Problem 5

The Bath Cube
(Revised)

1. General Description and Geometry

The "Bath cube" is an experiment set up at the University of Bath, U.K., with the aim of testing results given by eddy-current codes against measurements. It consists essentially in a large cavity between the poles of a large electromagnet (see Fig. 1). The lower pole is hollow; and will be referred to as "the box". The upper pole (henceforth called "the pole") almost completely closes the cavity in the box from above. In the parallelipipedic space so delimited, four blocks of aluminum, 70 x 70 x 60 mm each, are symmetrically disposed. Their conductivity is 2.703×10^7 S/m. The problem consists of case 3 of Ref. [1]. A constant sinusoidal MMF of 1000 A-turns is applied between pole and box, at 50 Hz. In the 4 mm wide air gap between the bottom of the box and the bottom side of one of the cubes, there is room for a Hall probe which can be moved, parallel to the y direction (see Fig. 1) along the lines z = 2 mm, x = 70 or z = 20 mm, x = 120 mm. The probe records the vertical magnitude B_Z or the horizontal magnitude B_X of the magnetic induction (a real positive number) and its phase with respect to the driving MMF. For more information, see Ref. [2] and [3].

2. Boundary Conditions

Consider only the quadrant $x \geq 0$, $y \geq 0$.

As pole and box are made of laminated iron, it is assumed that their permeability is infinite. Therefore, the field is normal to the boundaries of the pole and of the box. If your code will not accept these conditions, use $\mu_r = 1000$.

The field is tangential to the boundary in the symmetry planes x = 0 and y = 0, and also that part of the horizontal plane z = 96 mm (cf. Fig. 1) which is between the pole and the walls of the box. (In Ref. [1], this "zero-flux boundary" was placed at the level of the pole, z = 60 mm, but all present investigators put it slightly higher.)

3. Quantities to be Calculated and Presented

Find the field component B_z (magnitude and phase) along the line z = 2 mm, x = 70 mm. Find also the field component B_x (magnitude and phase) along the line z = 20 mm, x = 120 mm. Record the values at 10 mm intervals from y = 0 to y = 130 mm in Table 5.1. Also graph the results as follows.

4. Range and Scale of Graphs

For all graphs, the x axis is:

X axis range 0 to 150 mm, scale 1 mm = 1 mm, caption (y, mm)

Graph 5.1

y axis range 0 to 0.02 T, scale 0.001 T = 10 mm, caption (magnitude B_z, tesla)

Graph 5.2

y axis range -150 to 0 degrees, scale 1 degree = 1 mm, caption (phase B_z, degrees)

Graph 5.3

y axis range 0 to 0.01 T scale 0.OO1T = 20 mm, caption (magnitude Bx, tesla)

Graph 5.4

y axis range -50 to 0 degrees, scale 1 degree = 3 mm, caption (phase Bx, degrees)

5. References

[1] J.A.M. Davidson and M.J. Balchin, "Experimental Verification of Network Method for Calculating Flux and Eddy-Current Distributions in Three Dimensions," IEEE Proc., Pt. A, 128, 7 (1981), pp 492-496.

[2] A. Bossavit, "Results for Benchmark Problem 5, The Bath-Cube Experiment," COMPEL Vol. 7, No. 1 (March 1988).

[3] C.R.I. Emson and J. Simkin, "An Optimal Method for 3D Eddy Currents," IEEE Trans. MAG-19, 6 (1983), pp. 2450-2453.

[4] W. Renhart, H. Stogner, and K. Preis, "Calculations of 3D Eddy Current Problems by Finite Element Method Using Either an Electric or a Magnetic Vector Potential," IEEE Trans. MAG-24, (1988), pp. 122-125.

6. Captions

Figure 1. a) Frontview and view from above of the setup (from Ref. [4]);

b) Perspective view of the part of the system in the quadrant $x \geq 0$, $y \geq 0$.
All dimensions in mm.

Table 5.1

Results for Problem 5 - The Bath Cube

y (mm)	z = 2 mm, x = 70 mm		z = 20 mm, x = 120 mm	
	B_Z		B_X	
	Magnitude	Phase(degree)	Magnitude (T)	Phase(degree)
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
100				
110				
120				
130				

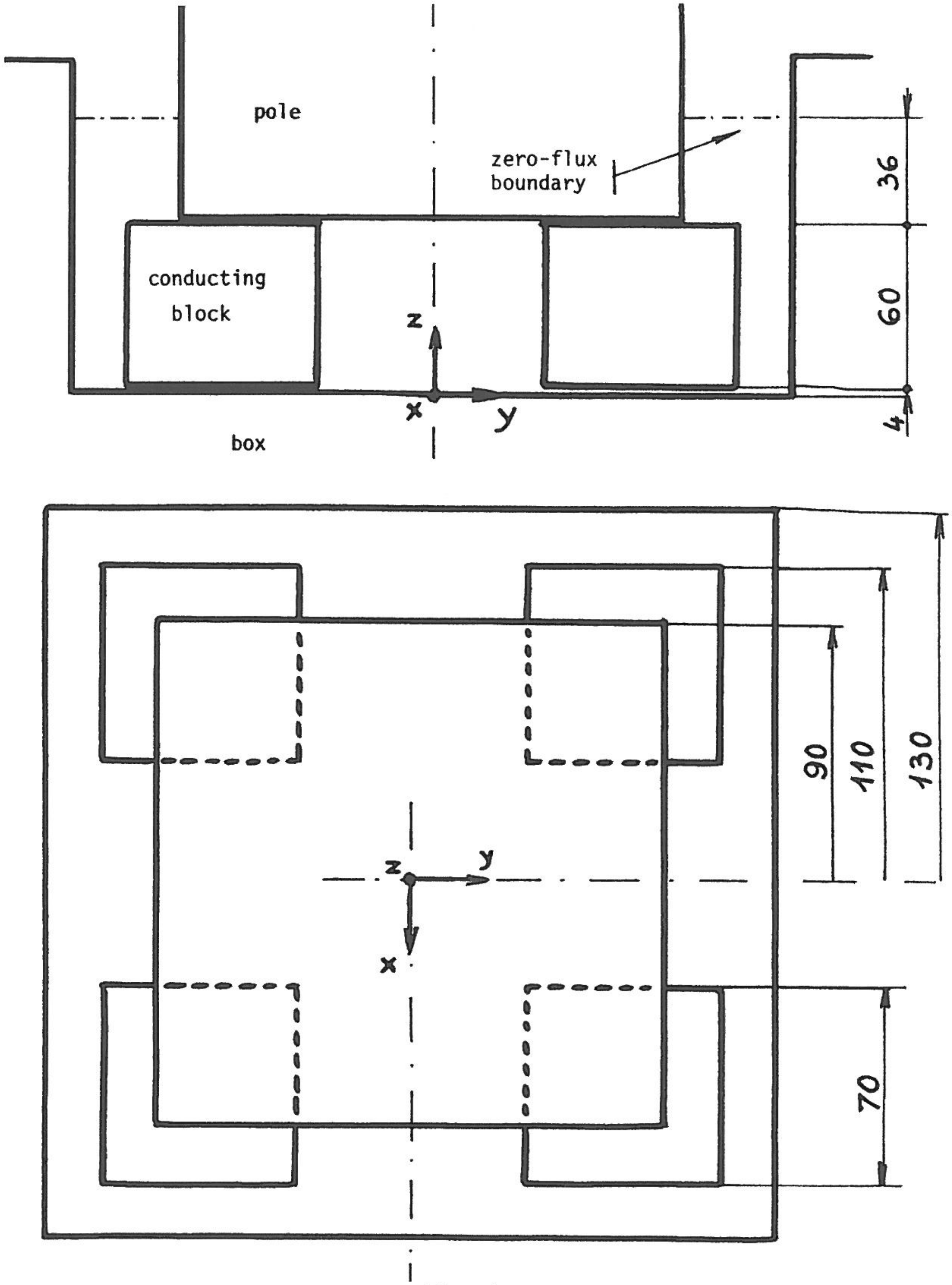
pole
zero-flux
boundary
conducting
block
z
x
y
box
36
60
4
z
y
x
90
110
130
70

Fig. 1a.

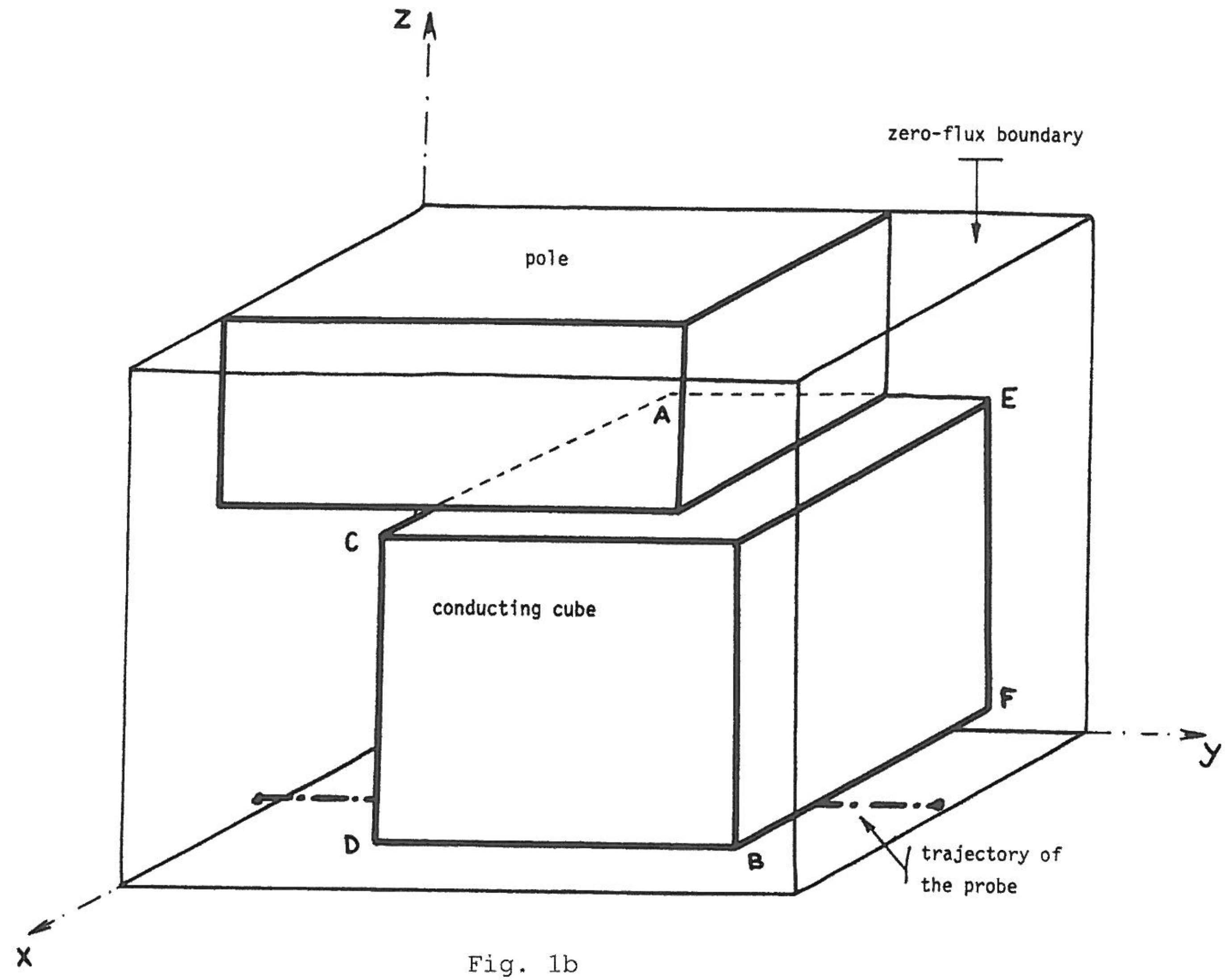
z
zero-flux boundary
pole
A
E
C
conducting cube
F
y
D
B
trajectory of
the probe
x

Fig. 1b