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Informal Report

MODIFIED SIX-BLOCK COIL GEOMETRY
FOR 12-CM DIPOLE

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NOTICE

MASTER

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Abstract

A simplified coil configuration is proposed for a dipole of 12-cm aperture, in which the coil geometry consists of six blocks of uniform current density separated by wedges of varying thickness.

Earlier ISA dipole designs, i.e., the 90-cm long "6-block" model dipoles currently undergoing tests (CRISP 72-25), incorporated ribbon spacers to spread the conductors over their respective block areas. This arrangement minimized the amount of azimuthal displacements necessary to obtain optimum block positions in order to cancel the leading Fourier coefficients in the two-dimensional "ideal" field distribution. In a subsequent preliminary design for a scaled up 3-m long prototype dipole of somewhat larger aperture (AADD 73-16), these spacers were largely effectively eliminated, and the conductors in the blocks away from the median plane were grouped close to the center line of each block, though a few spacers were retained to assure a symmetric distribution of conductors prior to the position optimization procedure. The latter requirement was still thought desirable to minimize the azimuthal displacements. Spacer ribbons were also visualized between current blocks, where room permitted. Since they are carried around the ends of the magnet, they result in a grading of the current density axially as well as azimuthally, thereby minimizing the additional axial displacements of conductor blocks required to produce end fields of acceptable harmonic content.

In practice, the azimuthal displacements are not very sensitive to whether the conductors are clustered or widely spaced. Moreover, these extra spacer turns are an added complication; they must be produced, and in such a way as to match the coefficient of expansion of the conductor, and they complicate the winding procedure. Finally, since the magnet ends will have to be molded or otherwise modified in any event to meet end field requirements, the spacers are perhaps of limited value.

Figure 1, accordingly, shows an alternative design of a dipole of 12-cm (physical) aperture. As in the earlier design, there are 87 conductors 0.027 inches thick and 3/4 inches wide, arranged in six blocks containing

21, 20, 17, 14, 10 and 5 turns, respectively. The inner radius of the iron shield is 8.35 cm. Conductor locations are listed in Table 1. They are positioned such that the midpoint of the base of each conductor lies in a circle of radius 6.0 cm.

The field quality, for the case of infinite μ iron, is essentially unchanged from that achieved in the earlier design. Summarized in terms of G. Parzen's criteria for acceptable field homogeneity, the present design has, ideally, an acceptable aperture on the median plane of 9.2 cm (77%) according to

$$\frac{1}{B_0} \frac{dB}{dR} < 0.6 \times 10^{-3} \text{ in.}^{-1}$$

or 8.2 cm (68%) according to

$$\frac{1}{B_0} \frac{d^2B}{dR^2} < 1 \times 10^{-3} \text{ in.}^{-2}$$

Perpendicular to the median plane, these regions are 8.6 cm (72%) and 7.8 cm (65%) respectively. At 70% of the aperture $\Delta B/B_0$ is 2.4×10^{-5} on the median plane. This ratio reaches 1×10^{-4} at 78% of the aperture.

The "load line" is 13.433 G/A for infinite μ iron; i.e., 3000 A are required to produce 40 kG. Saturation will raise this current value to approximately 3300 A.

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Fig.

TABLE I

CONDUCTOR THICKNESS = 0.068878 cm
CONDUCTOR WIDTH = 1.905 cm

X (cm)	Y (cm)	φ °
5.004081	0.000493	6.923077
5.003280	0.009780	
5.001652	0.128969	
5.999259	0.208063	
5.996073	0.277060	
5.992096	0.345961	
5.987331	0.414766	
5.981778	0.483476	
5.975429	0.552090	
5.968314	0.620609	
5.960404	0.689032	
5.951710	0.757360	
5.942230	0.825593	
5.931964	0.893731	
5.920912	0.961773	
5.909073	1.029719	
5.896446	1.097569	
5.883026	1.165324	
5.868815	1.232982	
5.853808	1.300541	
5.838004	1.368009	
5.820740	1.470667	20.456700
5.803018	1.587566	
5.784346	1.604188	
5.765325	1.670531	
5.745356	1.736895	
5.724847	1.802382	
5.703192	1.867892	
5.680995	1.933125	
5.658057	1.998032	
5.634377	2.062762	
5.609956	2.127167	
5.584794	2.191296	
5.558890	2.255148	
5.532244	2.318725	
5.504855	2.382022	
5.476722	2.445041	
5.447842	2.507786	
5.418214	2.570250	
5.387826	2.632436	
5.356704	2.694329	

X (cm)	Y (cm)	φ °
5.251667	2.908460	34.575027
5.217480	2.968551	
5.182637	3.028186	
5.147138	3.087374	
5.110984	3.146110	
5.074177	3.204394	
5.036718	3.262229	
4.998809	3.319616	
4.959847	3.376533	
4.920423	3.433042	
4.880270	3.489081	
4.839634	3.544672	
4.798287	3.599813	
4.756265	3.654508	
4.713591	3.708745	
4.670259	3.762523	
4.626271	3.815868	
4.583311	4.132594	47.787582
4.540524	4.182099	
4.496603	4.231017	
4.451449	4.279343	
4.407762	4.327088	
4.364544	4.374245	
4.320794	4.420815	
4.276514	4.466800	
4.231701	4.512199	
4.186358	4.557013	
4.140481	4.601239	
4.094073	4.644878	
4.047129	4.687928	
3.999652	4.730388	
3.104237	5.136985	62.474180
3.044603	5.171976	
2.985002	5.206263	
2.924834	5.239849	
2.864201	5.271722	
2.803402	5.304915	
2.742128	5.336296	
2.680509	5.366778	
2.618554	5.397253	
2.556152	5.426628	
1.618418	5.778529	75.998123
1.551873	5.796346	
1.485132	5.813294	
1.418211	5.829676	
1.351093	5.845190	