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Calculation of Booster power requirements and power line flicker for 1.5 GeV proton operation

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U.S. Department of Energy

USDOE Office of Science (SC)

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JULY 17, 1986

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The Booster power requirements and power line flicker has been previously calculated for the 1 GEV proton cycle.[1] Since then the maximum proton energy has been increased to 1.5 GEV, and the cycle period increased from 100 to 133 millisec. the design manual lists the peak magnet current as 2220A (previous value of 1672A). The maximum stored energy is increased by a factor of 1.763 and the power swing is increased by a factor of 1.32; increasing the flicker approximately by this factor.

The required magnet voltage has been calculated and is given in Figures 1 and 2 for the dipole and quadrupole strings. The total power at the AC bus bar is given in Figure 3. To calculate the reactive power, the dipole excitation is assumed to consist of 5 - 1000 volt supplies in series and sequentially switched. The quadrupole supply consits of 5 -175 volt supplies in series and sequentially switched.

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1. Booster Tech. Note #45, June 12, 1986.

The power line flicker has been calculated using the circuit analysis program ECAP and the electrical model of the lab site. For the flicker calculations the Booster is excited from a dedicated 20 MVA, 66 Kv/13.8 Kv power transformer with 7.5% leakage. The transformer is connected to the 69 Kv bus at the Fifth Avenue Substation using either:

1. The primary 69 Kv LILCO feeders 69 - 858 and 69 - 863, or
2. The alternate 69 Kv LILCO feeder 69 - 861.

The results of these calculations are given in Table 1.

Since the flicker is approaching a value of 0.5%, the effects of a reactive power compensator in reducing the flicker has been included in a second series of calculations. The reactive compensator consists of a 3 phase controllable power choke and a 3 phase capacitor bank. The inductance is controlled to give a total reactive power of zero. This equipment is manufactured by AEG Telefunken under the commercial names of Megasemi and Varoverter. The two differ in power levels. A schematic of the 69 Kv distribution system on site is given in Figure 4.

It is interesting to note that the reactive power compensating scheme is not effective in reducing the amplitude flicker in the 69 Kv line on site but is effective in reducing the flicker at the LILCO substation. The reason for this is that the r/x ratio for a transformer is much smaller than the r/x ratio for a feeder.

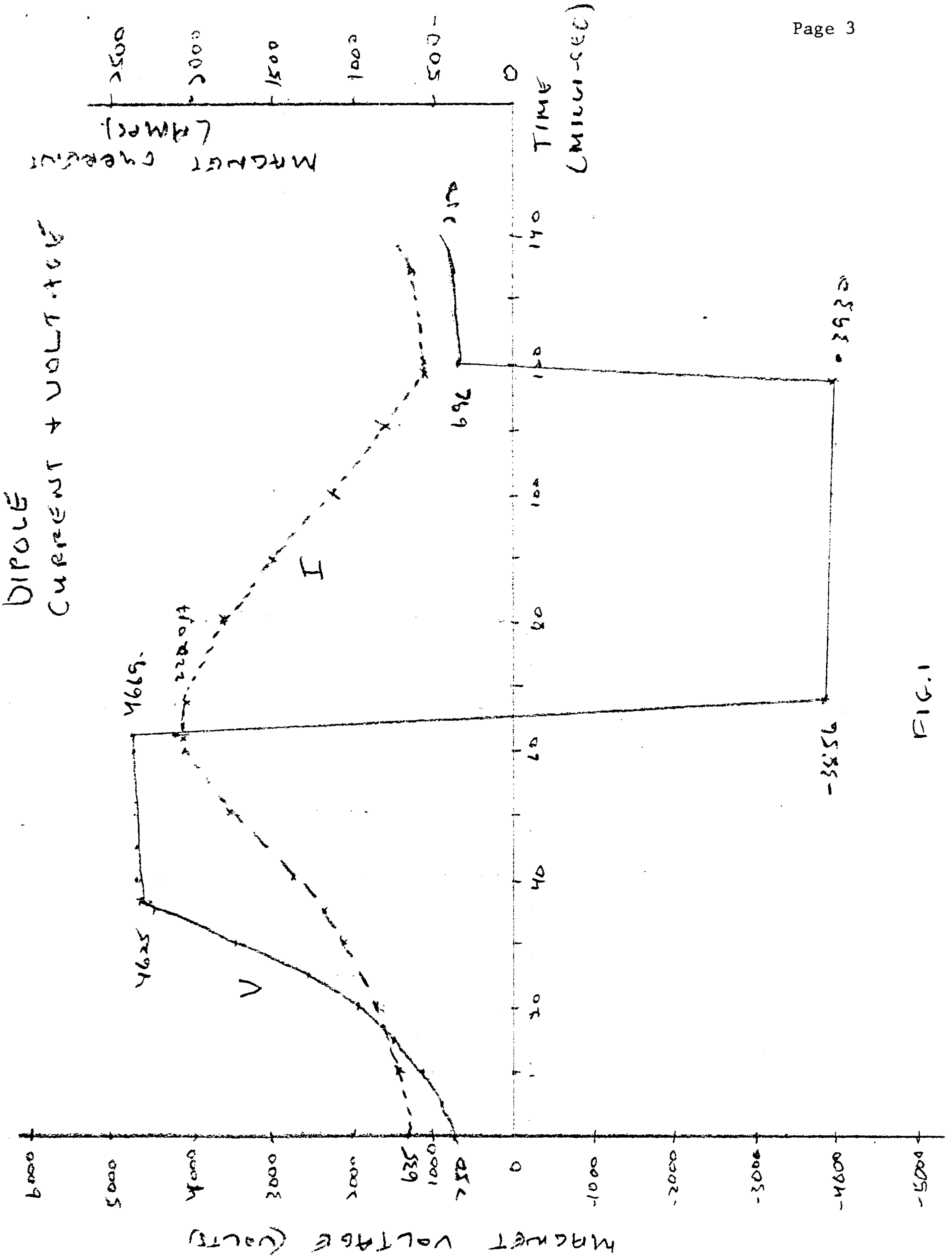

DIPOLE
CURRENT + VOLTAGE
MAGNET CURRENT (AMPS)
TIME (MILLI-SEC)
MAGNET VOLTAGE (VOLTS)
I
V
4625
4669
2280
696
3556
3932
635
350
0
20
40
60
80
100
140
500
1000
1500
2000
2500
1000
2000
3000
4000
5000
6000
-1000
-2000
-3000
-4000
-5000

FIG. 1

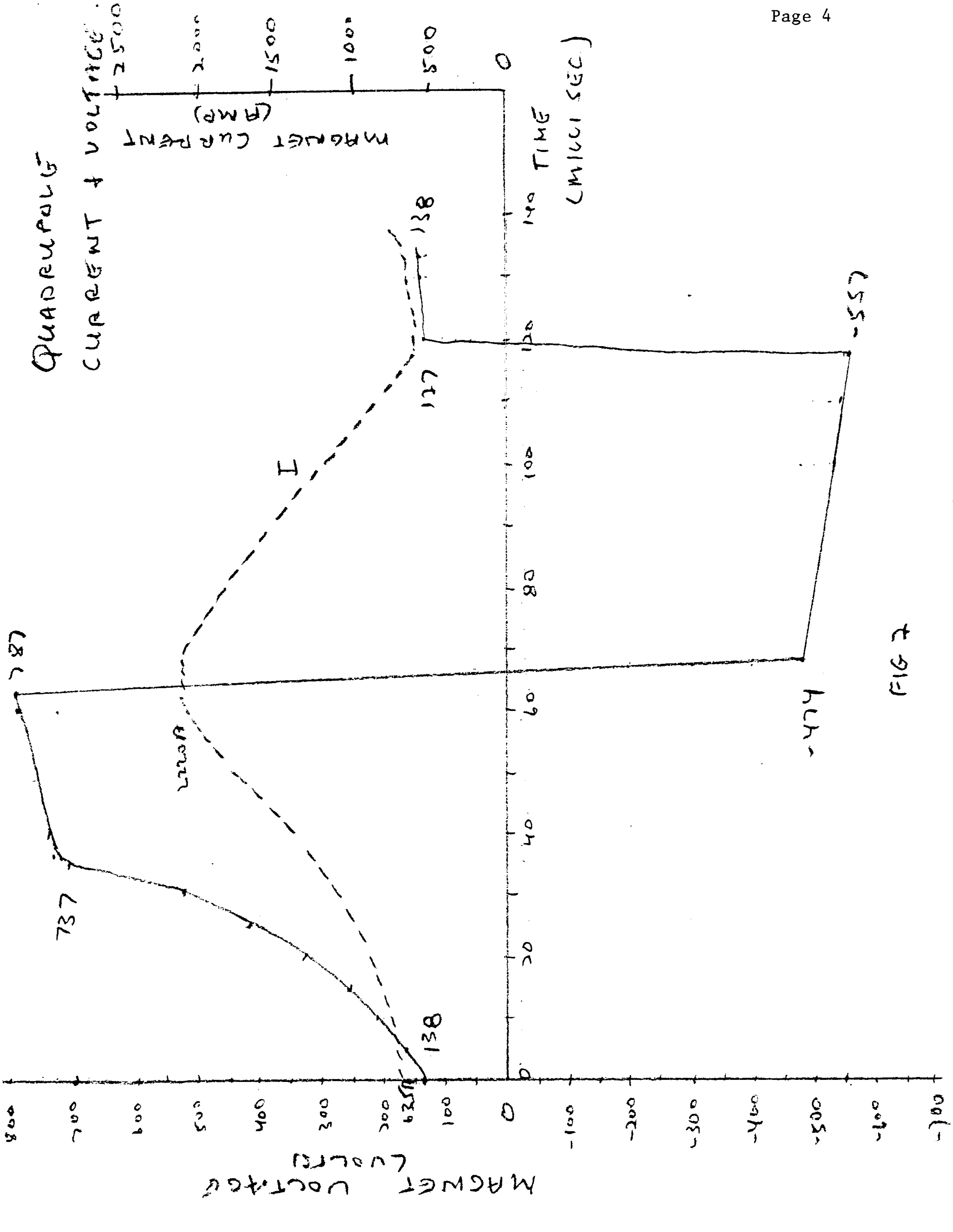
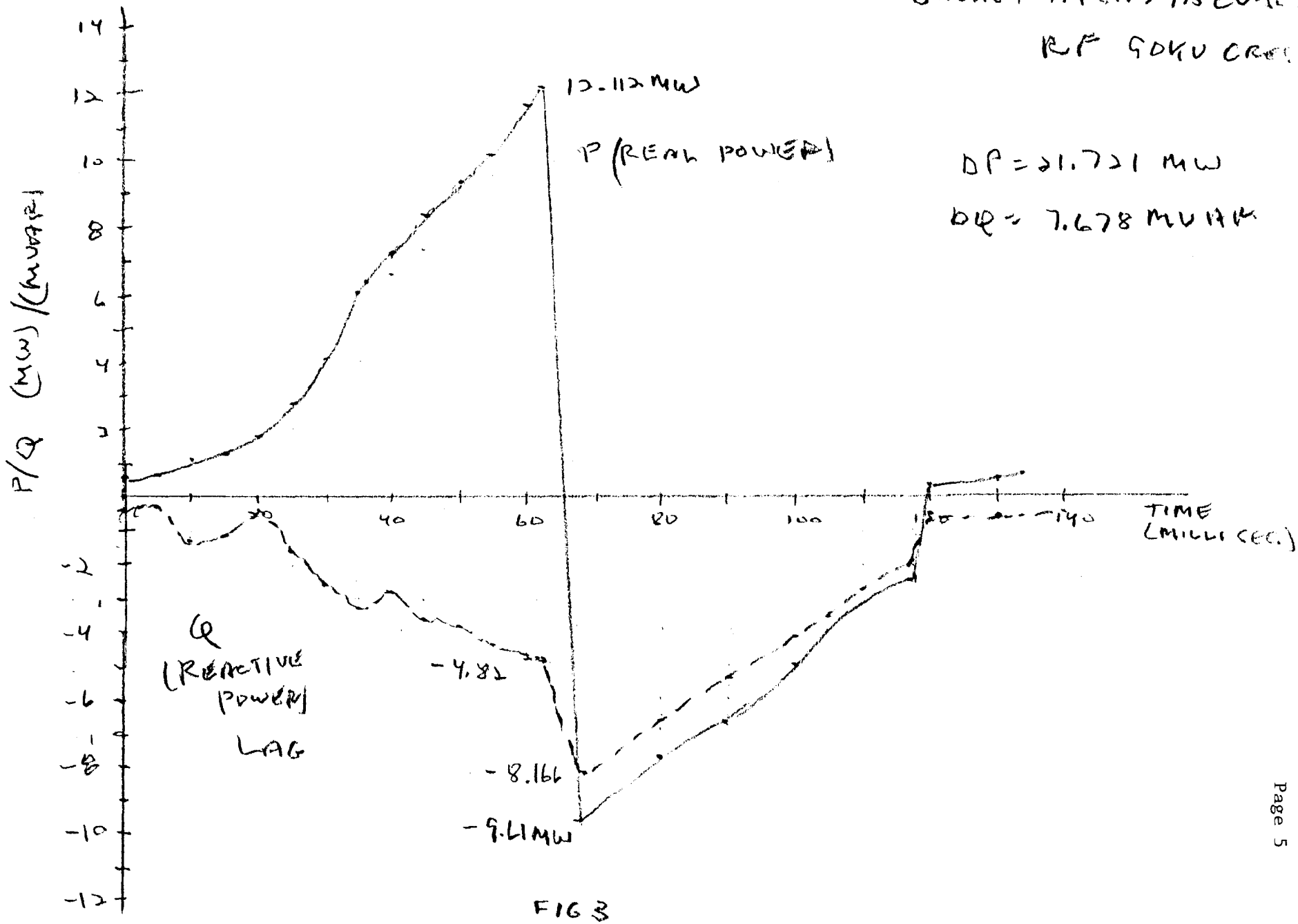

QUADRUPOLE
CURRENT + VOLTAGE
MAGNET CURRENT (AMP)
2500
2000
1500
1000
500
0
TIME (MICRO SEC)
MAGNET VOLTAGE (VOLTS)
787
737
138
127
-557
-474
I

FIG 2

11.5 GEV PROTONS
BUCKET AREA = 1.5 EV-SEC
RF 90KV CREST



ΔP = 21.721 MW

ΔQ = 7.678 MVAR

FIG 3

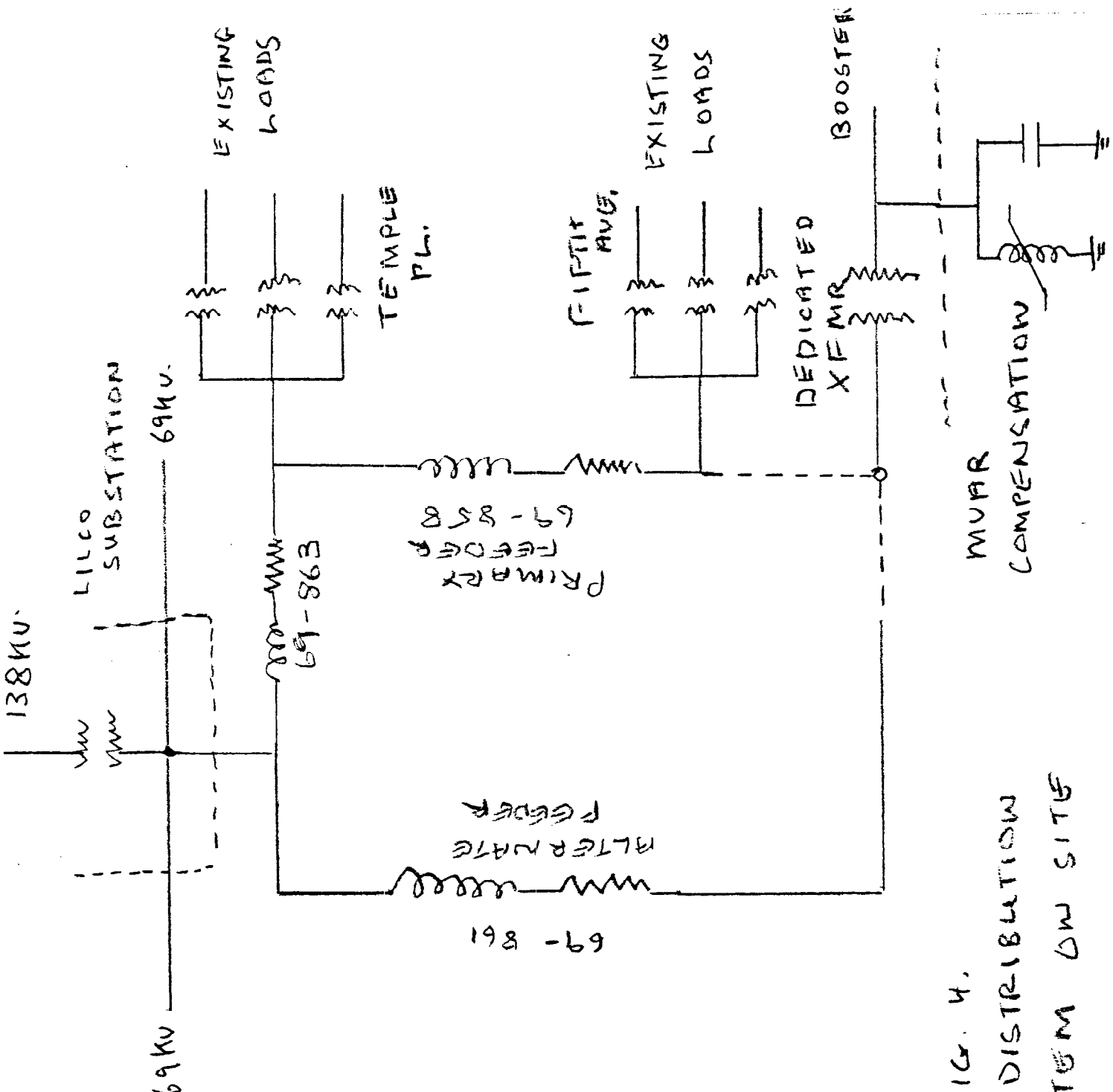


FIG. 4.
69KV DISTRIBUTION SYSTEM ON SITE

	DEDICATED TRANSFORMER CONNECTED TO PRIMARY FEEDER				DEDICATED TRANSFORMER CONNEDTED TO ALTERNATE FEEDER			
	No Compensation		Mvar Compensation		No Compensation		Mvar Compensation	
Location	Maximum Amplitude Flicker	Maximum Phase Flicker	Maximum Amplitude Flicker	Maximum Phase Flicker	Maximum Amplitude Flicker	Maximum Phase Flicker	Maximum Amplitude Flicker	Maximum Phase Flicker
LILCO Substation	.27%	.51°	.14%	.51°	.27%	.51°	.14%	.52°
69 Kv Temple Pl.	.42%	.62°	.38%	.62°	.27%	.51°	.14%	.52°
69 Kv Fifth Ave.	.45%	.67°	.40%	.66°	.27%	.51°	.14%	.52°
13.8 Kv Booster	2.78%	5.21°	.89%	5.27°	2.91%	5.32°	.82%	5.38°

Table 1

POWER LINE FLICKER FOR
1.5 GEV PROTON CYCLE