

MI-0005

A MAGNETIC DESIGN FOR A DIPOLE WITH
COPPER ON THE MEDIAN PLANE

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MAIN INJECTOR DIPOLE

(median plane coil w/bedstead ends-downsized version)

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References

- 2D Field Code - POISSON/CERN version w/Les Oleksiuk mods
 - Median Plane Field and Harmonic Analysis

| | | |
|---------|--------------------|--------------------|
| I= 90A | $\mu=100000$ | MIDIPA-080189-1545 |
| I= 470A | Armco B3 Steel B-H | MIDIPA-080289-1300 |
| I= 850A | Armco B3 Steel B-H | MIDIPA-080389-1545 |
| I=1230A | Armco B3 Steel B-H | MIDIPA-080489-1630 |
| I=1645A | Armco B3 Steel B-H | MIDIPA-080489-1630 |
 - Field Map in Magnet Cross-Section

| | | |
|---------|--------------------|--------------------|
| I=1645A | Armco B3 Steel B-H | MIDIPA-072889-1630 |
|---------|--------------------|--------------------|
- 3D Field Code - GFUN3D/RAL code w/SCS mods(GFS)
 - I=1915A Armco B3 Steel B-H MIENDA-101389-0830
- 3D Pictorial Representation of Magnet End
 - DANCAD3D/ver. 1.30 registered with Daniel H. Hudgins

Performance Parameters

| | |
|--|------------------------|
| Central Field | 17.30 kG |
| Central Integrated Field | 4152.00 kG-in. |
| Central Radius of Curvature | 954.80 ft |
| Magnet Length (effective - see 3D Field Calculation) | 240.00 in. |
| Sagitta | 0.629 in. |
| Length of End Block (each end) | |
| - iron length | 5.625 in. |
| - magnetic length | 6.110 in. |
| Arc Length of Magnet Body | 227.78 in. |
| Gap Height | ±1.000 in. |
| Good Integrated Field Width -injection | ±1.750 in. |
| -transition | ±1.750 in. |
| -150 GeV | ±0.875 in. |
| Integrated Field Quality within Good Field Region | ±0.015 % |
| Number of Conductor Turns | 23/pole |
| Conductor Current | 1645 A |
| Conductor Cross Section | 1.000 in. by 4.000 in. |
| Conductor Hole Diameter | 0.500 in. |
| Conductor Corner Radius | 0.094 in. |
| Coil Resistance (series connected) | 0.03188 Ω |
| Magnet Inductance | 0.06466 H |
| Voltage Drop (linear ramp w/0.50 sec. rise time) | 212.74 V |
| Voltage Drop (d.c.) | 52.45 V |
| Power Consumed (d.c.) | 86.28 kW |
| Power Consumed (0.50 duty factor) | 43.14 kW |
| Cooling Water Pressure Drop | 85 psi |
| Number of Water Paths in Parallel | 4 |
| Water Flow | 10.3 GPM |
| Temperature Rise (0.50 duty factor) | 15.9 °C |
| Magnet Weight: | |
| - body laminations | 26194 lbs |
| - end blocks (both ends) | 1260 lbs |
| Coil Weight (upper pole + lower pole) | 4538 lbs |
| Magnet Size(body) | 29½ in. by 17¼ in. |
| (ends) | 29½ in. by 17¼ in. |

Profiles

| Iron | | Iron | | Coil Package | |
|-------|-------|--------|-------|--------------|-------|
| x(in) | y(in) | x(in) | y(in) | x(in) | y(in) |
| 0.000 | 1.000 | 4.875 | 2.000 | 2.250 | 0.062 |
| 2.000 | 1.000 | 4.875 | 3.875 | 4.987 | 0.062 |
| 2.125 | 0.995 | 9.750 | 3.875 | 4.987 | 0.937 |
| 3.250 | 0.995 | 9.750 | 0.000 | 2.250 | 0.937 |
| 3.375 | 1.063 | 14.750 | 0.000 | 5.043 | 0.062 |
| 3.500 | 1.250 | 14.750 | 6.500 | 9.642 | 0.062 |
| 3.750 | 1.875 | 12.625 | 8.625 | 9.642 | 3.786 |
| 4.750 | 1.875 | 0.000 | 8.625 | 5.043 | 3.786 |

2D Field Calculation (x-y calculation)

Median Plane Field ($\Delta B/B_0$ - unit=.0001) - see p. 7 for plot.

| x(in)\B ₀ (kG) | 1.024 | 5.313 | 9.604 | 13.819 | 17.326 |
|---------------------------|-------|-------|-------|--------|--------|
| 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.125 | 0.00 | 0.01 | 0.01 | -0.01 | -0.05 |
| 0.250 | 0.01 | 0.02 | 0.02 | -0.01 | -0.14 |
| 0.375 | 0.03 | 0.05 | 0.04 | -0.02 | -0.30 |
| 0.500 | 0.06 | 0.09 | 0.08 | -0.03 | -0.52 |
| 0.625 | 0.11 | 0.15 | 0.13 | -0.04 | -0.81 |
| 0.750 | 0.18 | 0.23 | 0.20 | -0.04 | -1.17 |
| 0.875 | 0.26 | 0.34 | 0.30 | -0.04 | -1.60 |
| 1.000 | 0.40 | 0.49 | 0.43 | -0.01 | -2.13 |
| 1.125 | 0.56 | 0.68 | 0.60 | 0.02 | -2.76 |
| 1.250 | 0.75 | 0.89 | 0.79 | 0.05 | -3.53 |
| 1.375 | 0.85 | 1.10 | 0.98 | 0.04 | -4.50 |
| 1.500 | 1.00 | 1.19 | 1.04 | 0.13 | -5.85 |
| 1.625 | 0.71 | 0.94 | 0.75 | -0.69 | -7.84 |
| 1.750 | -0.40 | -0.15 | -0.37 | -2.16 | -11.02 |
| 1.875 | -3.24 | -2.97 | -3.23 | -5.43 | -16.40 |
| 2.000 | -9.46 | -9.18 | -9.48 | -12.19 | -25.72 |

Field Map in Magnet Cross Section at B₀=17.3kG - see p.8

2D Field Calculation (x-y calculation)

Field Harmonics at 1.00 in. radius. Armco B3 Steel except as noted

| N | I= 90 A $\mu=10^5$ Ampfac=1.0 | | I= 470A Ampfac=1.0064 | |
|---|-------------------------------|------------|-----------------------|------------|
| | BN(kG) | RN | BN(kG) | RN |
| 1 | 1.023933 | 1.0000000 | 5.313290 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 3 | 0.000022 | 0.0000215 | 0.000166 | 0.0000313 |
| 4 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 5 | 0.000016 | 0.0000161 | 0.000082 | 0.0000155 |
| 6 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 7 | 0.000004 | 0.0000035 | 0.000019 | 0.0000035 |

| N | I= 850A Ampfac=1.0069 | | I=1230A Ampfac=1.0127 | |
|---|-----------------------|------------|-----------------------|------------|
| | BN(kG) | RN | BN(kG) | RN |
| 1 | 9.604501 | 1.0000000 | 13.818493 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 3 | 0.000246 | 0.0000256 | -0.000185 | -0.0000134 |
| 4 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 5 | 0.000145 | 0.0000151 | 0.000153 | 0.0000111 |
| 6 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 7 | 0.000034 | 0.0000035 | 0.000040 | 0.0000029 |

| N | I=1645A Ampfac=1.0802 | |
|---|-----------------------|------------|
| | BN(kG) | RN |
| 1 | 17.326024 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 |
| 3 | -0.003406 | -0.0001966 |
| 4 | -0.000000 | -0.0000000 |
| 5 | -0.000218 | -0.0000126 |
| 6 | -0.000000 | -0.0000000 |
| 7 | -0.000000 | -0.0000000 |

3D Field End Simulation (x-y-z calculation w/Armco B3 steel B-H)

Central Field (B0 in midsection) 15.316484 kG

Integrated Field Harmonics at 1.00 in. radius

| N | GN (kG-in.) | RN |
|---|-------------|----------|
| 1 | 93.563980 | 1.000000 |
| 3 | 0.027368 | 0.000293 |
| 5 | 0.000440 | 0.000005 |
| 7 | 0.001312 | 0.000014 |

Effective Length of End Block

$$93.56398/15.31648=6.11 \text{ in.}$$

Thus the body section (29½" by 17¼") terminates 6.11 in. in from the effective entrance plane and 6.11 in. in from the effective exit plane; the distance between the planes being 20 ft.

Iron Length of End Block: $4.000 + 1.625 = 5.625 \text{ in.}$

Hence the effective field termination planes are outside the iron termination planes by: $6.110 - 5.625 = 0.485 \text{ in.}$ at each end.

Arc Length of Magnet Body:

The desired effective magnetic length is 20 ft or 240.00 in.
Subtracting 6.11 in. from each end gives:

$$240.00 - 2*6.11 = 227.78$$

Isometric View of Elements in End Block - see p. 9

Numerical Tables of Line Elements of End Block - see p. 10

Underlined points 1,2,3,.....,10 represent end shim bump.

12.03

*FERMPO

10.30

8.57

6.83

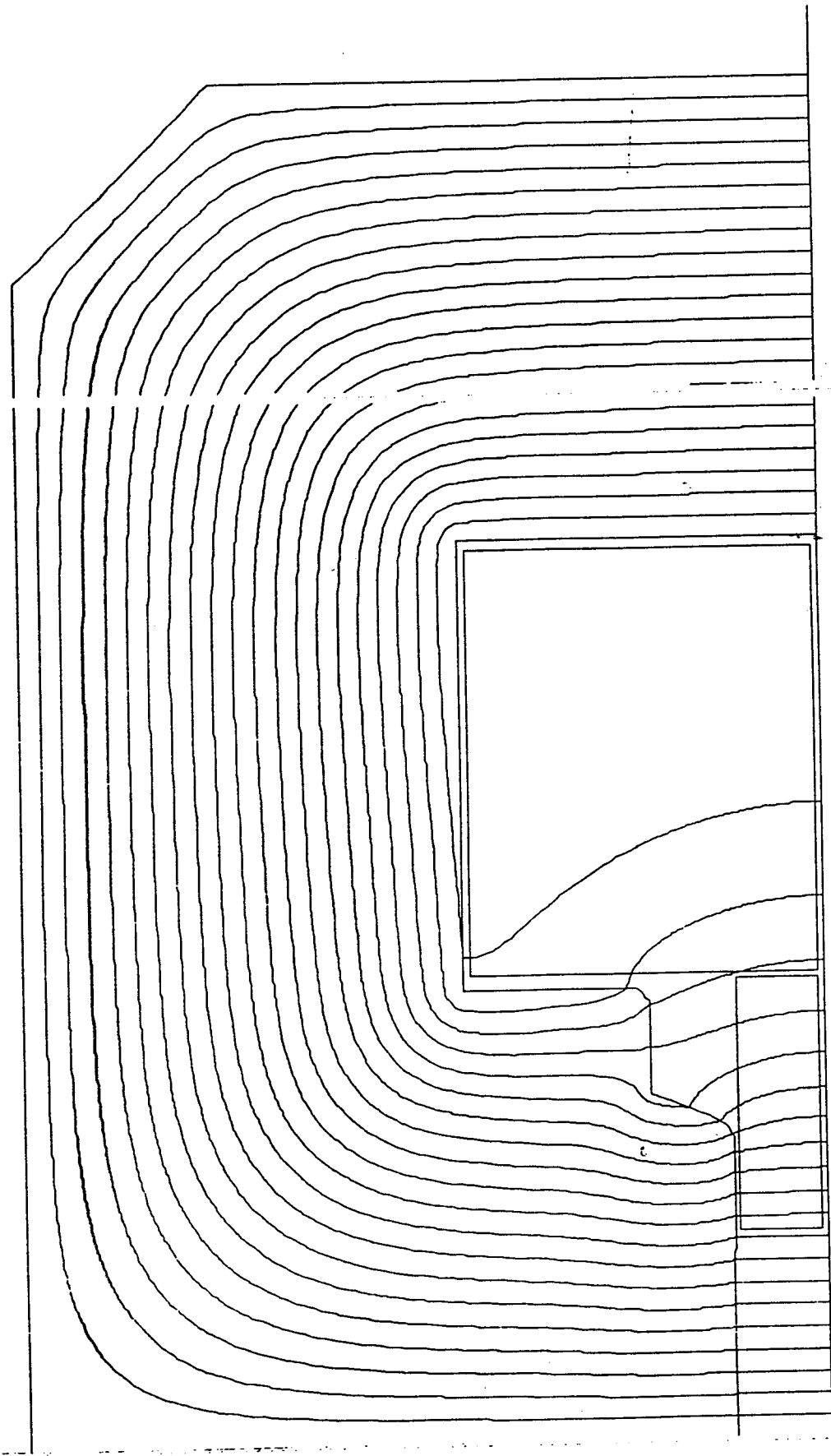
5.10

6.

3.37

1.63

1.10



17

- 10

1.63

3.37

5.10

6.83

8.57

10.30

12.03

13.77

15.50

2D-FIELD QUALITY ($\Delta B/B_0 = \pm .00015$)

ARMCO B3 STEEL B-H

| RUN | I (A) | B ₀ (kG) | GFLD (in.) | AMPFA |
|-----|----------|------------------------|---------------|--------|
| 23 | 90 | 1.024 | ±1.75 | 1.0000 |
| 24 | 470 | 5.313 | ±1.75 | 1.0064 |
| 25 | 850 | 9.604 | ±1.75 | 1.0069 |
| 26 | 1230 | 13.819 | ±1.75 | 1.0127 |
| 27 | 1645 | 17.326 | ±0.875 | 1.0802 |

