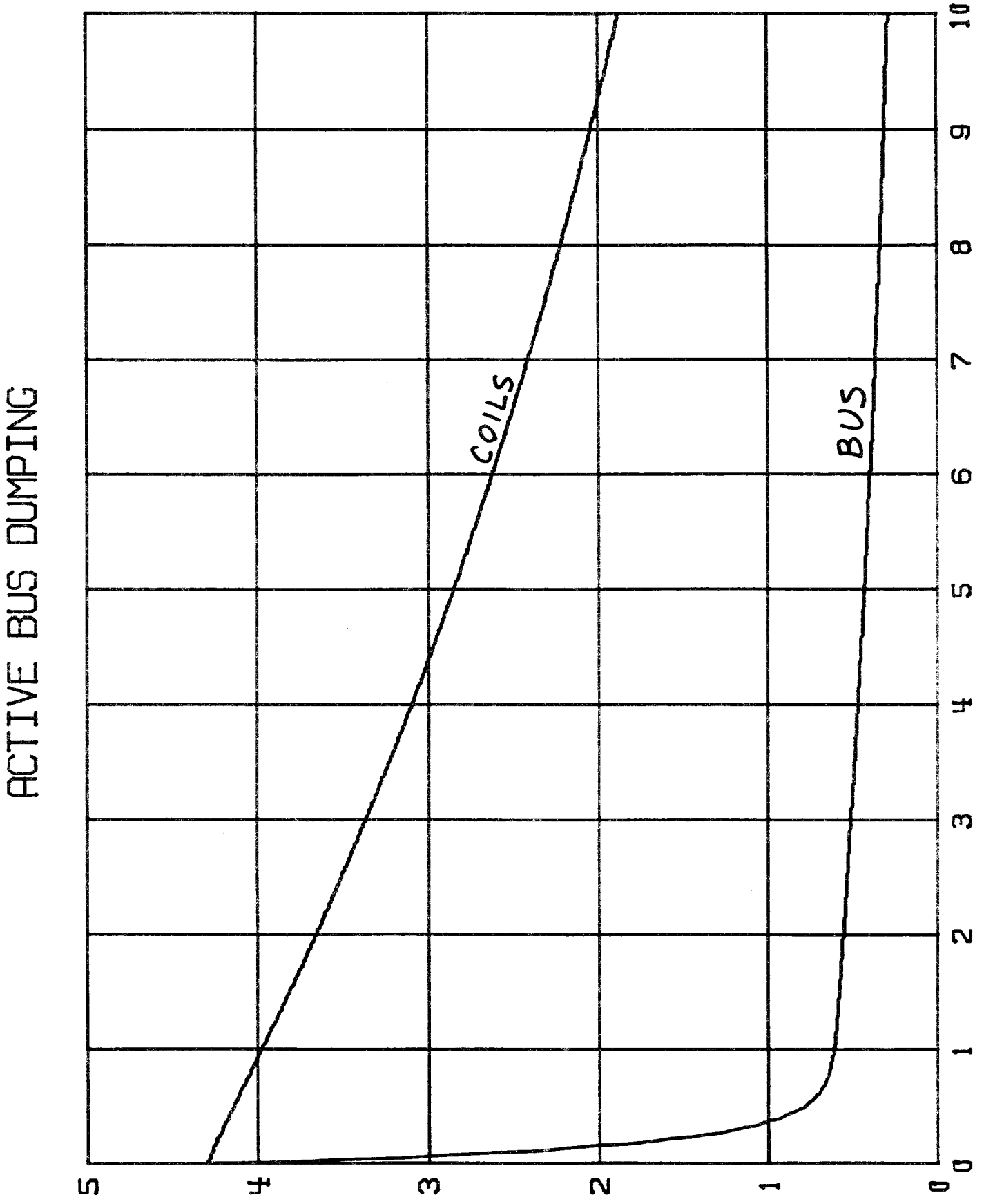

ACTIVE BUS DUMPING
CURRENT (KILOAMPS)
TIME (SECONDS)
COILS
BUS
0
1
2
3
4
5
0
1
2
3
4
5
6
7
8
9
10

Figure 2.

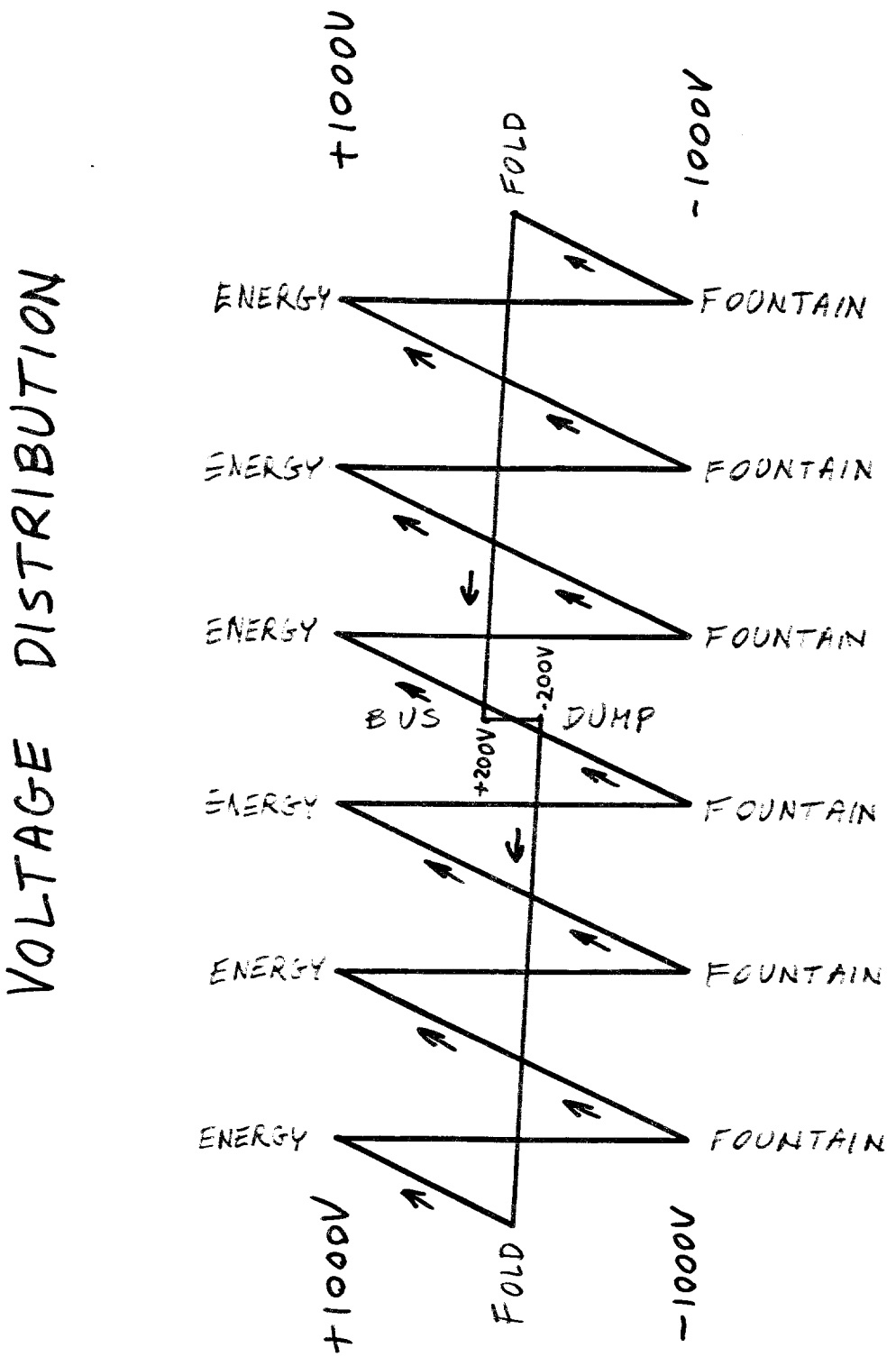

VOLTAGE DISTRIBUTION
+1000V
FOLD
-1000V
ENERGY
FOUNTAIN
ENERGY
FOUNTAIN
ENERGY
FOUNTAIN
BUS
+200V
-200V
DUMP
ENERGY
FOUNTAIN
ENERGY
FOUNTAIN
ENERGY
FOUNTAIN
+1000V
FOLD
-1000V

Figure 3