national accelerator laboratory

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EXTERNAL PROTON BEAM LINE MAGNET PROFILES

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PURPOSE

To develop magnet poleface contours suitable for the external proton beam line focusing and bending magnets.

METHOD

Conformal mapping methods developed in connection with booster magnet profiles were modified to be applicable to the design of quadrupoles and bending magnets. Several improvements were incorporated. In the case of the quadrupole, an exact design procedure was developed which eliminated the need of adjoining separately determined right hand and left hand pole terminations. This same feature was incorporated into the bending magnet and, in addition, the presence of the excitation coil was simulated by providing arbitrarily located current wires. In each case, improved methods of integrating in the complex plane were developed. Comparison of the median plane gradients with those determined from infinite permeability mesh calculations (LINDA) showed agreement for sufficiently small mesh intervals.

RESULTS

The general requirements for both the bending and the

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focusing magnet were suggested by R. Billinge (private communication). Application of the programs SQUAD and ZGPOLE resulted in the magnet contours given in Tables 1 and 3. Tables 2 and 4 indicate corner points of the rectangular coils inserted in LINDA. Figures 1 and 2 show the results of magnetic gradient calculations for various cases. The results of LINDA for finite permeability (several iron cycles) are shown for the excitations contemplated for 500 GeV operation, 5 kG/in for the quadrupole and 15 kG for the bending magnet.

TABLE 1. Quadrupole Magnet Outline

x(in)	y(in)	x(in)	y(in)	x(in)	y(in)	x(in)	y(in)
.0000	6.5000	.5180	1.9920	1.1150	1.0090	2.0175	.5184
.0000	6.0000	.5196	1.9797	1.1714	.9604	2.0307	.5203
2.6875	6.0000	.5226	1.9675	1.2297	.9149	2.0443	.5231
3.4375	5.2500	.5270	1.9553	1.2891	.8728	2.0584	.5268
.7905	2.5612	.5330	1.9429	1.3492	.8340	2.0729	.5313
.7667	2.5194	.5451	1.9233	1.4097	.7984	2.0879	.5366
.7289	2.4530	.5609	1.9016	1.4702	.7658	2.1035	.5427
.6934	2.3907	.5799	1.8762	1.5304	.7361	2.1195	.5494
.6604	2.3323	.6004	1.8462	1.5904	.7091	2.1360	.5568
.6418	2.2992	.6201	1.8117	1.6264	.6941	2.1531	.5648
.6242	2.2674	.6374	1.7745	1.6626	.6799	2.1798	.5779
.6077	2.2369	.6524	1.7366	1.6993	.6662	2.2077	.5922
.5922	2.2077	.6662	1.6993	1.7366	.6524	2.2369	.6077
.5779	2.1798	.6799	1.6626	1.7745	.6374	2.2674	.6242
.5648	2.1531	.6941	1.6264	1.8117	.6201	2.2992	.6418
.5568	2.1360	.7091	1.5904	1.8462	.6004	2.3323	.6604
.5494	2.1195	.7361	1.5304	1.8762	.5799	2.3907	.6934
.5427	2.1035	.7658	1.4702	1.9016	.5609	2.4530	.7289
.5366	2.0879	.7984	1.4097	1.9233	.5451	2.5194	.7667
.5313	2.0729	.8340	1.3492	1.9429	.5330	2.5612	.7905
.5268	2.0584	.8728	1.2891	1.9553	.5270	5.2500	3.4375
.5231	2.0443	.9149	1.2297	1.9675	.5226	6.0000	2.6875
.5203	2.0307	.9604	1.1714	1.9797	.5196	6.0000	.0000
.5184	2.0175	1.0090	1.1150	1.9920	.5180	8.5000	.0000
.5177	2.0046	1.0607	1.0607	2.0046	.5177	8.5000	6.5000

TABLE 2. Quadrupole Magnet Coils

x_1(in)	y_1(in)	x_2(in)	y_2(in)	x_3(in)	y_3(in)	Excit.
.0000	3.3125	.7500	2.5625	3.4375	5.2500	.4076
.0000	3.6875	.3750	3.5000	2.5000	5.6250	.1754
.0000	4.0625	.3750	3.8750	2.1250	5.6250	.1469
.0000	4.4375	.3750	4.2500	1.7500	5.6250	.1185
.0000	4.8125	.3750	4.6250	1.3750	5.6250	.0900
.0000	5.1875	.3750	5.0000	1.0000	5.6250	.0616
2.5625	.7500	3.3125	.0000	6.0000	2.6875	-.4076
3.5000	.3750	3.6875	.0000	6.0000	2.3125	-.1754
3.8750	.3750	4.0625	.0000	6.0000	1.9375	-.1469
4.2500	.3750	4.4375	.0000	6.0000	1.5625	-.1185
4.6250	.3750	4.8125	.0000	6.0000	1.1875	-.0900
5.0000	.3750	5.1875	.0000	6.0000	.8125	-.0616

TABLE 3. Bending Magnet Outline

x(in)	y(in)	x(in)	y(in)	x(in)	y(in)	x(in)	y(in)
-8.0000	.0000	-2.1646	.8206	.0000	.7500	2.1646	.8206
-5.4375	.0000	-2.1267	.7943	1.0303	.7505	2.2016	.8522
-5.4375	3.6875	-2.0880	.7727	1.2100	.7500	2.2379	.8894
-2.5625	3.6875	-2.0484	.7555	1.2701	.7493	2.2735	.9328
-2.5563	2.3969	-2.0077	.7423	1.3303	.7482	2.3083	.9826
-2.5619	2.2343	-1.9657	.7327	1.3904	.7465	2.3423	1.0395
-2.5619	2.0800	-1.9222	.7265	1.4501	.7442	2.3752	1.1039
-2.5566	1.9345	-1.8772	.7230	1.5092	.7410	2.4067	1.1763
-2.5463	1.7982	-1.8304	.7220	1.5671	.7373	2.4367	1.2571
-2.5315	1.6712	-1.7817	.7231	1.6236	.7332	2.4646	1.3467
-2.5125	1.5536	-1.7310	.7256	1.6783	.7291	2.4901	1.4455
-2.4901	1.4455	-1.6783	.7291	1.7310	.7256	2.5125	1.5536
-2.4646	1.3467	-1.6236	.7332	1.7817	.7231	2.5315	1.6712
-2.4367	1.2571	-1.5671	.7373	1.8304	.7220	2.5463	1.7982
-2.4067	1.1763	-1.5092	.7410	1.8772	.7230	2.5566	1.9345
-2.3752	1.1039	-1.4501	.7442	1.9222	.7265	2.5619	2.0800
-2.3423	1.0395	-1.3904	.7465	1.9657	.7327	2.5619	2.2343
-2.3083	.9826	-1.3303	.7482	2.0077	.7423	2.5563	2.3969
-2.2735	.9328	-1.2701	.7493	2.0484	.7555	2.5625	3.6875
-2.2379	.8894	-1.2100	.7500	2.0880	.7727	5.4375	3.6875
-2.2016	.8522	-1.0303	.7505	2.1267	.7943	5.4375	.0000
						8.0000	.0000
						8.0000	6.2500
						.0000	6.2500

TABLE 4. Bending Magnet Coils

x_1(in)	x_2(in)	y_1(in)	y_2(in)	Excit.
-5.3125	-2.6875	.8750	3.6250	1.
2.6875	5.3125	.8750	3.6250	-1.

Subject

EXTERNAL PROTON BEAM LINE QUADRUPOLE MAGNET
PROFILE - SQUAD - 7/16/70 - DWG. 0624-MC-19425
EXCITATION - 7.5 kG (Pole) or 5 kG/in AMP FAC = 1.0917

□ - CONFORMAL TRANSFORMATION (SQUAT

• - .0625" - ZERO CYCLE

o - .0625" - 6 - CYCLE

x - .03125" - ZERO CYCLE

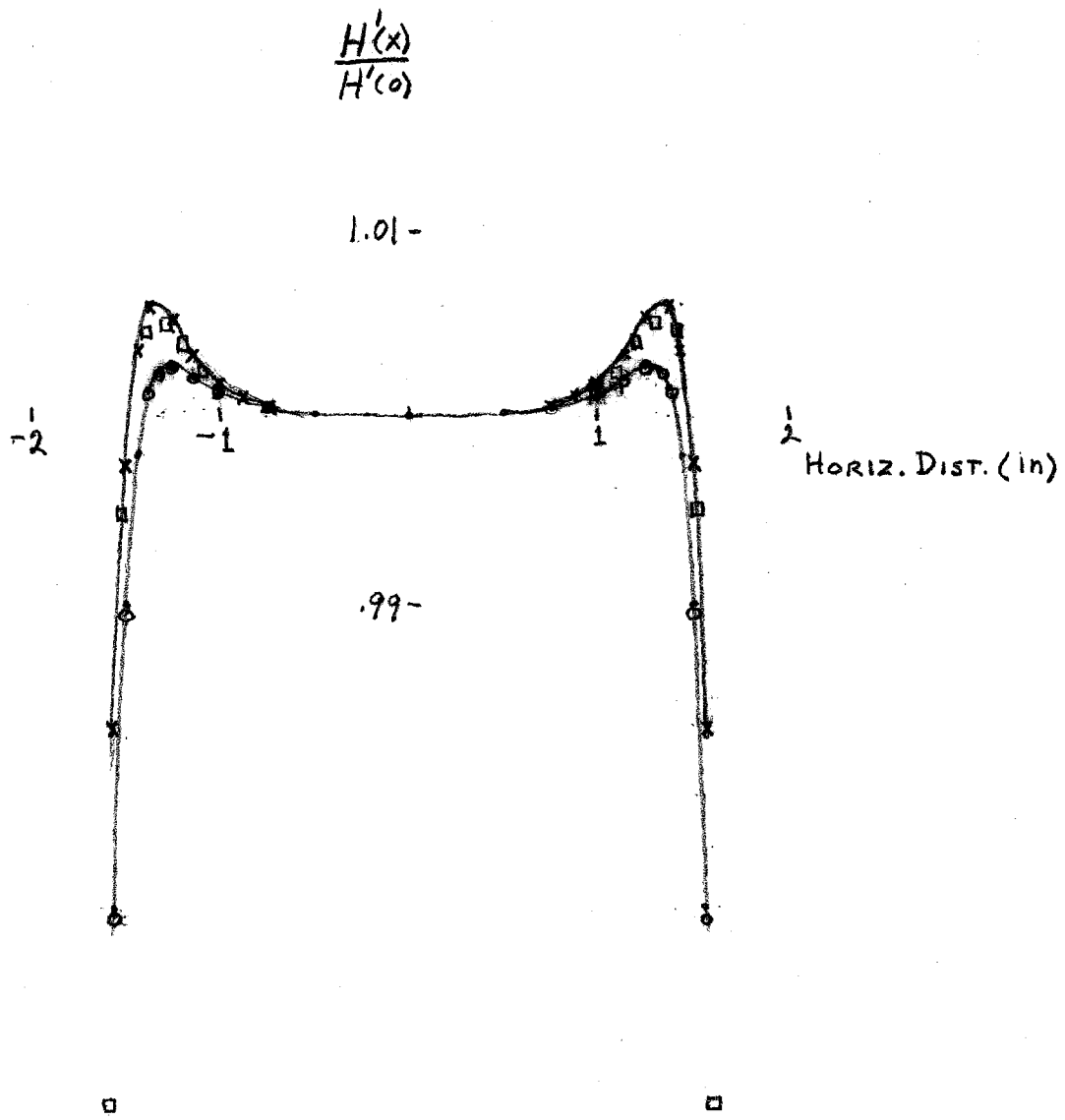

FIG. 1.

EXTERNAL PROTON BEAM LINE BENDING MAGNET
PROFILE – ZGPOLE(6600) – 8/24/70 – DWG. 0621-MD-19418 (A)
EXCITATION – 15kG AMPFAC = 1.18

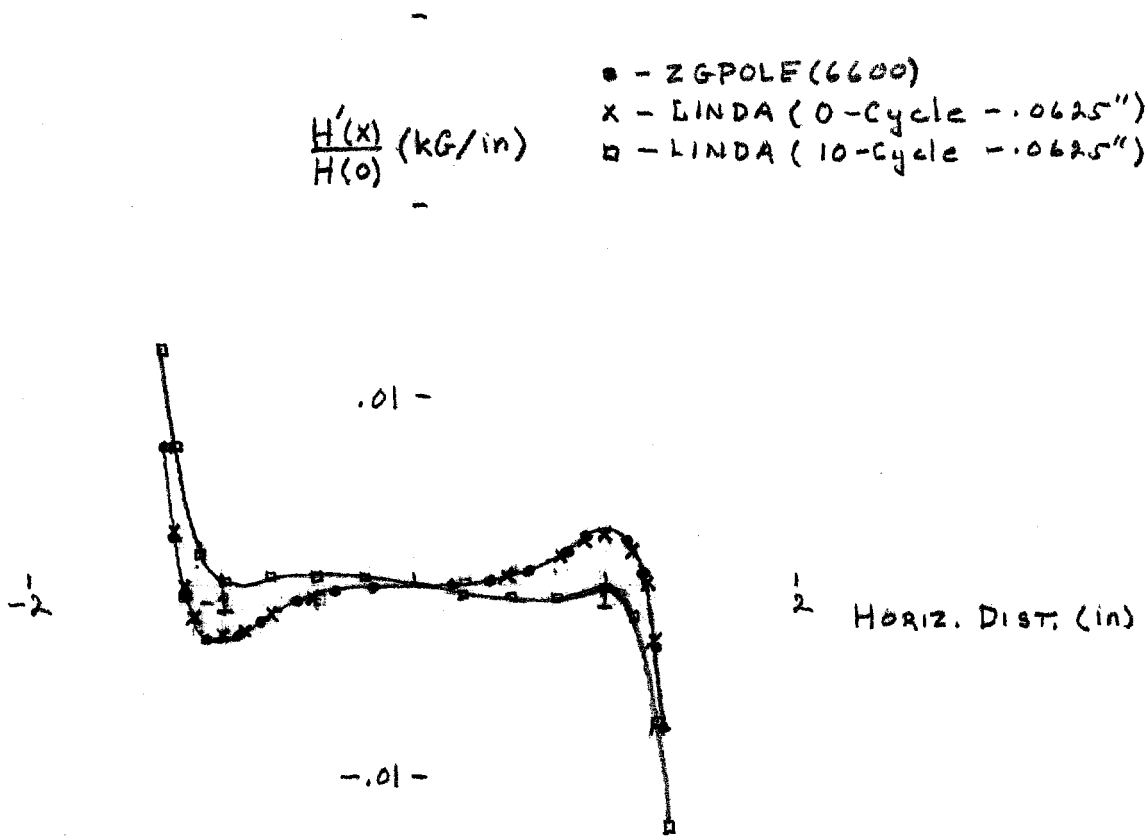

FIG. 2.