BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

ACCELERATOR DEPARTMENT
Informal Report

MAGNET POWER SOURCE FOR ISABELLE

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November 29, 1971

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CRISP 71-47
ISABELLE PROJECT

INTERSECTING STORAGE ACCELERATOR NOTES

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The stored energy in the bending magnets for ISABELLE depend on the final aperture and final configuration. Table I shows three possible apertures and their corresponding stored energies at full field. From the stored energy and current, the inductance can be computed from the well known

$$J = 1/2 LI^2 .$$

The maximum magnet voltage can be determined from $E = L \frac{di}{dt}$ once the acceleration time is specified.

Table I tabulates these results for the three apertures chosen.

The required magnet voltage is somewhere between 200 and 300 volts. This is an ideal voltage range for solid state rectifiers with SCR controls.

Figure 1 shows a possible schematic. Ripple filtering is accomplished by a combination of the effects of the passive filter, consisting of the R, L and C's shown, and the feedback system controlling the firing of the SCR rectifiers.

Table II tabulates versus frequency the raw ripple, the attenuation that results from the two filtering systems, the resulting ripple voltage and finally the ratio ($\Delta I/I$) for the ripple current in the bending magnet system. For the purpose of these calculations, the rectifier system was assumed to have a 5% reactance, and the inductance of the magnet system was assumed to be 10 henries. The total fractional ripple current will therefore be of the order of one part in 10^9 . This small value is due to the large inductance of the cryogenic magnet.

The total number of dewars containing bending magnets is 106, thus the maximum voltage per dewar is about 3 volts. This low voltage makes possible

a simple protection scheme to dissipate the large stored energy in the event a magnet goes normal.

If a series set of power diodes (2 or 3) are connected across each dewar, these diodes provide an alternate path for current to flow. Current will not flow in these diodes until a threshold voltage is reached. This threshold voltage can be increased by increasing in number of cells in series across each dewar. If a magnet goes normal, the voltage will easily reach the threshold and current will divert into the diode system. The diodes will also limit this voltage rise across the dewar and thus limit the maximum rate of energy delivery to the faulting dewar system. If 3 diodes are used, the maximum power rate is 11.25 kW (4.5 volts and 2500 amperes). This power will boil 4 liter/sec which is not an excessive rate of boiling. These diodes can be attached to a air-cooled heat sink and can deliver the heat generated in the diode to convecting air. This will not depend on water flow. Since the failure mode for power diode is always too short, never to open this creates a fail safe system. The heat sink is about 12 x 12 x 6 in. of extruded aluminum.

TABLE I

Aperture	50.8 mm	57.2 m	63.5 mm
Stored energy per bending magnet	91.8 kJ	116.4 kJ	143.5 kJ
Stored energy per dewar	275.5 kJ	349.2 kJ	430.5 kJ
Total stored energy, bending magnet	31.2 MJ	39.5 MJ	48.8 MJ
Magnet current	2500 A	2500 A	2500 A
Inductance per bending magnet	29.4 mH	37.3 mH	45.9 mH
Total inductance, bending magnet	9.2 H	11.63 H	14.33 H
di/dt, 120 sec rise	20.83 A/sec	20.83 A/sec	20.83 A/sec
Magnet voltage	191.6 V	242.3 V	298.6 V

TABLE II

<u>Harmonic Number</u>	<u>Frequency</u>	<u>Raw Ripple V(p to p)</u>	<u>Attenuation From Feed- Back</u>	<u>Attenuation From Filter</u>	<u>Final Ripple (Mil-V)</u>	<u>$\frac{\Delta I}{I}$ Parts in 10^9</u>
1	60 Hz	1/2 V	.03	.25	3.7	.4
2	120	3 V	.01	.065	1.95	.10
3	180	1 V	.03	.03	.9	.03
6	360	2 V	.05	.007	.7	.012
12	720	76.4 V	1.0	1.7×10^{-3}	130.0	1.15
24	1440	30.3 V	1.0	$.43 \times 10^{-3}$	13.0	.06
36	2160	12.4 V	1.0	$.2 \times 10^{-3}$	2.4	.007
48	2880	2.2 V	1.0	$.1 \times 10^{-3}$	.22	.0005

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Fig. 1