CHAPTER IV

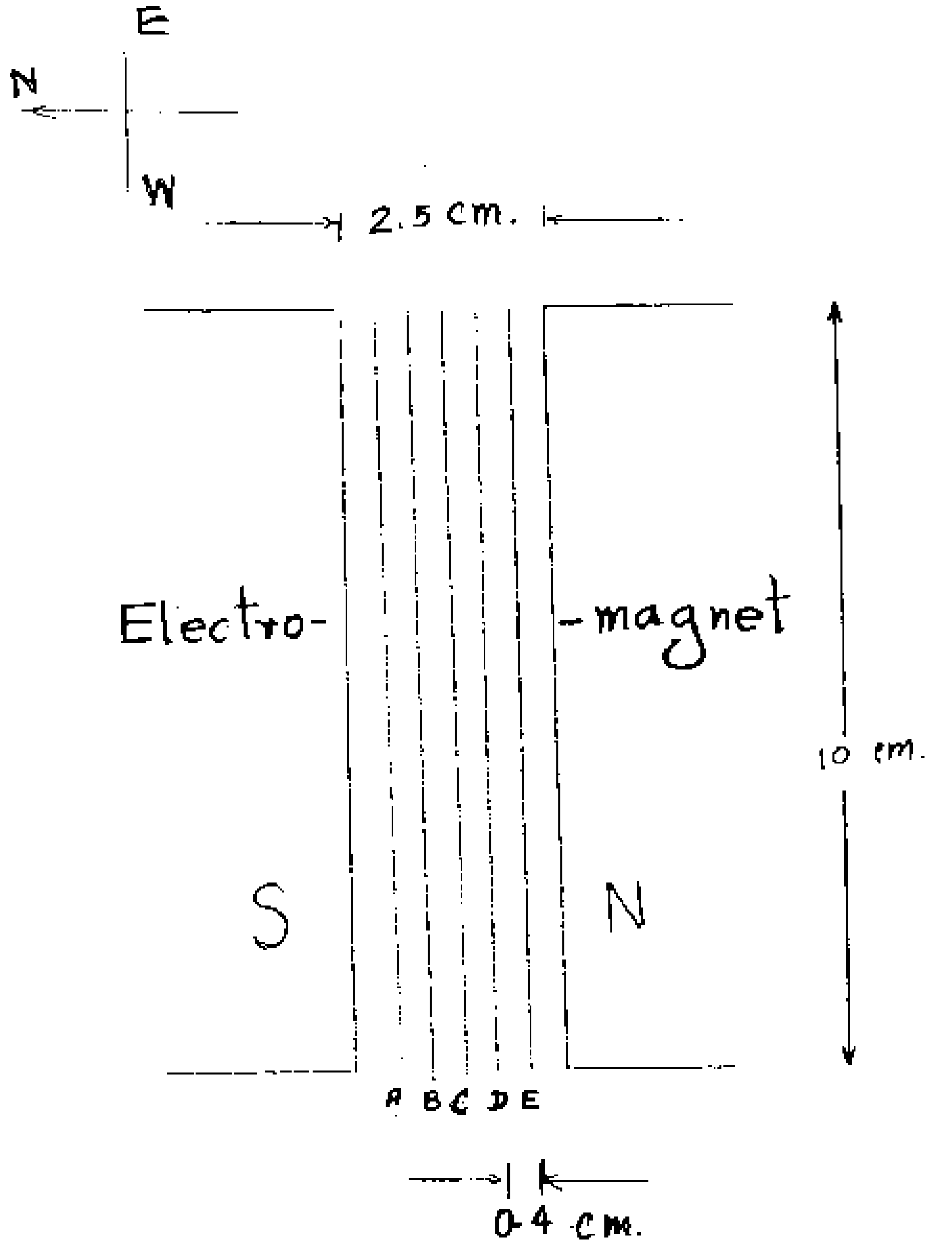
EXPERIMENTAL RESULT AND DISCUSSIONS

4.1 Magnetic Field Mapping at various Positions.

In order to investigate the homogeneity of the magnetic field of this electromagnet, the magnetic field strengths at various positions between the 2.5 cm. gapwidth were observed and measured. In the experiments, the space-gap between the poles was divided into 5 parallel planes, i.e. A,B,C,D and E as shown in Fig. 4.1. The distance between each plane was 0.4 cm. apart.. The plane C was on the middle one between the poles. In each plane the observations were made at various points. The point # 0 of every plane lie on the central axis of the poles. The points # 1, #2, ..., # 7 and # 8 lie along the circumference about the central axis with the radius of 1.0 cm. The points # 9, # 10,......., # 15 and # 16 lie along the circumference about the central axis with the radius of 2.5 cm. as shown in Fig. 4.2.

The resonant frequencies at various points were measured and tabulated in the table 4 - 1. And the magnetic field strengths were also calculated and tabulated in the table 4-2. During the entire experiment the d.c. current supply was kept constant at 1.5 amp.

The homogeneity of the magnetic field within 1 c.c. volume was also determined at the central region of the gap as shown in Fig. 4.3. The magnetic field strengths were measured at the points F_1, F_2,......F_8 . These points were at



Gapwidth of the poles	=	2.5	cm.
Distance between successive planes	=	0.4	cm.

Fig. 4.1. . The Planes of observations .

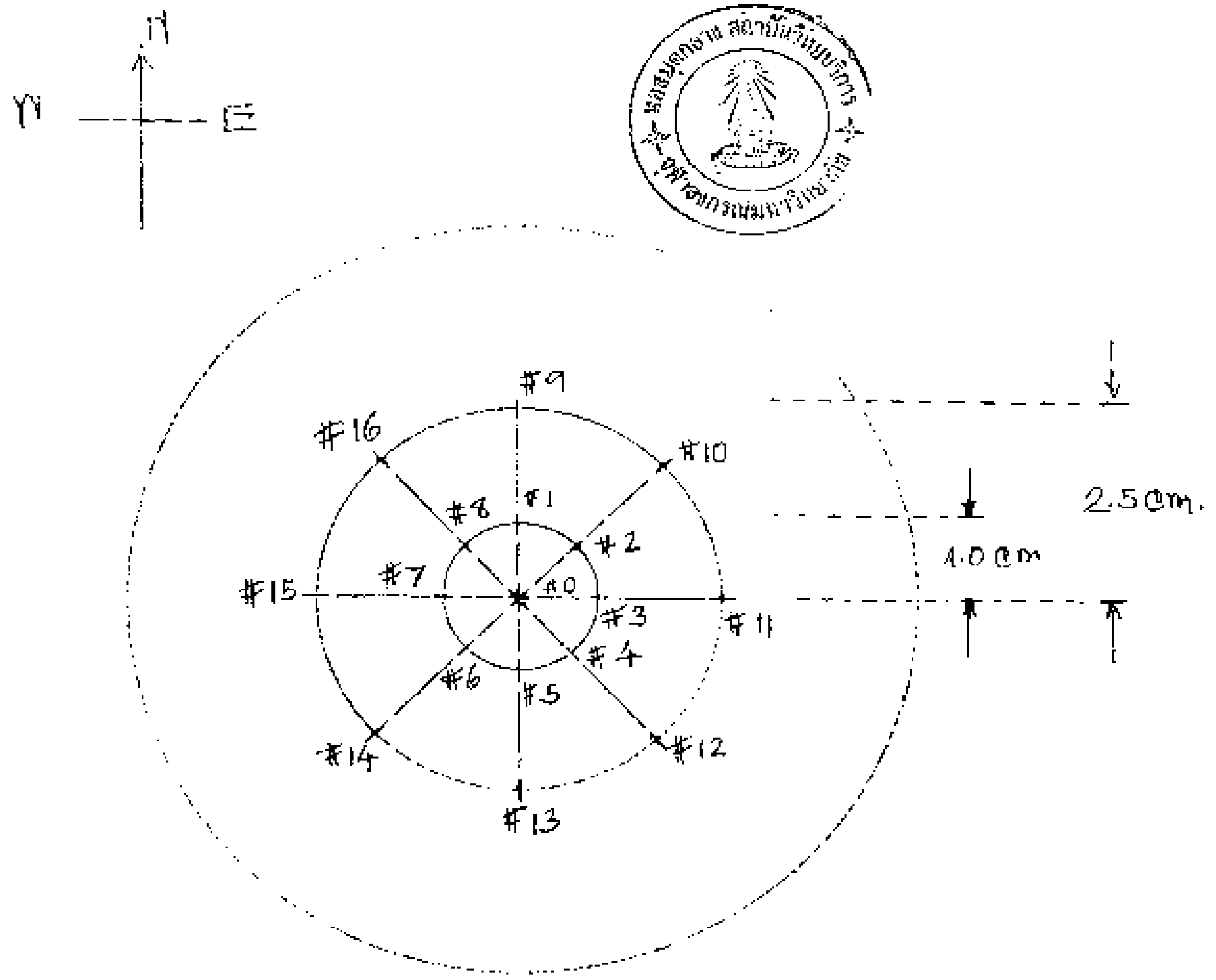


Fig. 4.2. The Points of Observations .

Table 4-1.

The Resonant Frequencies at various Positions by Mapping with the R. F. Probe .

#	Resonant Frequencies (Mc/s).				
	A_i	B_i	C_i	D_i	E_i
0	21.2750±0.0012	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.2750±0.0008
1	21.1625±0.0012	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1625±0.0012
2	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008
3	21.1375±0.0012	21.1250±0.0008	21.1125±0.0008	21.1250±0.0008	21.1250±0.0008
4	21.1375±0.0012	21.1250±0.0008	21.1125±0.0008	21.1250±0.0008	21.1375±0.0012
5	21.1375±0.0012	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1375±0.0012
6	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008
7	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008
8	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008	21.1250±0.0008
9	20.8750±0.0012	20.8700±0.0012	20.8600±0.0012	20.8720±0.0012	20.8750±0.0012
10	20.8750±0.0012	20.8700±0.0012	20.8600±0.0012	20.8700±0.0008	20.8750±0.0012
11	20.8750±0.0012	20.8700±0.0012	20.8625±0.0012	20.8700±0.0008	20.8750±0.0012
12	20.8750±0.0012	20.8675±0.0012	20.8550±0.0008	20.8650±0.0008	20.8750±0.0012
13	20.8750±0.0012	20.8625±0.0012	20.8500±0.0012	20.8625±0.0012	20.8750±0.0012
14	20.8875±0.0008	20.8875±0.0012	20.8875±0.0012	20.9000±0.0012	20.9000±0.0008
15	20.9000±0.0012	20.8875±0.0012	20.8875±0.0012	20.8875±0.0012	20.9125±0.0008
16	20.9500±0.0008	20.9500±0.0008	20.9500±0.0008	20.9500±0.0008	20.9500±0.0008

For the gapwidth = 2.5000±0.0035 cm.

D.C.Current supply to the electromagnet = 1.50 Amp.

Modulation current = 100 mA.(rms.)50 c/p.

The R.F.level = 0.30—0.40 cm.on the galvanometer scale.

Table 4-2

Magnetic Field Strength at Various Positions by Mapping with the R.F. Probe.

#	Magnetic Field Strengths, (Gauss)				
	A_i	B_i	C_i	D_i	E_i
0	4997.65±0.28	4962.41±0.18	4962.41±0.18	4962.41±0.18	4997.65±0.18
1	4971.22±0.28	4962.41±0.18	4962.41±0.18	4962.41±0.18	4971.22±0.28
2	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18
3	4965.23±0.28	4962.41±0.18	4959.48±0.18	4962.41±0.18	4962.41±0.18
4	4965.23±0.28	4962.41±0.18	4959.48±0.18	4962.41±0.18	4965.23±0.28
5	4965.23±0.28	4962.41±0.18	4962.41±0.18	4962.41±0.18	4965.23±0.28
6	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18
7	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18
8	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18	4962.41±0.18
9	4903.69±0.28	4902.51±0.28	4900.16±0.28	4902.98±0.28	4903.69±0. 28
10	4903.69±0.28	4902.51±0.28	4900.16±0.28	4902.51±0.18	4903.69±0.28
11	4903.69±0.28	4902.51±0.28	4900.16±0.28	4902.51±0.18	4903.69±0.28
12	4903.69±0.28	4901.93±0.28	4898.99±0.18	4901.34±0.18	4903.69±0.28
13	4903.69±0.28	4900.75±0.28	4897.82±0.28	4900.75±0.28	4903.69±0.28
14	4906.51±0.28	4906.51±0.28	4906.51±0.28	4909.56±0.28	4909.56±0.18
15	4909.56±0.28	4906.51±0.28	4906.51±0.28	4906.51±0.28	4912.50±0.18
16	4921.31±0.18	4921.31±0.18	4921.31±0.18	4921.31±0.18	4921.31±0.18

For the gapwidth = 2.5000±0.0035 cm.,

D.C. current supply to the electromagnet = 1.50 Amp.,

modulation current = 100 mA. (r.m.s.) 50 c/s. ,

the r.f. level = 0.30 - 0.40 cm. on the galvanometer scale.

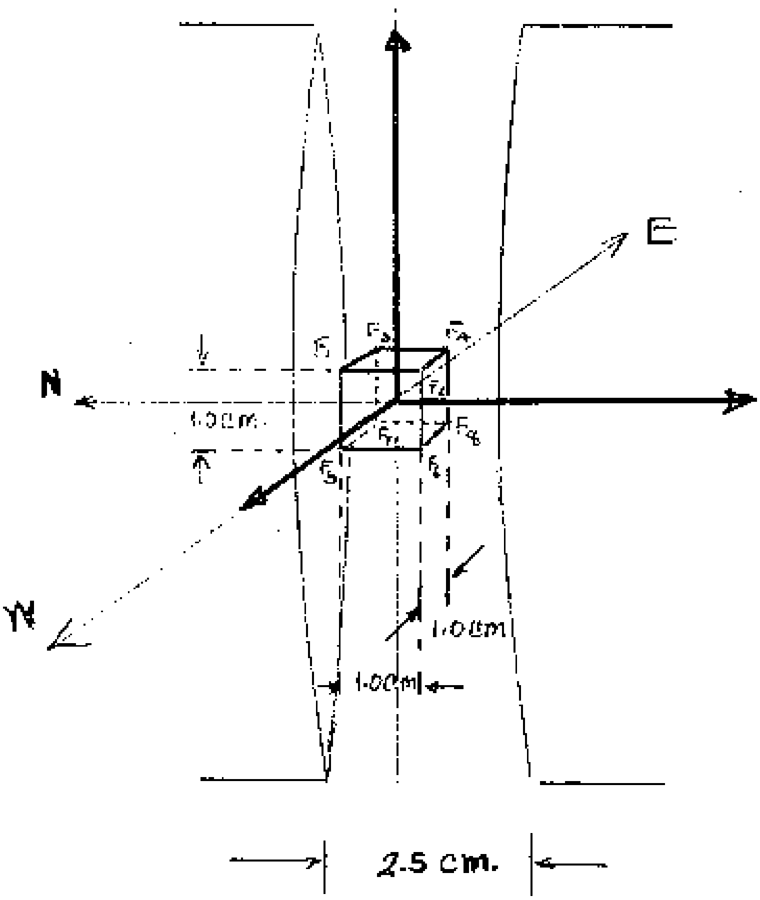


Fig. 4.3. Observation of the Field Inhomogeneity .

Table 4-3

To Observe the Field Homogeneity within 1 cc. Volume at the Central Region of the Gap.

Positions (Points)	Resonant Frequency (Mc/sec.)	Magnetic field Strength (Gauss)
F_1	21.1250 ± 0.0008	4962.41 ± 0.18
F_2	21.1250 ± 0.0008	4962.41 ± 0.18
F_3	21.1250 ± 0.0008	4962.41 ± 0.18
F_4	21.1250 ± 0.0008	4962.41 ± 0.18
F_5	21.1250 ± 0.0008	4962.41 ± 0.18
F_6	21.1250 ± 0.0008	4962.41 ± 0.18
F_7	21.1280 ± 0.0012	4963.12 ± 0.28
F_8	21.1280 ± 0.0012	4963.12 ± 0.28

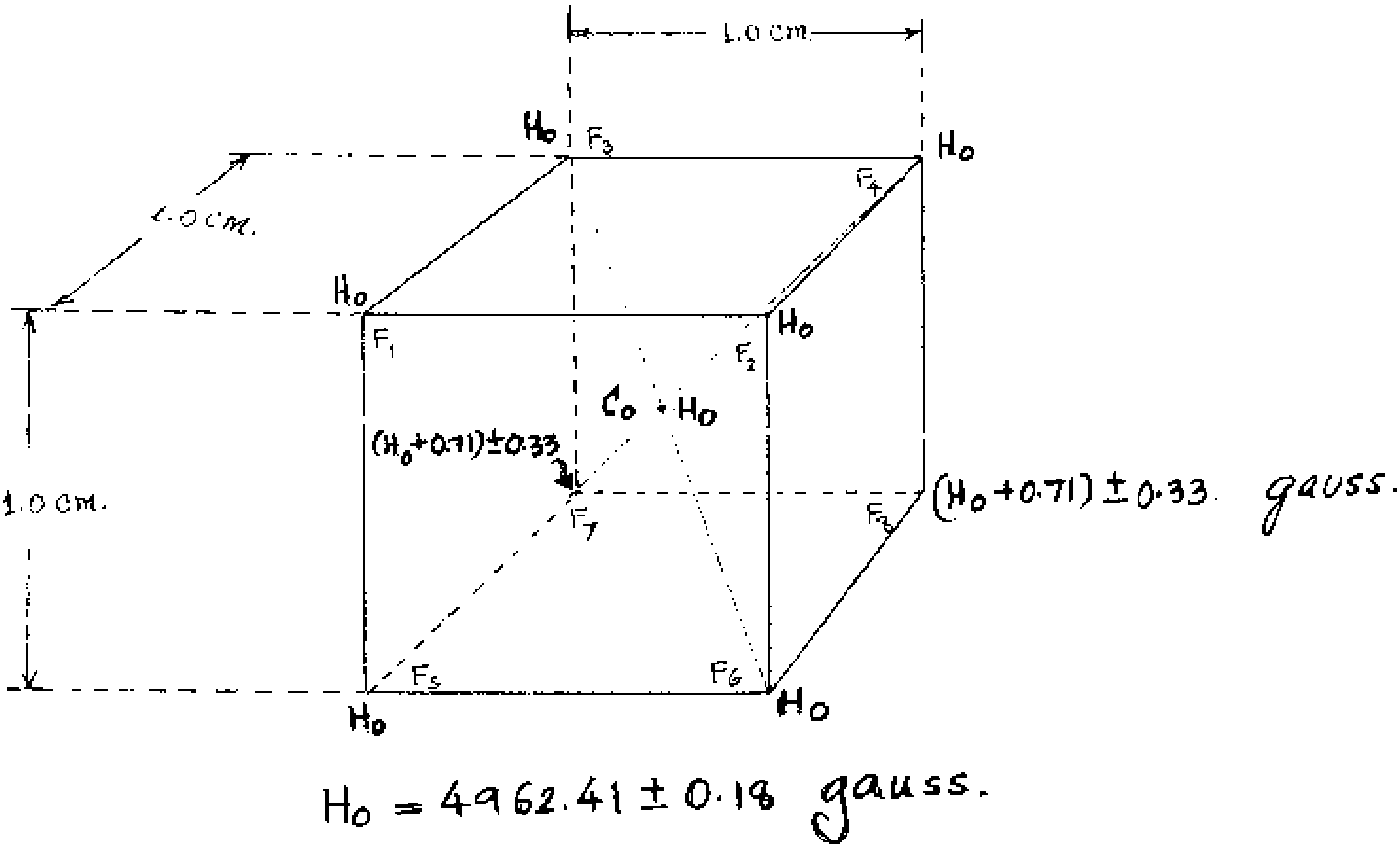


Fig.4.4. Model for Studying the Homogeneity of the Magnetic Field

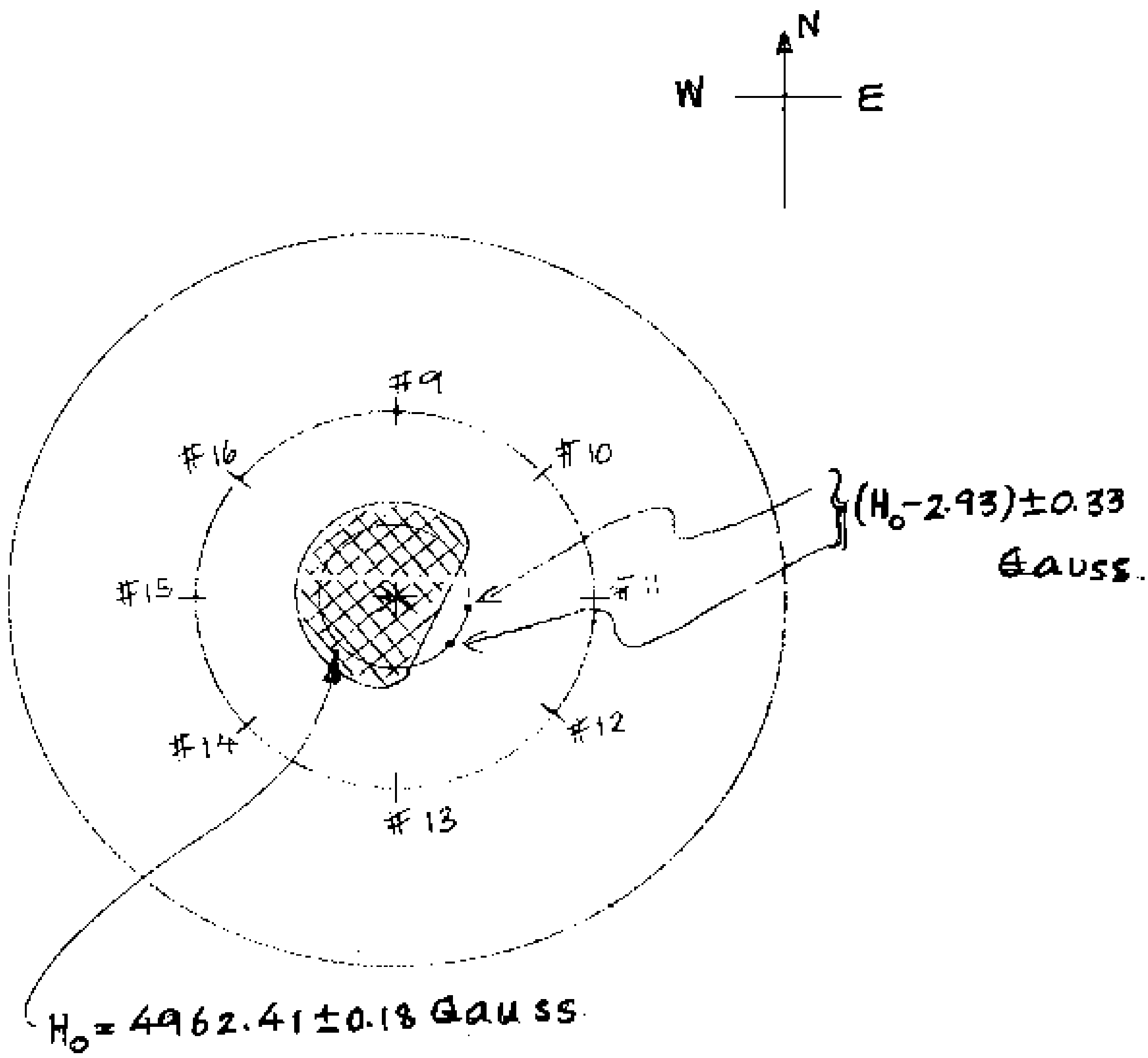


Fig.4.5.a. The Shape of the Homogeneity of the Magnetic Field .

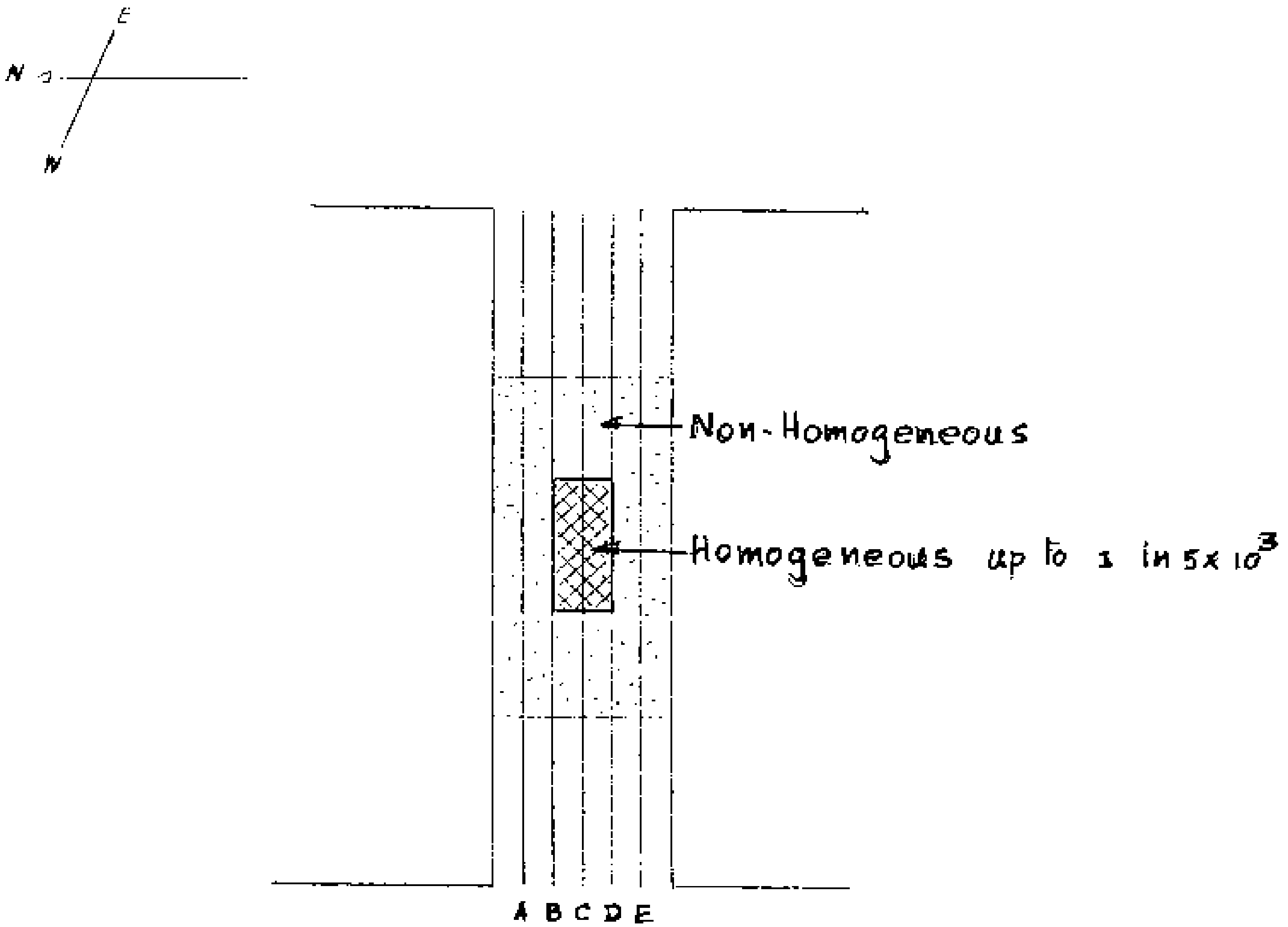


Fig.4.5.b. Region investigated in the Magnet Gap.

the corners of the cubic volume. The results were listed in the table 4-3. From these results, we are able to draw the map of the magnetic field for the study of its homogeneity as shown in Fig. 4.4. From Fig. 4.4 we can conclude that the inhomogeneity is of the order of 1 gauss over the 1 c.c. volume and that the uniform field is about 4962.41 ± 0.18 gauss. Thus the inhomogeneity is 1 in 5×10^3 over one c.c. volume at the center of the gap.

From the data in the tables 4 - 1, 4 - 2 and 4 - 3, and by drawing magnetic field map, we can see that there is a homogeneity between the plane B and the plane D with the radius of 1 cm., but the shape is not completely cylindrical. It is almost a cylindrical. The cross section along the plane C is shown in Fig. 4.5. But, for the radius of 2.5 cm., it is found that the magnetic field is not homogeneous.

4.2 Magnetic Field Strength Dependence on D.C. Current Supply.

The other experiment performed was to find the magnetic field strength in relation with the d.c. current supply. The results of this may be used as a standard field for calibrating the magnetic field strength of the other magnets or electromagnets, such as that by the Search Coil Method. In this experiment, the point C_o at the center of the plane C was selected to be the point of observations. The magnetic field strengths were measured and the d.c. current supply to the electromagnet was also varied from 1.25 amp. d.c. to 1.60 amp. d.c. The results were listed in the table 4-4 and its relation was shown in Fig. 4.6. From the graph in Fig. 4.6., we

Table 4-4

Magnetic Field Strength Dependence on D.C. Current Supply.

The gap width 2.5 cm.

Modulation current 100 mA. (rms) 50 c/s.

The rf. level 0.20 ± 0.05 cm. on the galvanometer scale.

D.C. Current supply to the electro-magnet (Amp.)	Resonant Frequency (Mc/sec.)	Magnetic Field Strength (gauss)
1.60	21.9375 ± 0.0008	5153.28 ± 0.18
1.50	21.1250 ± 0.0008	4962.41 ± 0.18
1.45	20.4750 ± 0.0008	4809.73 ± 0.18
1.40	20.0125 ± 0.0012	4701.08 ± 0.28
1.35	19.5000 ± 0.0012	4580.69 ± 0.28
1.30	18.9250 ± 0.0008	4445.62 ± 0.18
1.25	18.3375 ± 0.0008	4307.61 ± 0.18

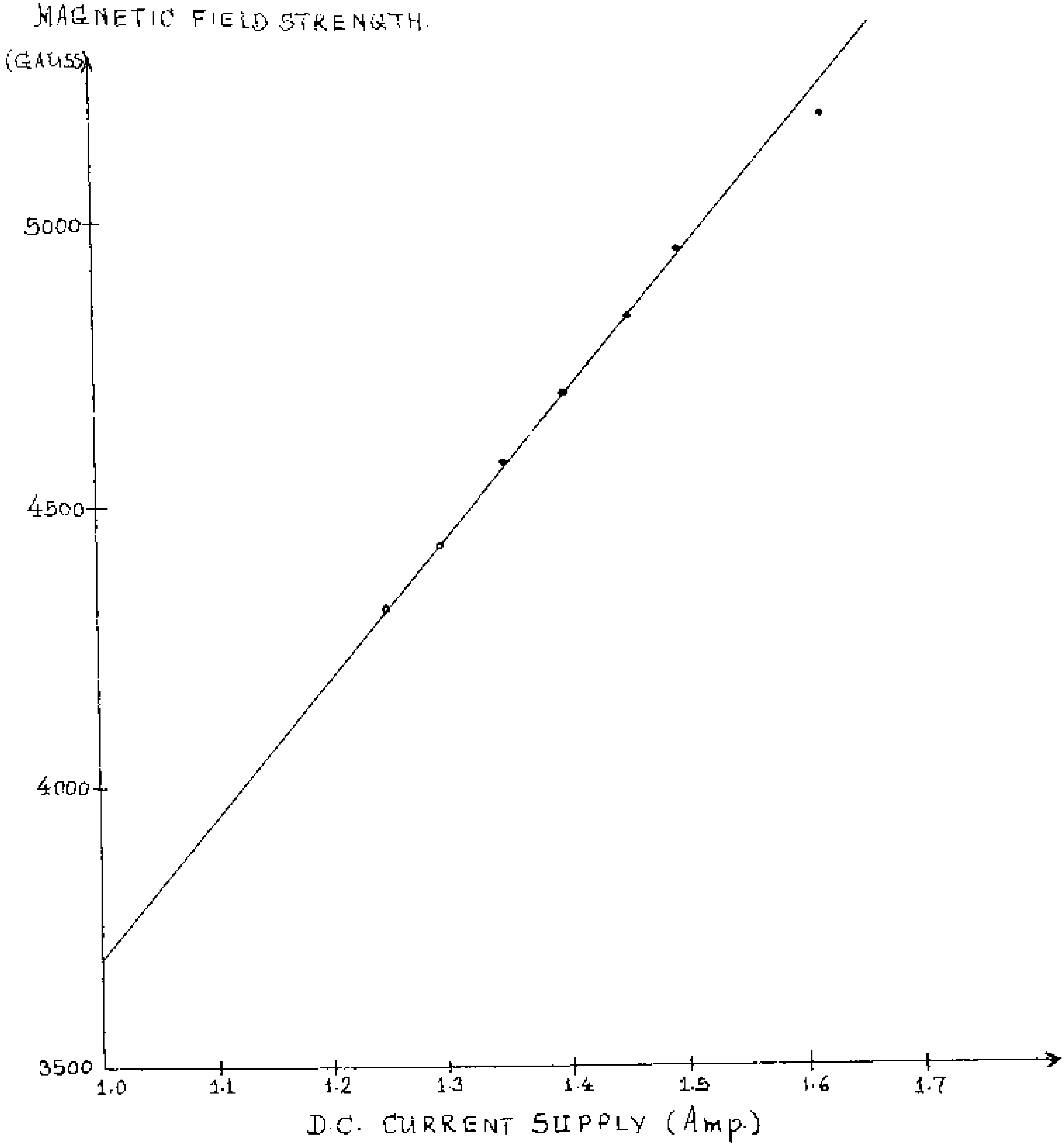


Fig.4.6. Magnetic Field Strength vs. the D.C.Current Supply.

can see that the magnetic field strengths of this electromagnet are linearly proportion to the d.c. current supply.

4.3 Dependence of the Battery Voltage after used.

The third experiment performed was to find the magnetic field strength drift. This effect occured because of the slight decrease of the voltage of the storage batteries while being used. The 1.5 amp. d.c. current supply was supplied to the electromagnet about 30 minutes before the measurement. Then the magnetic field strength at the point C_o at the center of plane C was measured every 5 minutes. The results were listed on the table 4 - 5 . The graph of the magnetic field strength vs. time in min. was plotted as shown in Fig. 4.7. We can see that, from the 0^{th} minute to the 30^{th} minute the rate of drift of the magnetic field strength is 1.17 $\pm$ 0.06 gauss/min., from the 30^{th} minute to the 40^{th} minute; the rate is about 12 gauss/min., and from the 40^{th} minute to the 60^{th} minute; the rate is 0.59 $\pm$ 0.06 gauss/min.

Two more similar runs were also made. The results are shown in Fig. 4.8 and Fig. 4.9.

4.4 Discussions.

From the results in the section 4.1, we can conclude that the homogeneity of the magnetic field at the middle region between the poles of this Tickford electromagnet is homogeneous up to 1 in 5 x 10^3 over one c.c. volume. The width of the resonance peak is also an indicator of homogeneity, thus allowing the use of the instrument for locating the most homogeneous point in a field or for establishing the boundaries

Table 4–5

Drift of Magnetic Field due to the Battery Voltage Supply.

Time (min.)	Resonant Frequency (Mc/sec.)	Magnetic Field Strength (gauss)
0	21.1250 ± 0.0008	4962.41 ± 0.18
5	21.1125 ± 0.0012	4959.48 ± 0.28
10	21.0875 ± 0.0012	4953.60 ± 0.28
15	21.0625 ± 0.0008	4947.73 ± 0.18
20	21.0375 ± 0.0008	4941.86 ± 0.18
25	21.0125 ± 0.0008	4935.98 ± 0.18
30	20.9625 ± 0.0008	4924.24 ± 0.18
35	20.8875 ± 0.0012	4906.62 ± 0.28
40	20.6250 ± 0.0012	4844.96 ± 0.28
45	20.6125 ± 0.0008	4842.02 ± 0.18
50	20.6125 ± 0.0008	4842.02 ± 0.18
55	20.6000 ± 0.0008	4839.08 ± 0.18
60	20.6000 ± 0.0008	4839.08 ± 0.18

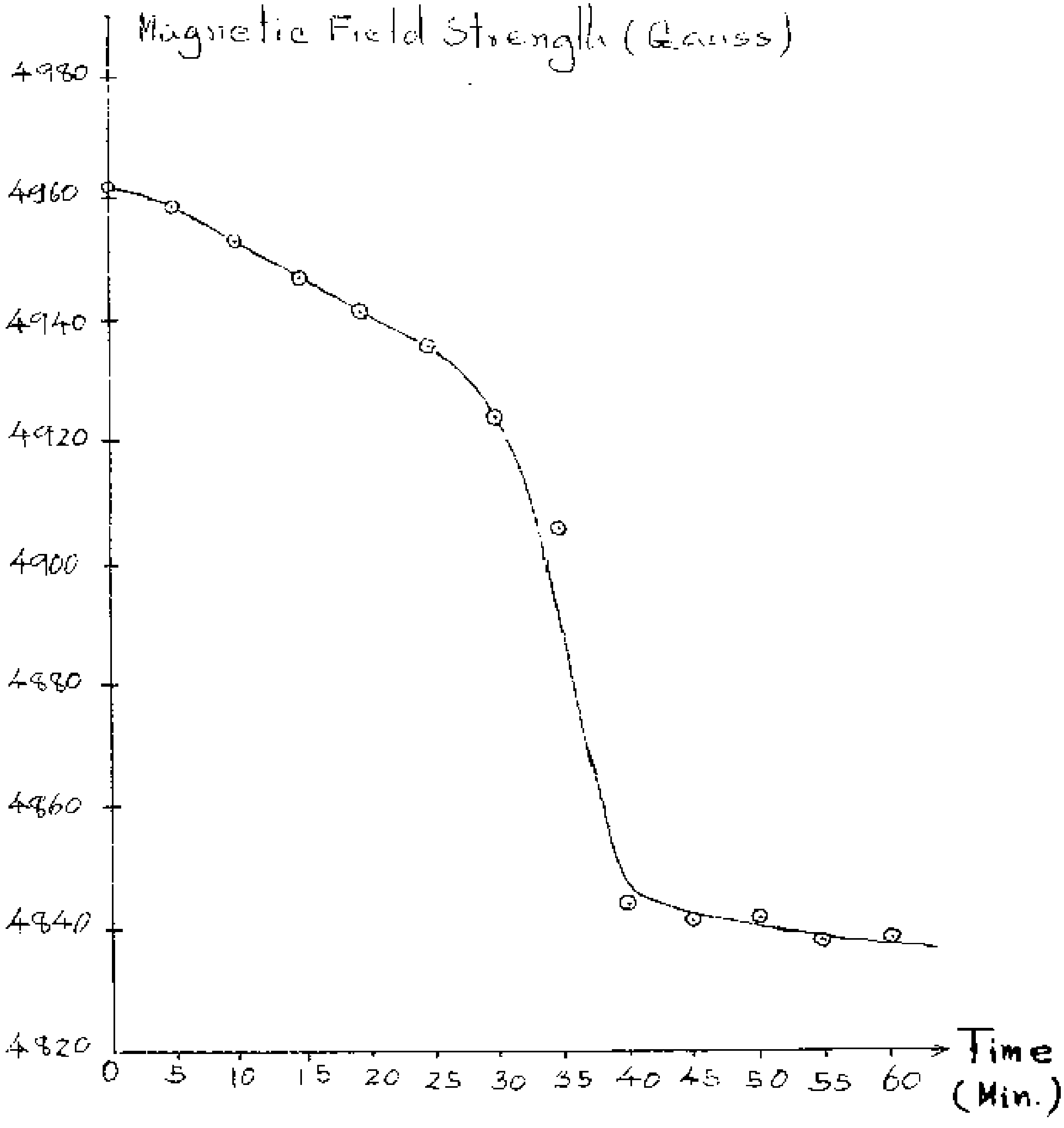


Fig.4.7. Magnetic Field Strength vs. Time (Run No.1).

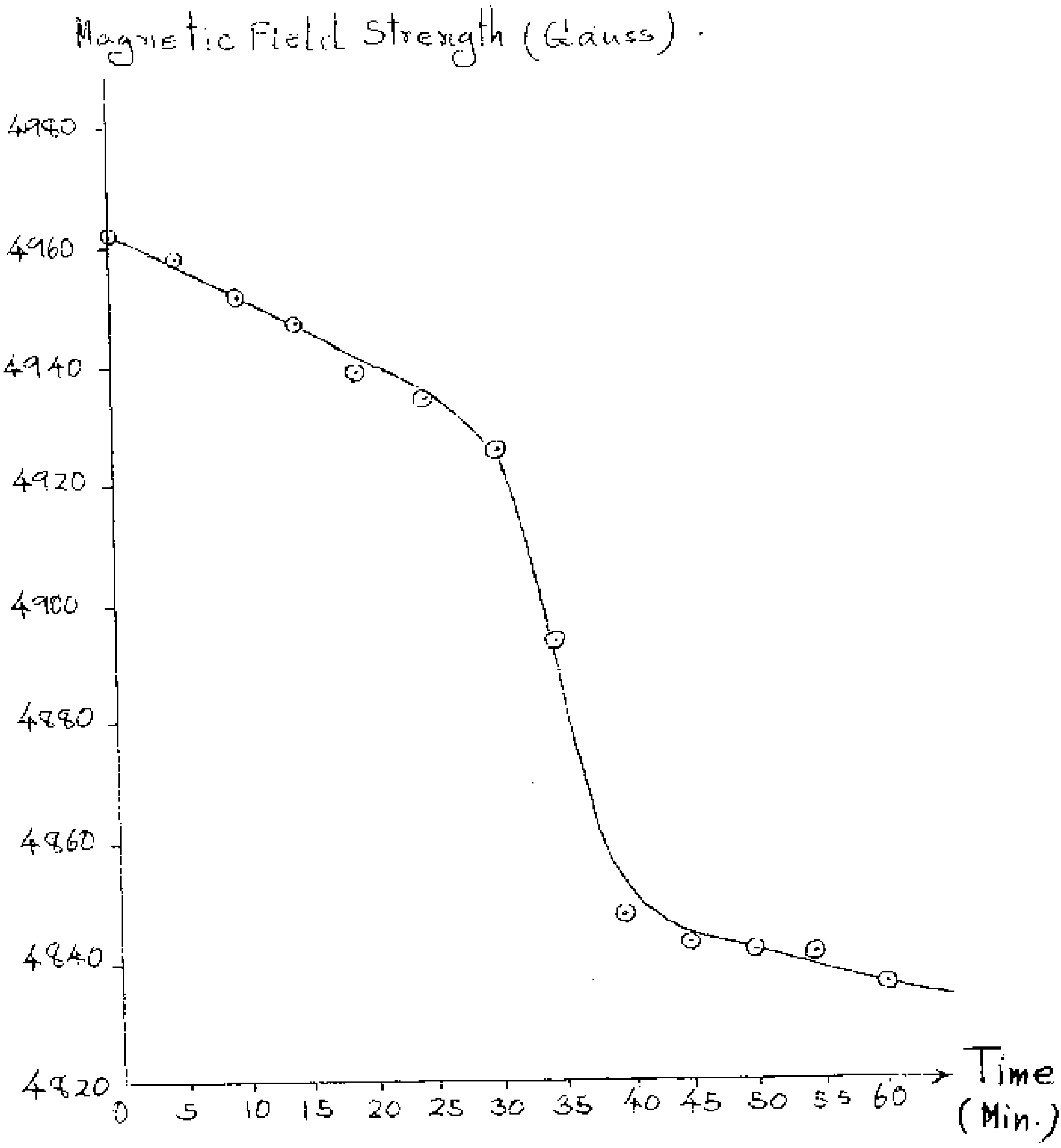


Fig. 4.8. Magnetic Field Strength vs. Time (Run No 2).

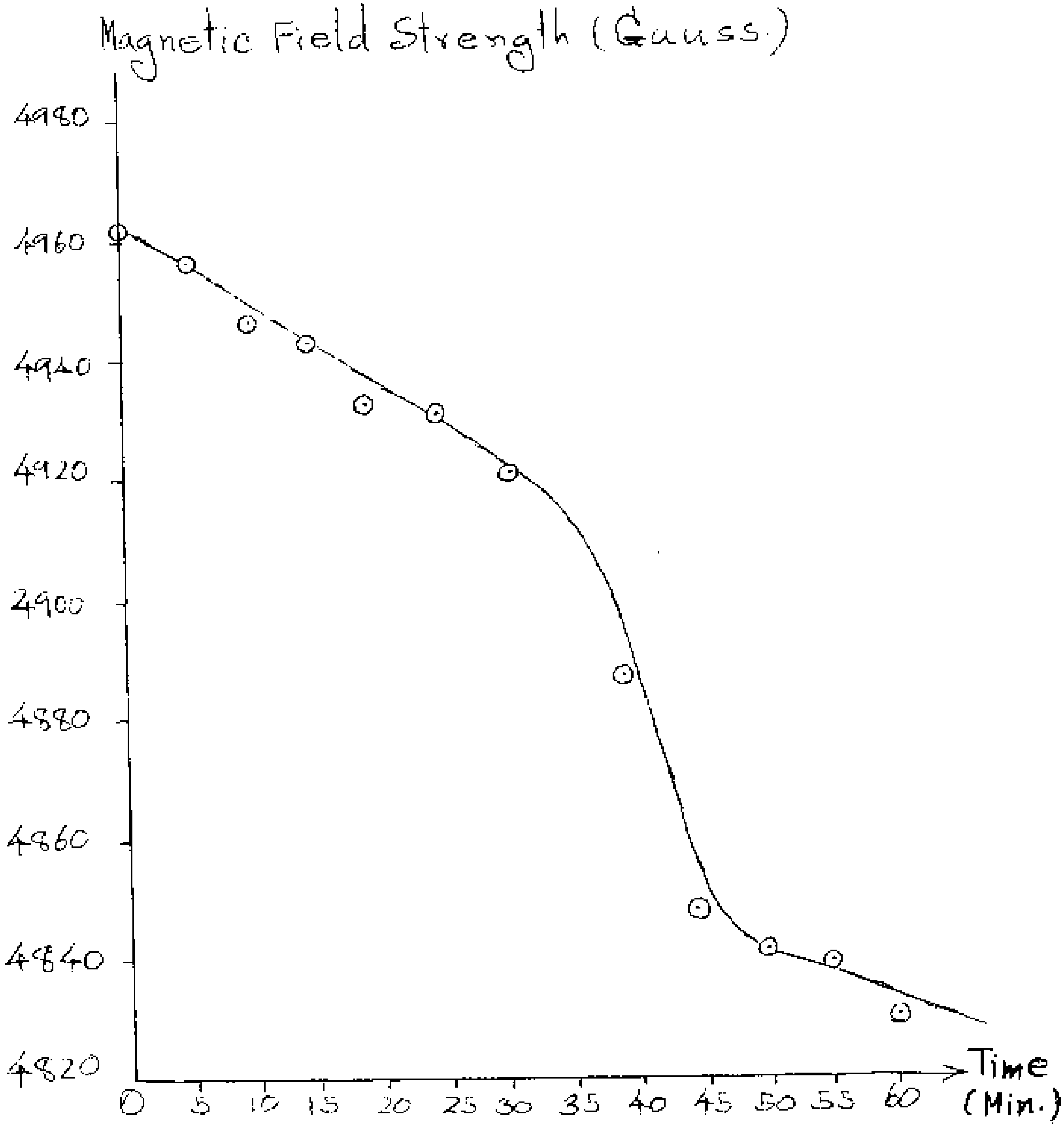


Fig.4.9. Magnetic Field Strength vs. Time (Run No 3.).

of the region in which the field is uniform. The poor homogeneity could arise from non-smoothness of the surfaces of the magnetic poles and the property of material of the magnetic poles. If it was caused by the first one, it may be improved by polishing its pole faces. However, the machine work will to a certain extent cause hardening in the material. Proper annealing will have to be done. Thus if the other chemical samples were performed, it would be hard to see the resonant peak because of the inhomogeneity of the magnetic field was too large. And that this electromagnet could not be used in the high-resolution analysis.

The results in the section 4.2 may be used for calibrating the magnetic field strength of the other magnets or magnetic fields.

From the results in the section 4.3, we can see that the magnetic field strength was decreased because of the drift of the d.c. current supply from the storage batteries. It could arise from its chemical process or the thermal effect on the resistance of the coils of the electromagnet or both. Thus we can study the performance of the storage batteries by this method. We can see that within 1 hour the rate of drift of the magnetic field strength is not steady. By using the relation of the magnetic field strength and the d.c. current supply in Fig. 4.6, we can find the rate of drift of current or hence the voltage of the storage batteries.