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FIRST PROPOSAL FOR A NEW AIR-COOLED PFW SYSTEM FOR A HIGH INTENSITY PS, YIELDING INDEPENDENT CORRECTING QUADRUPOLE, SEXTUPOLE AND OCTUPOLE FIELDS

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1. Introduction and summary

In a recent note [1] preliminary specifications have been published for a high intensity PS PFW system which would yield independent harmonic field multipoles (quadrupole, sextupole and octupole); in a second note [2] the principle of creating such multipoles or any of their linear combination within the (PS)-aperture by a number of discrete and individually powered current conductors along the pole contour has been described.

In this note we present the first results of computations for two air-cooled conductor configurations, yielding the required multipole parameters of

$$\frac{\partial B}{\partial \rho} = 0.4 \text{ Tm}^{-1}, \quad \frac{\partial^2 B}{\partial \rho^2} = 12 \text{ Tm}^{-2} \text{ and } \frac{\partial^3 B}{\partial \rho^3} = 70 \text{ Tm}^{-3}$$

within $\pm$ 6 cm of the PS horizontal aperture.

The first system consists of 15 individual conductors and of 2 (3) return conductors, also located along the pole contour. The individual currents are with one exception below 1000 A; only

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program of Halbach and Holsinger, Berkeley, computes iron shim and current configurations for a required field within a prescribed aperture). In this operation the currents are assumed as point sources located in the centre of the conductors. Using the POISSON magnetic field program (Halbach, Holsinger) and the MAGNET program (Ch. Iselin) the field errors were computed for the real conductor configuration and compensated by applying the "unit current field contribution method".

The two variant conductor locations are shown in figs. 1 and 2; the required currents for fields with

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are summarized in Tables I and II.

The assumed PFW current density is $3.5 \frac{A}{mm^2}$ [3] and the current form factors for the various field harmonics are

$$\left(\frac{I_{rms}}{I_{max}}\right) = 0.27 \text{ for the quadrupole,}$$

$$0.37 \text{ for the sextupole, and}$$

$$0.5 \text{ for the octupole.}$$

Figs. 3 to 5 show the remaining field errors on the midplane for variant I, figs. 6 to 8 for variant II.

In what follows some figures are given which may be of interest for the design of such PFW configurations :

optimization of the multipole fields within a prescribed elliptic aperture, the corresponding current distribution should be determined.

The influence of conductor positioning and current setting tolerances for this distribution to be determined by using the "MAGNET" program.

The influence of the PS magnet saturation on the multipole field errors should be determined by using the "MAGNET" and "FATIMA" programs.

b) Experimental work

It seems important to check the permissible current density in such a PFW configuration. It is suggested to improvise a, say, 2 m long PFW model which should have "bad" thermal contact with the pole contour, to feed the conductors with currents corresponding to $|\Sigma I_{rms}|$ according to Tables I and II and to measure the temperature increase for different clearances δ between PFW and pole.

c) Practical lay-out

The available space for the new PFW within the magnet gap has to be defined taking into account the present situation on all magnet units and as far as possible future modifications.

A preliminary study of the new PFW power supplies should indicate whether it is desirable to replace certain single conductors by several conductors in series.

It would be helpful to establish the field errors of the PS magnet system in terms of multipole coefficients for various excitation levels, as well as the desired amount of Q-shift. One could then define the required strength of the correction multipoles as a function of proton energy.

References :

1	J. Gareyte P. Lefèvre	Proposition pour de nouveaux enroulements polaires pour le PS MPS/DL/Note 72-27/Rev.
2	A. Ašner	Computation of PFW systems yielding harmonic multipole fields MPS-SI/Note MAE/72-8, 20.10.1972
3	F. Rohner	Private communication

…tribution : (closed)

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TABLE I

CONDUCTOR CURRENTS FOR VARIANT I

Conductor No.	Quadrupole I [A]	Sextupole I [A]	Octupole I [A]	$\lvert\Sigma\rvert$ I [A]
1	1600	- 3750	807.7	6157.7
2	800	- 954.5	53.9	1808.4
3	200	- 120	- 6.5	326.5
4	180	- 69	- 10.8	259.8
5	208	- 1.5	- 76.5	286
6	113.2	60	43.1	216.4
7	147.2	- 4.5	- 23.7	175.4
8	149.2	84	- 5.4	229.4
9	136	120	1.1	257.1
10	129	153	- 30	312
11	100	180	21.5	301.5
12	112	204	29.1	345.1
13	208	488.8	95.9	792.7
14	113	556.5	147.5	817
15	148	618	215.4	981.4
R	---	- 57	10.8	67.8
R_{ℓ}	- 3110.2	4751	- 807.7	8368.9
R_r	- 1327.4	- 2258.8	- 475.4	4161.6

TABLE II

CONDUCTOR CURRENTS FOR VARIANT II

Conductor No.	Quadrupole I [A]	Sextupole I [A]	Octupole I [A]	$\|\Sigma\|$ I [A]
0	36.3	- 478.7	- 16.6	531.6
1	2685.1	- 3336.8	879.5	6901.4
2	40.1	- 905.8	- 25.2	971.1
3	565.8	- 39.0	- 32.6	637.4
4	282.6	- 123.9	- 18.6	425.1
5	316.8	185.8	- 18.2	520.8
6	223.3	229.8	15.6	468.7
7	307.6	475.9	33.8	817.3
8	461.5	146.6	265.6	873.7
9	2481.0	1289.7	- 461.4	4232.1
10	- 657.6	953.1	128.2	1738.9
R_ℓ	- 3609.9	4884.2	- 786.5	9280.6
R_r	- 2209.6	- 3280.9	36.4	5526.3

TABLE III

INDUCED EMS IN CONDUCTOR RETURN LOOPS FOR VARIANT II WITH A PS FIELD RISE OF $\dot{B} = 2.2\ Ts^{-1}$

Loop	Induced EMS per unit length $[\frac{V}{m}]$
$0 - R_r$	0.14
$1 - R_r$	0.19
$2 - R_r$	0.25
$3 - R_r$	0.29
$4 - R_r$	0.324
$5 - R_\ell$	0.58
$6 - R_\ell$	0.532
$7 - R_\ell$	0.48
$8 - R_\ell$	0.426
$9 - R_\ell$	0.36
$10 - R_\ell$	0.3

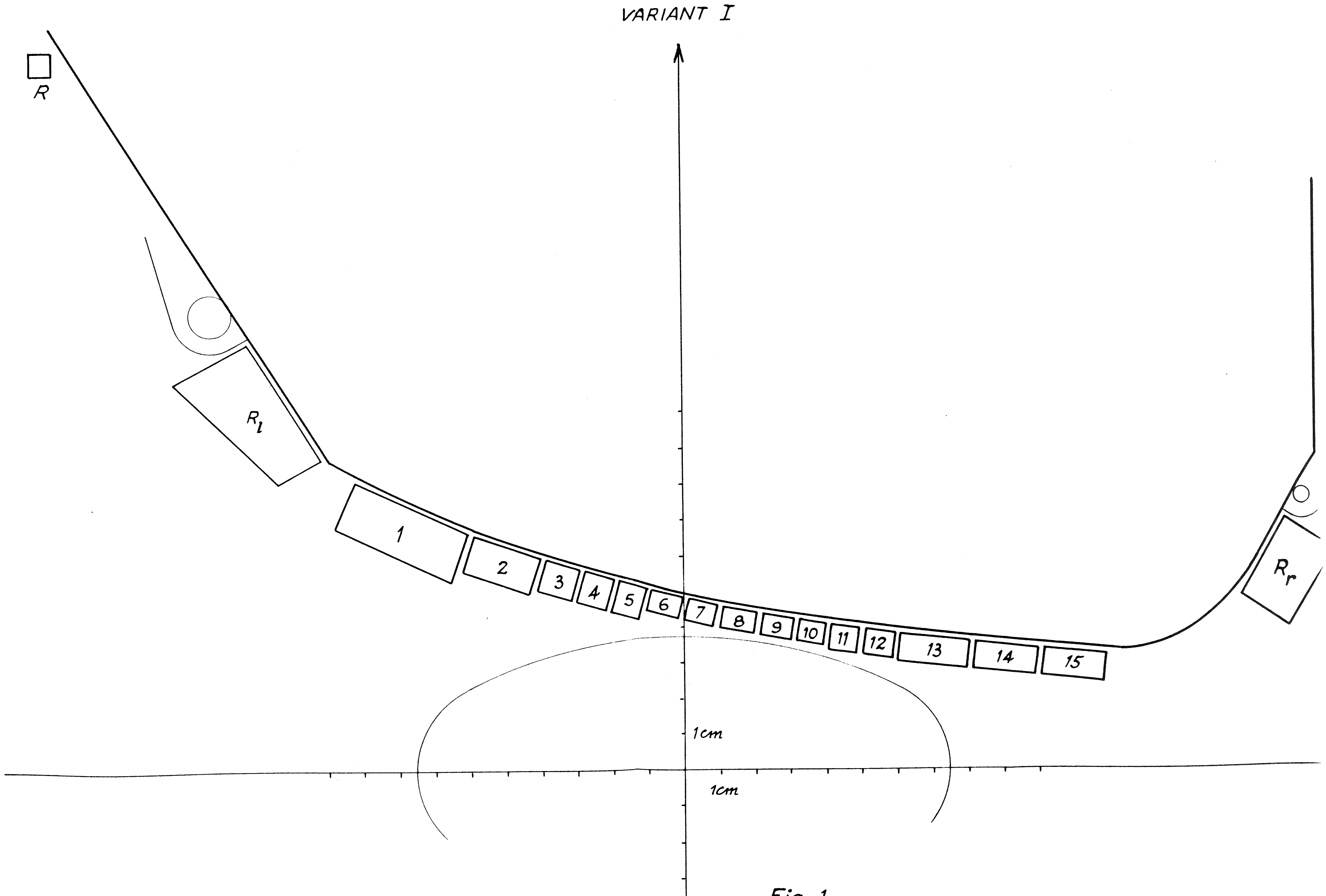


Fig. 1

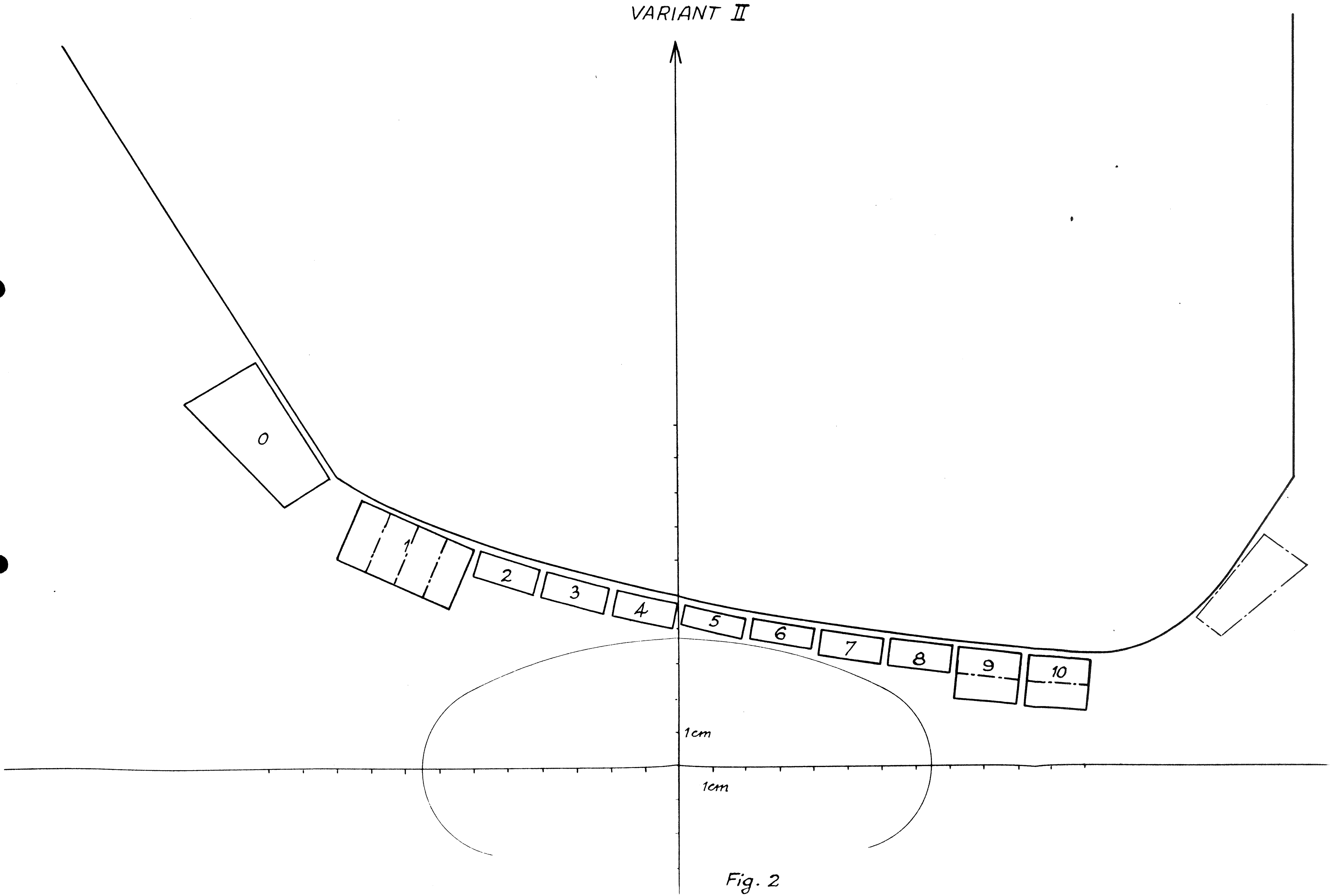


Fig. 2

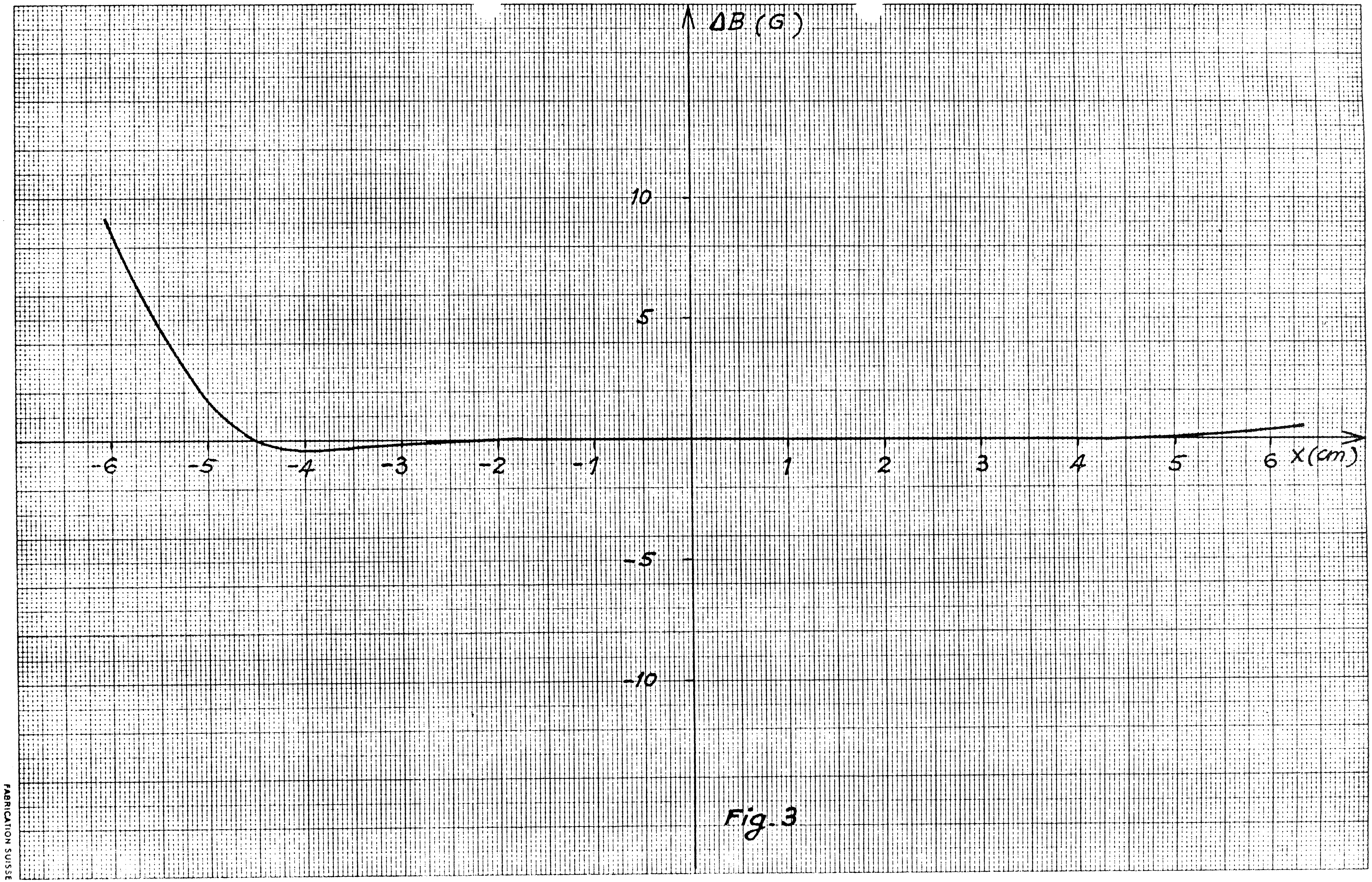
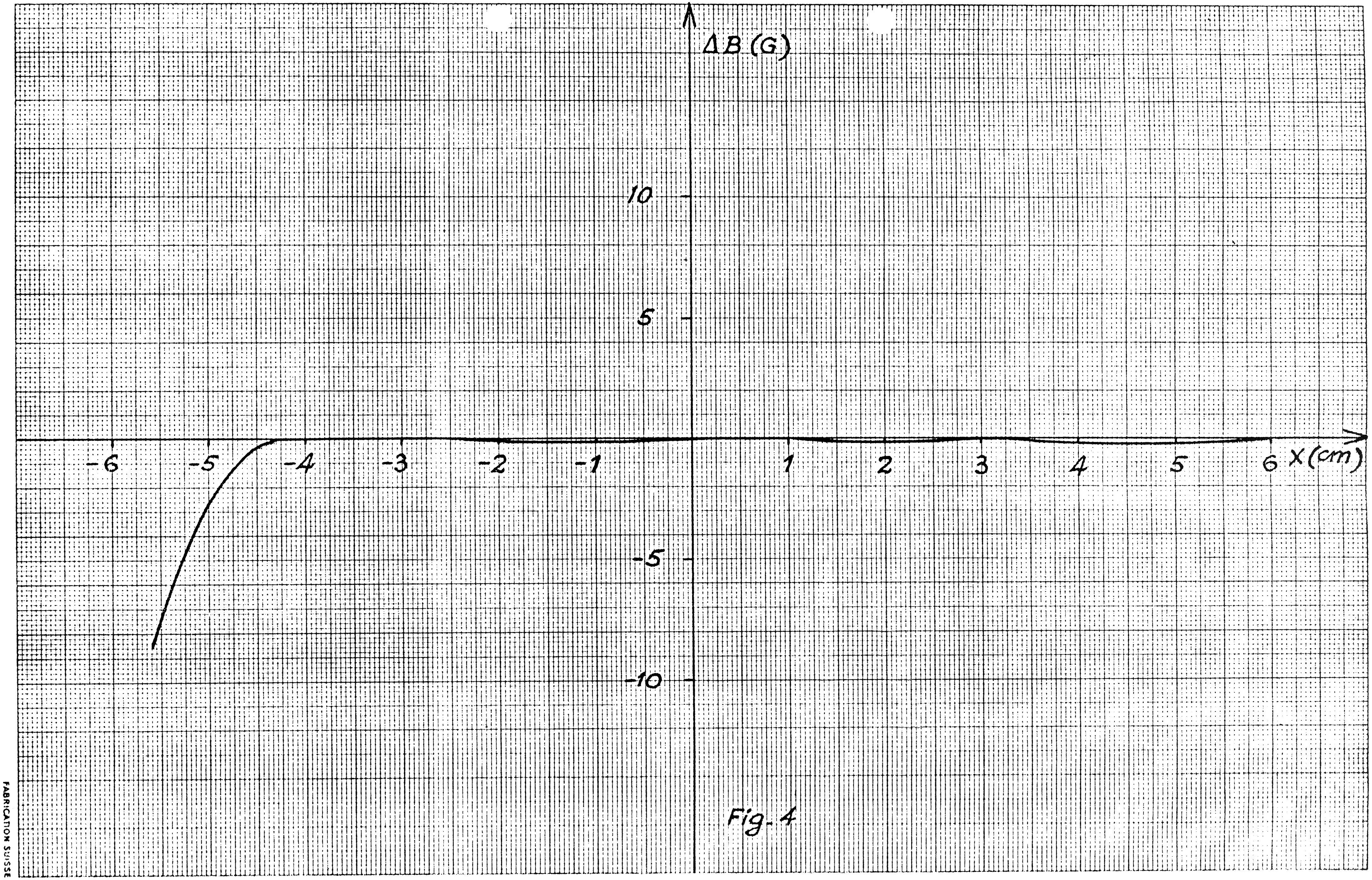
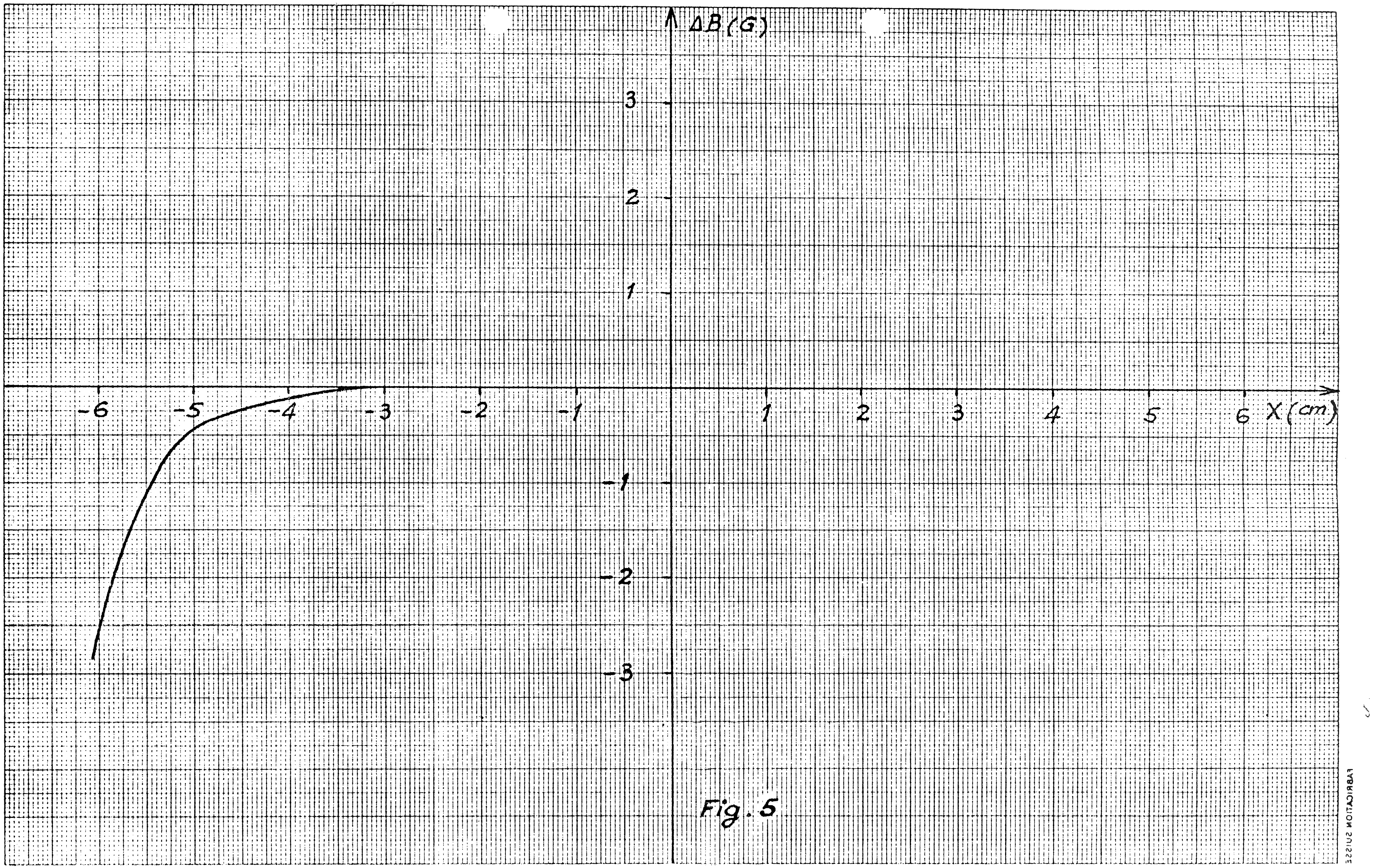


Fig. 3

Remaining quadrupole field error on midplane for $\frac{\partial B}{\partial \rho} = 40 \frac{G}{cm}$



Remaining sextupole field error on midplane for $\frac{\partial^2 B}{\partial x^2} = 12 \frac{G}{cm^2}$



Remaining octupole field error on midplane for $\frac{\partial^3 B}{\partial \rho^3} = 0.7 \frac{G}{cm^3}$

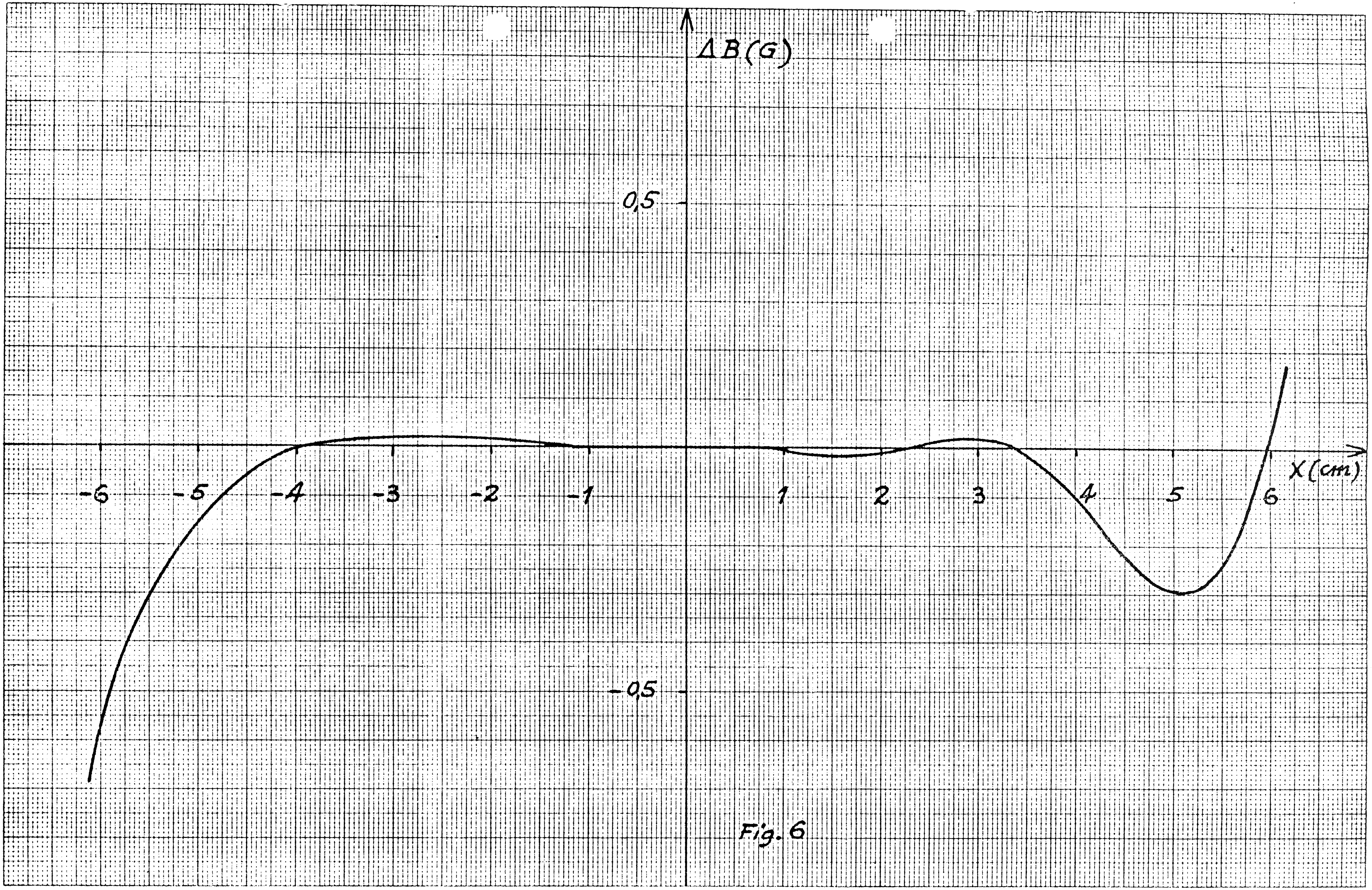
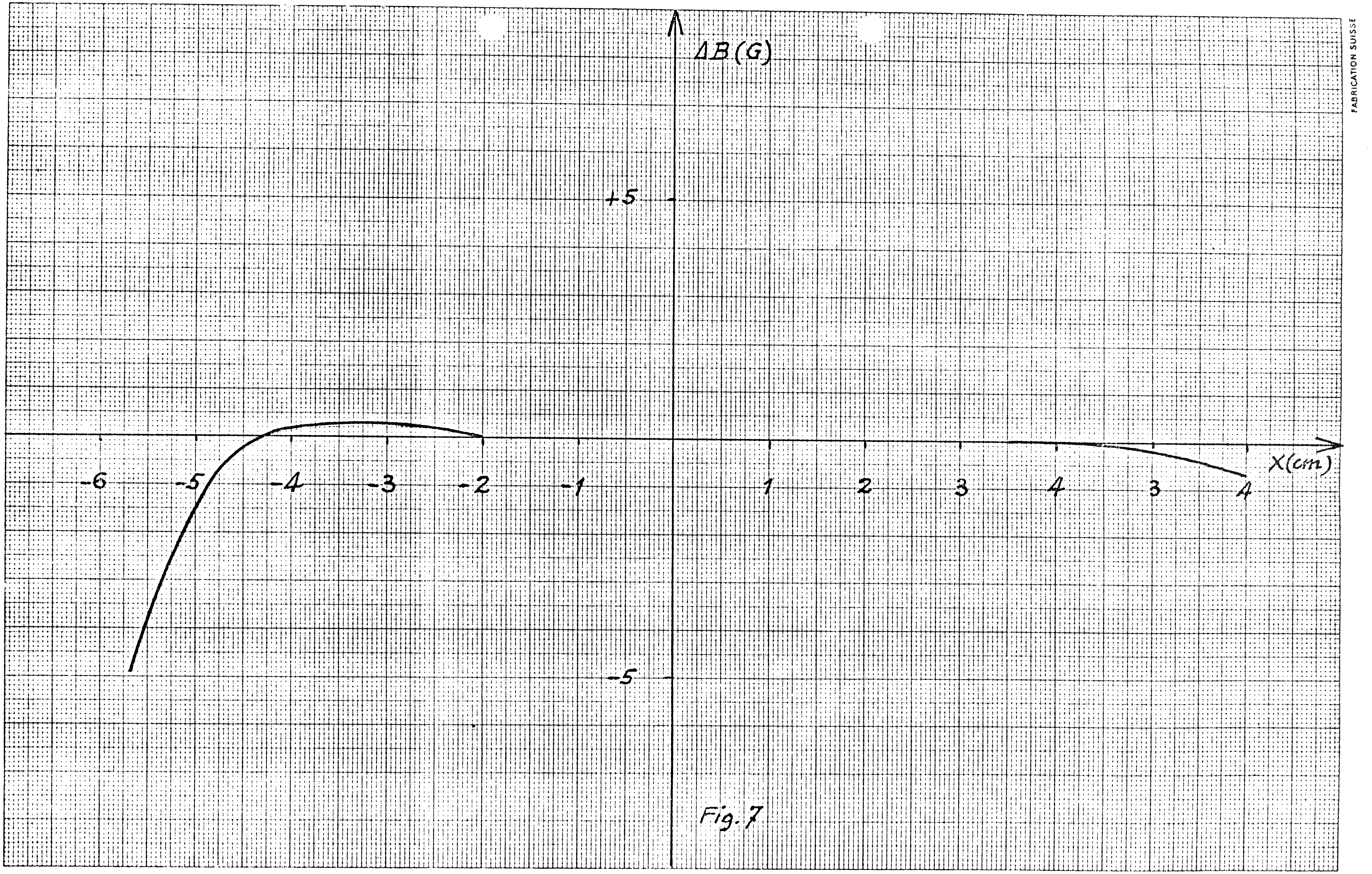


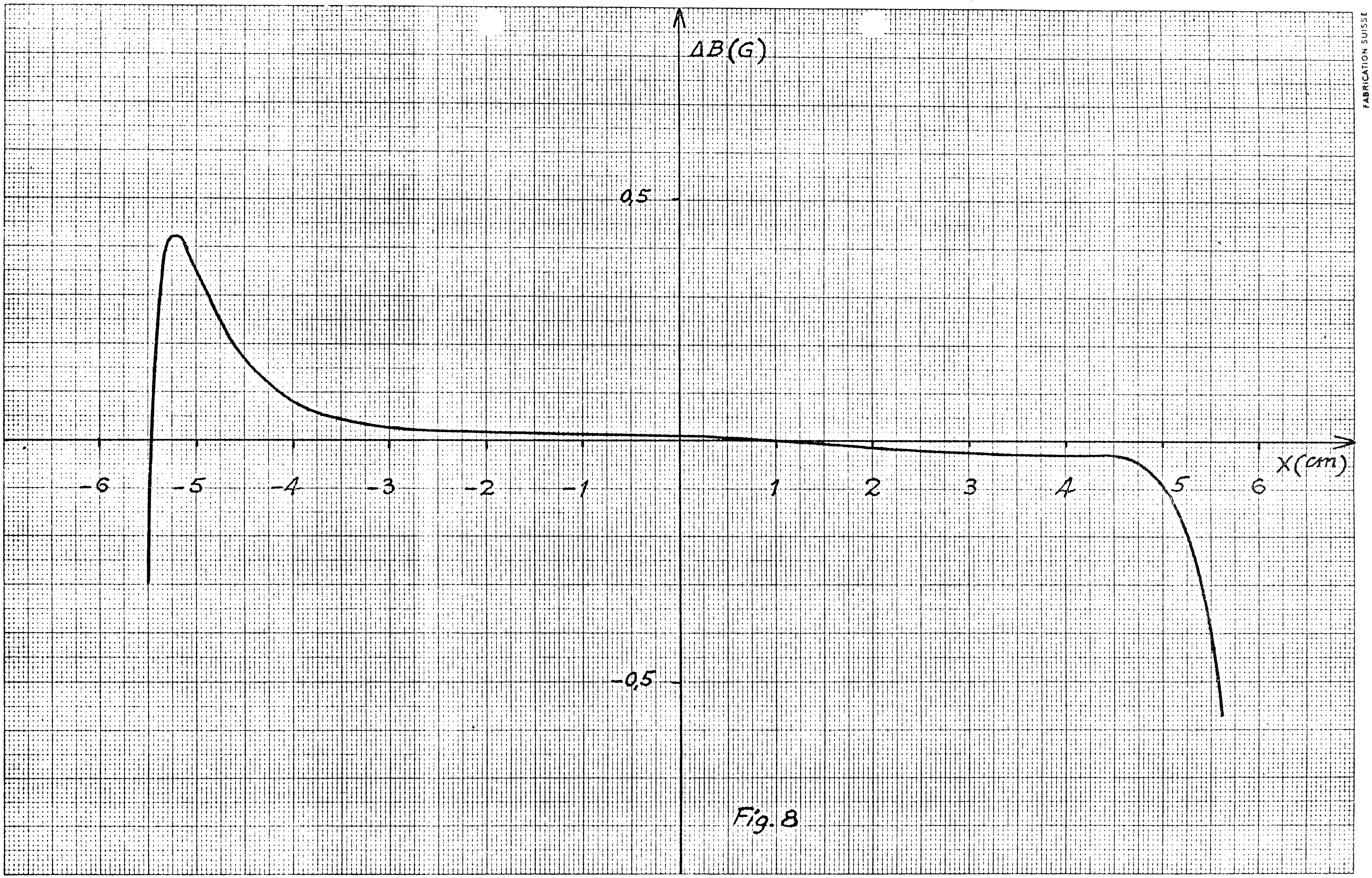
Fig. 6

Remaining quadrupole field error on midplane for $\frac{\partial B}{\partial \rho} = 40 \frac{G}{cm}$

FABRICATION SUISSE



Remaining sextupole field error on midplane for $\frac{\partial^2 B}{\partial \rho^2} = 12 \frac{G}{cm^2}$



Remaining octupole field error on midplane for $\frac{\partial^3 B}{\partial \rho^3} = 0{,}7 \frac{G}{cm^3}$