PS-CD/Note 78-3

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Planar Hall-Effect of the Plates
Types SBV 601, SBV 601-S1, SBV 585 and SBV 585-S1

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The Hall-plate is located in the x-y plane (Fig. 1) and the plate is very thin in the z-direction. The current flows only in the x-direction. For this case we can write

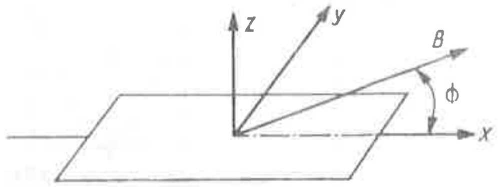


Fig. 1

$$E_x = \rho_o [1 + C (B_y^2 + B_z)] j_x$$

$$E_y = - \rho_o \cdot C B_x B_y j_x - R_H B_z j_x$$

For $B_y = 0$ or $B_x = 0$, that is if the vector B lies in the x - z plane or the y - z plane, the transverse field E_y is determined only by the z-component of B. The electric field strength E_y is

$$E_y = - R_H B_z j_x$$

This is the normal Hall-effect formula.

If the B_x as well as B_y is not zero, the situation is different. If, for example, the vector of B is located in the x - y plane, then B_z will be zero.

If ϕ is the angle between B and the x-axis then the E_y is

$$E_y = - \rho_o C B^2 \cos\phi \sin\phi \; j_x$$

$$= - \frac{1}{2} \rho_o C B^2 \sin 2\phi \; j_x$$

E_y is proportional to B^2 which disappears for $\phi = 0, 90, 180$ degree and which is a maximum at $\phi = 45$ and 135 degree. This effect is called the planar Hall-effect. It is proportional to the coefficient C which describes the magnetoresistance effect.

For a defined plate, with the thickness d, the width b, $j_x = \frac{i}{bd}$ and $E_y = \frac{Upl}{b}$, the planar Hall-voltage will be

$$Upl = - \frac{1}{2d} \cdot \rho_o CB^2 . \sin 2\phi . i$$

Fig. 2 shows the planar Hall-voltage Upl for example dependent on the angle ϕ between B and i at B constant.

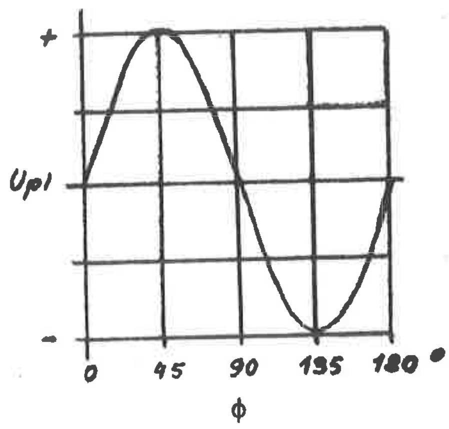


Fig. 2

The maximum of the planar Hall-voltage with $\phi = 45^o$ is

$$Upl_{max} = - \frac{1}{2d} \cdot \rho_o CB^2 i$$

The nominal Hall-voltage with B perpendicular to the plate is

$$U_H = - \frac{R_H}{d} . Bi$$

The ratio of Upl_{max}/U_H is

$$\frac{Upl_{max}}{U_H} = \frac{\rho_o CB}{2R_H}$$

The planar Hall-voltage does disappear only if the isotropic material has neither a tranverse nor a longitudinal magnetoresistance.

Measurement of the Planar Hall-Voltage and the Ratio Upl_{max}/U_H

The measurement was done on two types of plate. The geometric shows on Fig. 3 (type SBV 601) and Fig. 4 (SBV 585).

The field B is in the plan of the plate.

The angle $\phi = 45^o$. The current i = 100 mA.

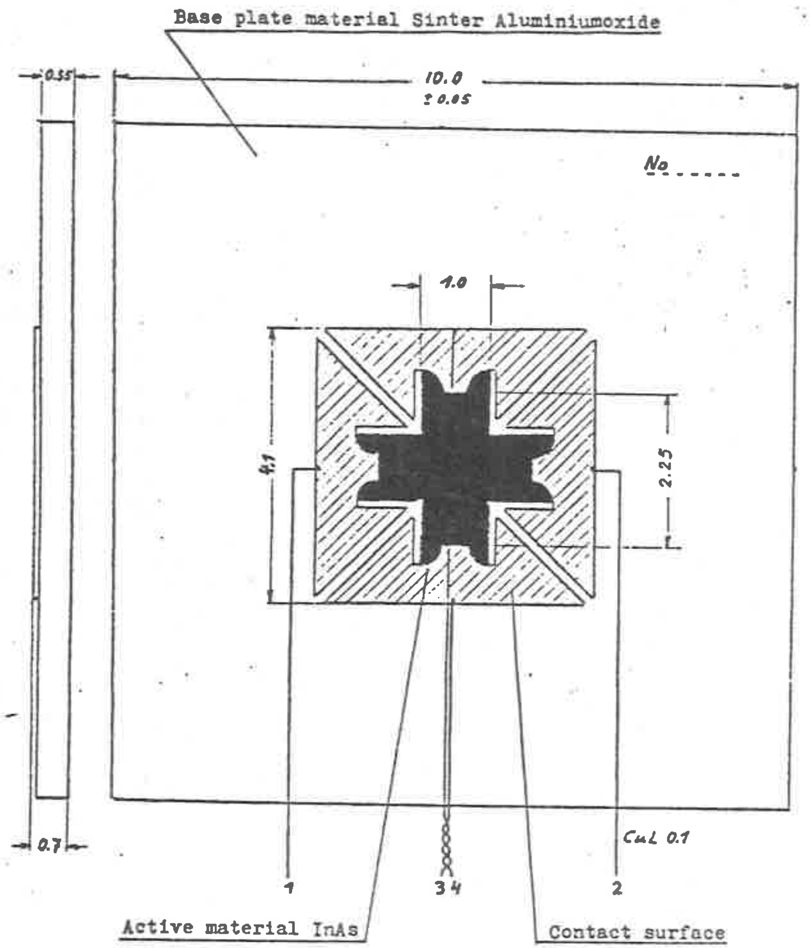
Fig. 5	SBV 601 $R_H \sim 100$ Upl = f(B)
Fig. 6	SBV 601 $R_H \sim 100$ ratio Upl/U_H = f(B)
Fig. 7	SBV 601-S1 $R_H \sim 10$ Upl = f(B)
Fig. 8	SBV 601-S1 $R_H \sim 10$ ratio Upl/U_H = f(B)

Fig. 9	SBV 585 $R_H \sim 100$ Upl = f(B)
Fig. 10	SBV 585 $R_H \sim 100$ ratio Upl/U_H = f(B)
Fig. 11	SBV 585-S1 $R_H \sim 10$ Upl = f(B)
Fig. 12	SBV 585-S1 $R_H \sim 10$ ratio Upl/U_H = f(B)

List of Symbols

B	magnetic induction (Vs/cm^2)
B_x, B_y, B_z	components of the vector B
b	width of the Hall-plate (cm)
C	coefficient which describes the magnetoresistance effect (cm^2/Vs)
d	thickness of the Hall-plate (cm)
E	electrical field strength (V/cm)
E_x, E_y, E_z	components of vector E
i	control current (A)
j_x	component of electric current density (A/cm^2)
R_H	Hall coefficient (cm^3/AS)
Upl	planar Hall-voltage (V)
U_H	Hall-voltage (normal effect) (V)
ρ_o	resistivity in zero magnetic field (Ω cm)
ϕ	angle between magnetic induction B and the x-axis

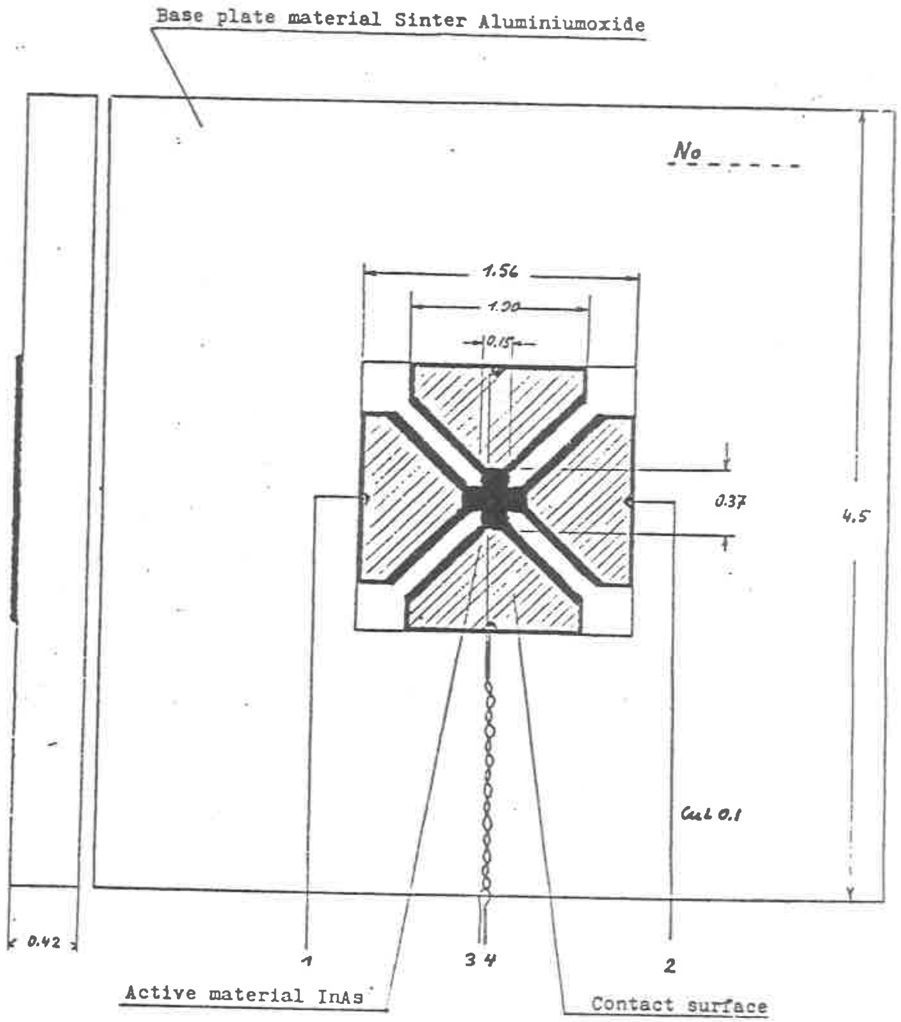
Fig. 3 Hallgenerator SBV 601 and SBV 601-S1 Siemens



Hall-voltage 3,4

control current 1,2

Fig. 4 Hallgenerator SBV 585 and SBV 585-S1 Siemens



Hall-voltage 3,4

Control current 1,2

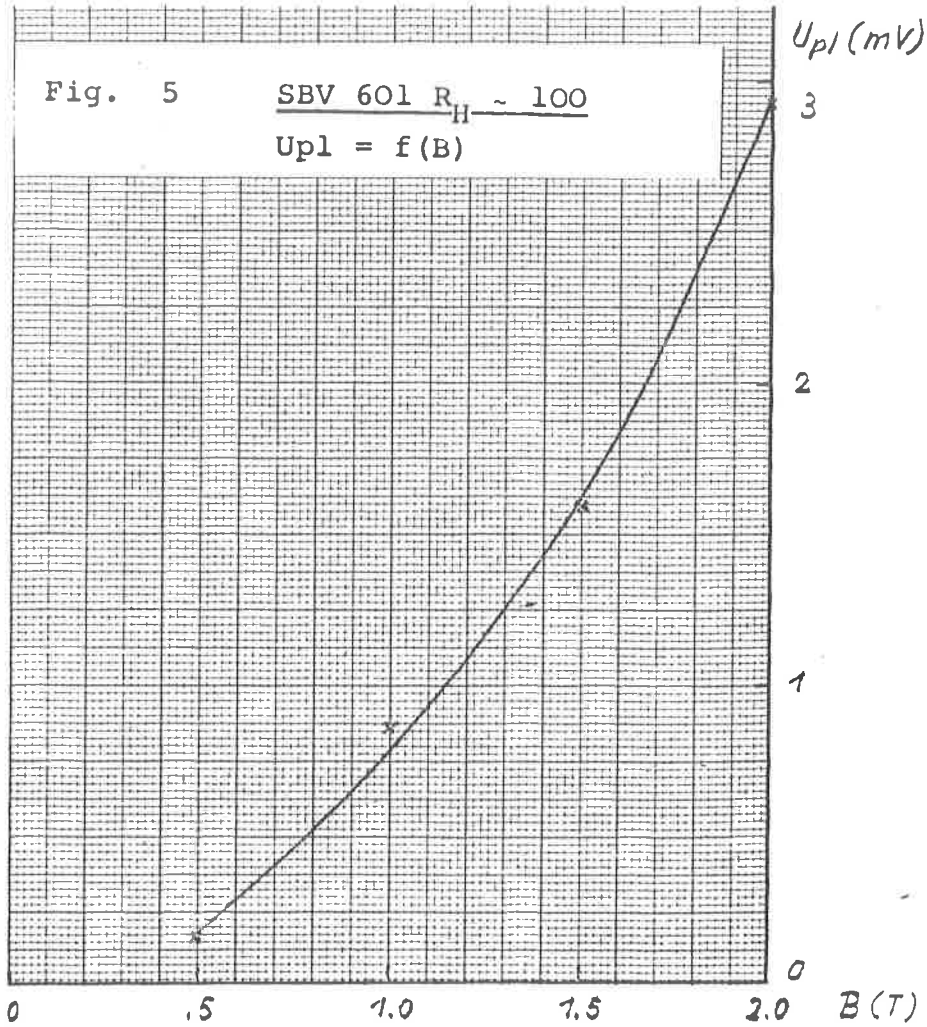


Fig. 5
SBV 601 R_H ~ 100
Upl = f(B)
U_{pl} (mV)
3
2
1
0
0
.5
1.0
1.5
2.0
B (T)

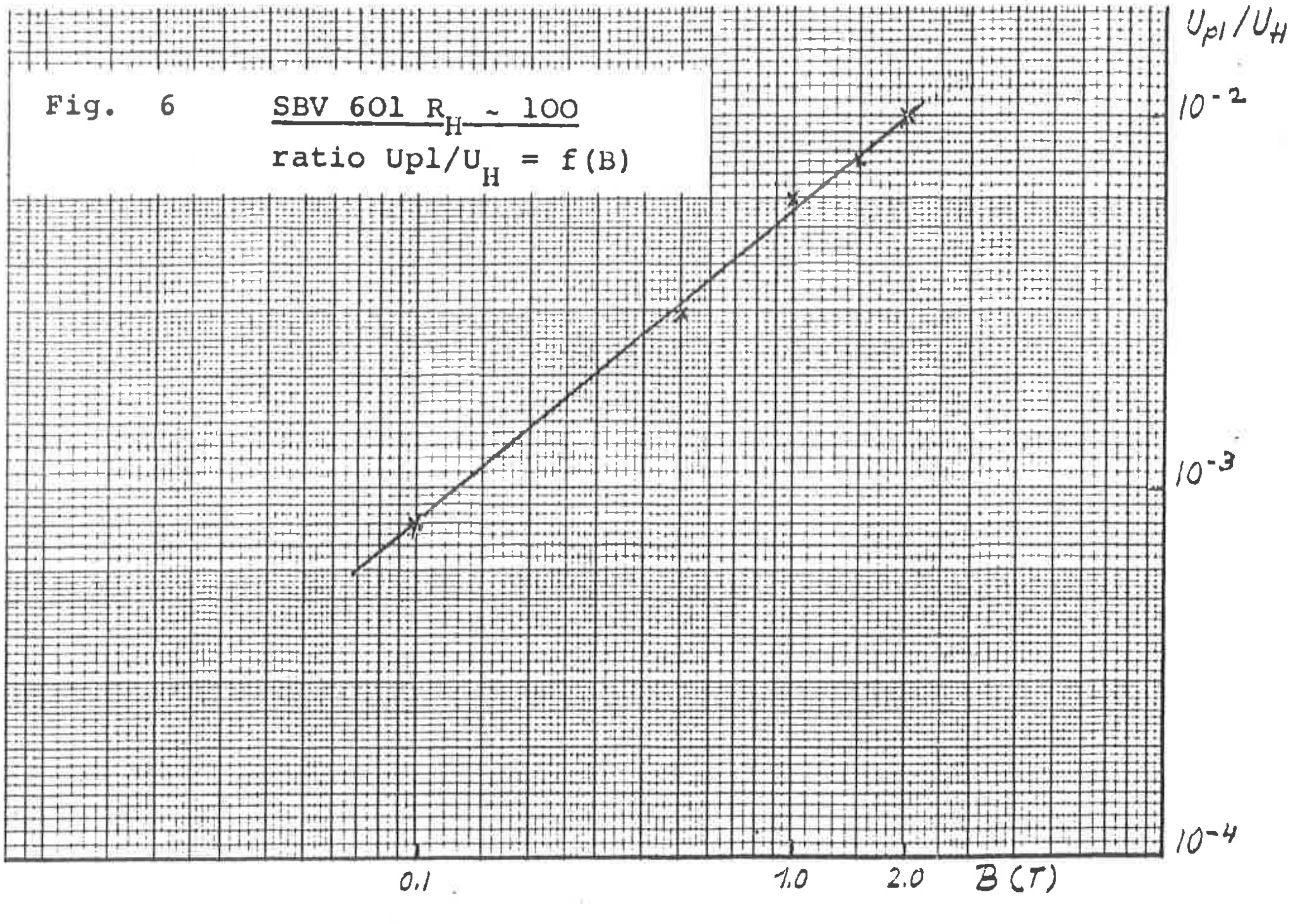


Fig. 6
SBV 601 R_H ~ 100
ratio Upl/U_H = f(B)
U_{pl}/U_H
10^{-2}
10^{-3}
10^{-4}
0.1
1.0
2.0
B (T)

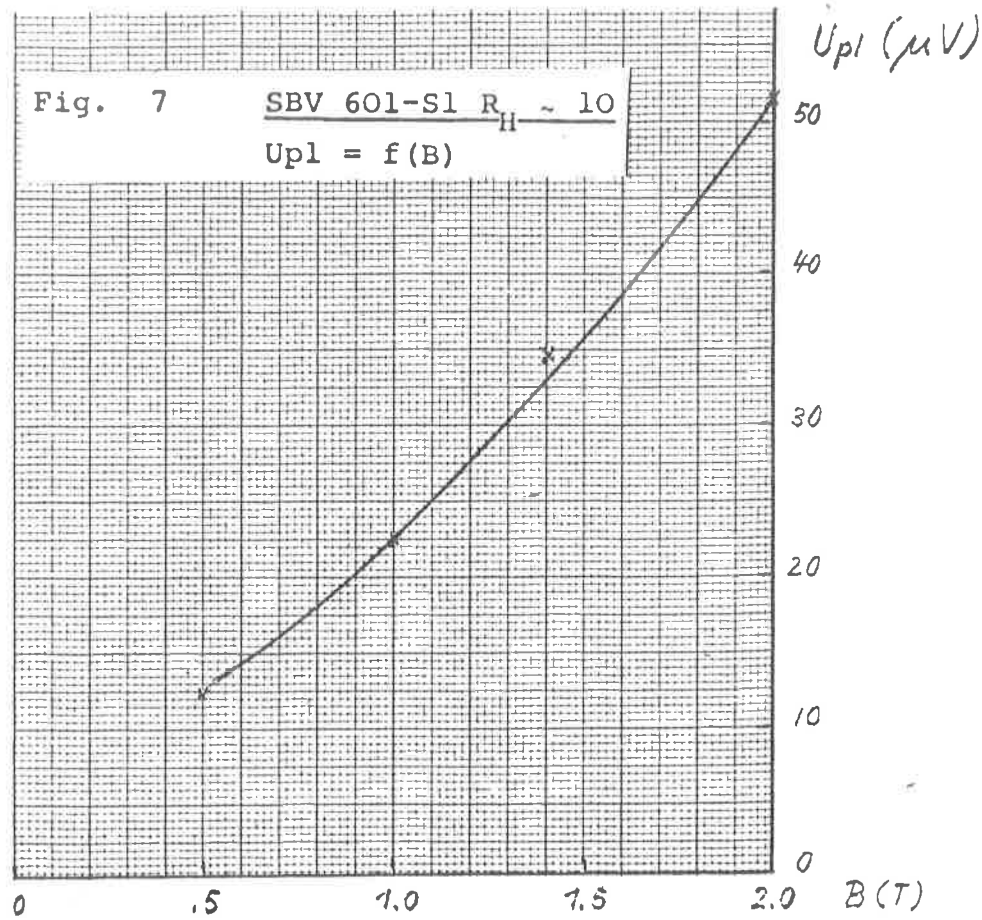


Fig. 7 SBV 601-S1 $R_H \sim 10$

Upl = f(B)

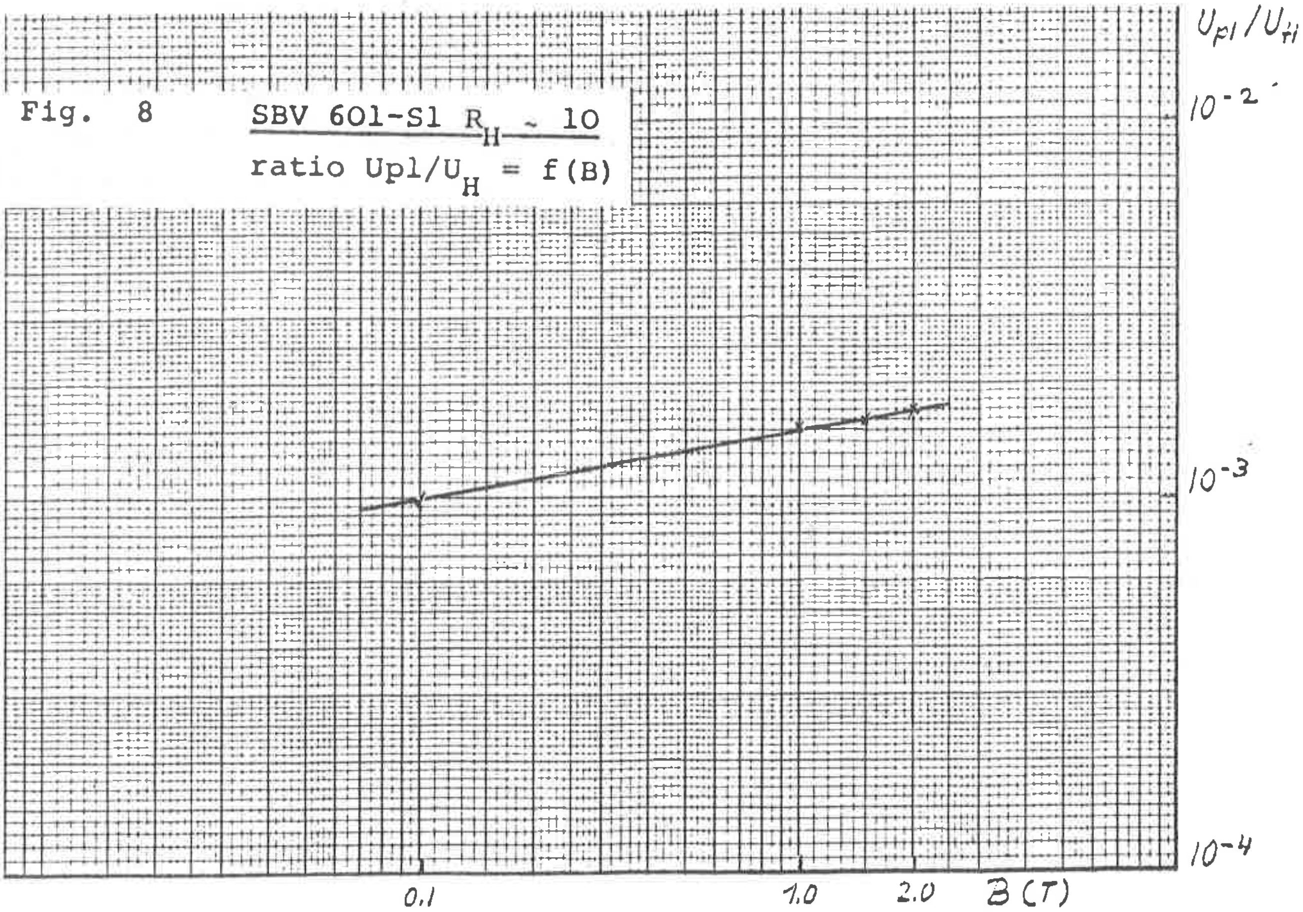


Fig. 8 SBV 601-S1 $R_H \sim 10$

ratio Upl/U_H = f(B)

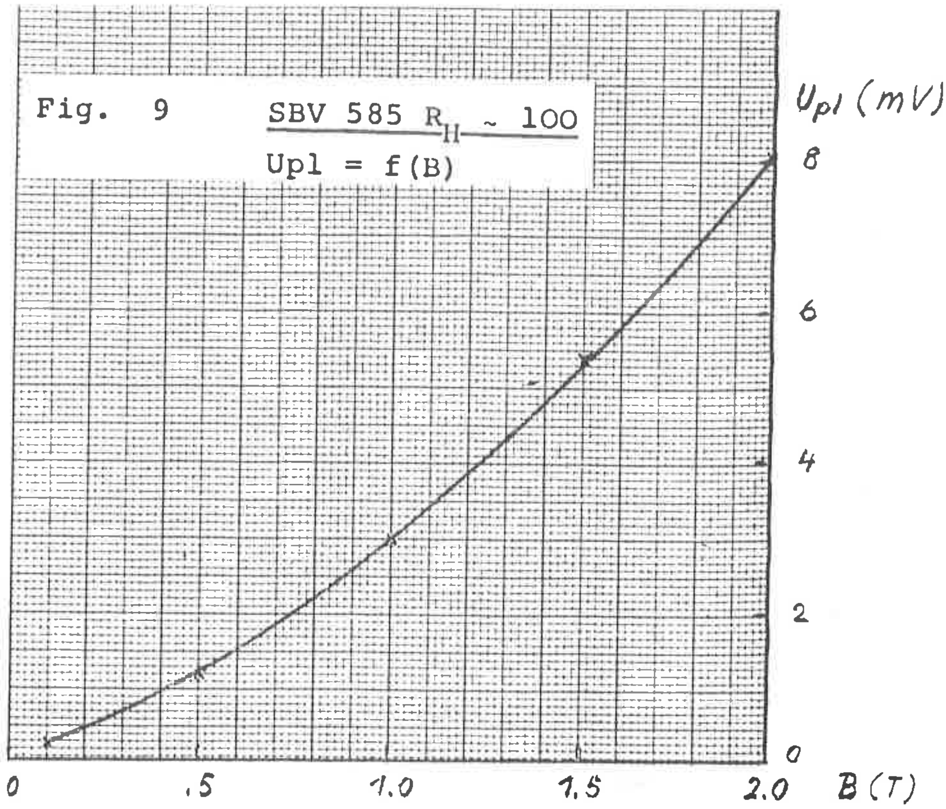


Fig. 9 SBV 585 $R_H \sim 100$

Upl = f(B)

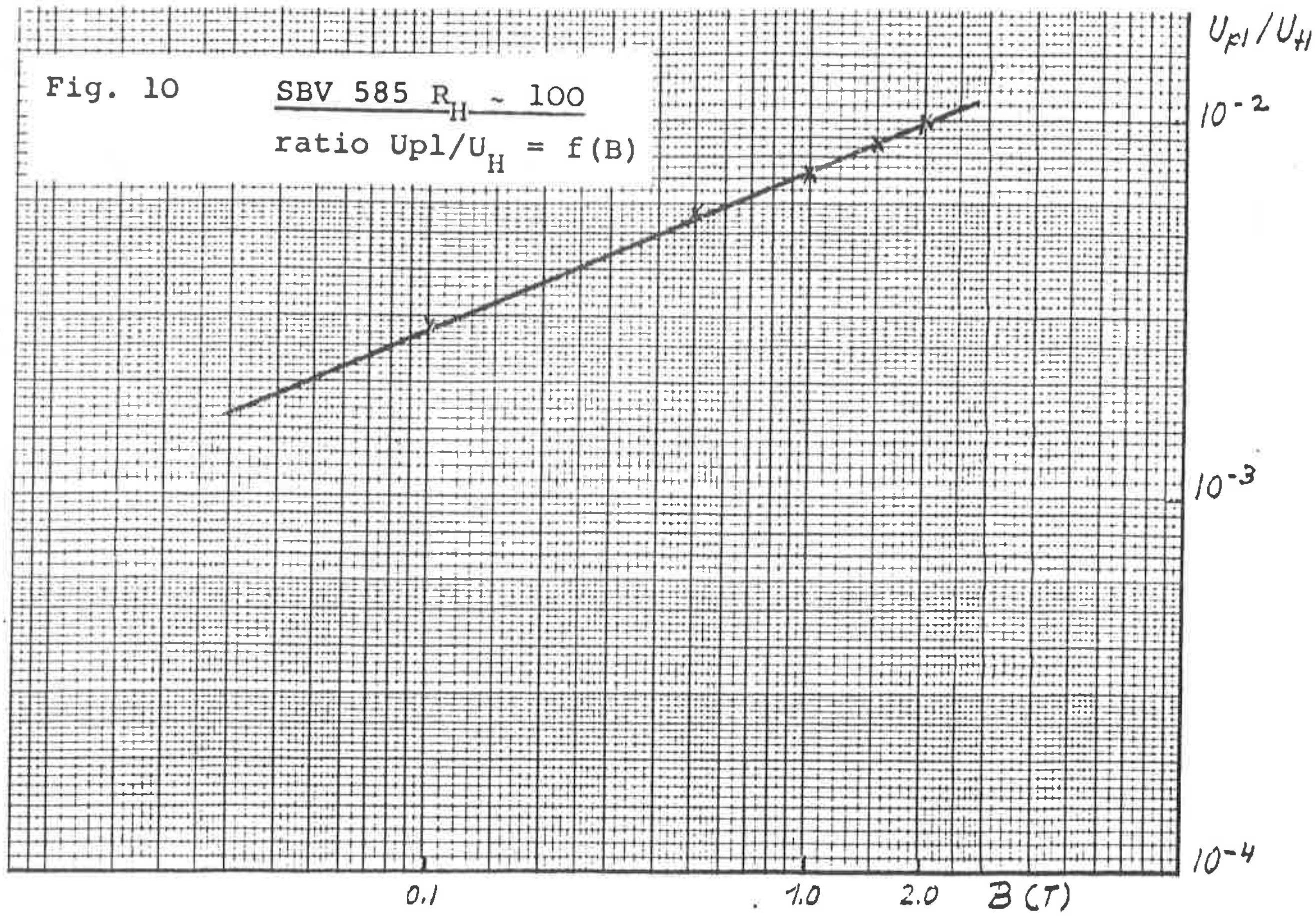


Fig. 10 SBV 585 $R_H \sim 100$

ratio Upl/U_H = f(B)

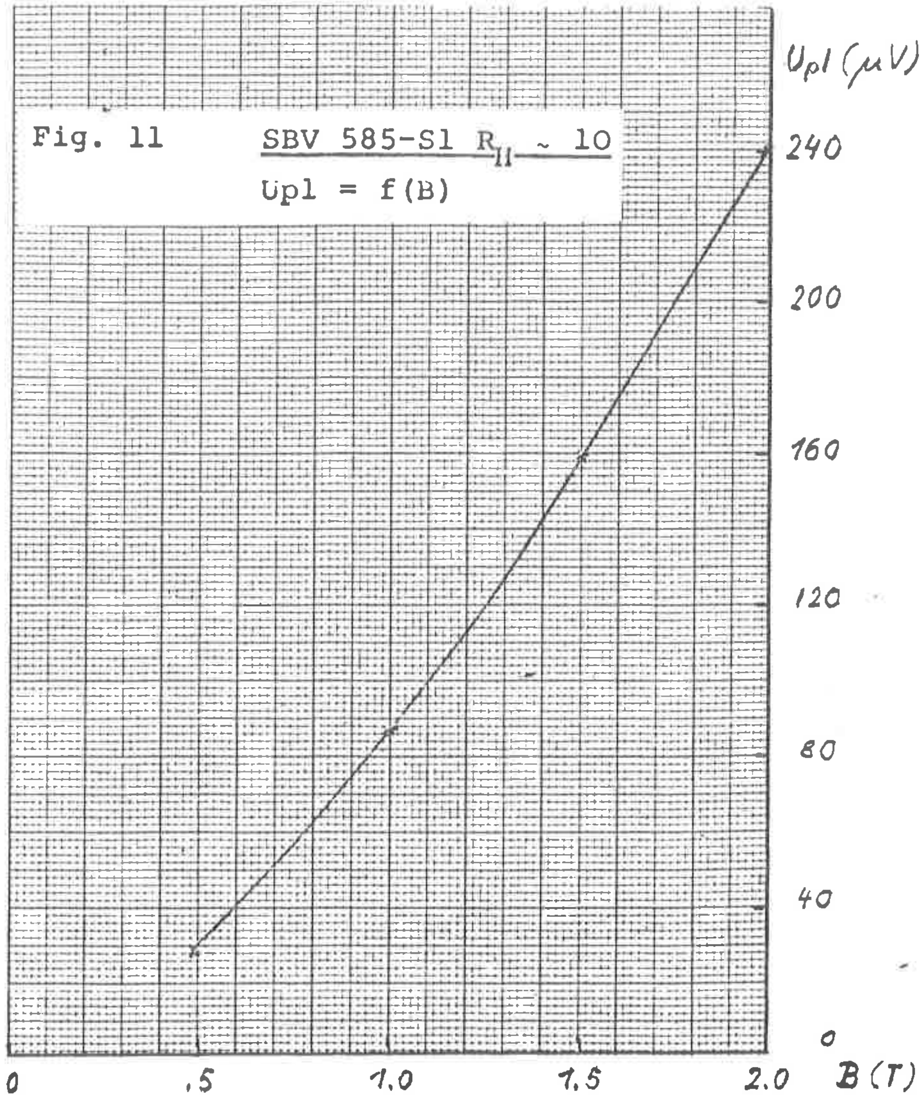


Fig. 11 SBV 585-S1 R_H ~ 10

Upl = f(B)

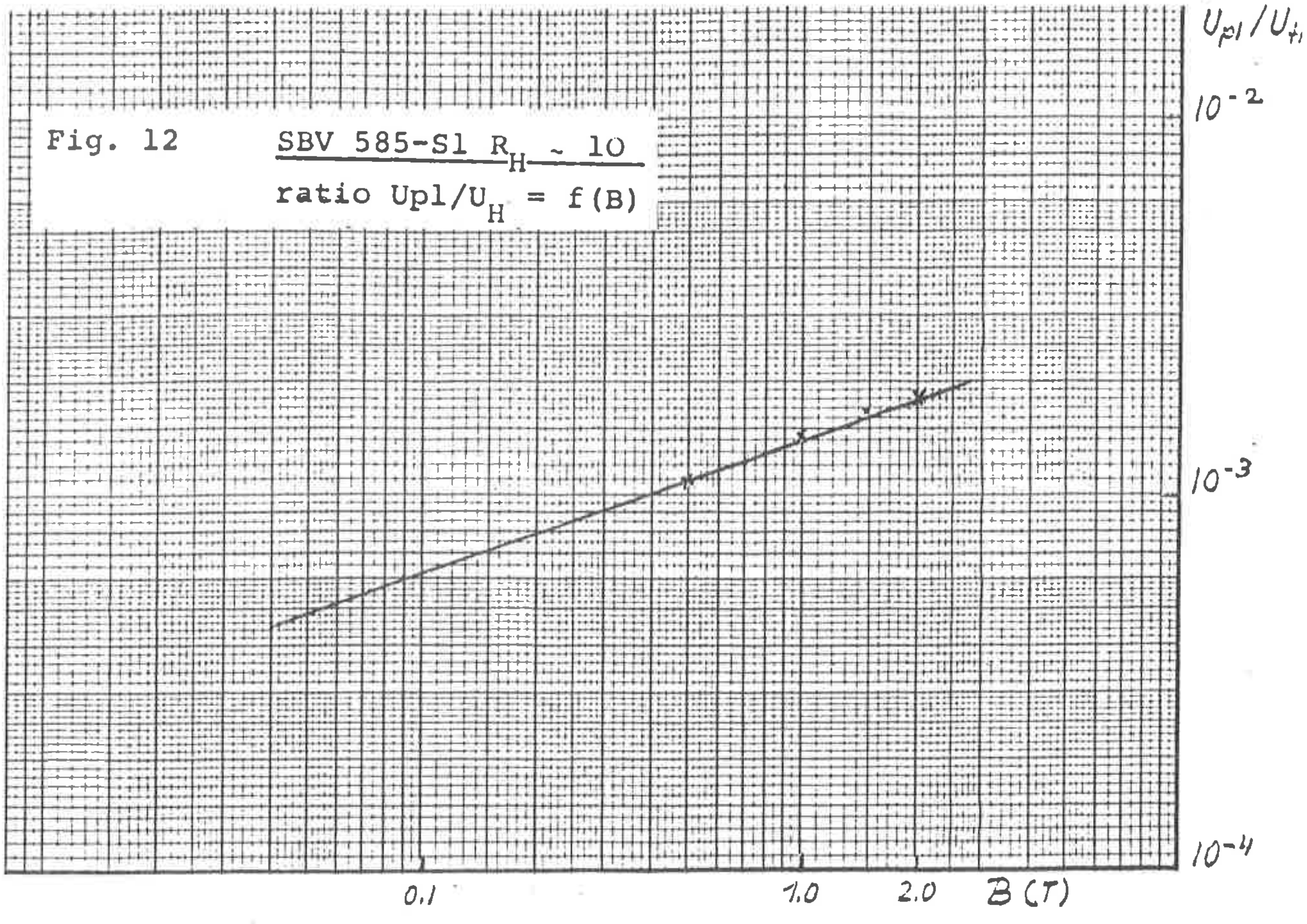


Fig. 12 SBV 585-S1 R_H ~ 10

ratio Upl/U_H = f(B)