PS/Int. EA 59-10
3rd August 1959

MAGNETIC MEASUREMENTS ON STEEL SAMPLES FOR BEAM TRANSPORT MAGNETS.

In the specifications of the steel for the bending and quadrupole magnets for beam transport we asked for a low carbon steel with a low sulphur content, annealed at about 800°C with the following magnetic specifications: The coercive force of the steel should be smaller than 2.4 At/cm and when subjected to a magnetizing force of 300 At/cm the flux density should be larger than 2.0 Wb/m^2.

The tenderers were asked to supply a sample of the type of steel they proposed to use. The samples should be rings with inner diameter 76 mm, outer diameter 114 mm and thickness 15 mm. For some samples the chemical composition was also given while for other samples it was not known. The chemical composition, together with the results of the magnetic measurements are shown in Table I. In the cases that more than one sample was measured, Table I gives the average values. The magnetisation curves are shown in Figs. 1 to 10.

The values of B at H = 300 At/cm are very similar for all samples. There is a tendency for B to decrease with increasing impurity content, but the effect is quite small. The spread in coercive force is much larger. As is well known, the coercive force is very sensitive to the heat treatment of the sample and the latter was in general not known. However, since all samples showed a coercive force below 2.4 At/cm this point was not investigated further.

The steel Oerlikon 40'285 will be used for the construction of the beam transport magnets.

The steel Oerlikon Fischer 29'371 can be considered as a good average magnetic steel, while the steel Smit 2 has the lowest permeability at high fields of the samples tested. For these two samples the magnetisation curves have been measured for values of H up to 1300 At/cm, in order to have some reference for future magnet design. For $H > 1300$ At/cm the steel is completely saturated so that its incremental permeability is unity and the increase in B is equal to the increase in $\mu_o H$.

One firm gave us 12 samples taken from different melts of the same type of steel in order to study the spread among those. The difference in B at H = 300 At/cm between the extremes of 11 samples is only 0.04 Wb/m^2. It is not understood why sample 4 is so different. Large variations occur in the coercive force of these samples.

The sample "Pontier rond" was taken with its plane perpendicular to the plane of rolling and the sample "Pontier carré" was taken in the plane of rolling of the same plate of hot rolled steel. The difference between the two is negligible.

In order to see, to what extent a "magnetic steel" must be considered as a special steel, a sample was made from a bar of soft steel with a diameter of 120 mm, taken from the workshop, and measured magnetically. It is indicated as "soft steel" in Table I and Fig. 10. It is clear that also this steel would be excellent for the construction of magnets.

B. de Raad

/fv

Distribution: Magnet Group
Parameter Committee

Messrs: A. Achermann
B. Hedin
H. Horisberger
M. Morpurgo
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TABLE I

Designation of sample	Fig. No	C(o/o)	Si(o/o)	S(o/o)	P(o/o)	Mn(o/o)	Cr(o/o)	Ni(o/o)	Cu(o/o)	B(WB/m^2) at H=300At/cm	Hc(At/cm)
Oerlikon 40'285	1	0.05	0.02	0.01	0.01	0.30				2.07	0.84
Oerlikon Fischer 29'371	1	0.07	0.18	0.01	0.01	0.24	0.18	0.11	0.07	2.05	0.80
Smit 2	1	0.2	0.3	0.03	0.03	0.6				1.98	1.94
Savoisienne 1-12	2	0.1		0.05						2.04	2.23
Metrovick 1 - 3	3	0.15		0.05	0.05	0.5				2.03	1.25
Ansaldo 1 - 3	4	0.10	0.13	0.02	0.02	0.55	0.15	0.19	0.23	2.03	2.02
Pontier XC 10	5	0.11	0.3	0.04	0.03	0.5				2.00	1.53
Pontier 8119	5	0.08	0.9			0.3				2.04	1.24
Pontier rond, carré	5	0.06	0.08	0.03	0.03	0.4				2.04	1.34
Vickers	6	0.2	0.2			0.6				2.02	1.83
Imphy	7									2.05	0.64
SW	8									2.06	1.78
Siemens	9	0.1	0.3	0.02	0.02	0.4				2.03	1.27
Soft steel	10									2.08	1.0

scale Band C

scale A

B Gauss.

Oerlikon
40'285

Oerlikon-Fischer
29'371.

scale A

Oerlikon-Fischer
29'371

Smit 2

scale C

Smit 2

Oerlikon
40'285

Oerlikon-Fischer
29'371

Smit 2

scale B

Oerlikon - Fischer
29'371 ; Hc : 0,8 At/cm

Oerlikon
40'285 ; Hc : 0,84 At/cm.

Smit 2 ; Hc : 1,94 At/cm.

23'000 22'000 21'000 20'000 19'000 18'000 17'000 16'000 15'000 14'000 13'000 12'000

11'000 10'000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0

100 200 300 400 500 600 700 800 900 1000 1100 1200 1300

scale C

H At/cm

0 0,1 ·5 1 1,5 2 2,5 3 3,5 4 4,5 5 5,5 6

scale A

SIS. R59/528

Fig.1

SIS. R59/527

B. Gauss.

SAVOISIENNE

n°	H_c	
1	1.51	At/cm
2	1.55	
3	2.35	
4	2.70	
5	2.60	
6	2.75	
7	3.71	
8	1.86	
9	1.53	
10	1.99	
11	1.89	
12	2.18	

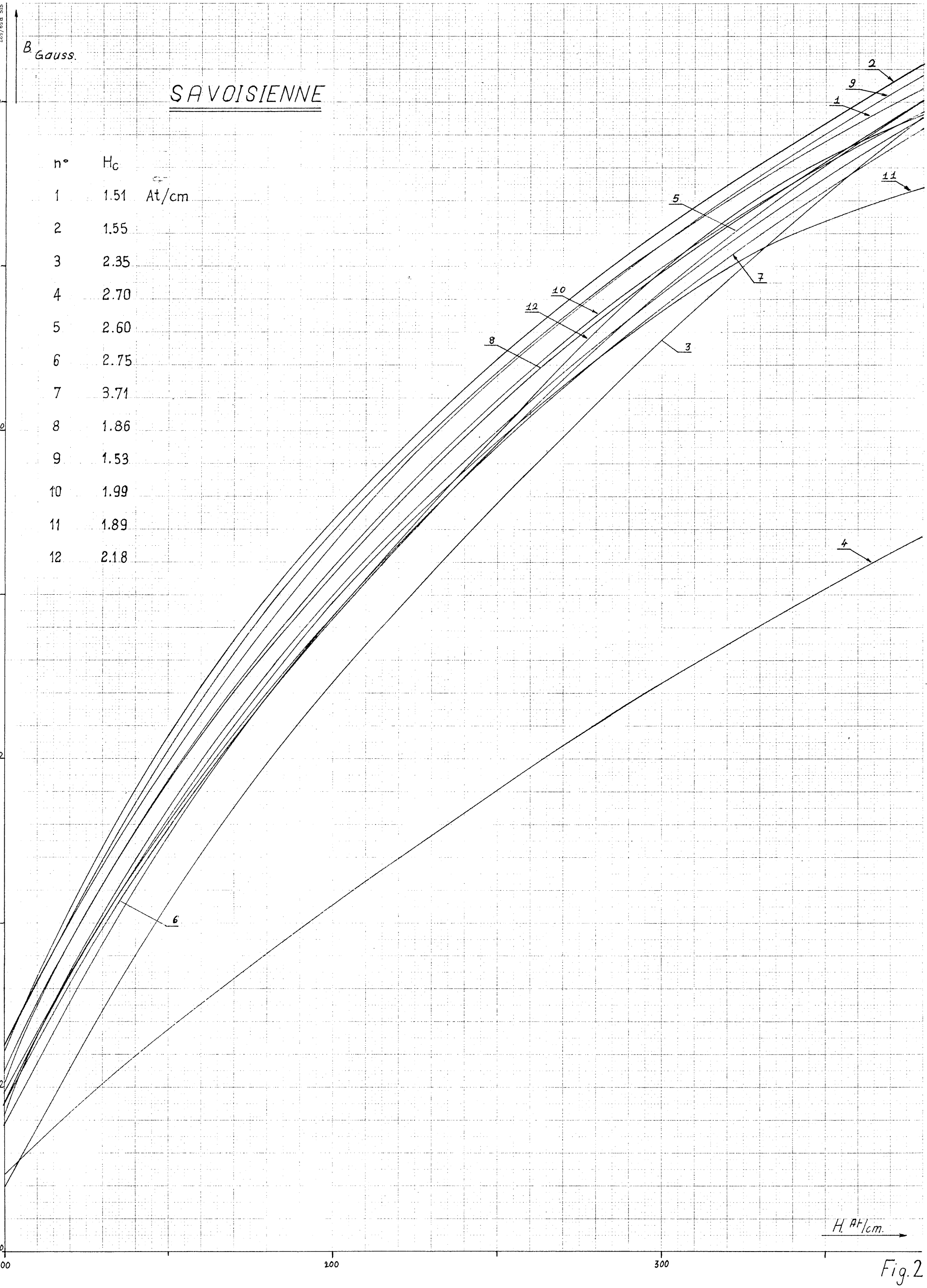


Fig. 2

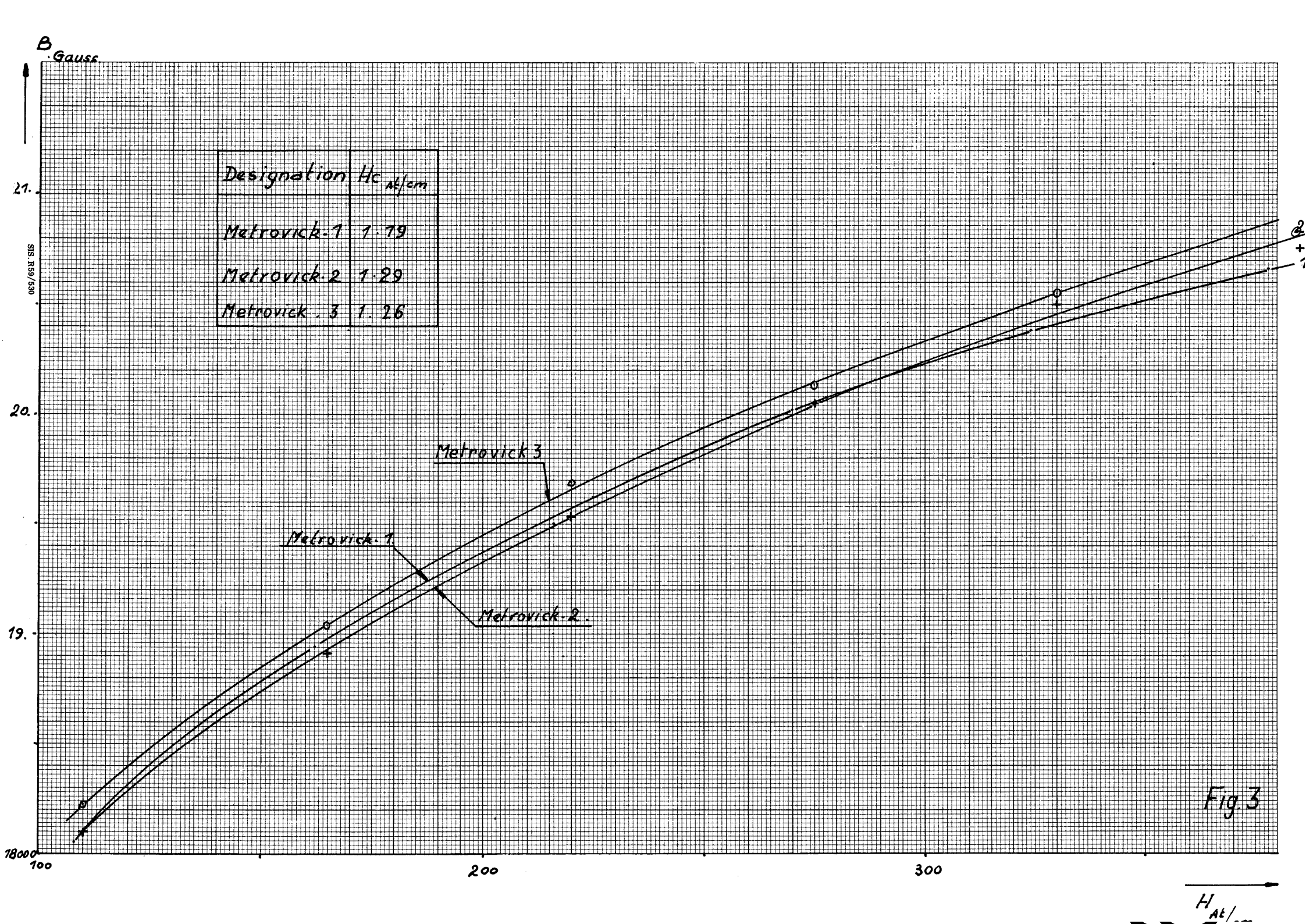

B
Gauss
Designation | Hc At/cm
Metrovick-1 | 1.79
Metrovick-2 | 1.29
Metrovick . 3 | 1.26
21.
20.
19.
18000
100
200
300
Metrovick 3
Metrovick. 1.
Metrovick. 2.
H
At/
SIS. R69/530

Fig. 3

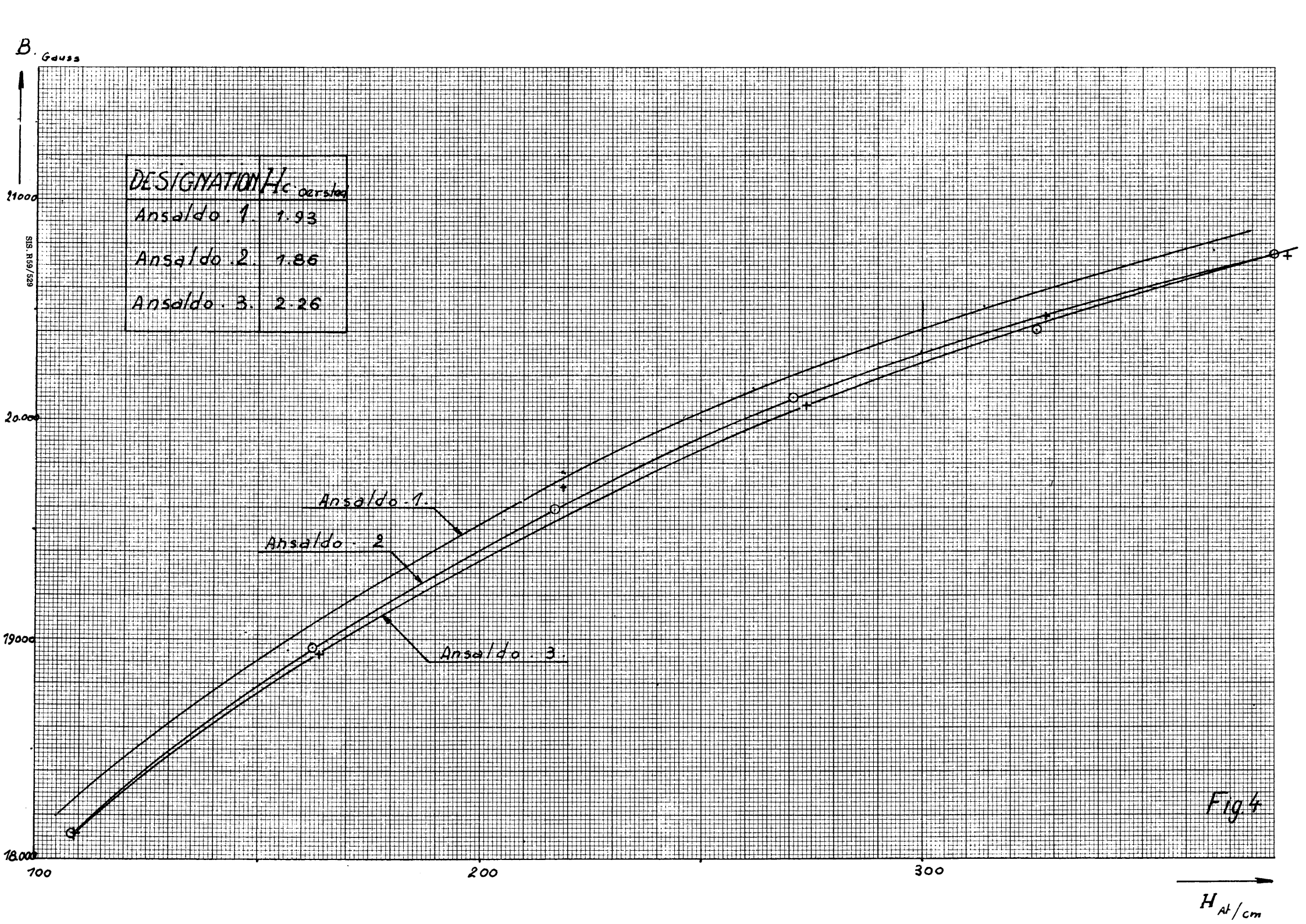
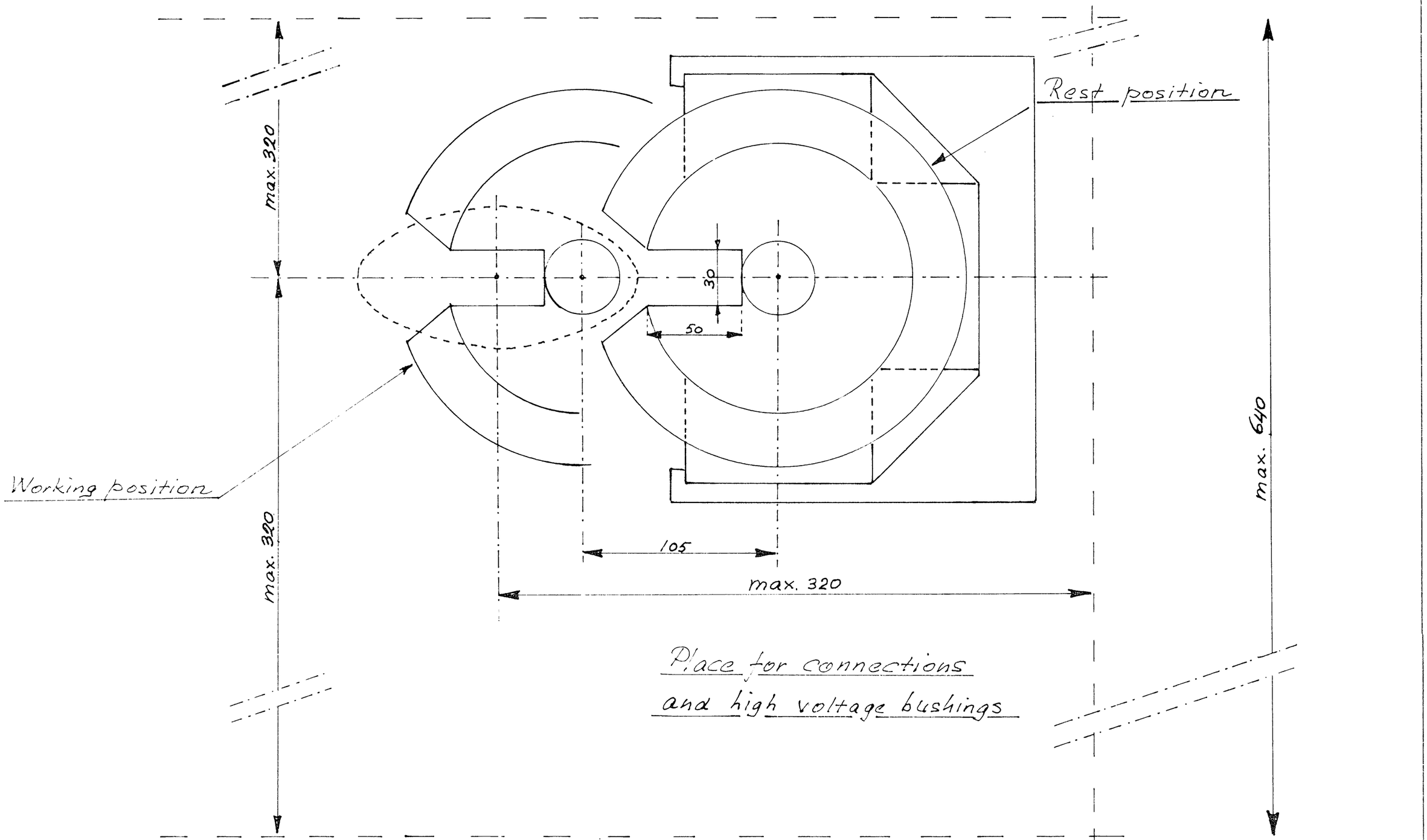

B. Gauss
21000
20000
19000
18000
100
200
300
H At/cm
DESIGNATION
Hc oersted
Ansaldo 1. 1.93
Ansaldo 2. 1.86
Ansaldo 3. 2.26
Ansaldo 1.
Ansaldo 2
Ansaldo 3.
SIS. R59/529

Fig. 4



Item Pos.	No. req. Nb. de p.	Descriptions	Material Matière	Pattern Modèle	Observations
1 11					
2 12					
3 13	III II I	Section of kicker-magnet with course of its movement.		Scale Echelle 1:2.	CERN- GENÈVE
4 14					
5 15					
6 16					
7 17		Modifications	Signatures		Fig. 4
8 18					
9 19					
10 20					

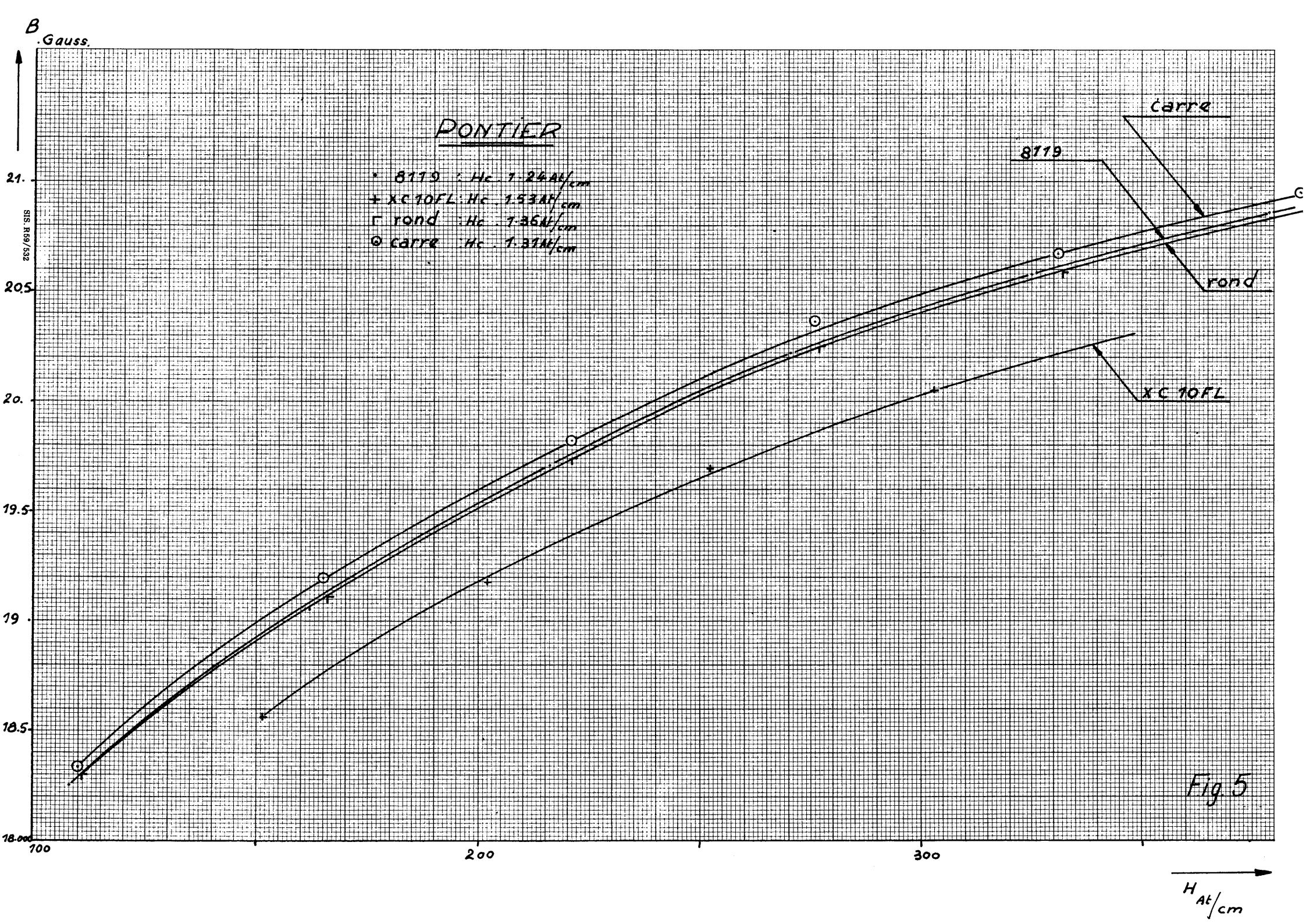
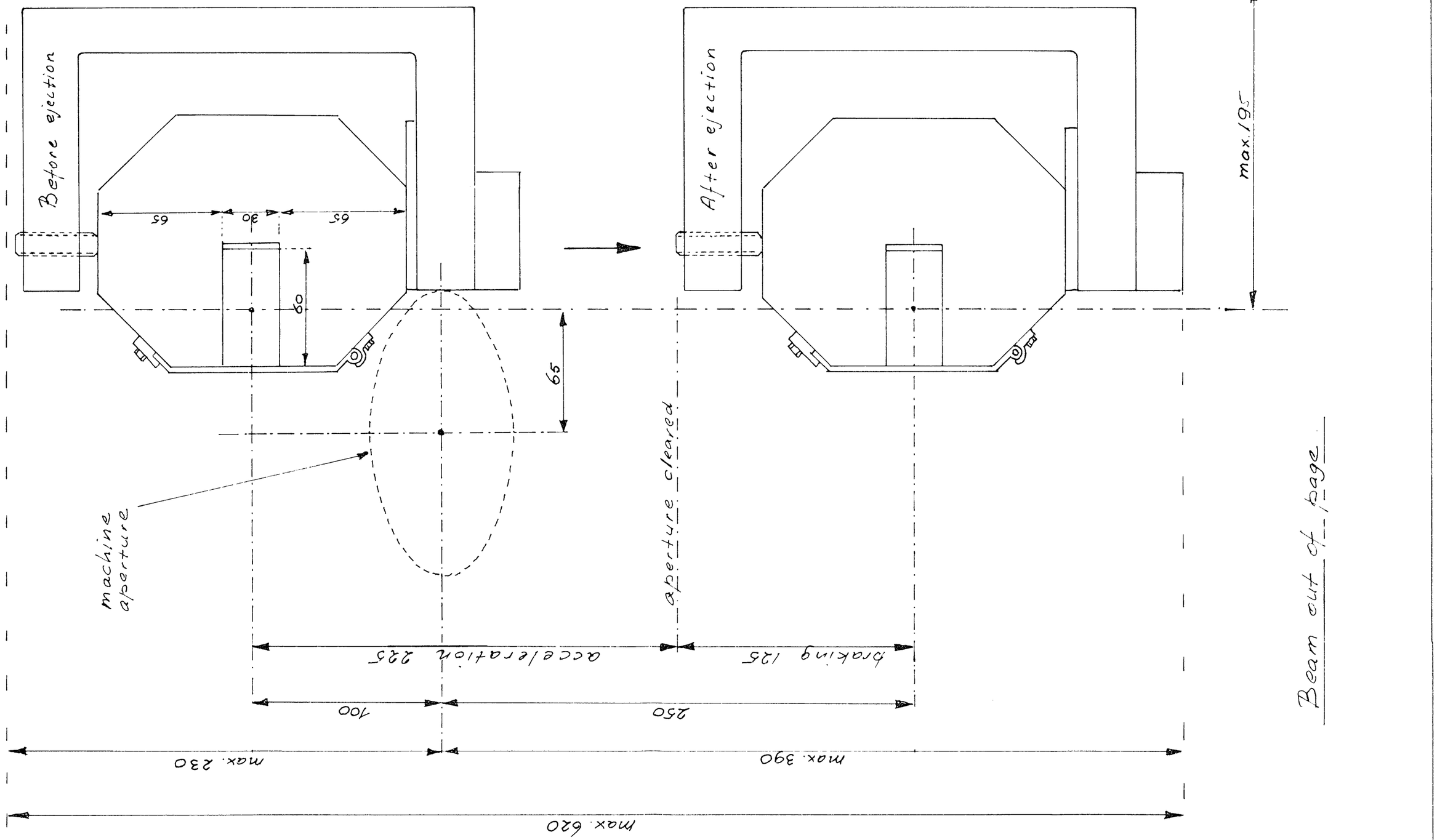

B
Gauss
PONTIER
• 8119 : Hc 1·24 At/cm
+ XC 10FL : Hc 1·53 At/cm
⊓ rond : Hc 1·36 At/cm
⊙ carre : Hc 1·31 At/cm
carre
8119
rond
XC 10FL
SIS. R59/532
21.
20.5
20.
19.5
19
18.5
18.000
100
200
300
H At/cm

Fig. 5



Item Pos.	No. req. Nb. de p.	Descriptions	Material Matière	Pattern Modèle	Observations
		Section of bending-magnet with course of its movement.		Scale Echelle 1:2	CERN- GENÈVE
		Modifications	Signatures		Fig. 5

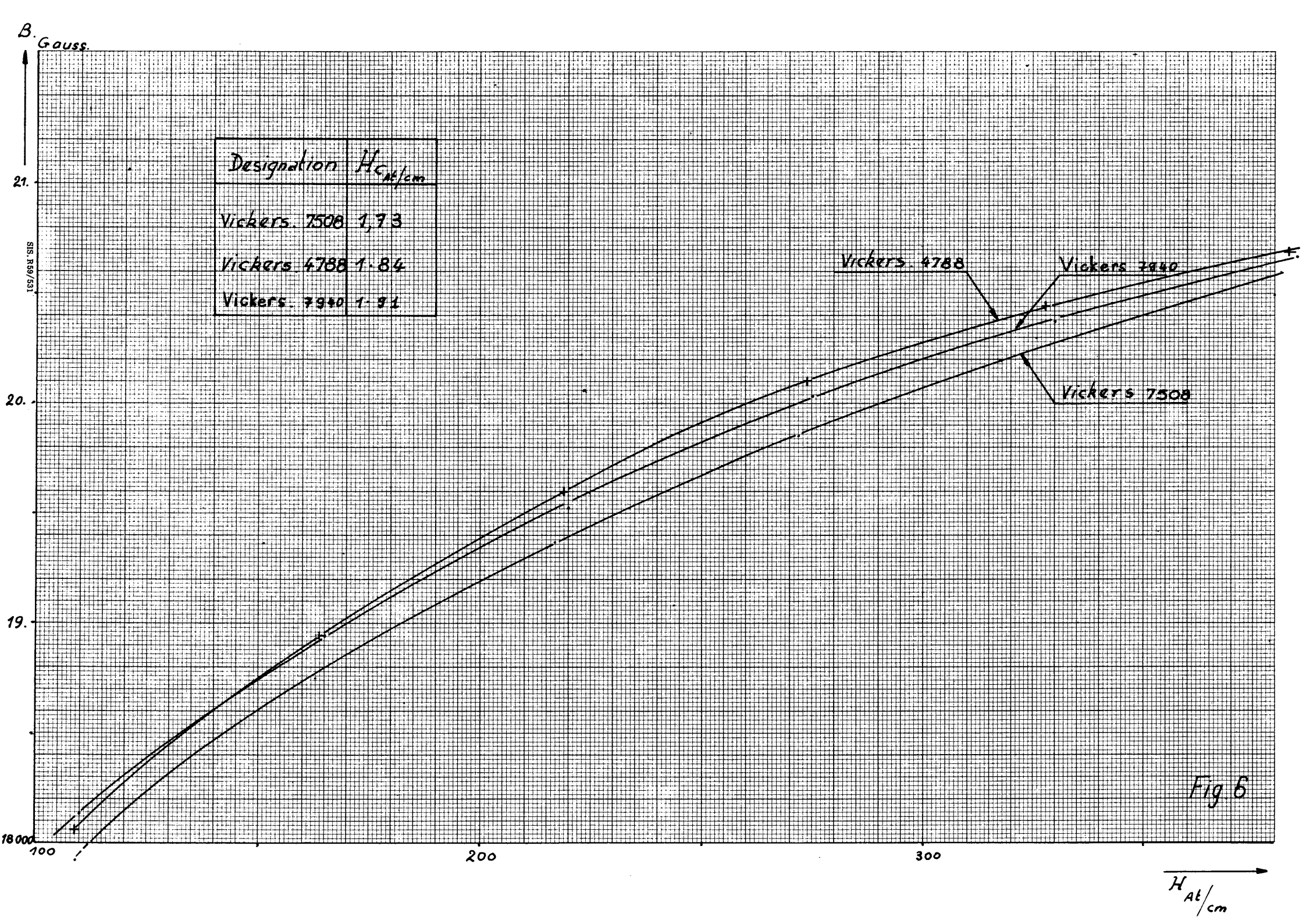

B. Gauss.
21.
20.
19.
18000
100
200
300
$H_{At/cm}$
Designation | $H_{c\,At/cm}$
Vickers. 7508 | 1,73
Vickers 4788 | 1·84
Vickers. 7940 | 1·91
Vickers. 4788
Vickers 7940
Vickers 7508
SIS. R59/531

Fig 6

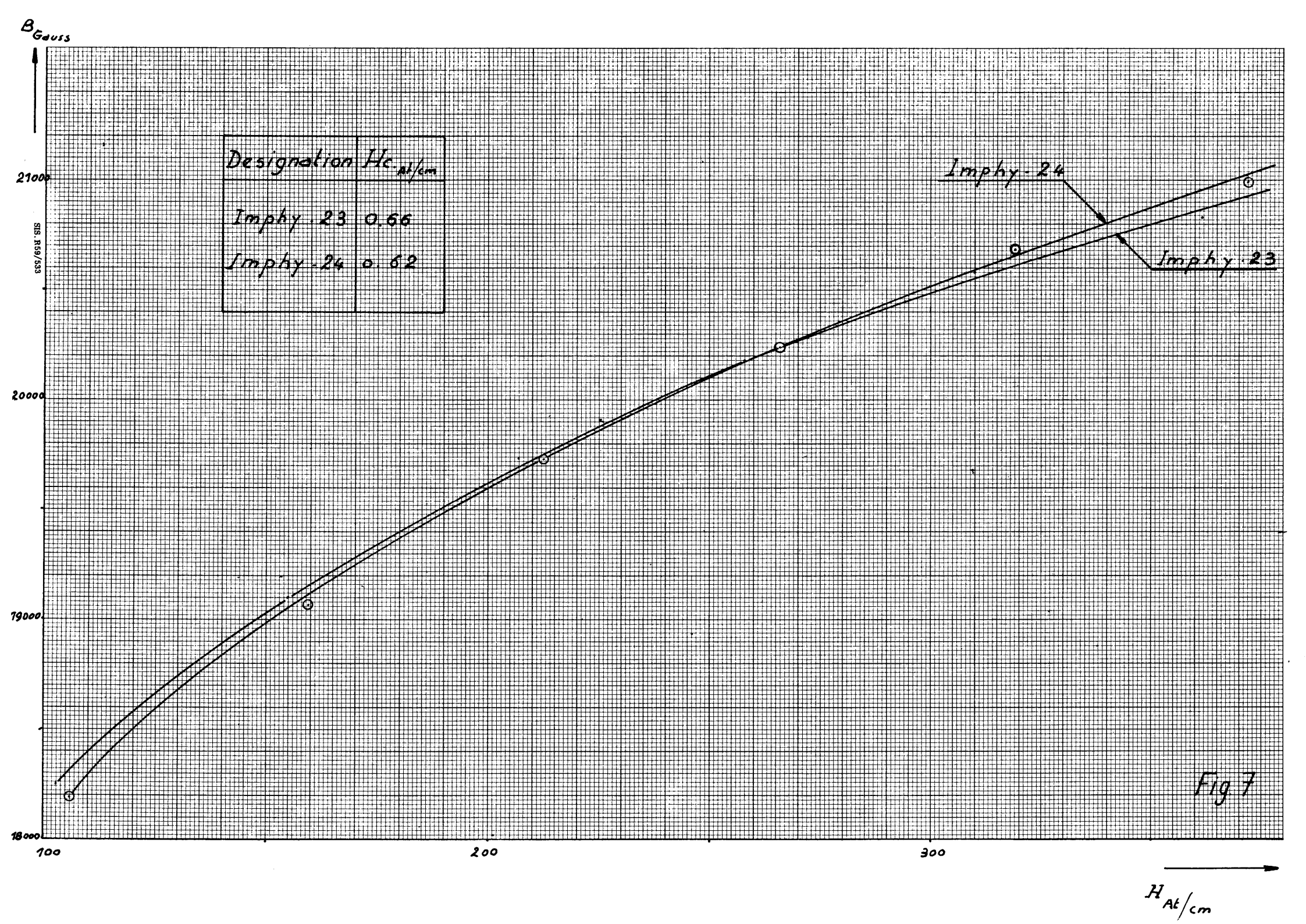

B Gauss
Designation
Hc At/cm
Imphy-23
0.66
Imphy-24
0.62
Imphy-24
Imphy-23
21000
20000
19000
18000
100
200
300
H At/cm
SIS. R59/533

Fig 7

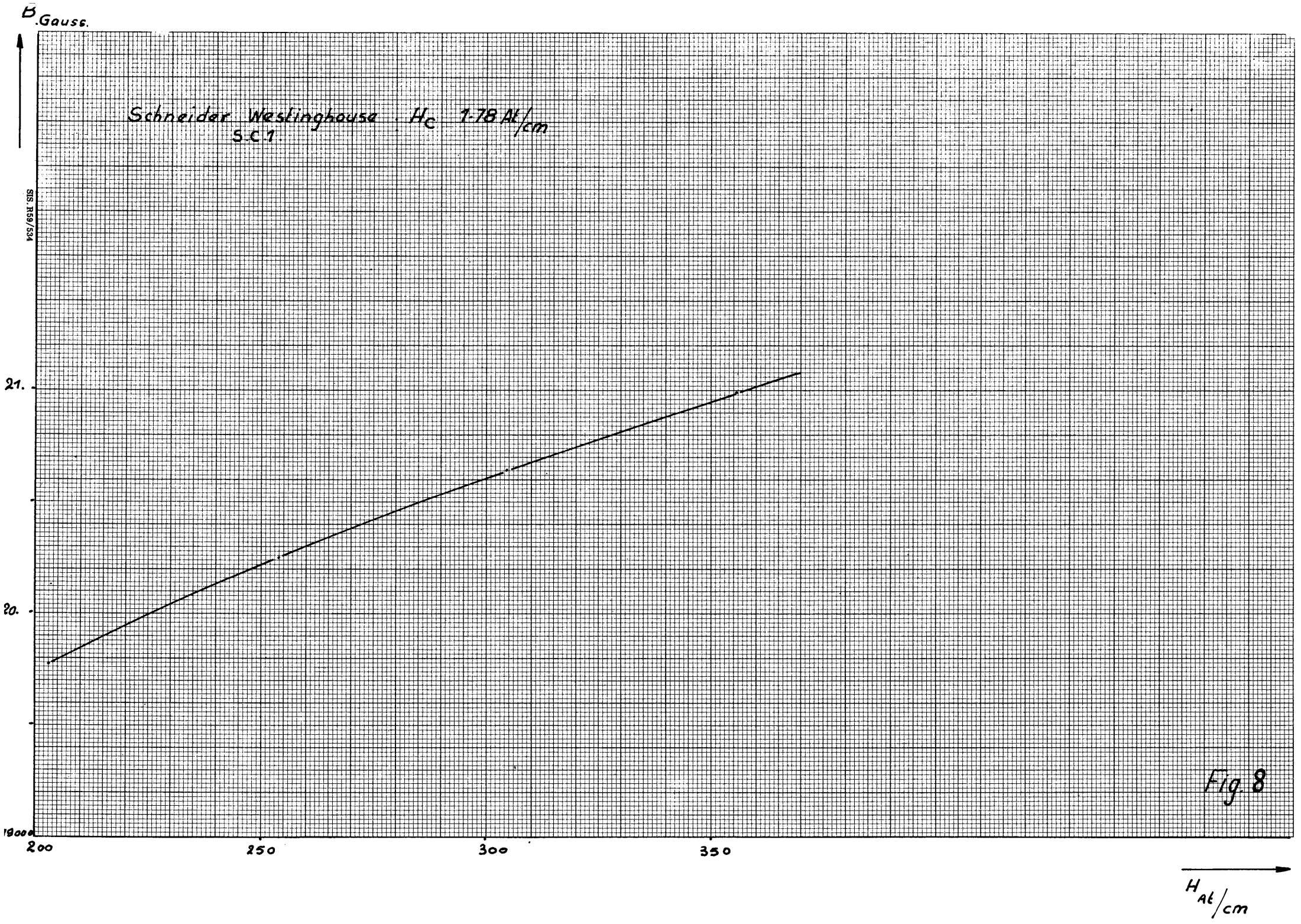

B Gauss.
Schneider Westinghouse . Hc 1-78 At/cm
S.C.1.
SIS. R59/534
21.
20.
19000
200
250
300
350
H At/cm

Fig. 8

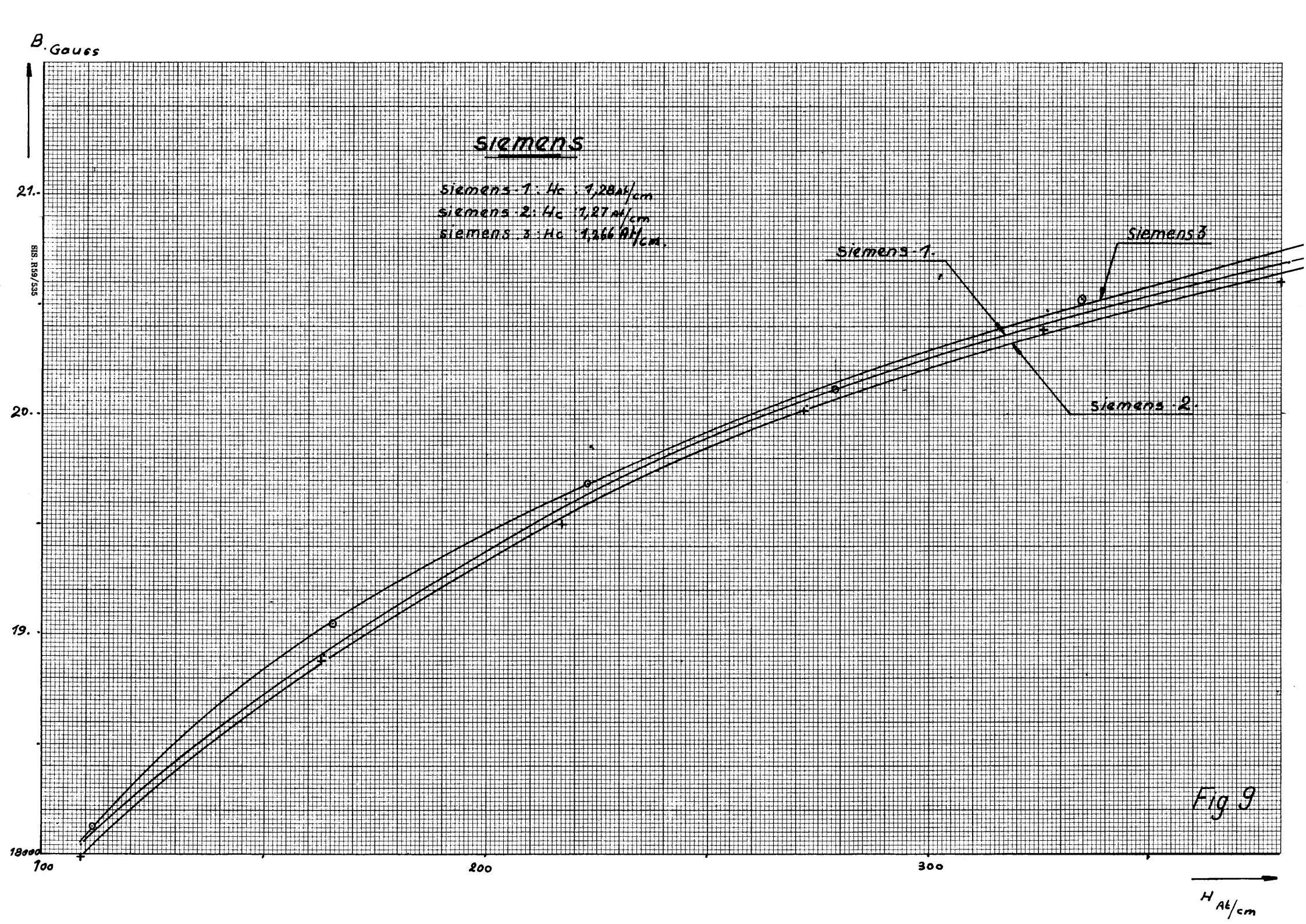

B. Gauss
Siemens
Siemens-1: Hc : 1,28 At/cm
Siemens-2: Hc : 1,27 At/cm
Siemens-3: Hc : 1,266 At/cm.
Siemens-1.
Siemens 3
Siemens-2.
21.
20.
19.
18000
100
200
300
H At/cm
SIS. R59/535

Fig 9

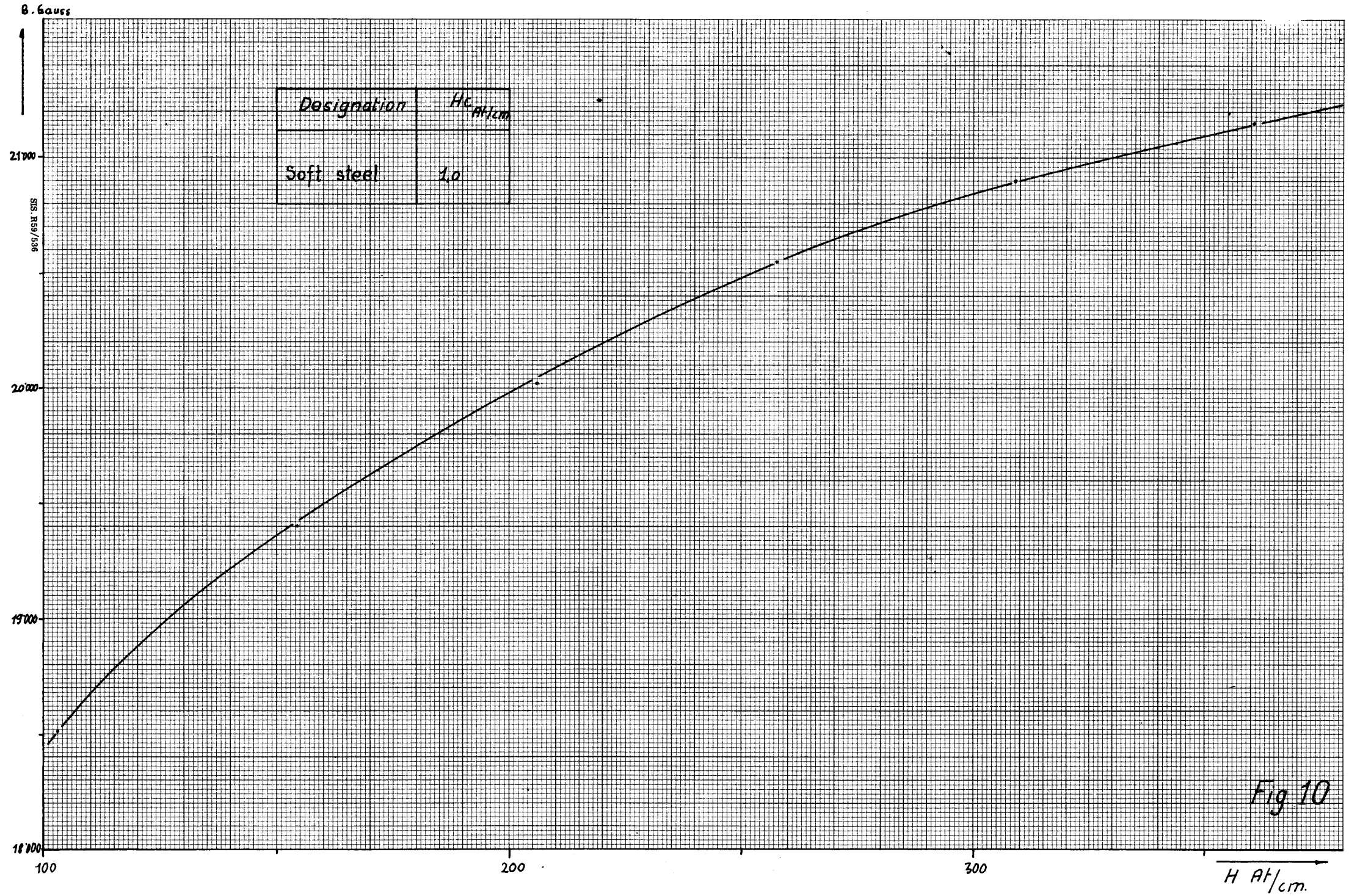

B. Gauss
21'000
20'000
19'000
18'000
100
200
300
H At/cm.
Designation
Hc At/cm
Soft steel
1,0
SIS. R59/536

Fig 10

Sandwich construction

etc. etc.

Unit 2 (62)

Open sector

Closed sector

etc. etc.

Unit 100 (60)

Detail of joint to flange in Fig. 11, sec. A.

Sec. A see fig. 11

Item Pos.	No. req. Nb. de p.	Descriptions	Material Matière	Pattern Modele	Observations
1 11					
2 12	III II I	Ejection Vacuum Chamber in unit 1 (61)		Scale Echelle 1:25	CERN- GENÈVE
3 13		DETAIL OF THE ENDS.			
4 14					
5 15					
6 16					
17		Modifications	Signatures		Fig. 10
18					
19					
10 20					

FE-1.