COMISION NACIONAL DE ENERGIA ATOMICA

Manual del Curso

DOSIMETRIA EN RADIOTERAPIA

ATLAS

BUENOS AIRES
REPUBLICA ARGENTINA
1973

COMISION NACIONAL DE ENERGIA ATOMICA
DEPENDIENTE DE LA PRESIDENCIA DE LA NACION

A T L A S

MANUAL DEL CURSO
DOSIMETRIA EN RADIOTERAPIA

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† 17 noviembre 1971

BUENOS AIRES
REPUBLICA ARGENTINA
1 9 7 3

Fig. II-1

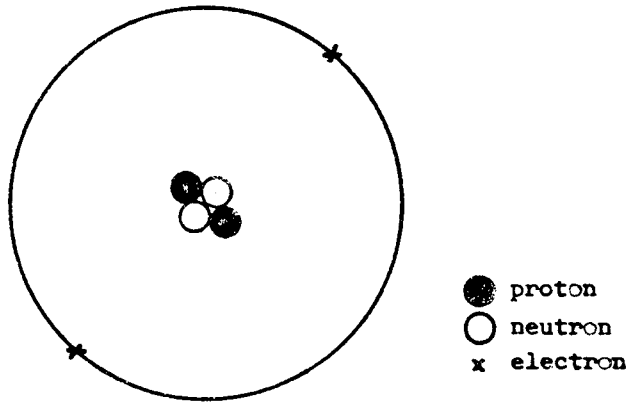


Fig. II-2

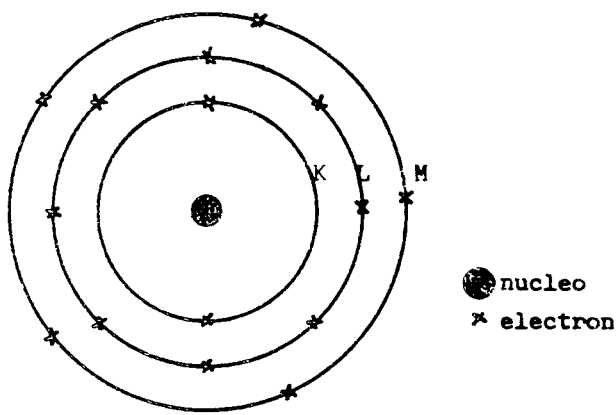


Fig. II-3

Esquema de desintegración del ^{244}Cm

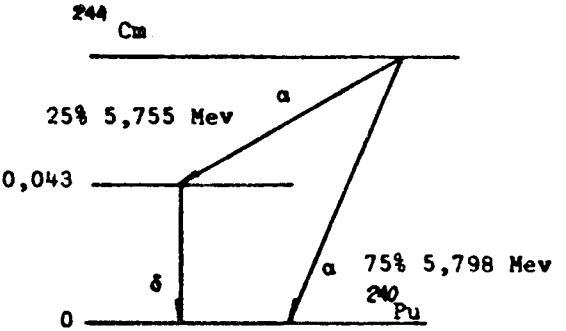


Fig. II-4

Esquema de desintegración del ^{60}Co

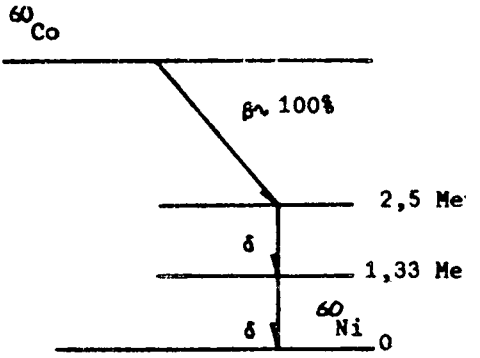


Fig. II-5

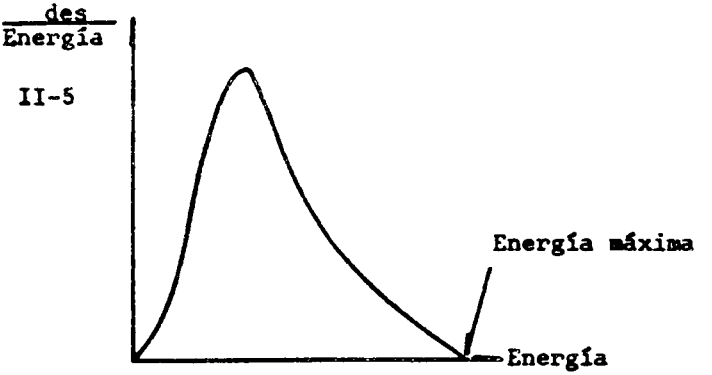


Fig. II-6

Esquema de desintegración del ^{42}K

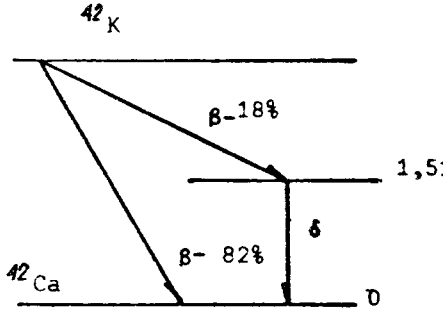


Fig. II-7

Esquema de desintegración del ^{73}As

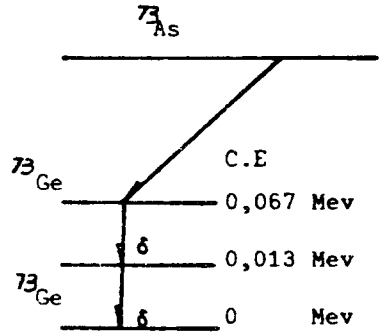


Fig. II-8

Esquema de desintegración del ^{137}Cs

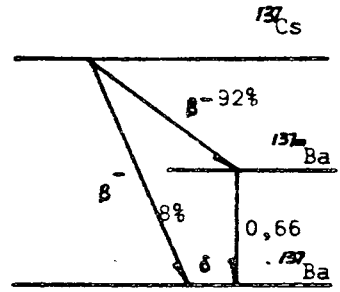


Fig. II-9

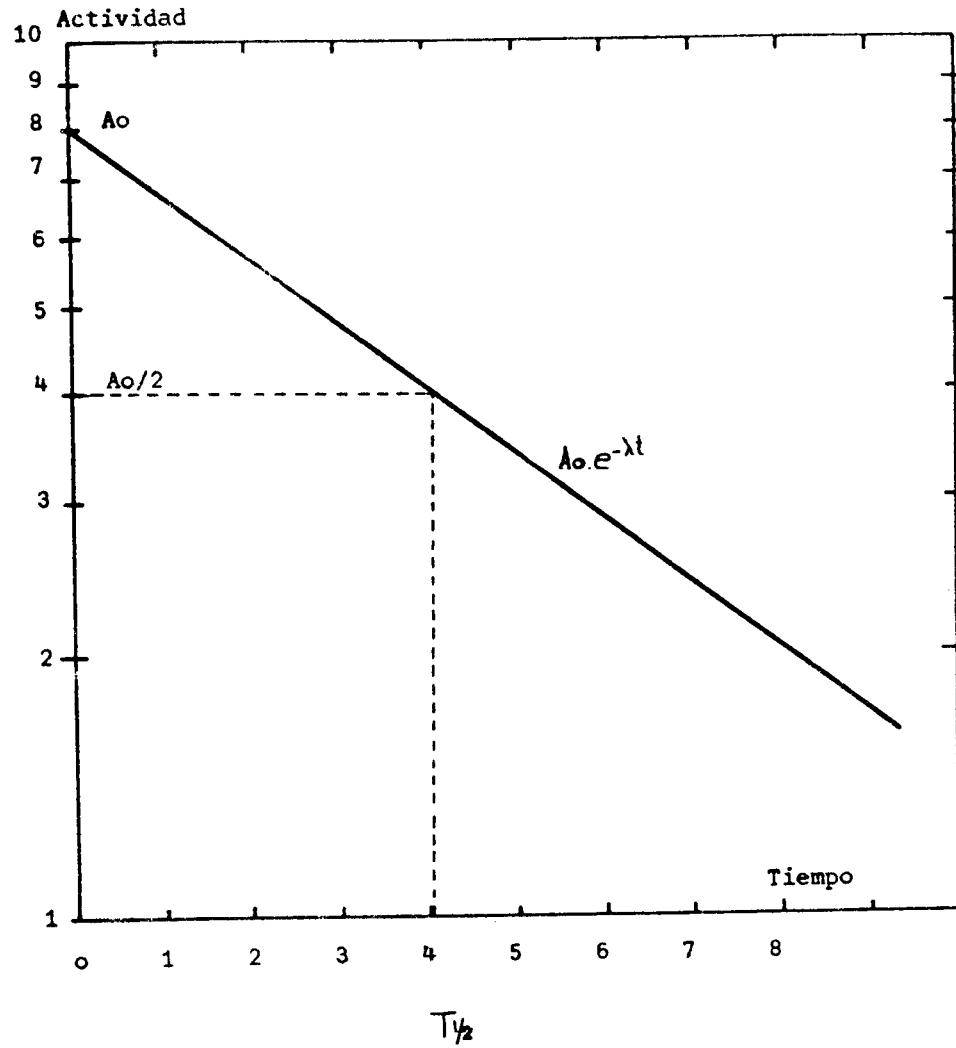


Fig. III-1

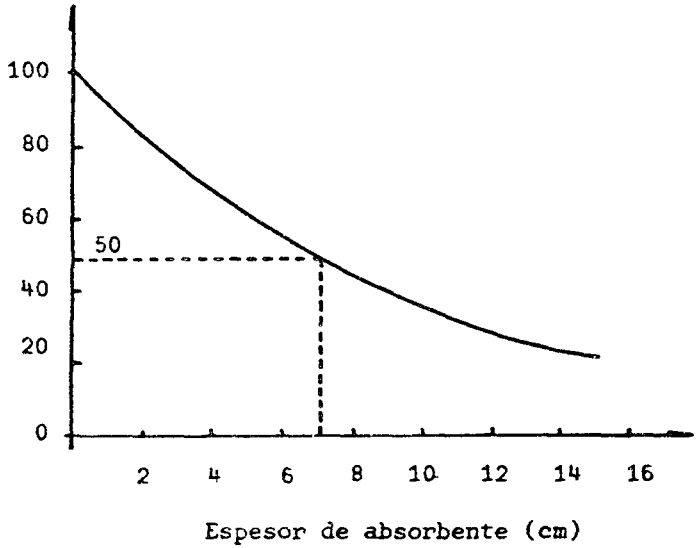


Fig. III-2

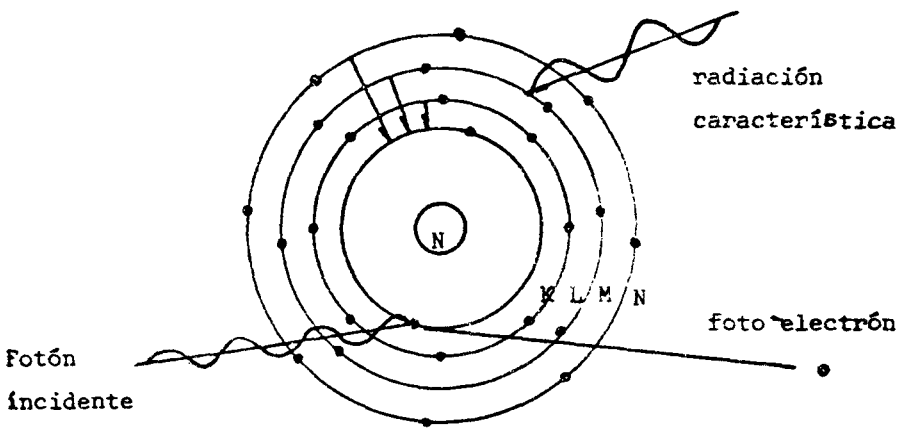


Fig. III-3

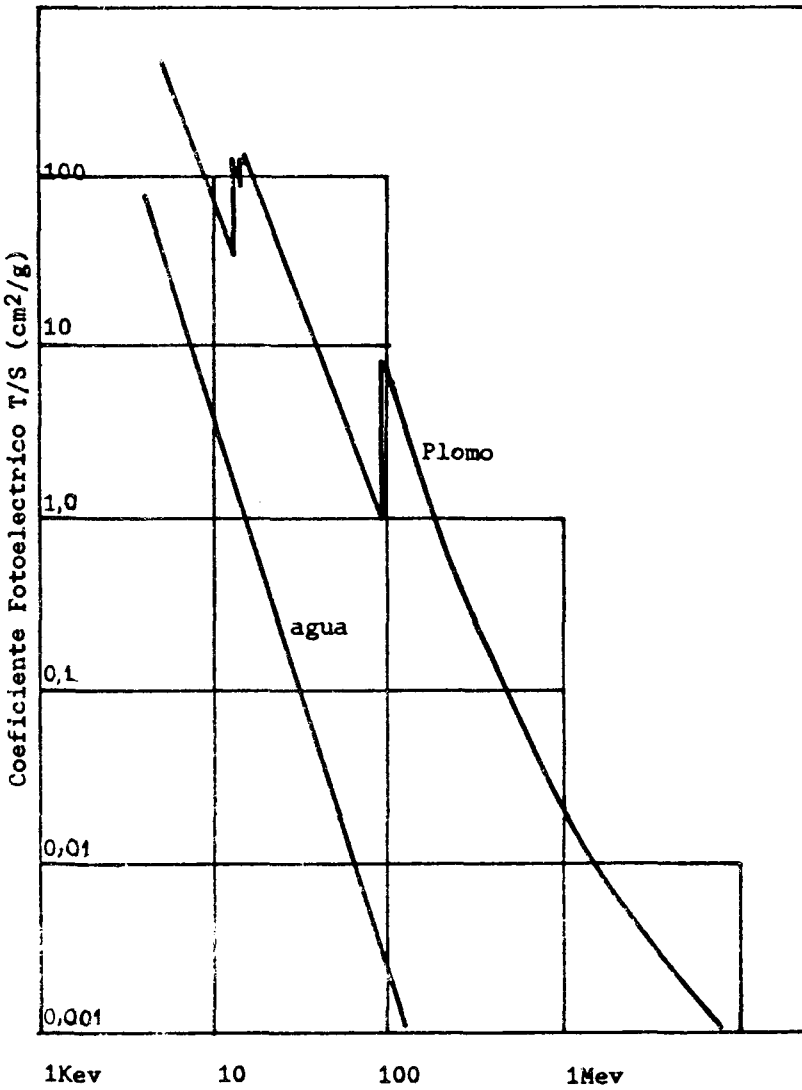
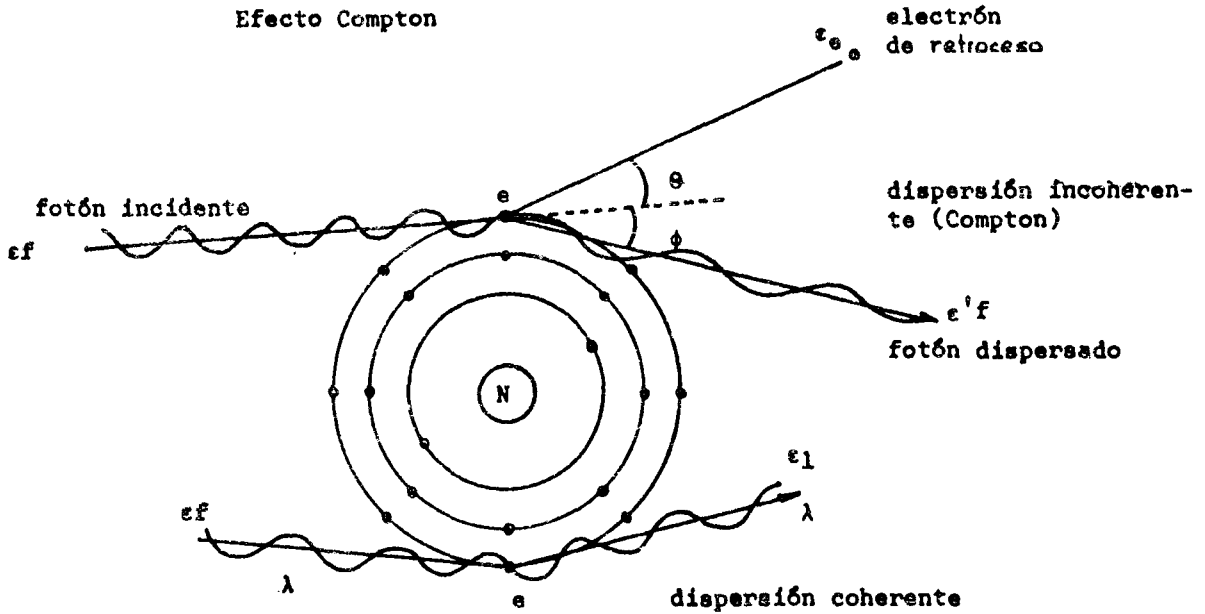

100
10
1,0
0,1
0,01
0,001
Coeficiente Fotoelectrico T/S (cm²/g)
Plomo
agua
1Kev
10
100
1Mev
Energía del fotón

Fig. III-4



electrones libres

Fig. III-5

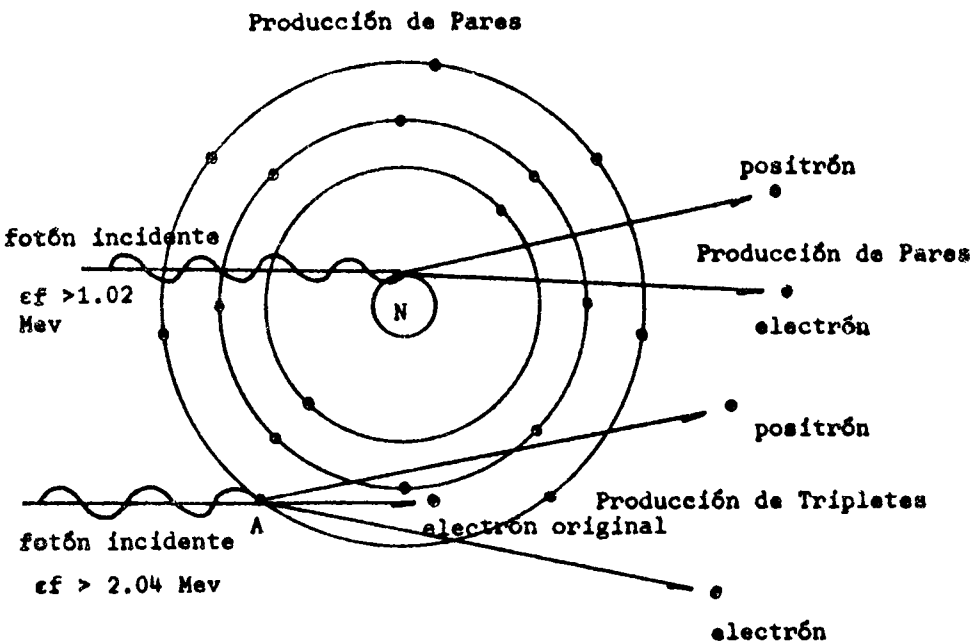

Producción de Pares
positrón
fotón incidente
Producción de Pares
εf >1.02
Mev
N
electrón
positrón
Producción de Tripletes
A
electrón original
fotón incidente
εf > 2.04 Mev
electrón

Fig. III-6

Coeficientes Másicos de Atenuación y Absorción

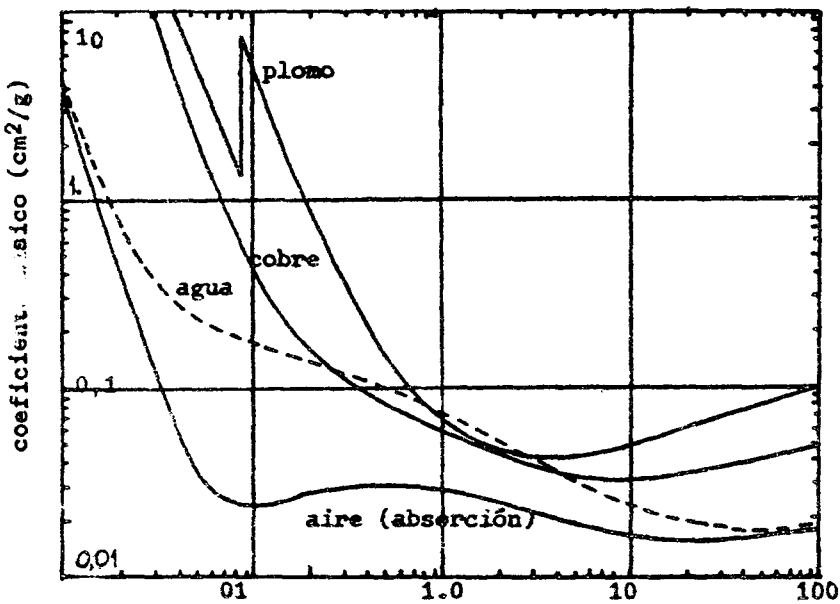
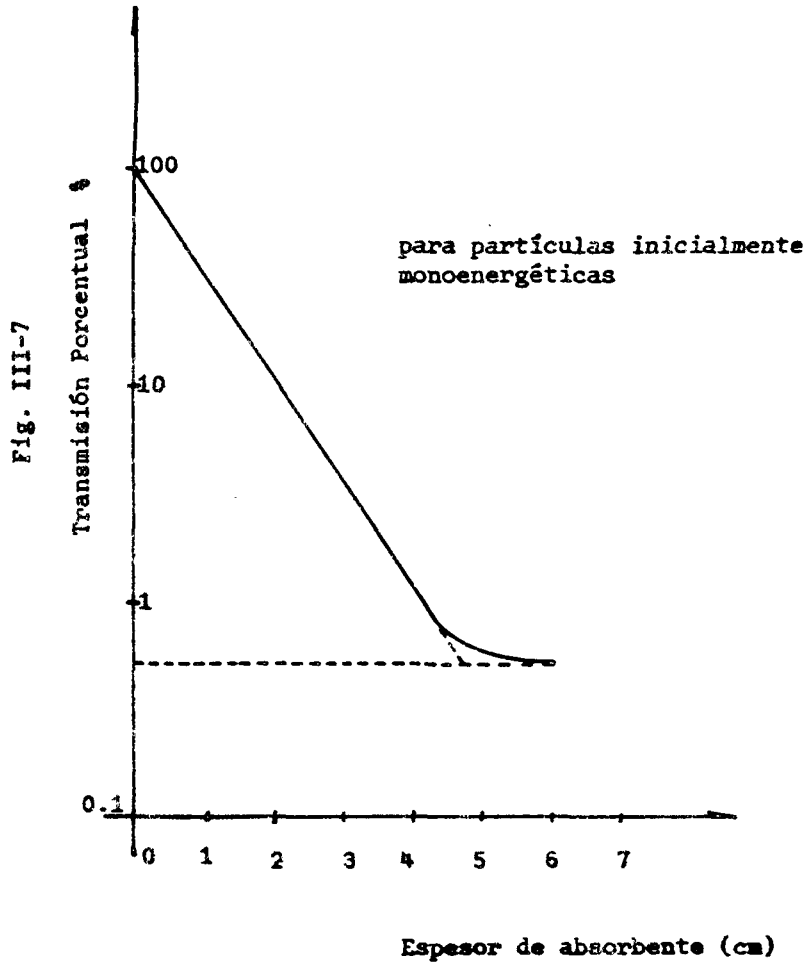


Fig. III-7

Transmisión Porcentual



ALCANCE DE ELECTRONES EN TEJIDO ACUOSO

Fig. III-8

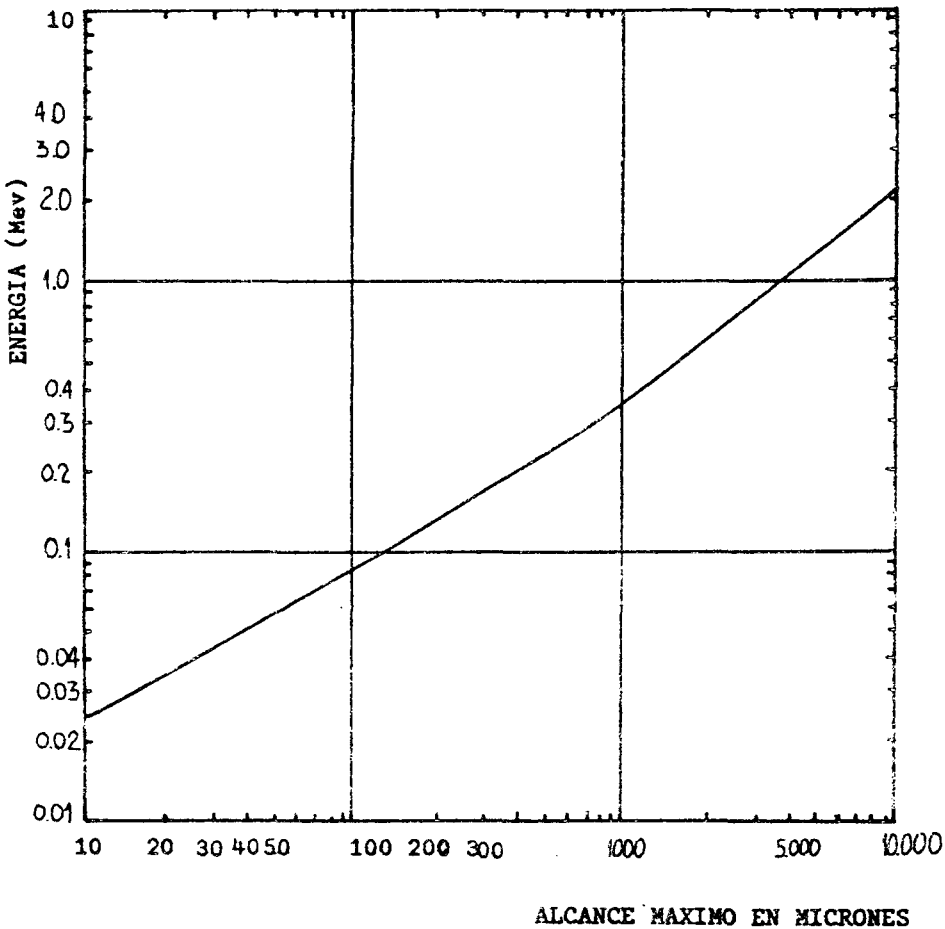


Fig. III-9

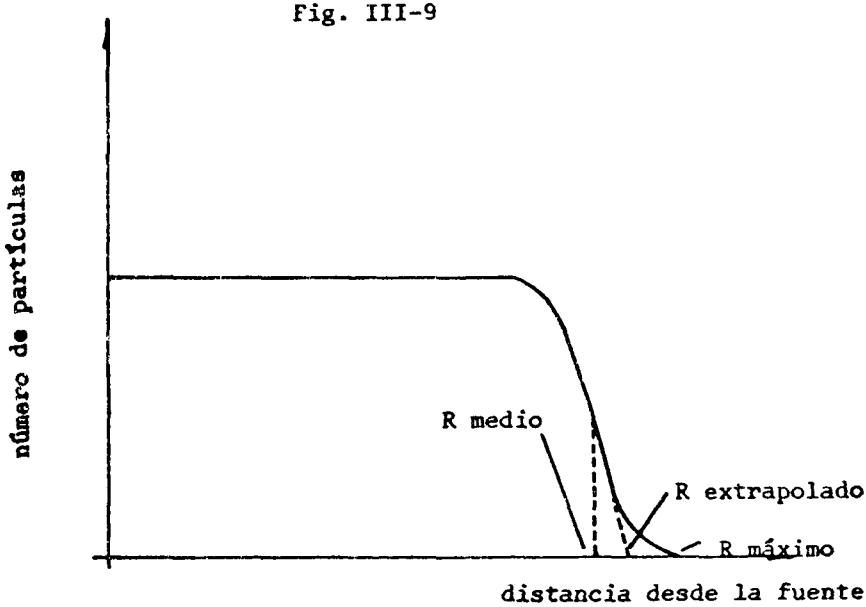


Fig. III-10

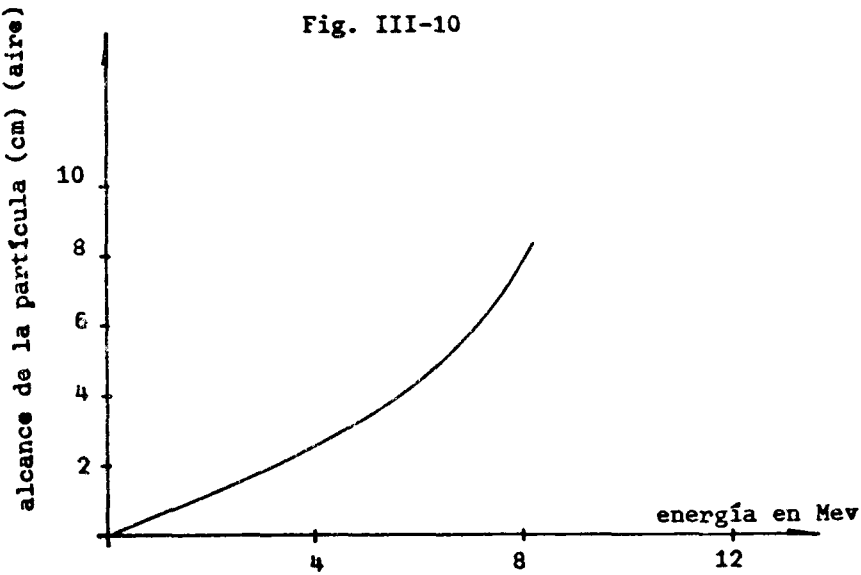


Fig. IV-1

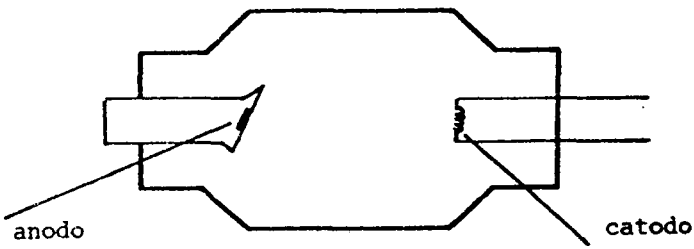
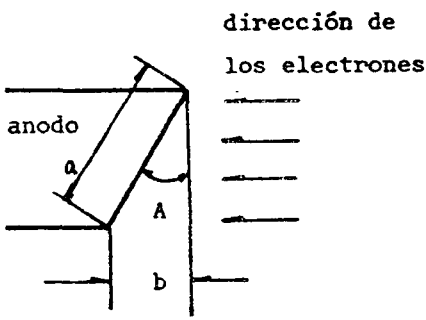


Fig. IV-2



$16° \leq A \leq 17,5°$

Fig. IV-3

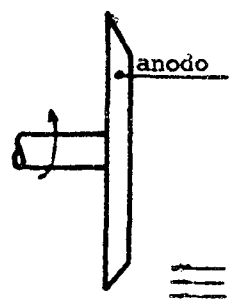


Fig. IV-4

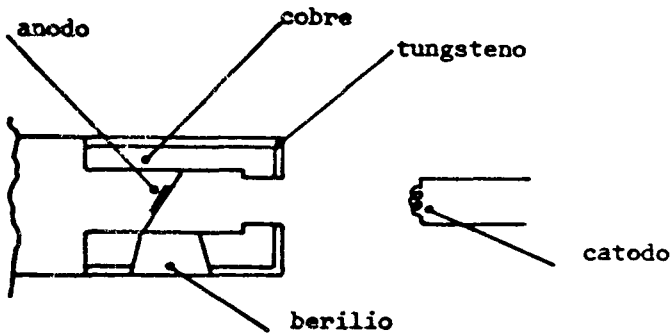


Fig. IV-5

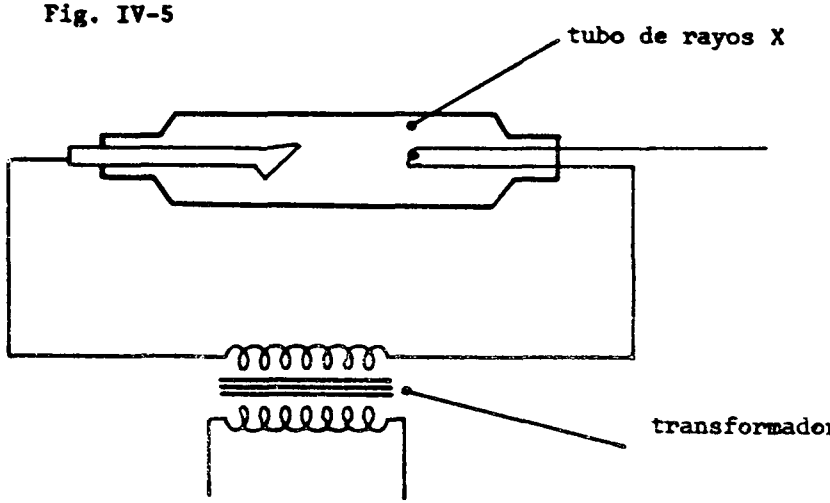


Fig. IV-6

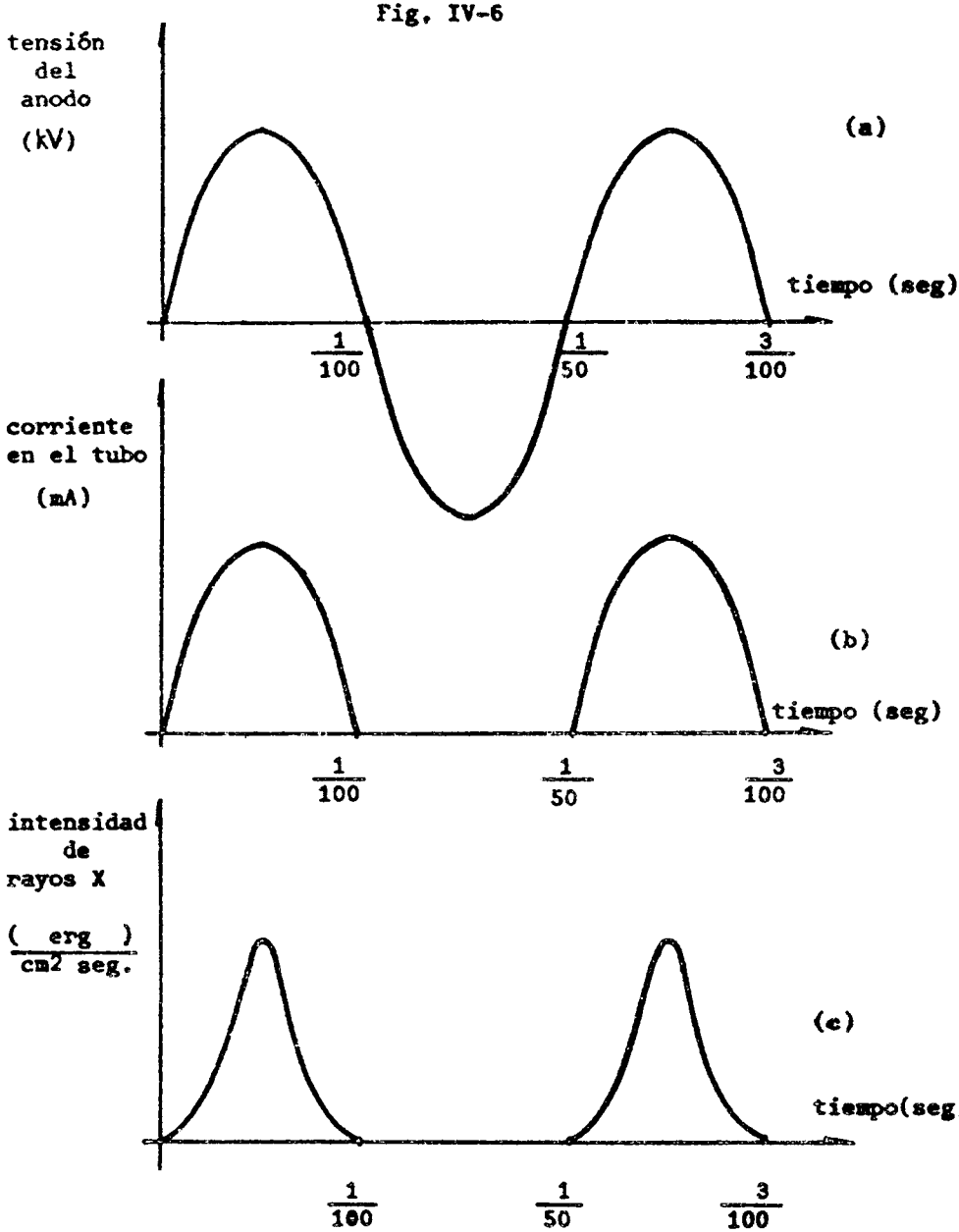

tensión del anodo (kV)
(a)
tiempo (seg)
1/100
1/50
3/100
corriente en el tubo (mA)
(b)
tiempo (seg)
1/100
1/50
3/100
intensidad de rayos X
(erg) / cm2 seg.
(c)
tiempo(seg)
1/100
1/50
3/100

Fig. IV-7

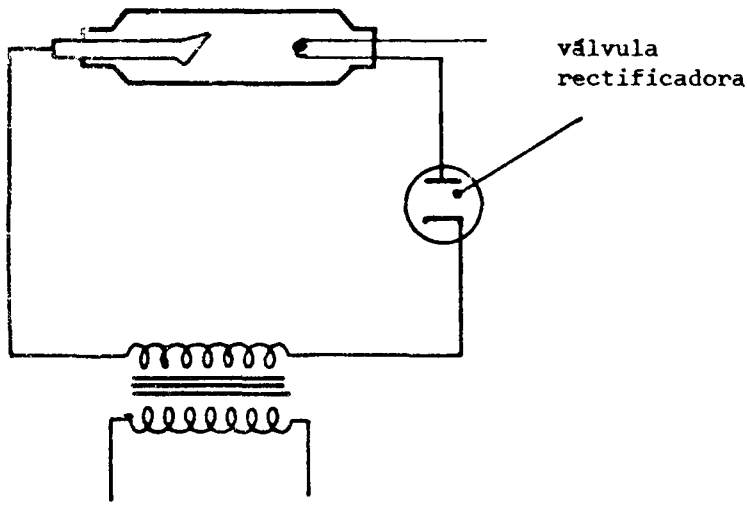


Fig. IV-8

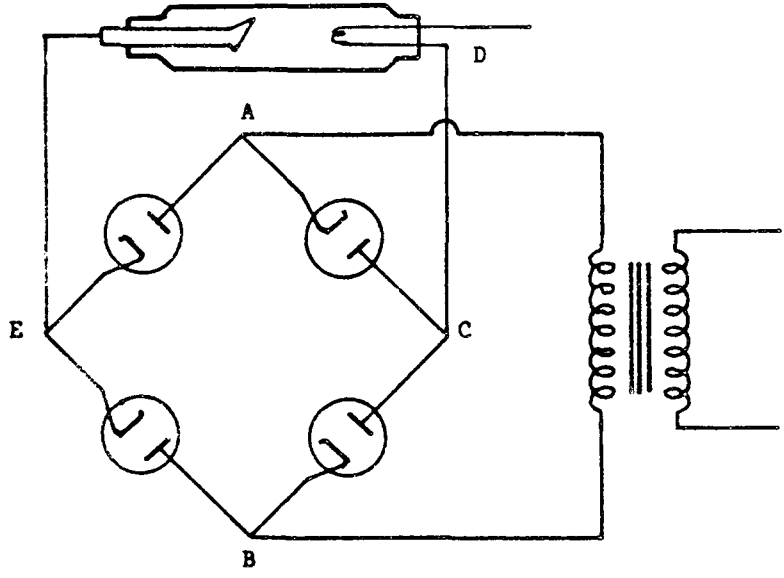


Fig. IV-9

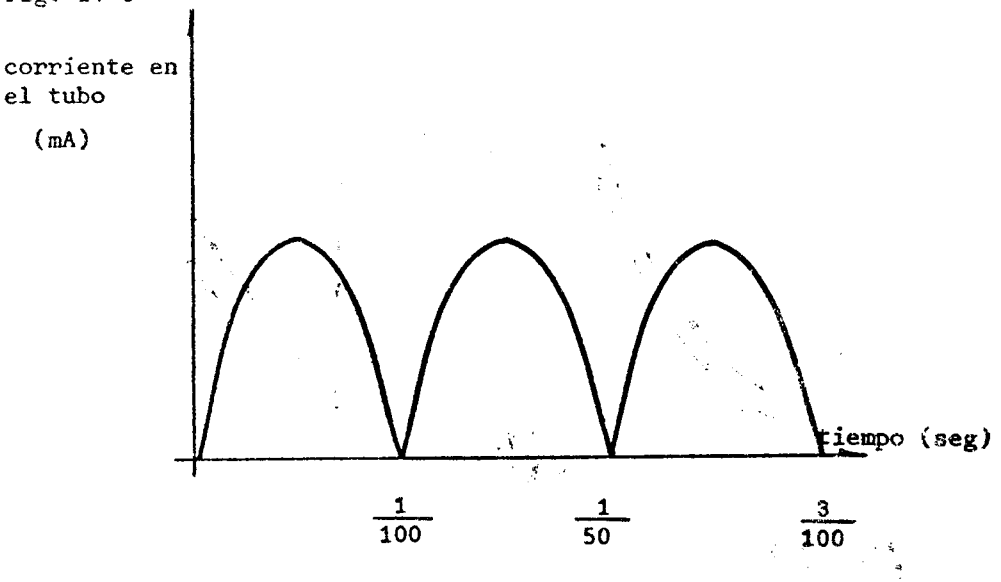


Fig. IV-10

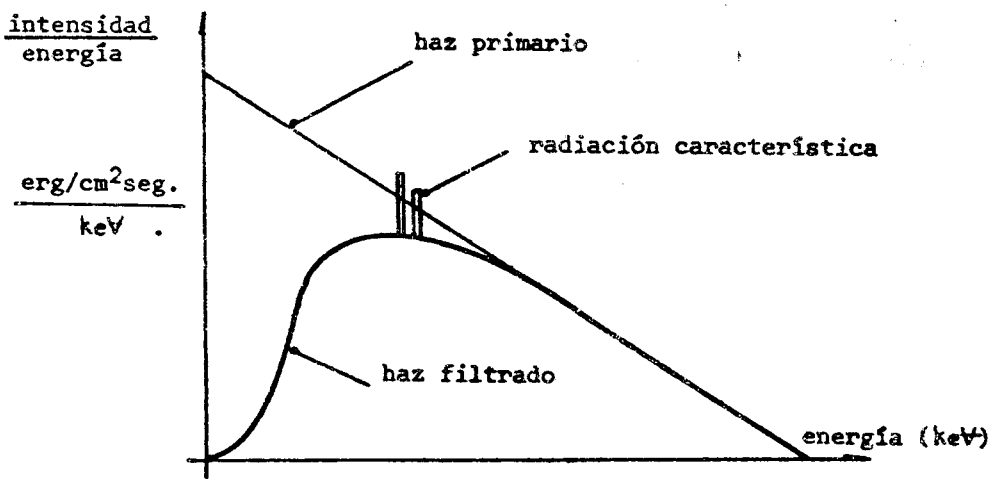


Fig. IV-11

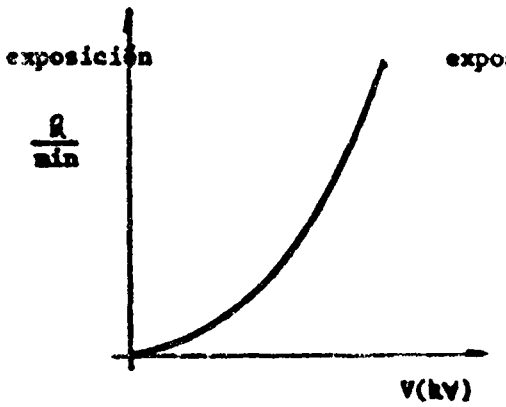


Fig. IV-12

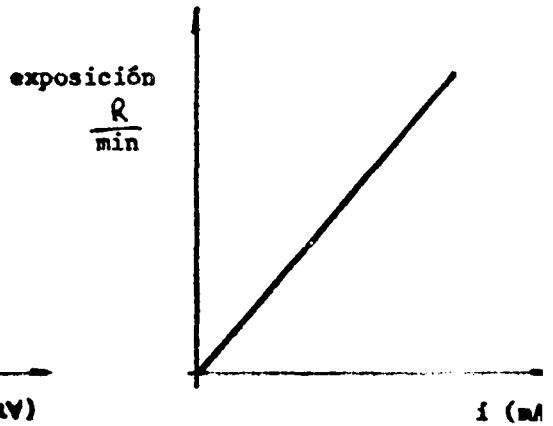


Fig. IV-13

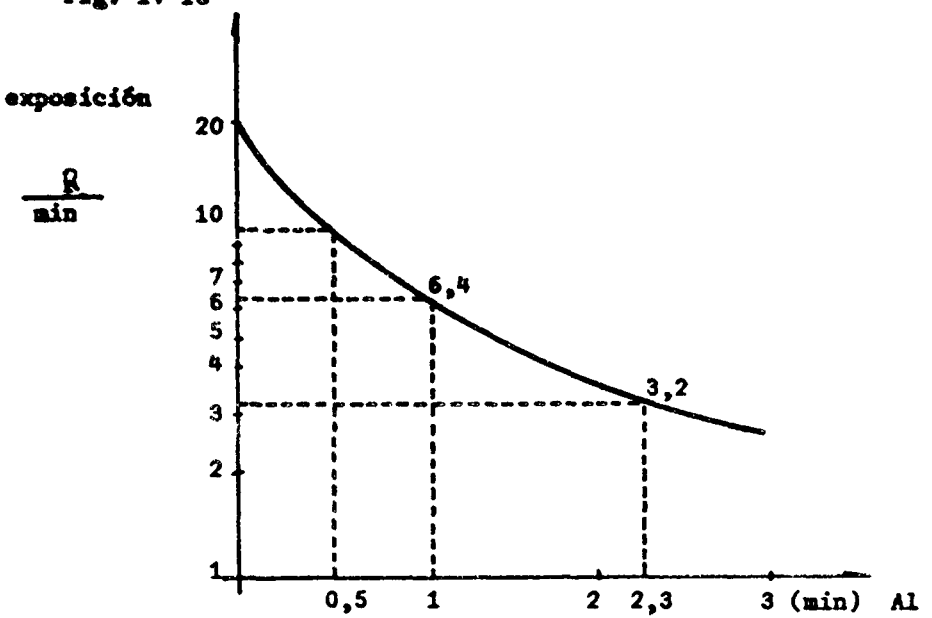


Fig.IV-14

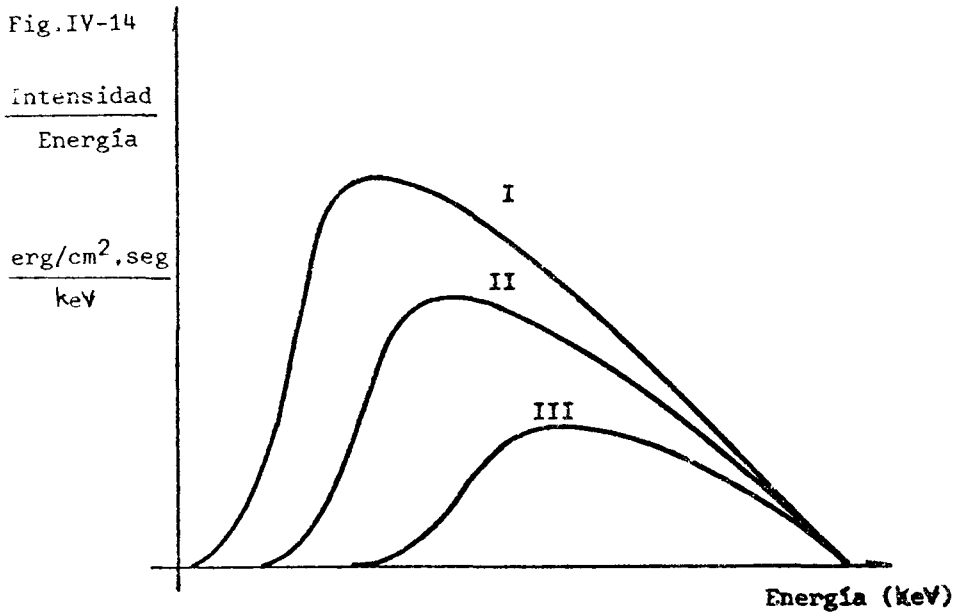


Fig. IV-15

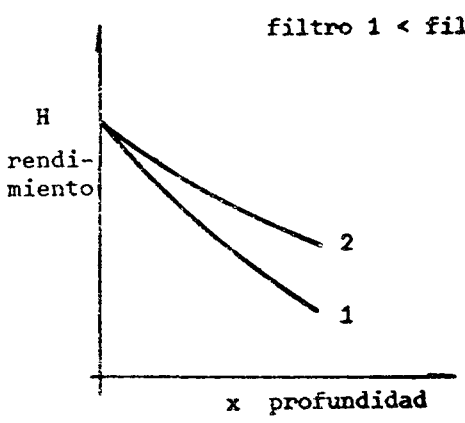


Fig. IV-16

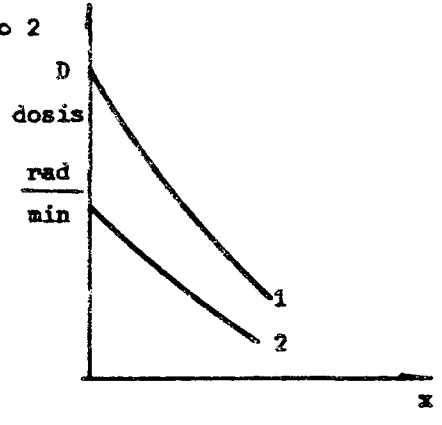


Fig. IV-17

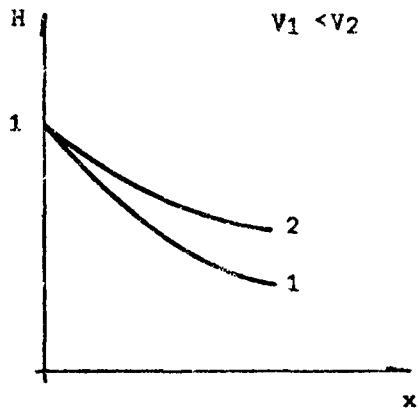


Fig.IV-18

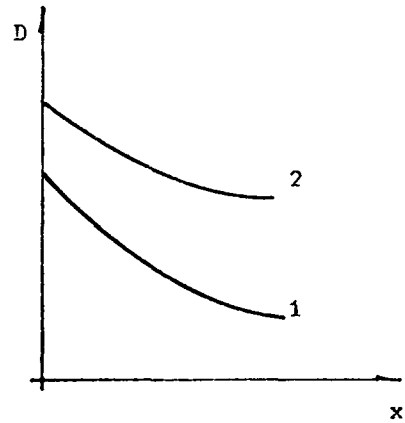


Fig. IV-19

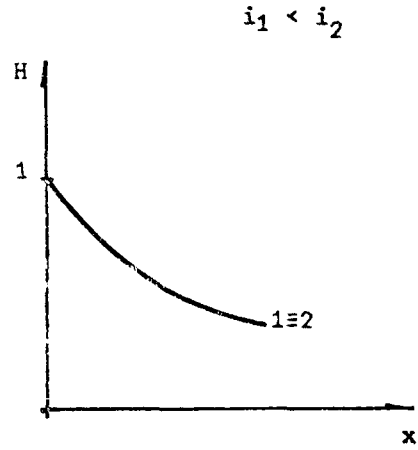


Fig. IV-20

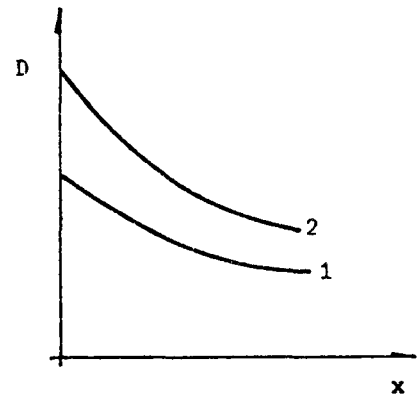
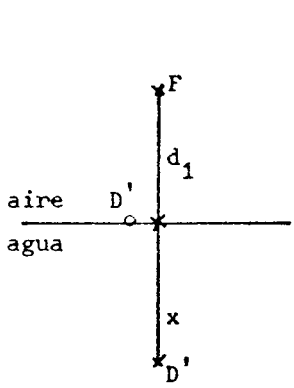


Fig. IV-21



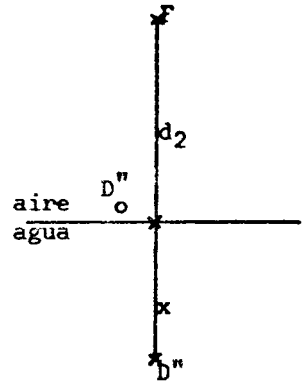


Fig. IV-22

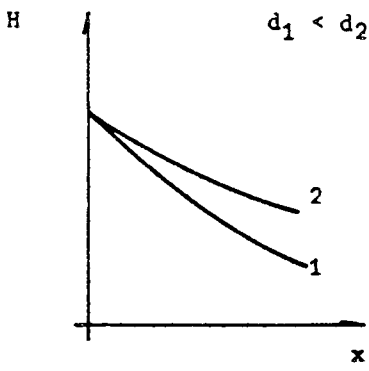


Fig. IV-23

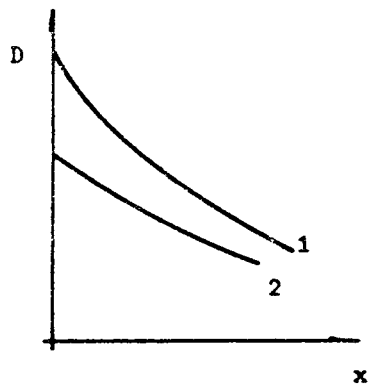
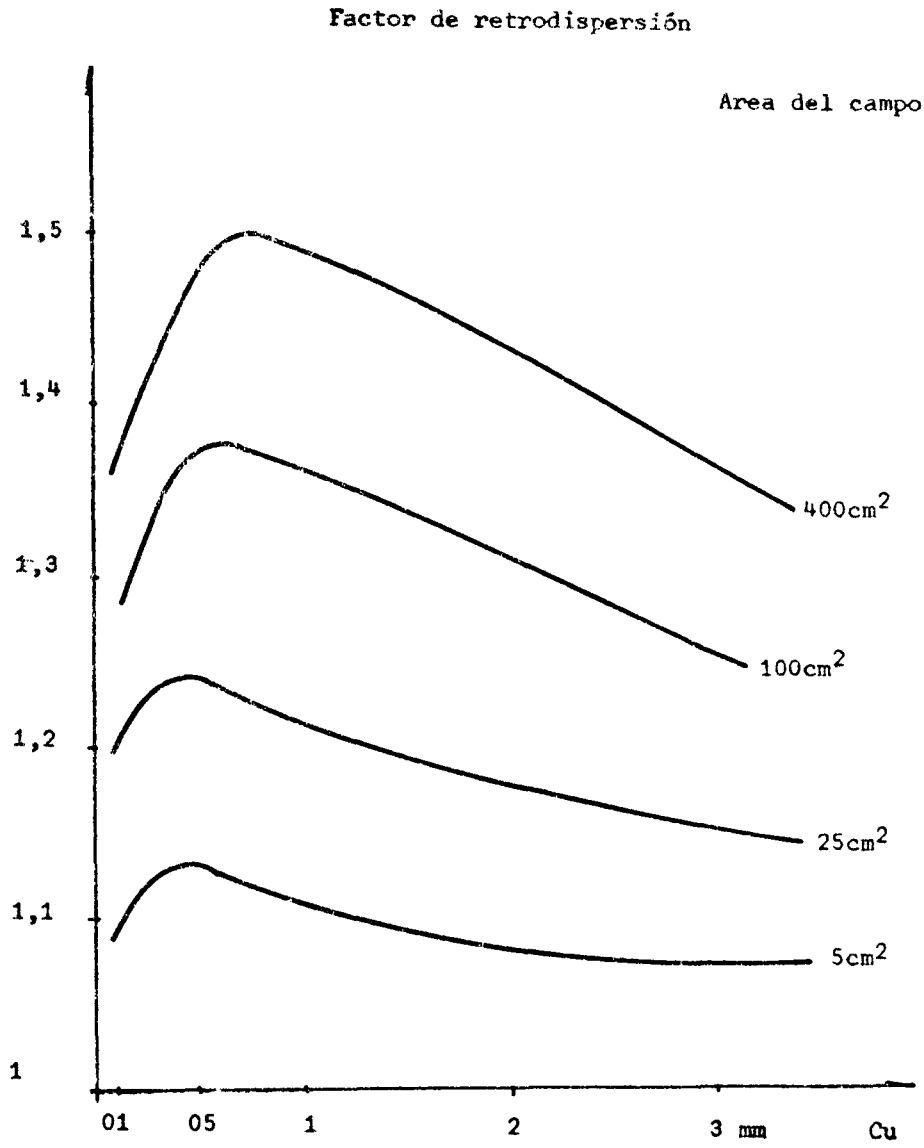


Fig. IV-24


Factor de retrodispersión
Area del campo
1,5
1,4
1,3
1,2
1,1
1
400cm2
100cm2
25cm2
5cm2
01
05
1
2
3 mm
Cu

Curvas de rendimiento

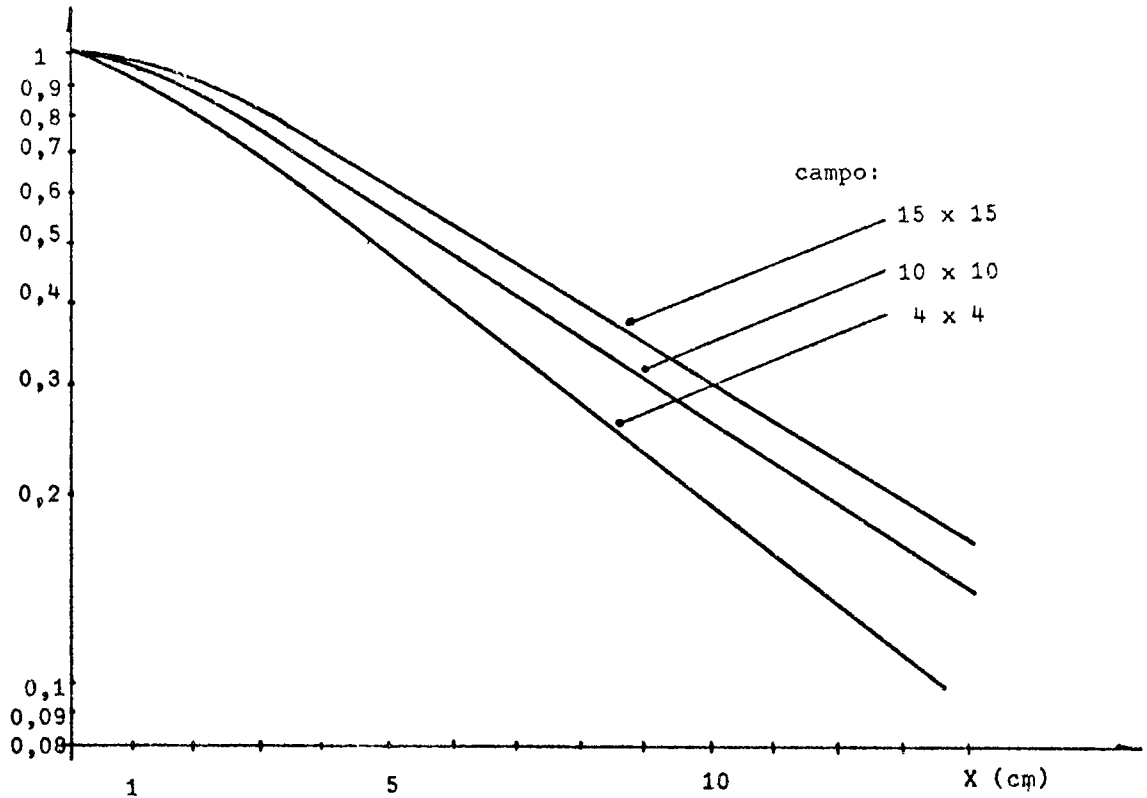
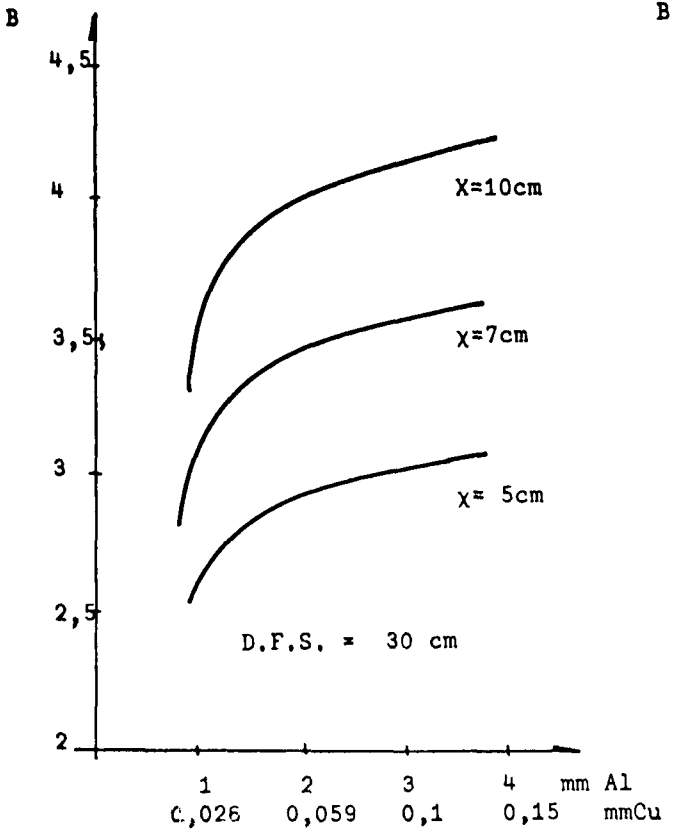


Fig. IV - 25


B
4,5
4
3,5
3
2,5
2
X=10cm
χ=7cm
χ= 5cm
D.F.S. = 30 cm
1
2
3
4
mm Al
0,026
0,059
0,1
0,15
mmCu

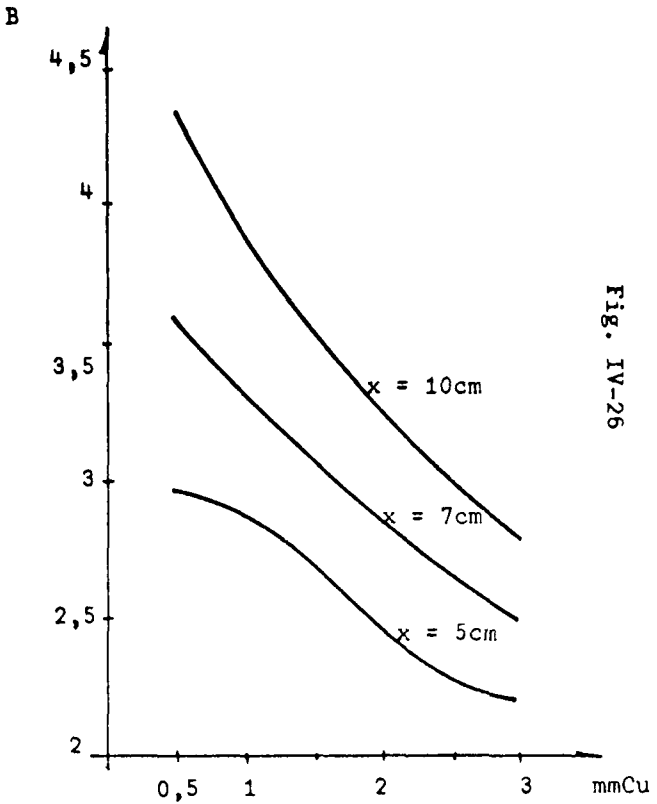

B
4,5
4
3,5
3
2,5
2
x = 10cm
x = 7cm
x = 5cm
0,5
1
2
3
mmCu

Fig. IV-26

Fig. V-1

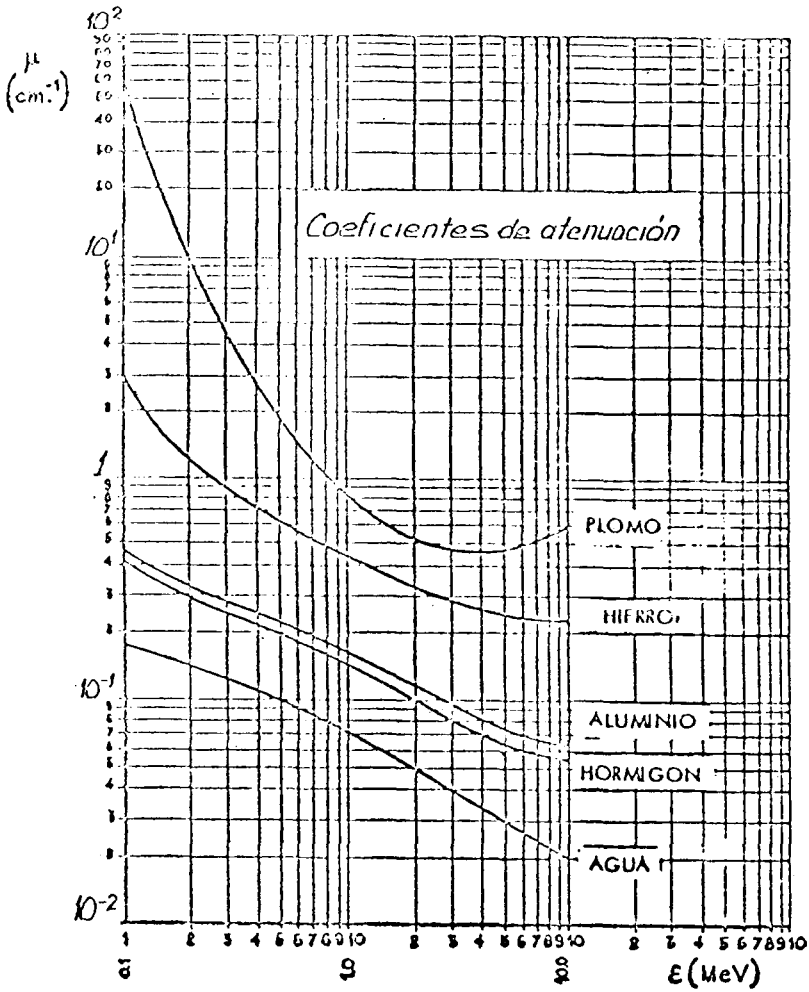
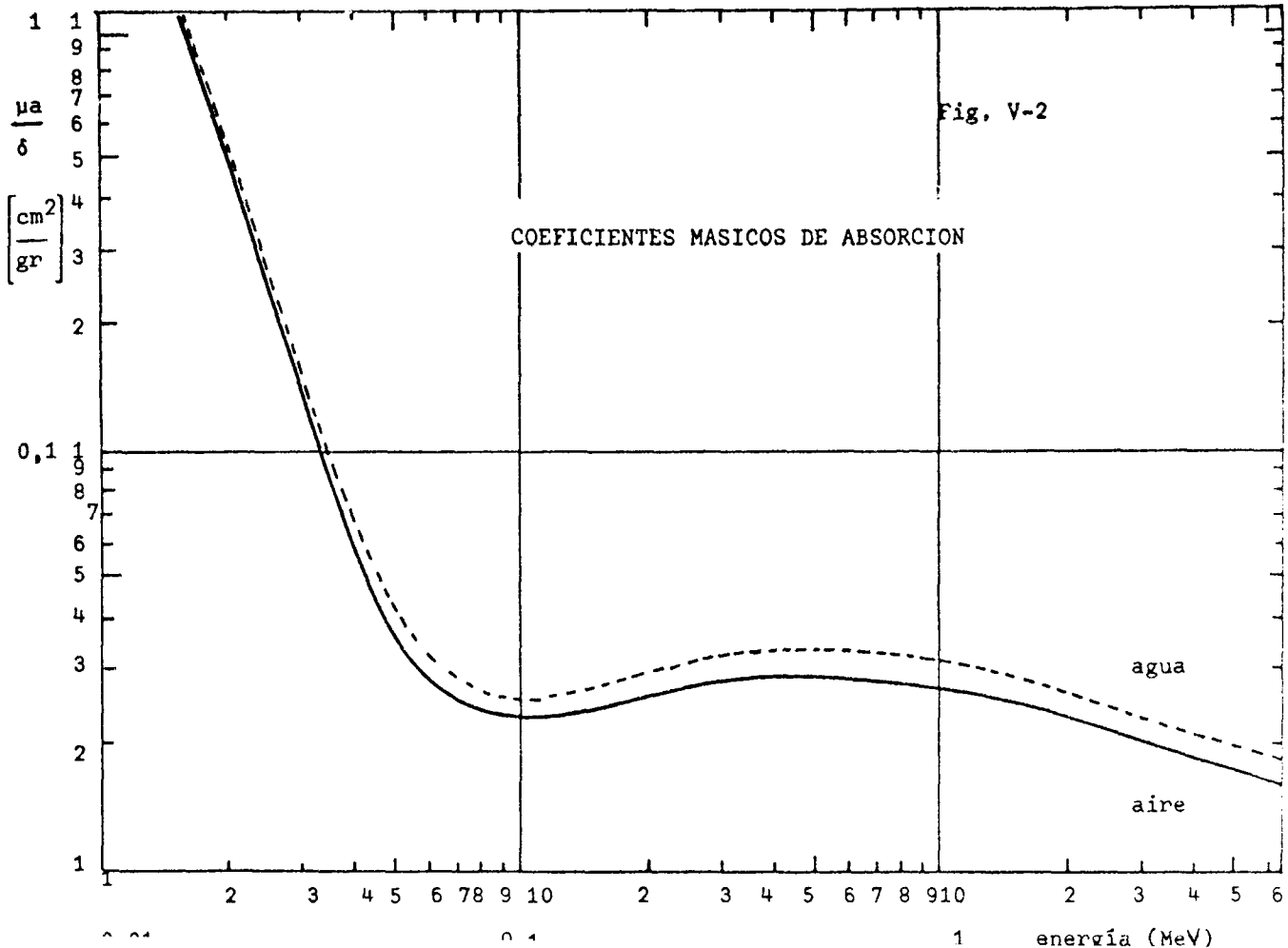

Coeficientes de atenuación
μ (cm.⁻¹)
PLOMO
HIERRO
ALUMINIO
HORMIGON
AGUA
ε (MeV)

Fig. V-2


COEFICIENTES MASICOS DE ABSORCION
μa/δ
[cm²/gr]
agua
aire
energía (MeV)

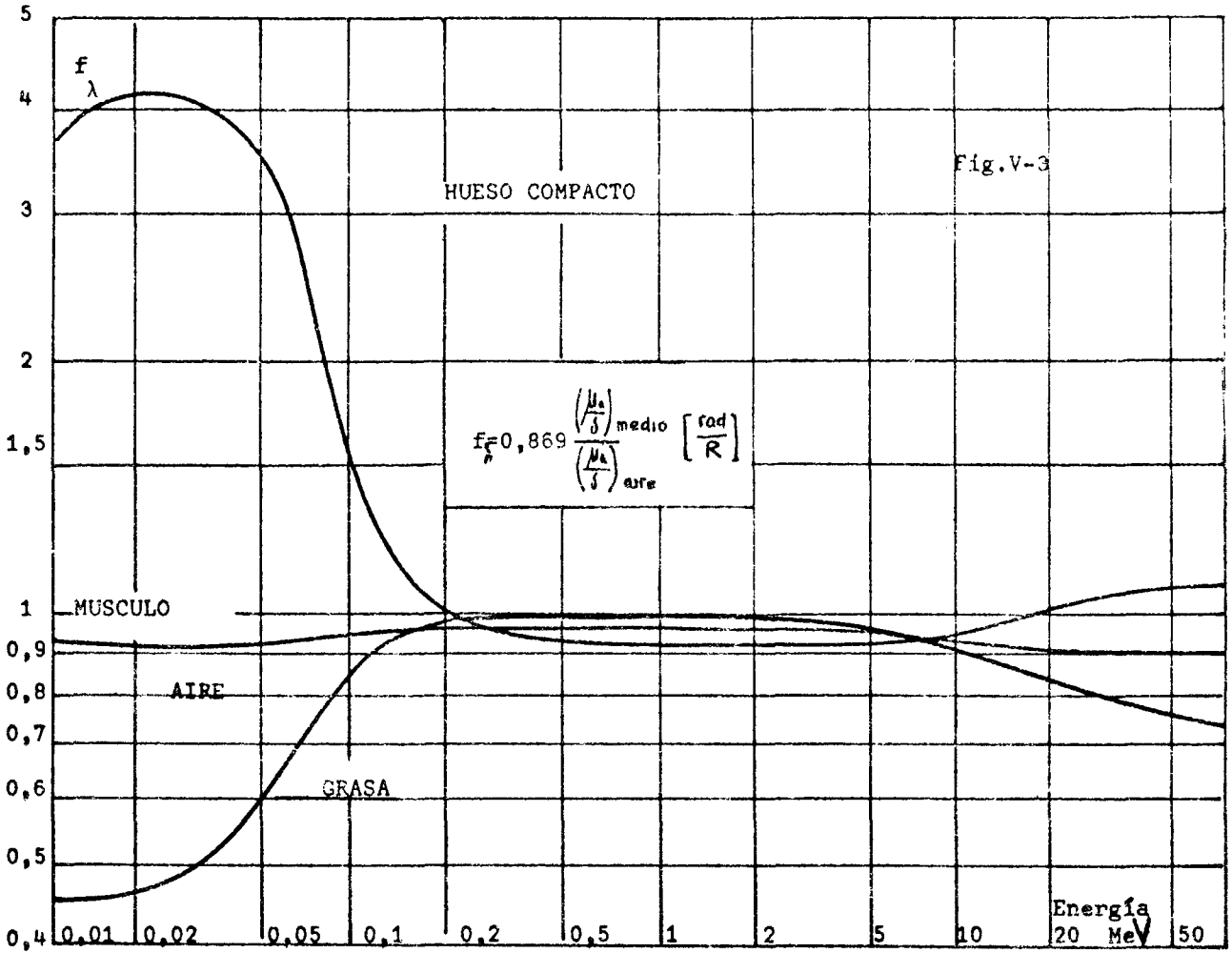
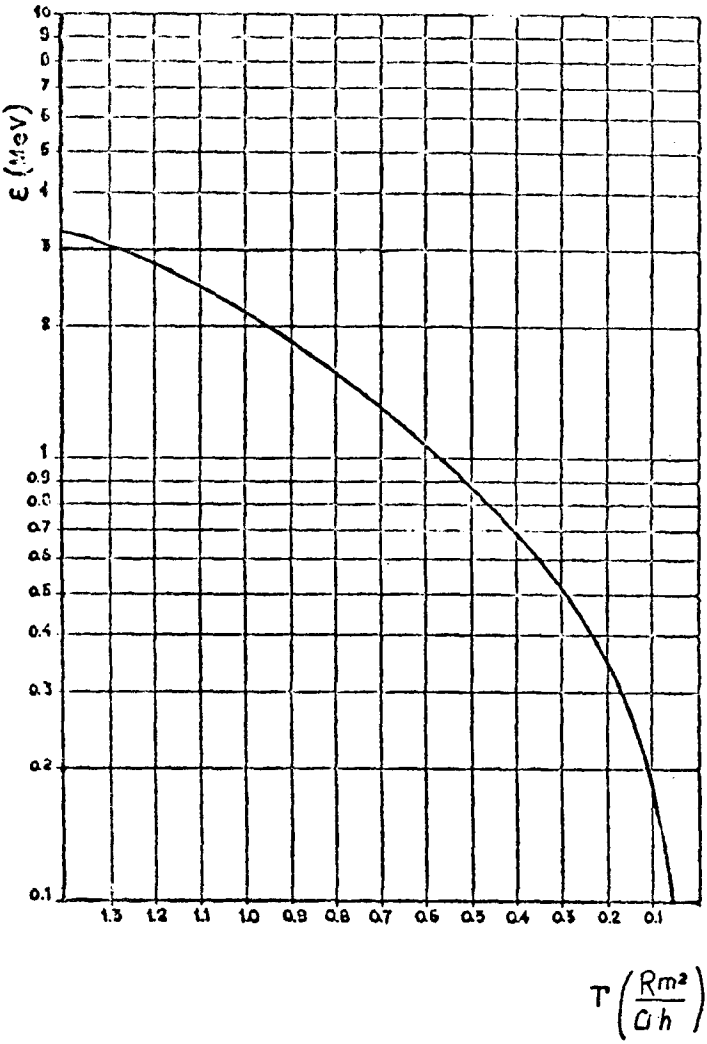

f
λ
HUESO COMPACTO
MUSCULO
AIRE
GRASA
$f_f = 0{,}869 \dfrac{\left(\frac{\mu_a}{\rho}\right)_{medio}}{\left(\frac{\mu_a}{\rho}\right)_{aire}} \left[\dfrac{rad}{R}\right]$
5
4
3
2
1,5
1
0,9
0,8
0,7
0,6
0,5
0,4
0,01
0,02
0,05
0,1
0,2
0,5
1
2
5
10
20
50
Energía MeV

Fig.V-3

Fig. V-4

Constante específica de radiación gamma



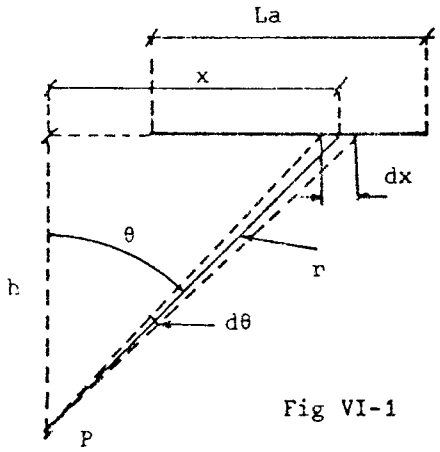


Fig VI-1

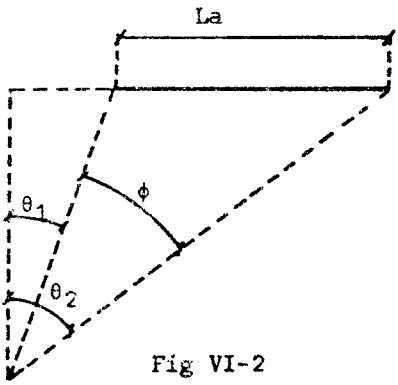
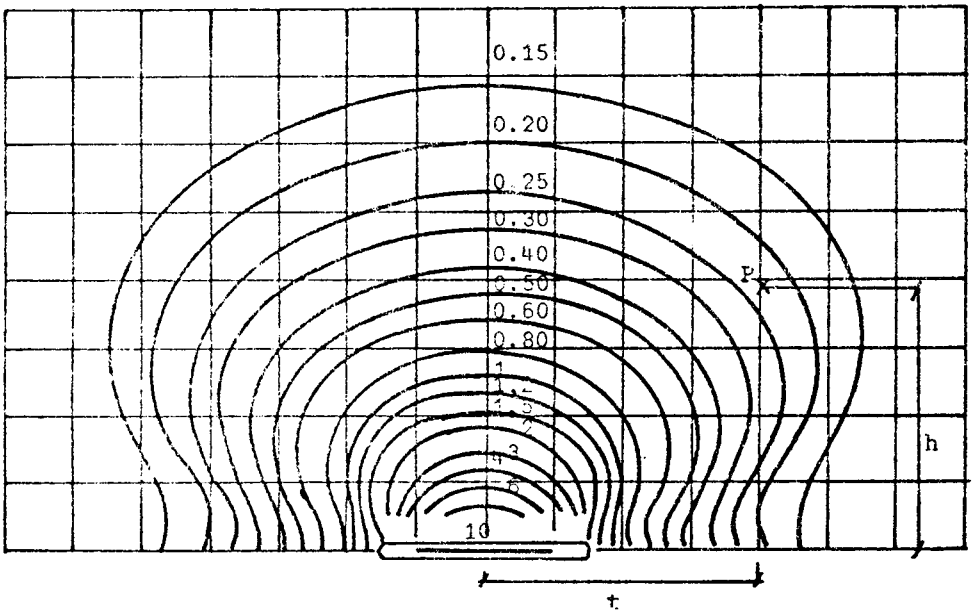


Fig VI-2

Fig VI-3

dosis en $\frac{\text{rad}}{\text{h.mCi}}$



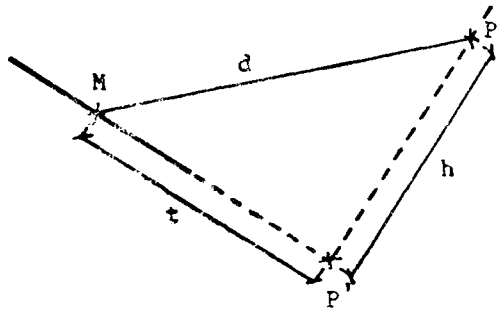


Fig VI-4

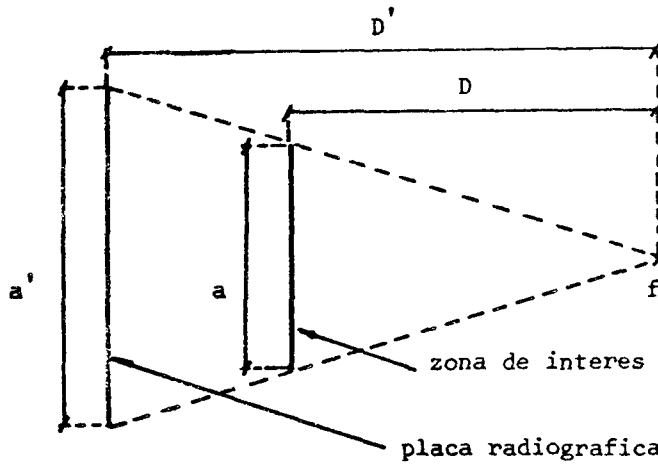


Fig VI-5

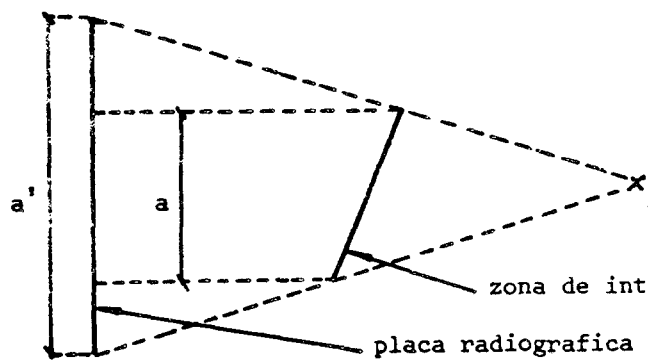


Fig VI-6

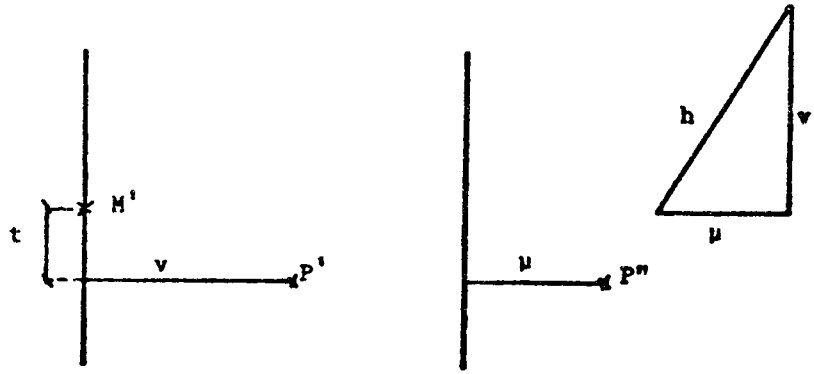


Fig VI-7

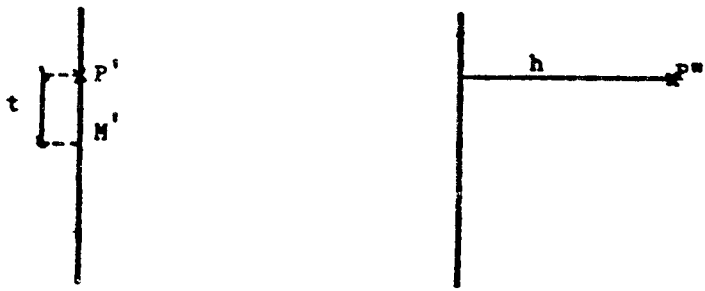


Fig VI-8

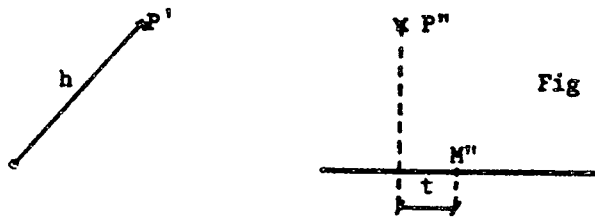


Fig VI-9

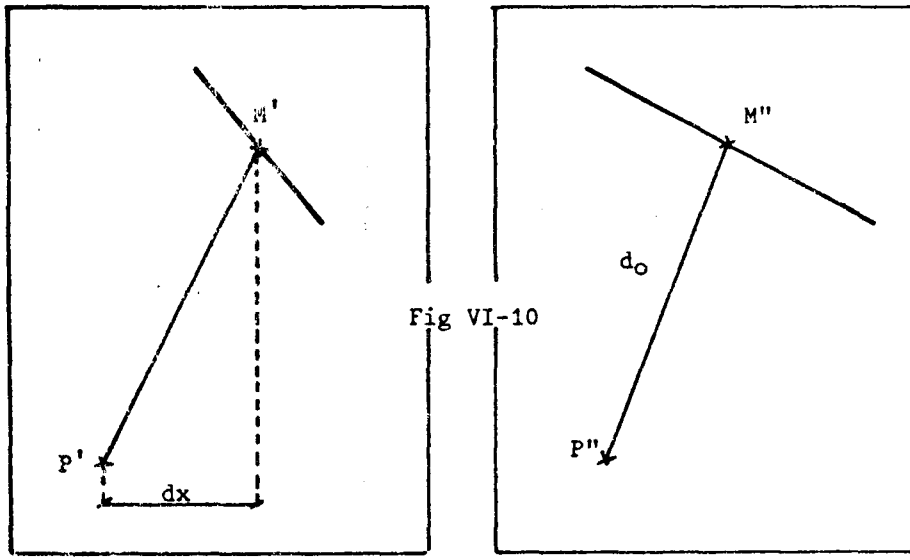
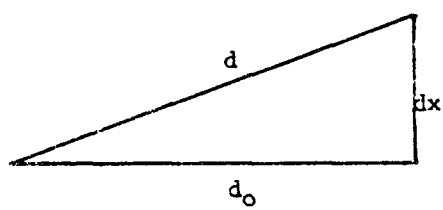


Fig VI-10

Fig VI-11



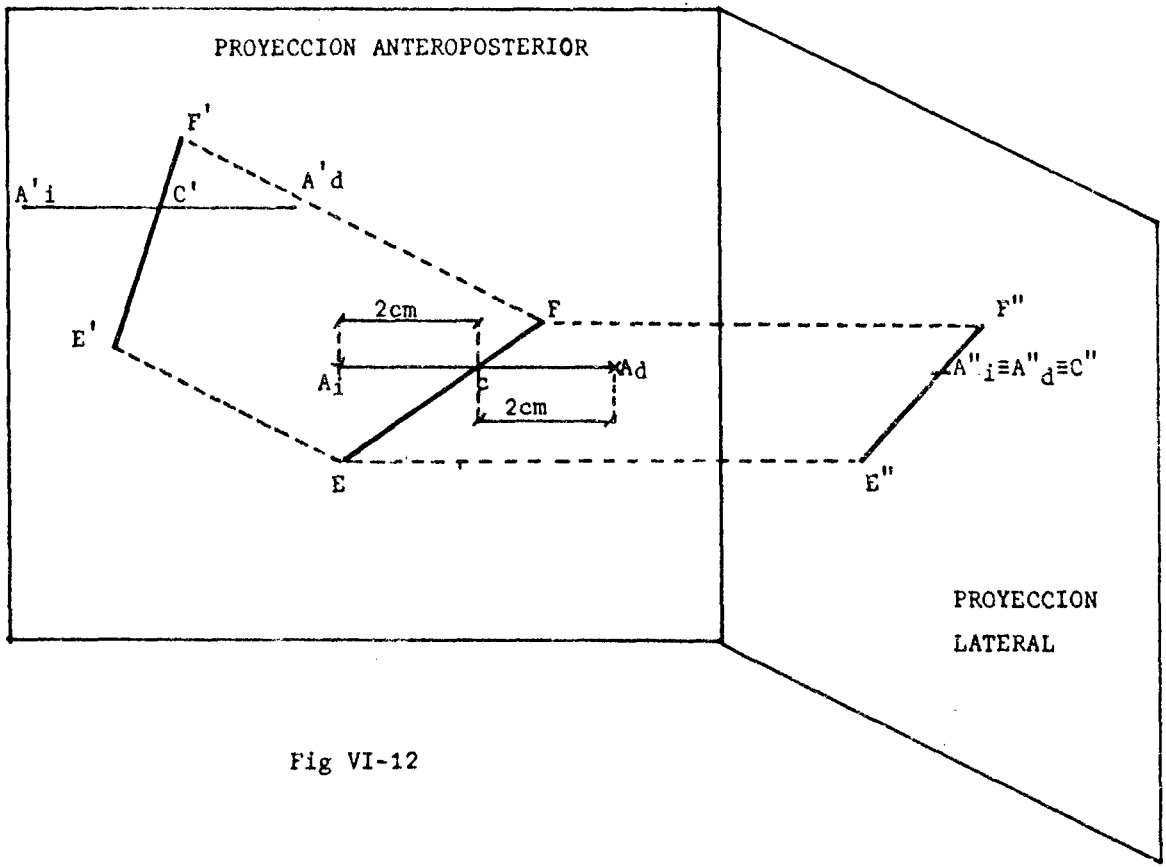

PROYECCION ANTEROPOSTERIOR
F'
A'i
C'
A'd
E'
2cm
F
F"
Ai
C
Ad
2cm
A"i≡A"d≡C"
E
E"
PROYECCION
LATERAL

Fig VI-12

Fig VI-13

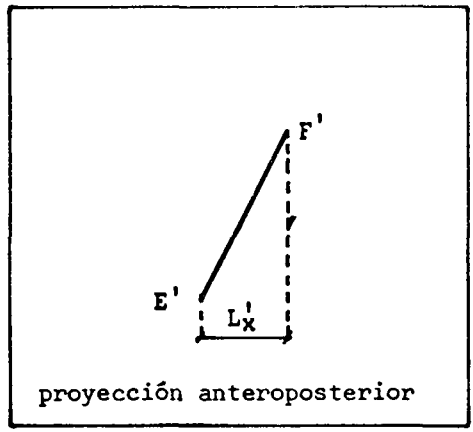
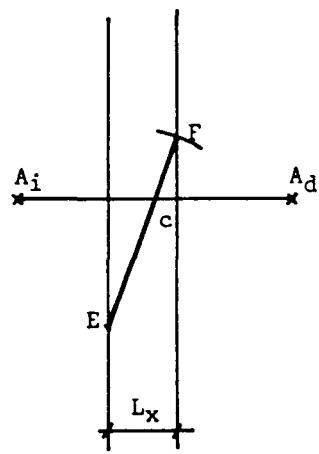


Fig VI-14



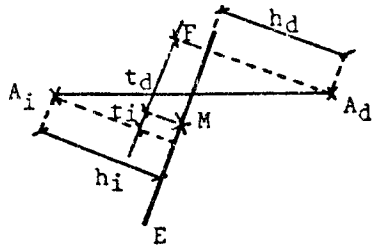
$$L_x = \frac{L_x'}{m_a}$$

$\overline{EC}$ = 2cm

$\overline{EF}$ = L

$\overline{A_iC} = \overline{CA_d}$ = 2cm

Fig VI-15



$h_i = h_d$

Fig VI-16

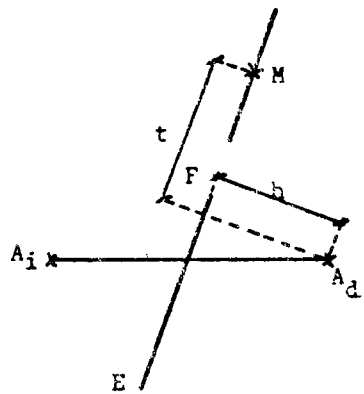


Fig VI-17

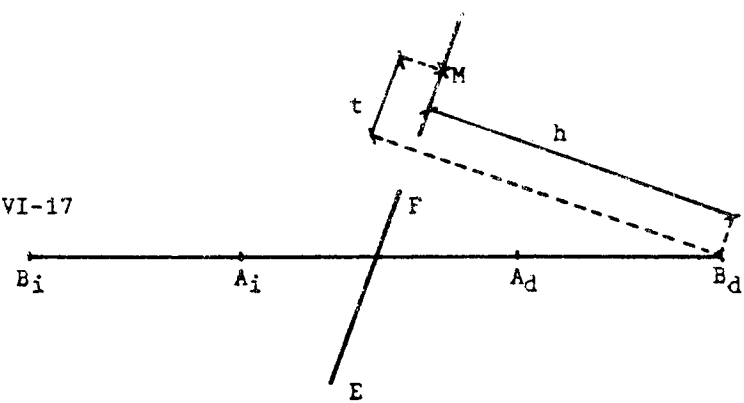
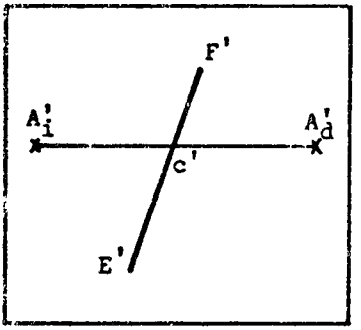


Fig VI-18

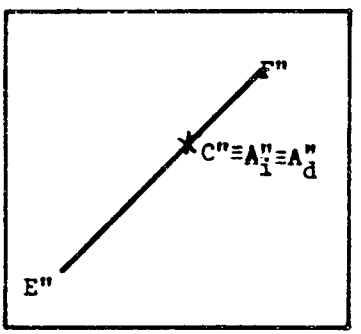


Anteroposterior

$E'C' = \frac{2cm}{L} E'F'$

$A'_iC = C'A'_d = 2cm.M_a$

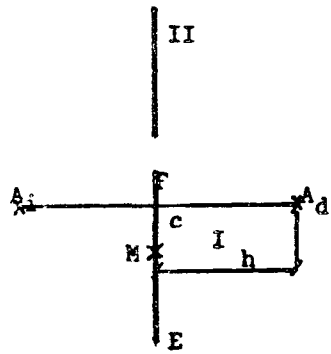
Fig VI-19



Lateral

$E"C" = \frac{2cm}{L} E"F"$

Fig VI-20



$\overline{EF} \perp A_iA_d$

$\overline{EC}$ = 2cm

$\overline{A_iC} = \overline{A_dC}$ = 2cm

h = 2cm

Fig VI-21

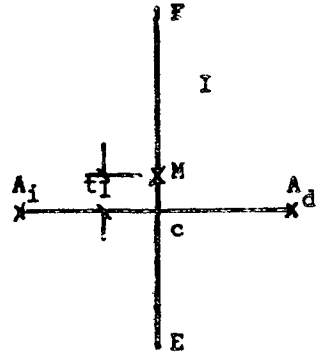
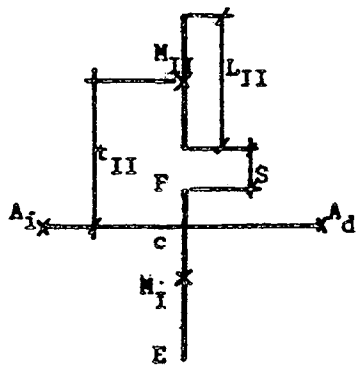


Fig VI-22



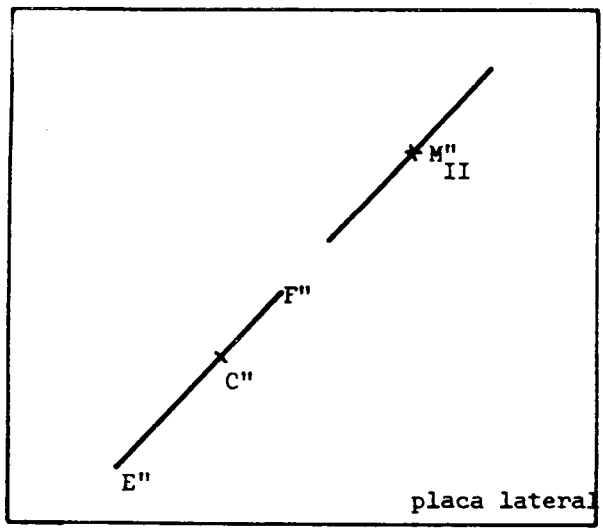


Fig VI-23

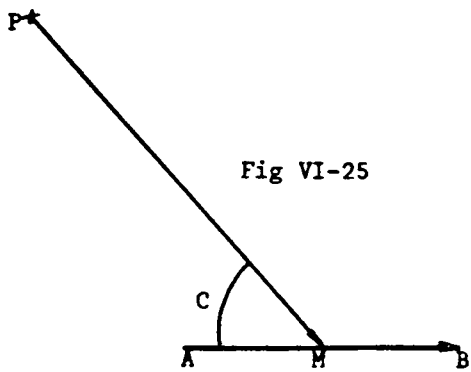


Fig VI-25

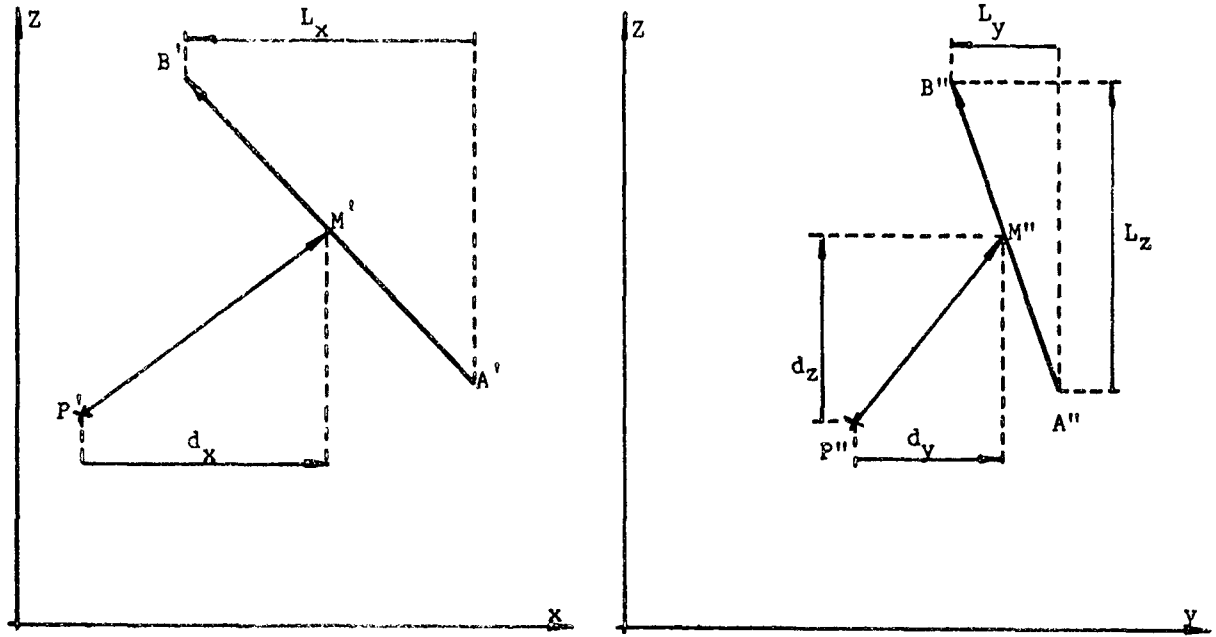


Fig VI-24

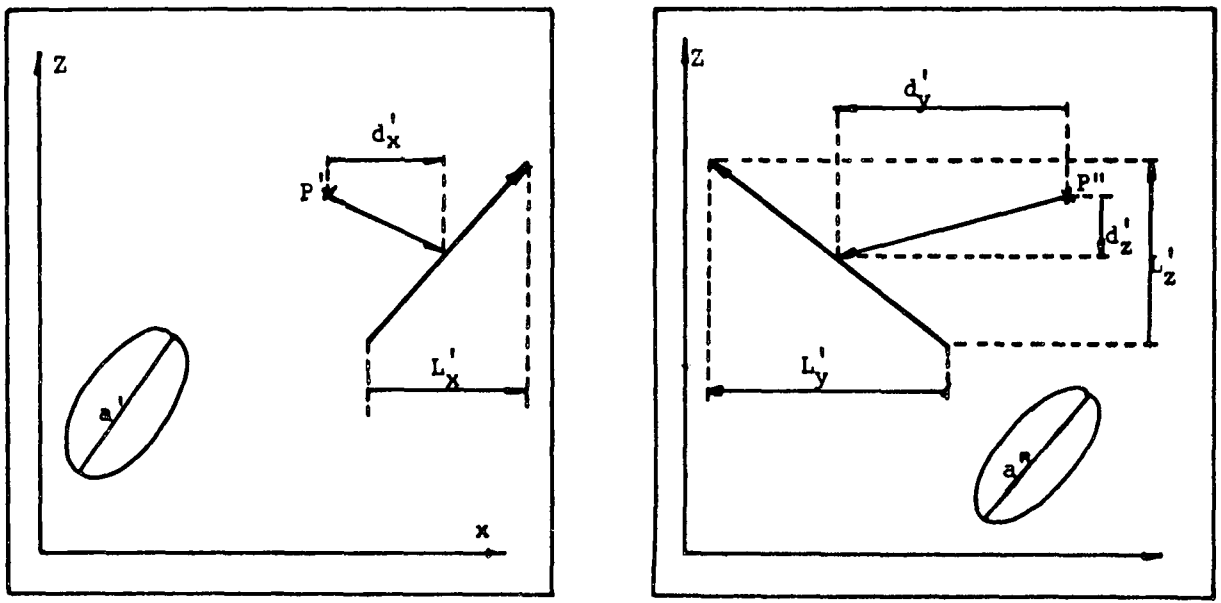
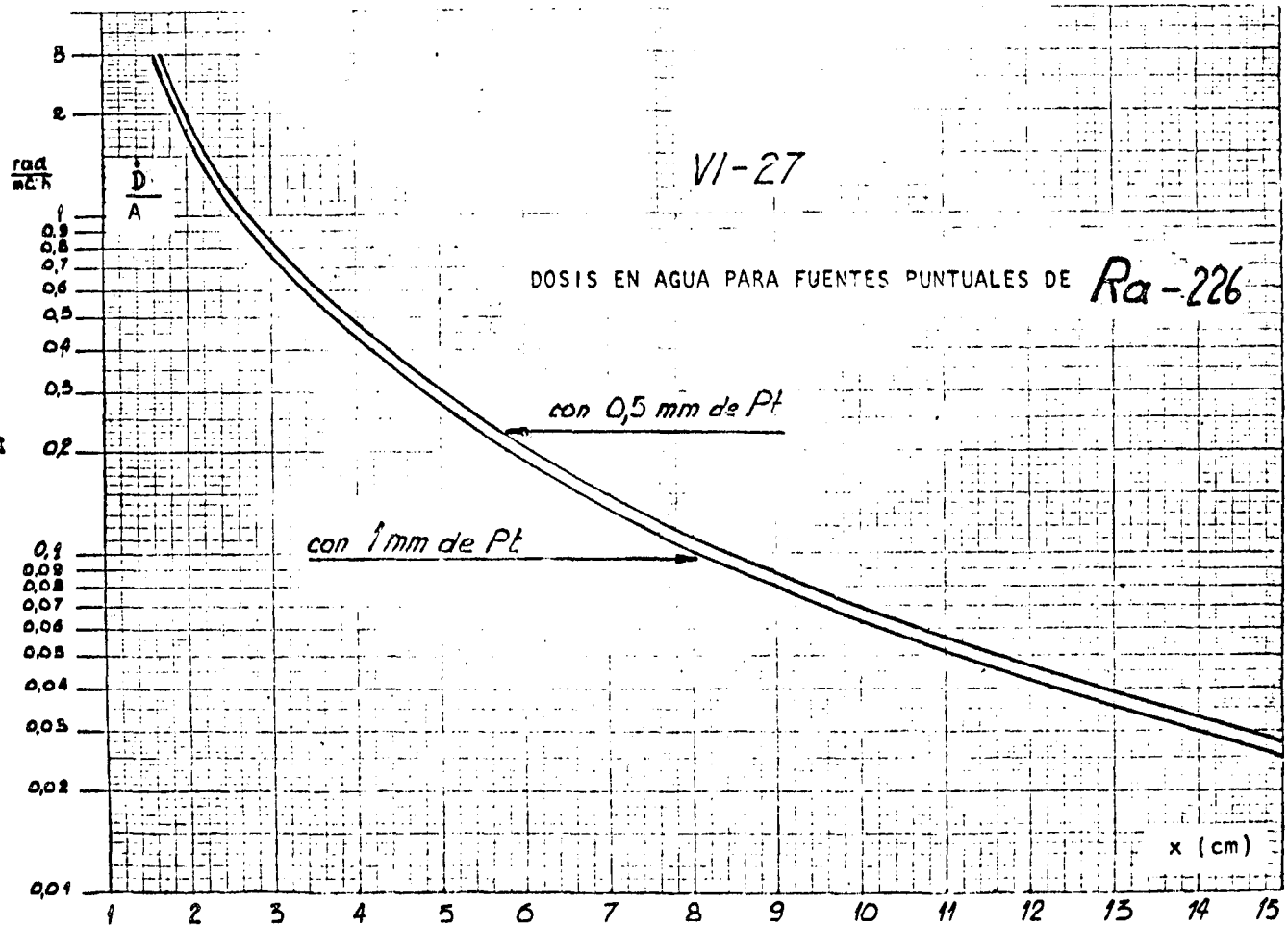
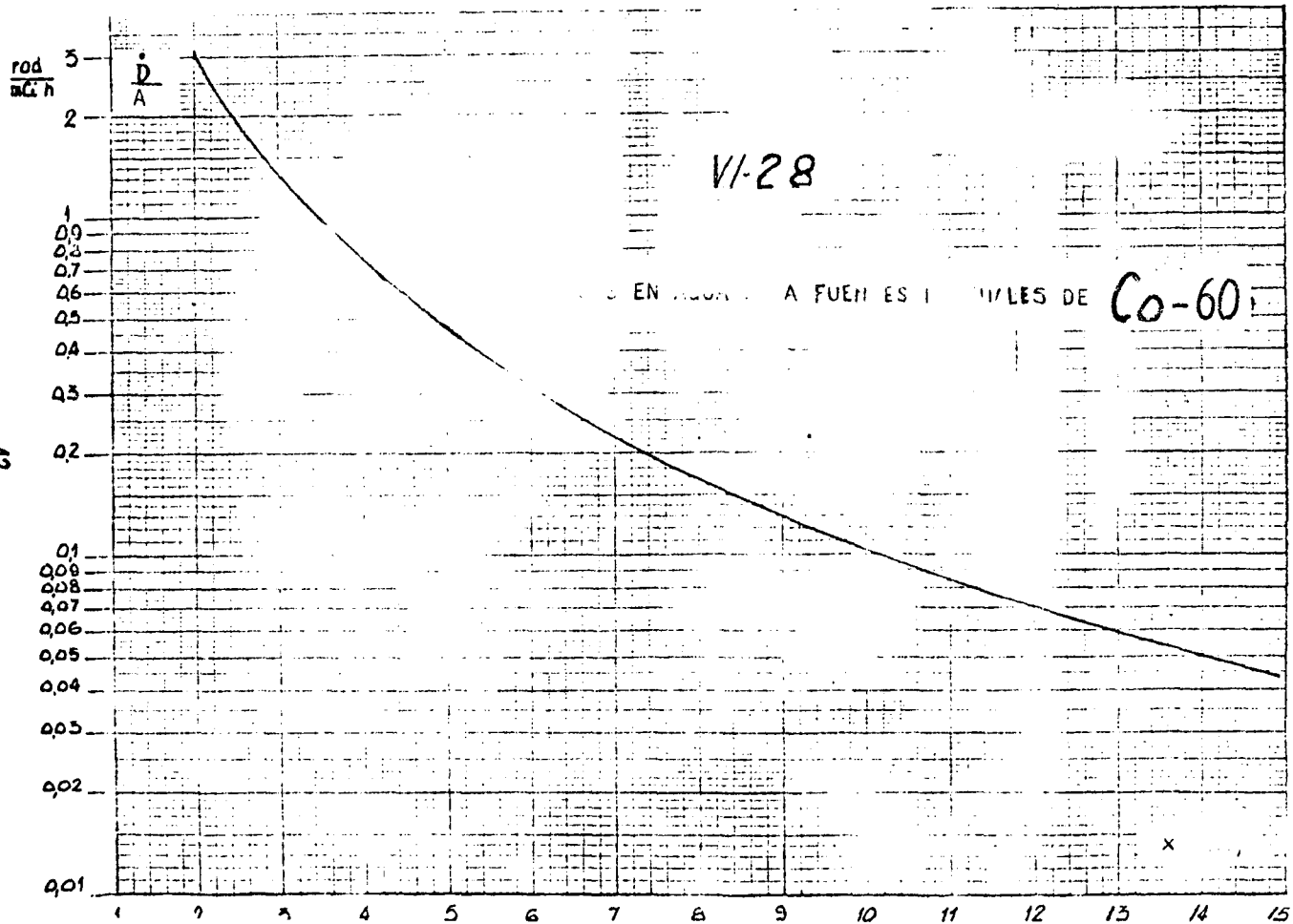


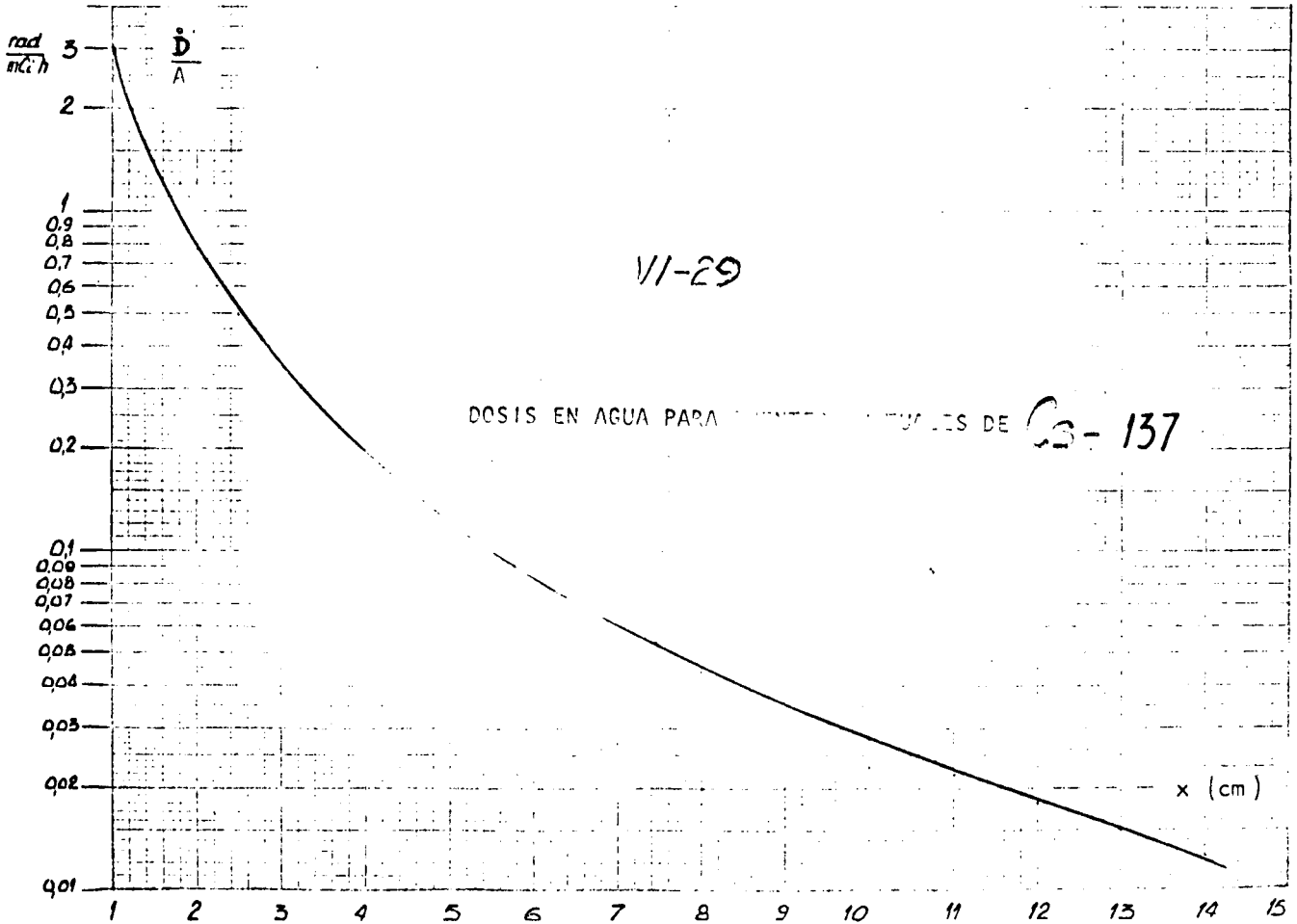
Fig VI-26

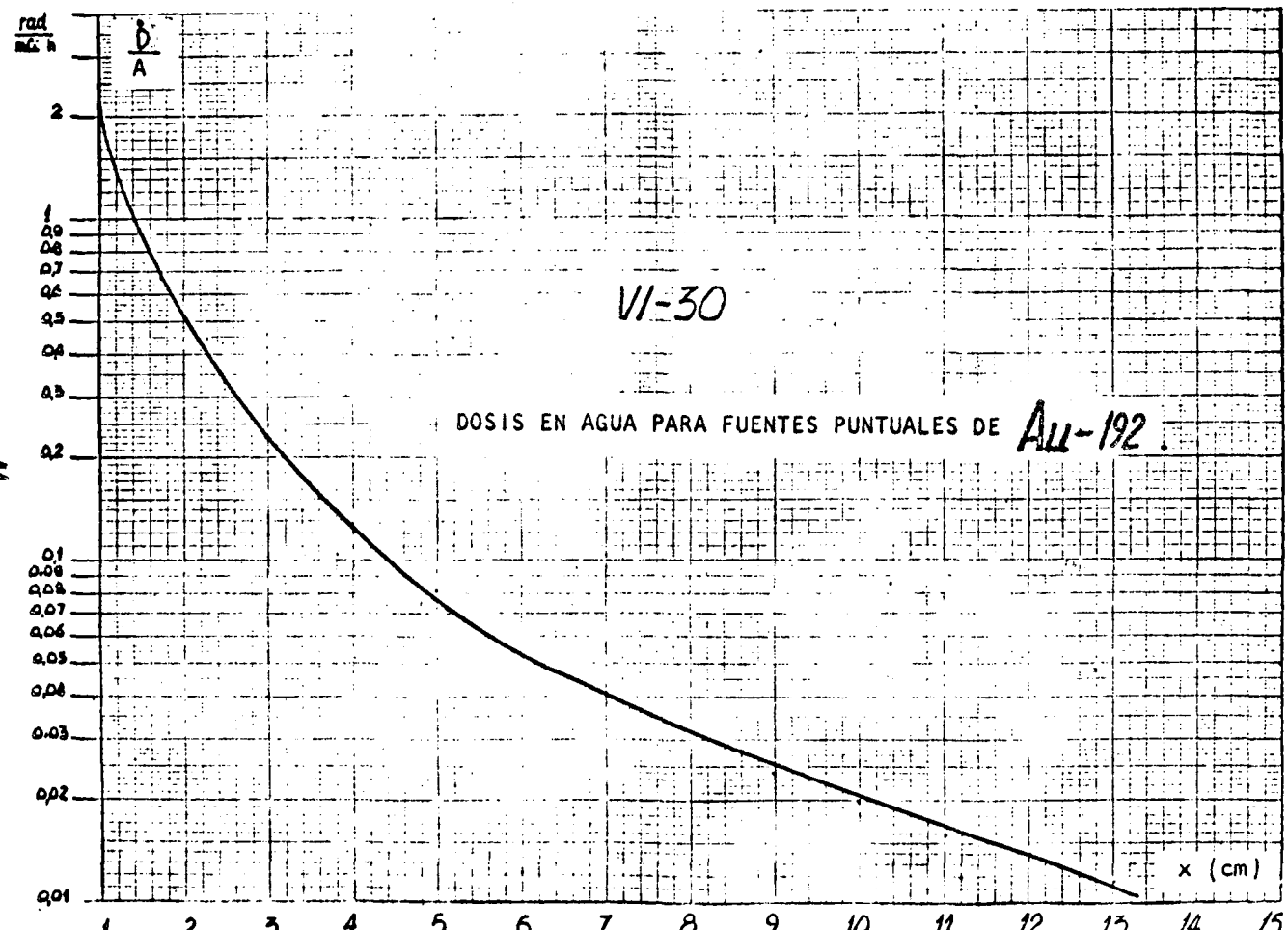

VI-27
DOSIS EN AGUA PARA FUENTES PUNTUALES DE Ra-226
rad / mC.h
D/A
con 0,5 mm de Pt
con 1 mm de Pt
x (cm)
3
2
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


rad/mCi h
Ḋ/A
V/-28
EN AGUA A FUENTES PUNTUALES DE Co-60
5
2
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
x

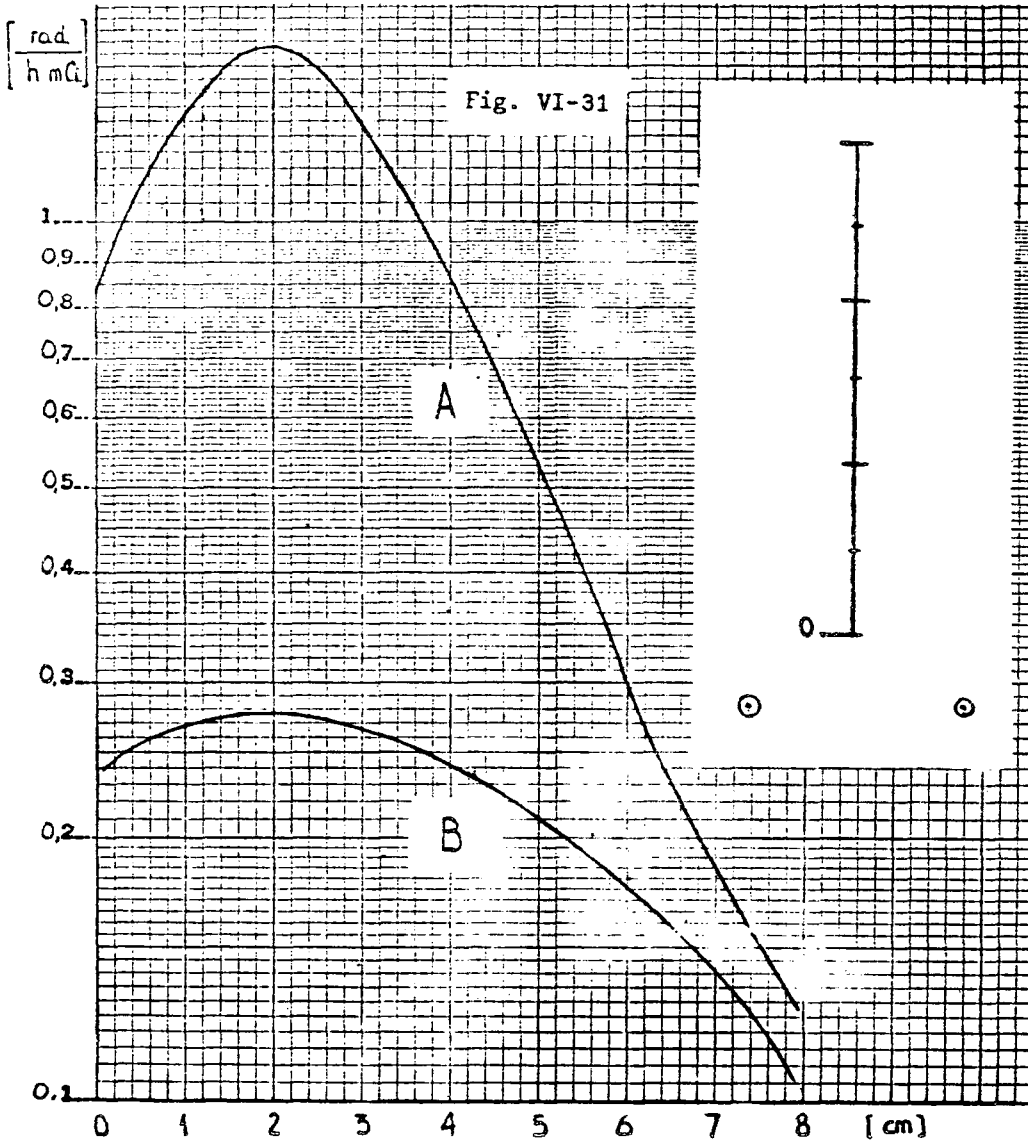
VI-29

DOSIS EN AGUA PARA [illegible] DE Cs - 137




rad
mCi h
D
A
2
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
VI-30
DOSIS EN AGUA PARA FUENTES PUNTUALES DE Au-192
x (cm)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

CALCULO DE DOSIS EN LOS PUNTOS "A" Y "B" PARA TUBOS DE Ra^{226}



CONTRIBUCION DE LOS COPOSTATOS AL PUNTO "A" = 1,03 rad/h mCi;
AL PUNTO "B" = 0,505 rad/h mCi.

Fig VII-1

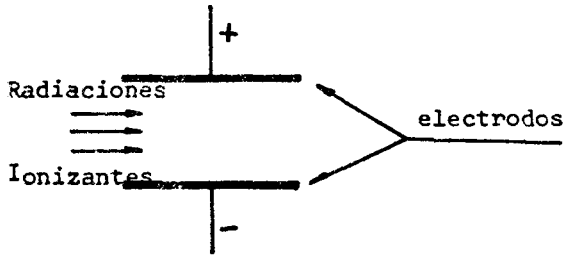


Fig VII-3

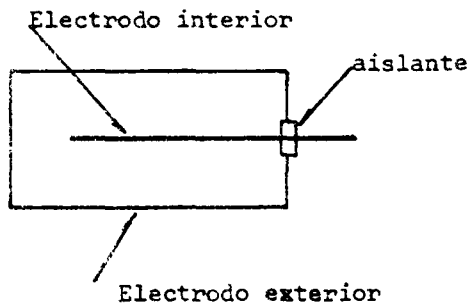


Fig VII-2

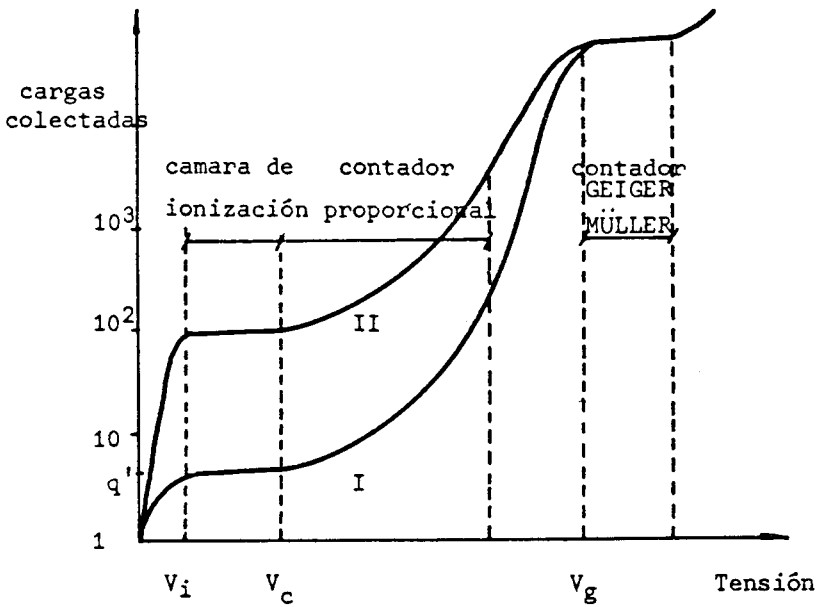

cargas
colectadas
camara de
ionización
contador
proporcional
contador
GEIGER
MÜLLER
10^3
10^2
10
q'
1
II
I
V_i
V_c
V_g
Tensión

Fig VII-4

Camara de aire libre

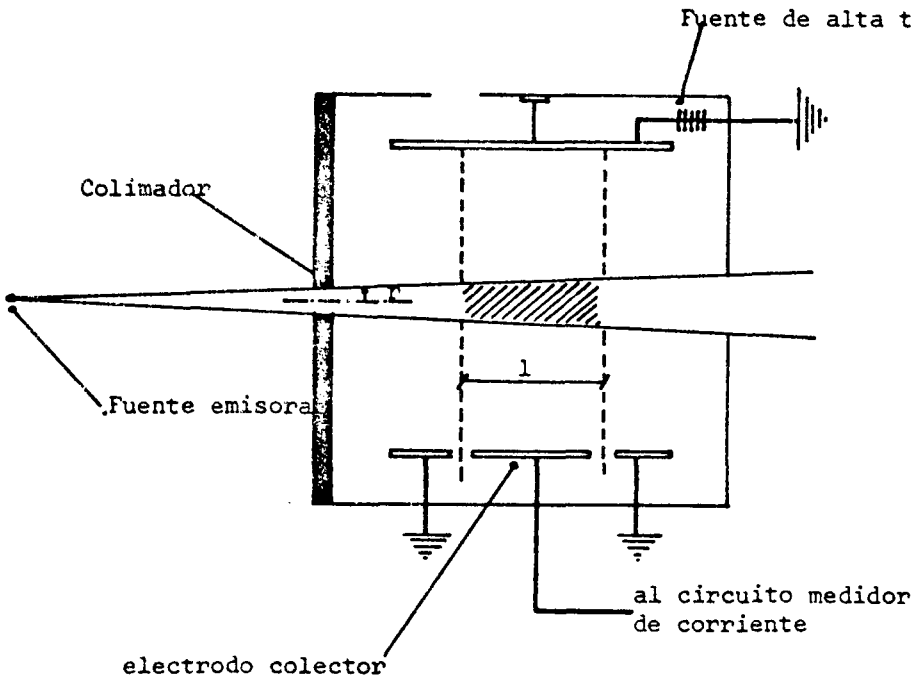


Fig VII-5

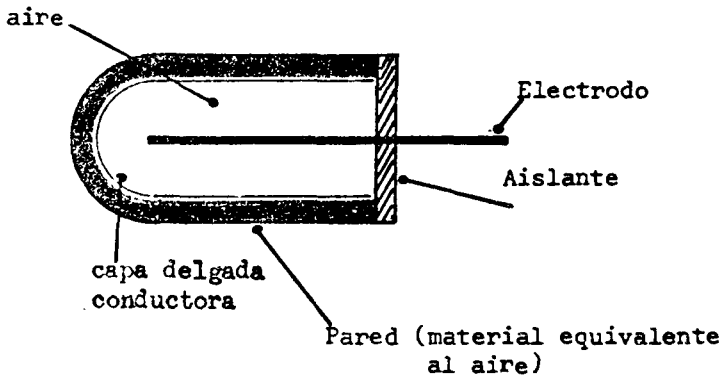


Fig VII-6

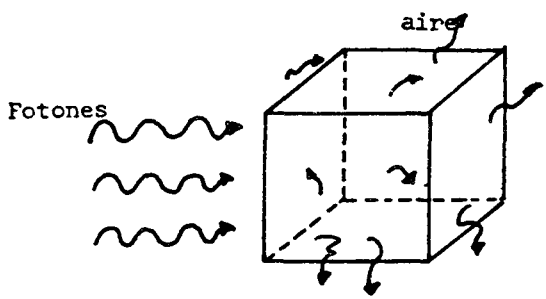


Fig. VII-7

ALCANCE DE LOS ELECTRONES EN DIVERSOS MEDIOS

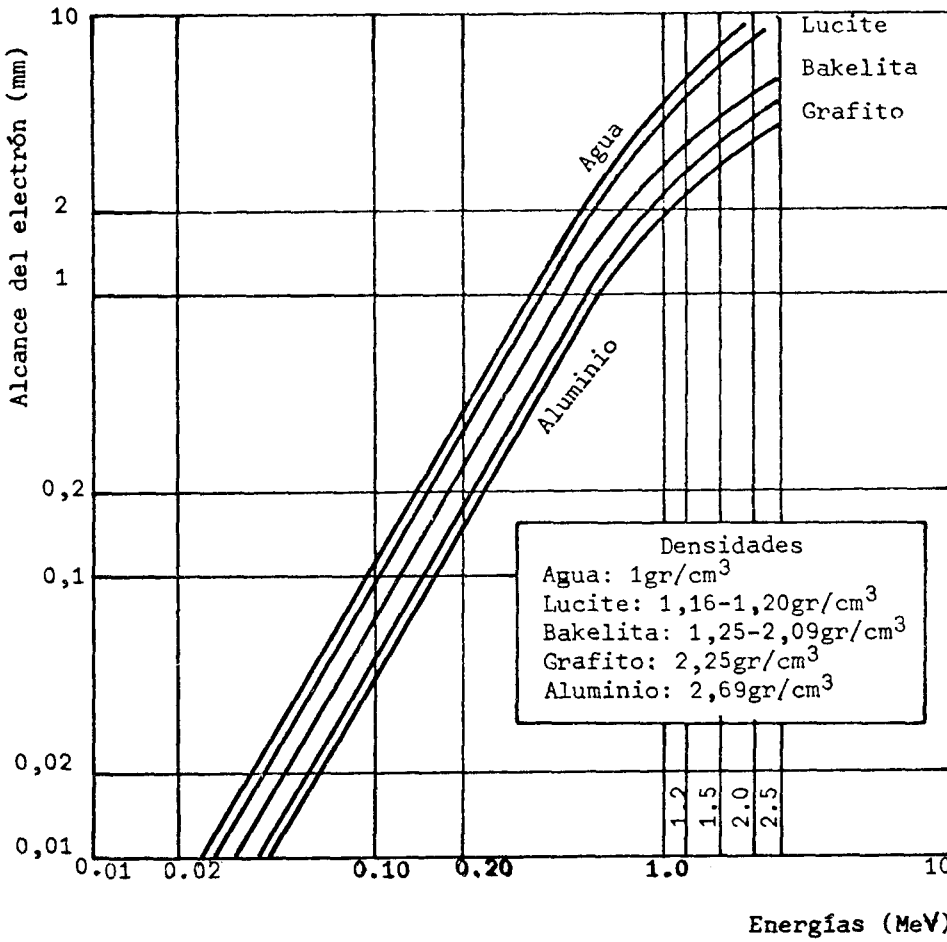


Fig. VII-8

METODO DE CALIBRACION DE FILM - DOSIMETROS

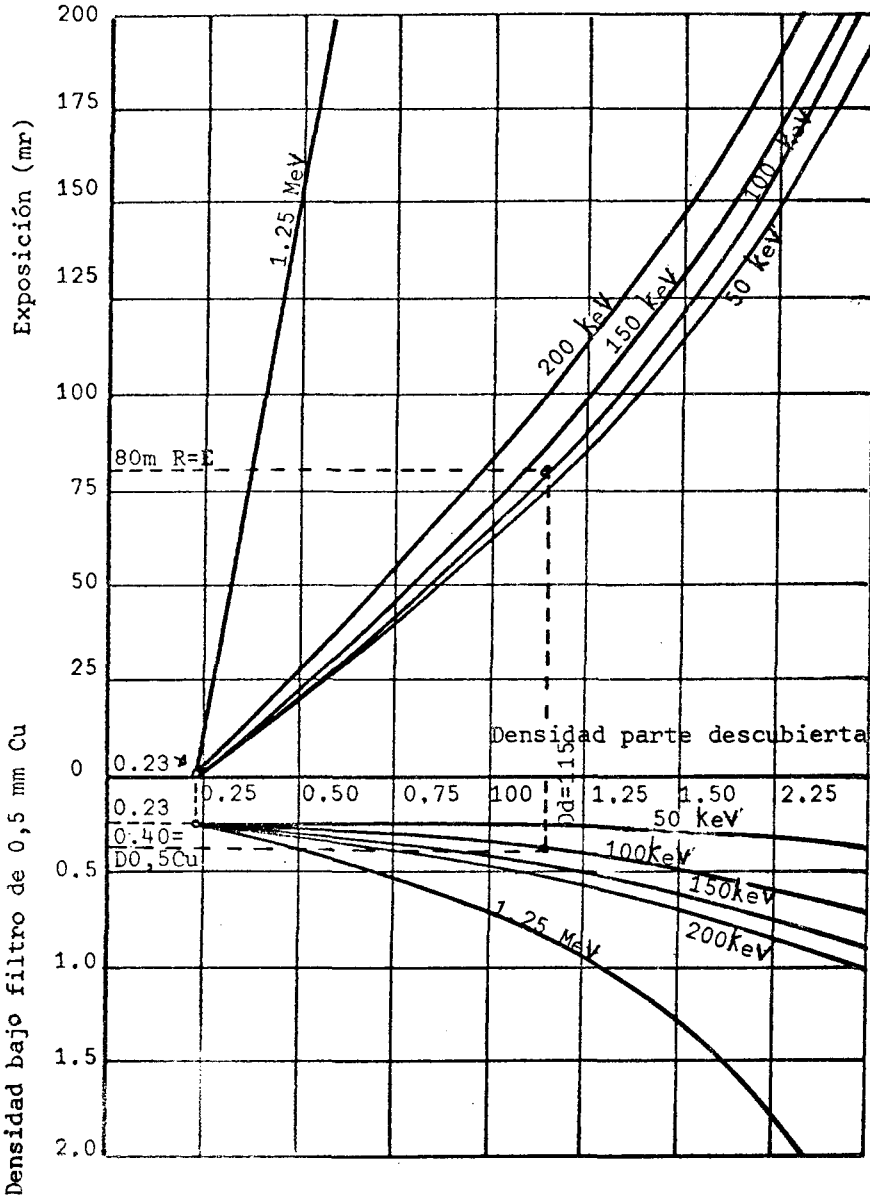
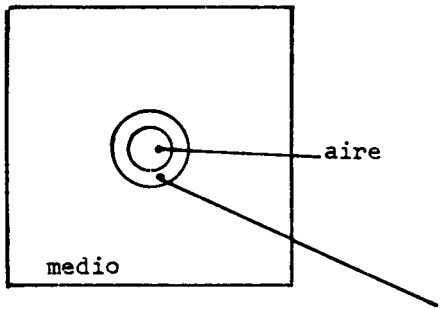


Fig.VII-9



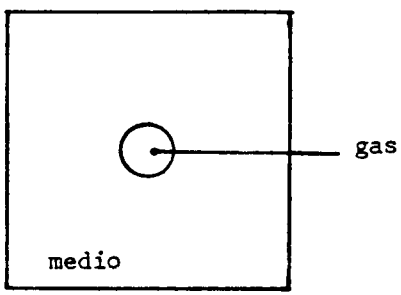
$$X = \frac{\Delta Q}{\Delta v}$$

$$D_m = f\frac{\Delta Q}{\Delta v}$$

Pared (material equivalente al aire)

(Para T y p normales y equilibrio electronico)

Fig.VII-10

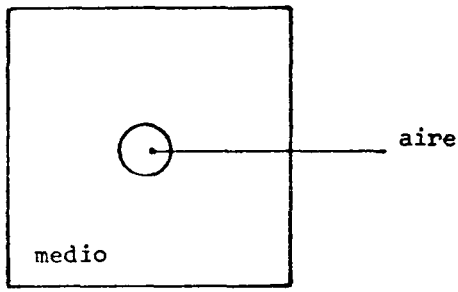


$$D_g = W.J$$

$$Dm = S\frac{m}{g}.\ W.\ J$$

(Bragg y Gray)

Fig. VII-11

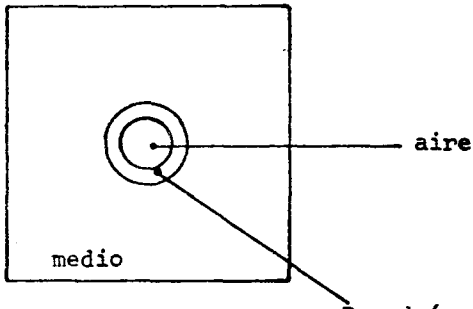


$$D_a = 0{,}869 \frac{\Delta Q}{\Delta v}$$

$$\overline{D_m} = 0{,}869\ S_a^m \frac{\Delta Q}{\Delta v}$$

(Para T y p normales)

Fig. VII-12



$$D_a = 0{,}869 \frac{\Delta Q}{\Delta v}$$

$$D_p = 0{,}869.\ S_a^p \frac{\Delta Q}{\Delta v}$$

$$D_m = 0869.\ S_a^p \frac{\Delta Q}{\Delta v} \cdot \frac{(\mu_a/\delta)_m}{(\mu_a/\delta)_p}$$

(Para T y p normales y equilibrio electronico)

Fig. VIII-1

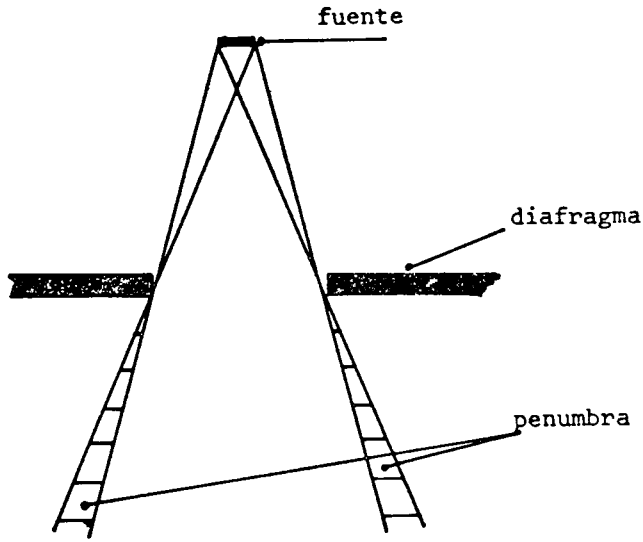


Fig. VIII-2

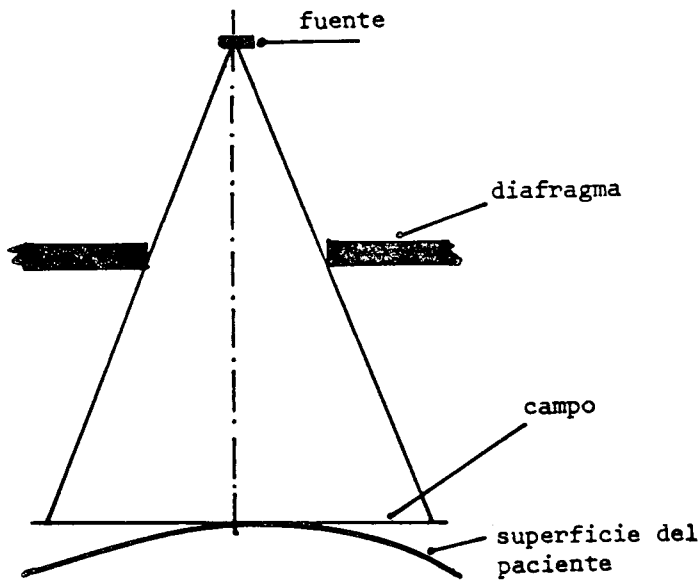


Fig.VIII-3

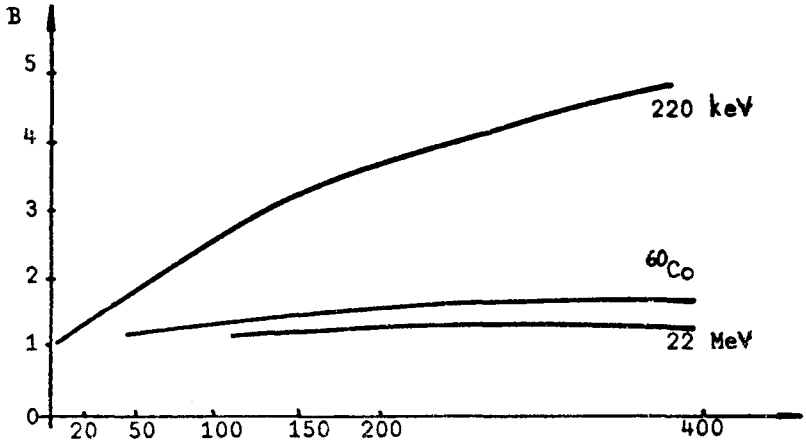


Fig.VII-4

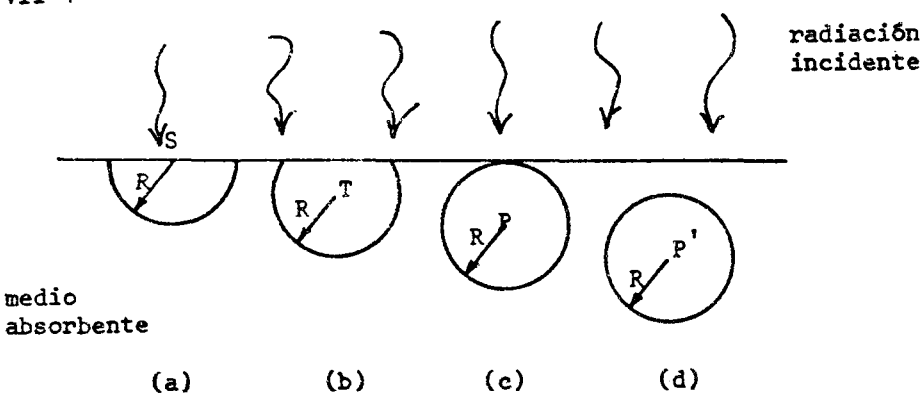


Fig. VIII-5

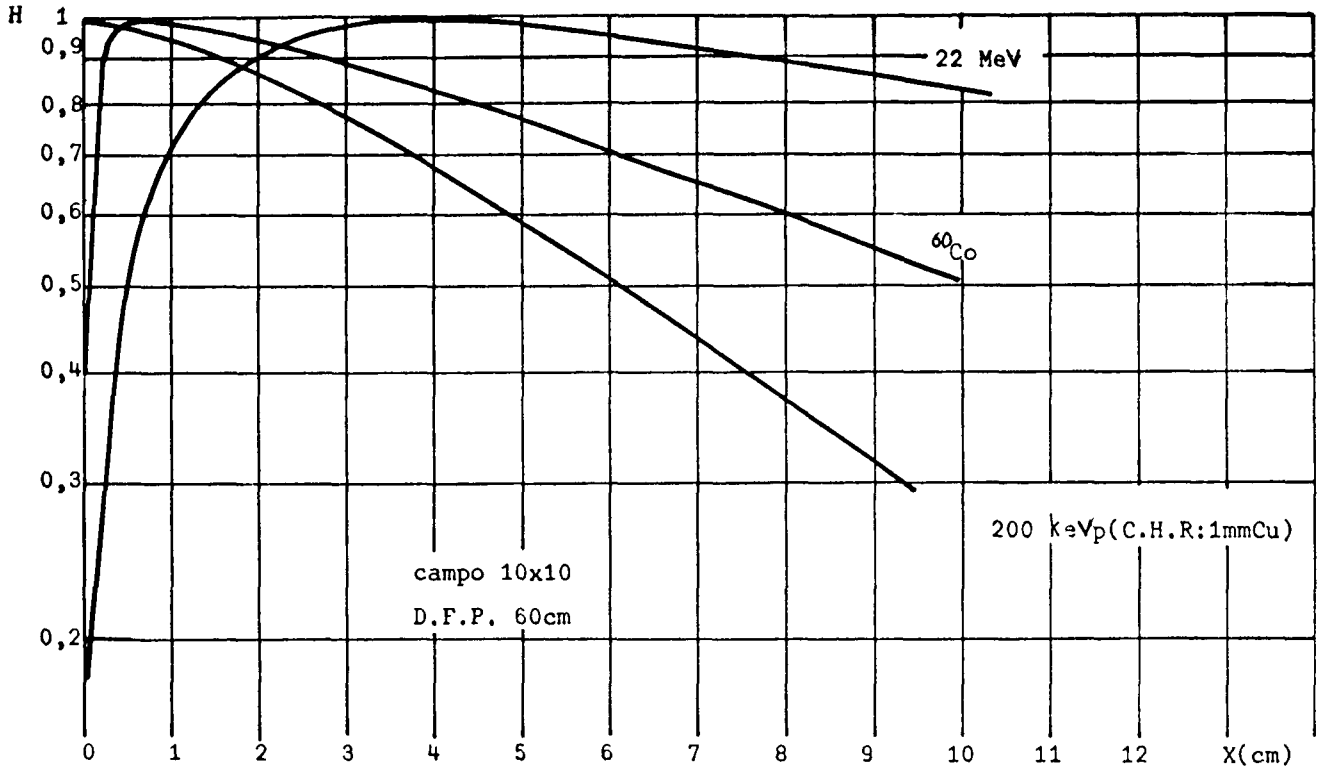

H
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
22 MeV
60Co
200 keVp(C.H.R:1mmCu)
campo 10x10
D.F.P. 60cm
0
1
2
3
4
5
6
7
8
9
10
11
12
X(cm)

Fig. VIII-6

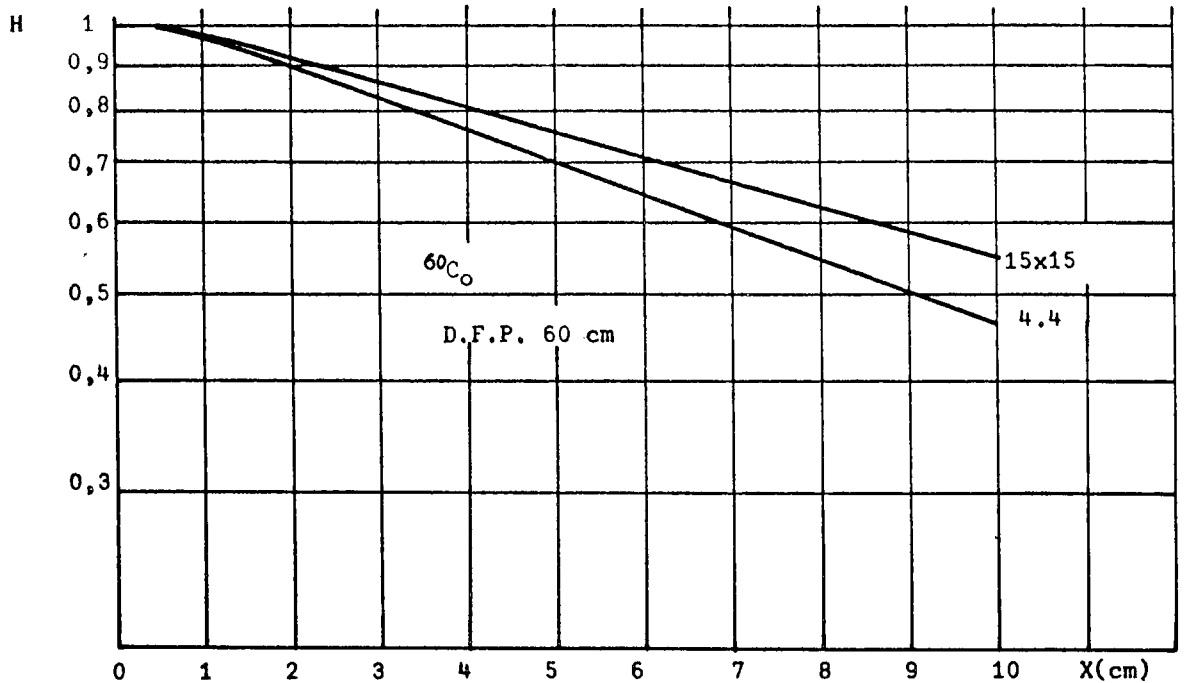


Fig.VIII-7

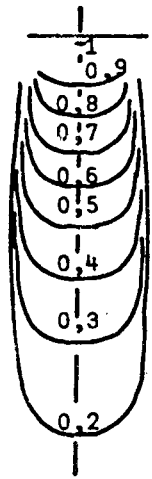


Fig.VIII-8

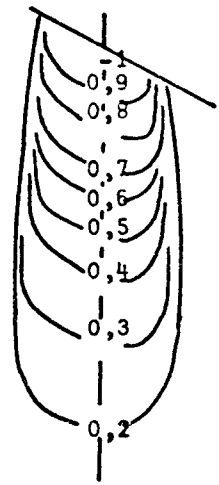


Fig. VIII-9

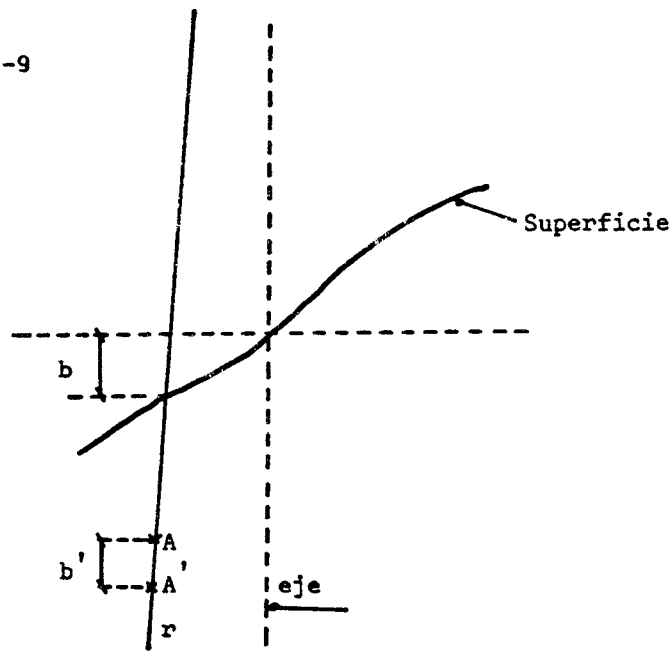


Fig.VIII-10

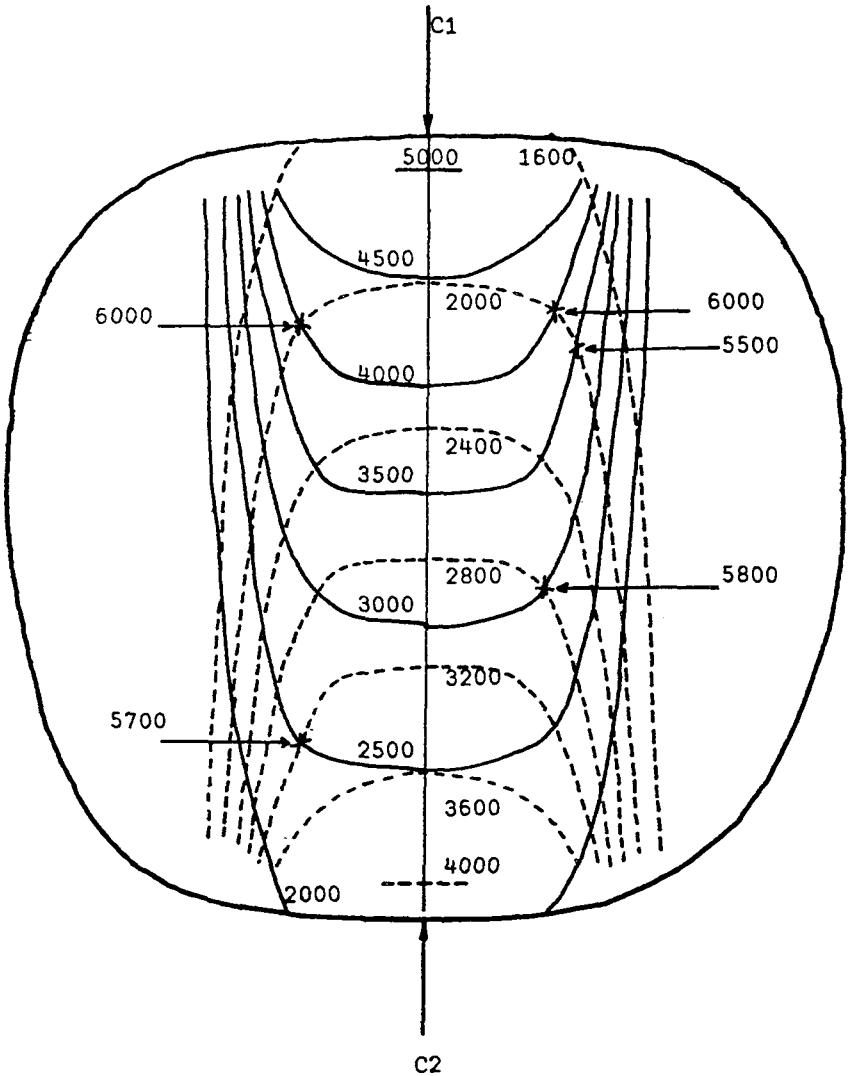

C1
5000
1600
4500
6000
2000
6000
5500
4000
2400
3500
2800
5800
3000
3200
5700
2500
3600
4000
2000
C2

Fig.VIII-11

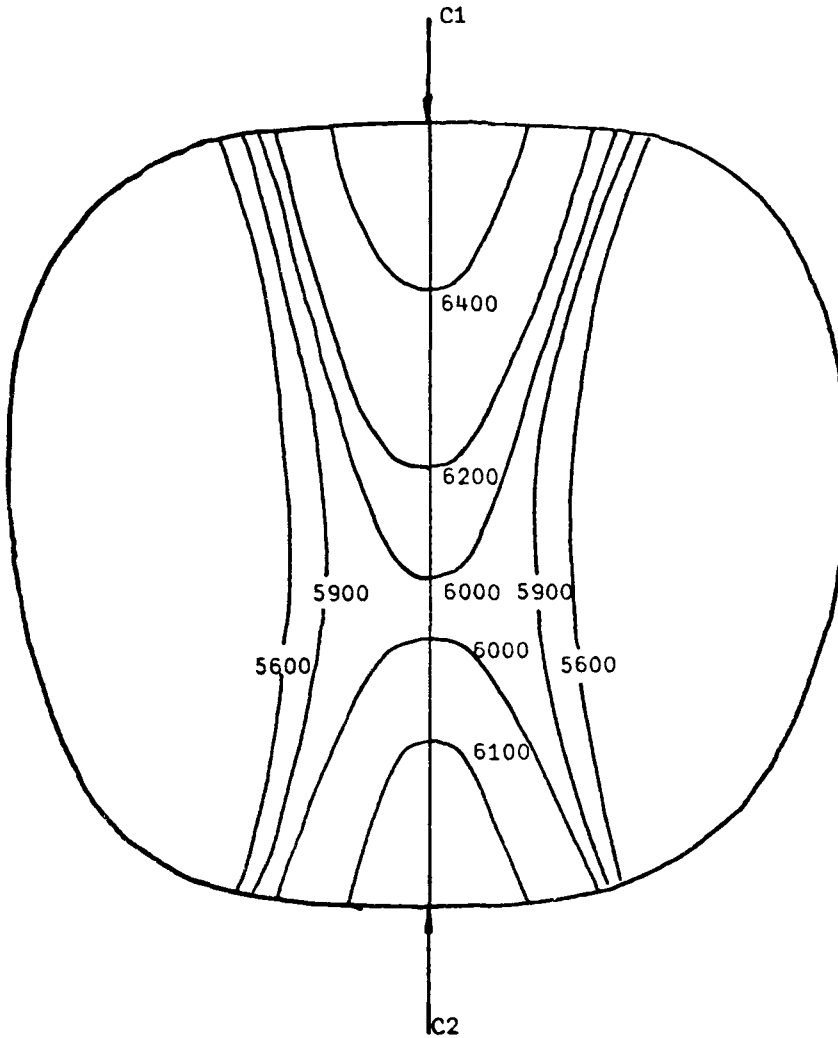
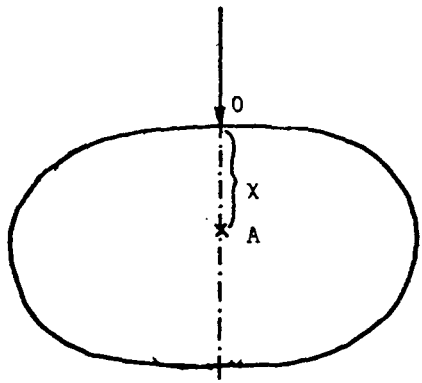
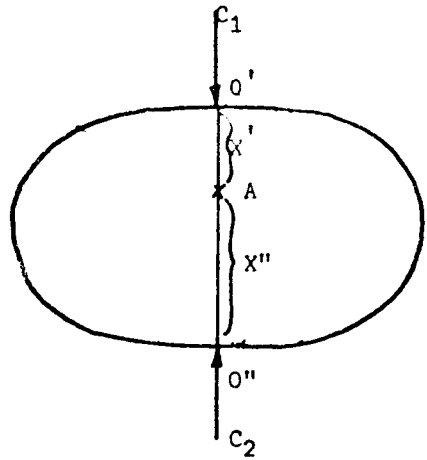


Fig.VIII-12



A	0	Punto
$\dot{D}$	$(\dot{D})_o$	Dosis por unidad de tiempo
D_a	$(D_o)_a$	Dosis por aplicación
D	D_p	Dosis total
H	1	Rendimiento en profundidad

Fig.VIII-13



O'	A	O''	Punto
$(\dot{D})'_o$	$\dot{D}'';\dot{D}'$	$(\dot{D}_o)''$	Dosis por unidad de tiempo
$(D_o)'_a$	D_a	$(D_o)''_a$	Dosis por aplicación
D'_o	$D';D''$	D''_o	Dosis total por cada campo
D'_p	D	D''_p	Dosis total
1	H'	H'_s	Rendimiento en profundidad por C1
H''_s	H''	1	Rendimiento en profundidad por C_2

$$R = \frac{D'}{D''}$$

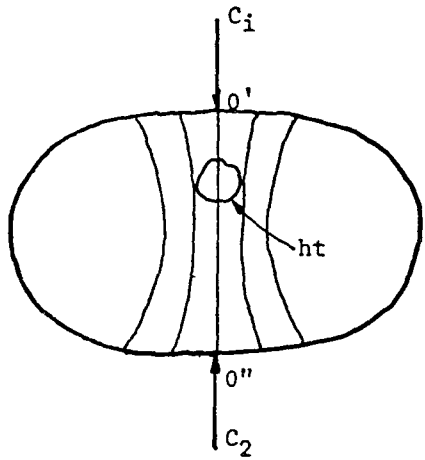
$$\rho = \frac{D'_o}{D''_o}$$

N;N°total de aplicaciones

N': N°Total de aplicaciones por C_1

N": N°total de aplicaciones por C_2

Fig VIII-14



0'	C.R.T	0"	Punto	
h_o'		$h_o'H_s'$	Por C_1	Valores Normalizados de dosis
$h_o''H_s''$		h_o''	Por C_2	
h_p'	h_t	h_p''	Por ambos campos	
D_o'	D_t	D_o''	Dosis total	

C.R.T: Curva que rodea al tumor

Fig. VIII-15

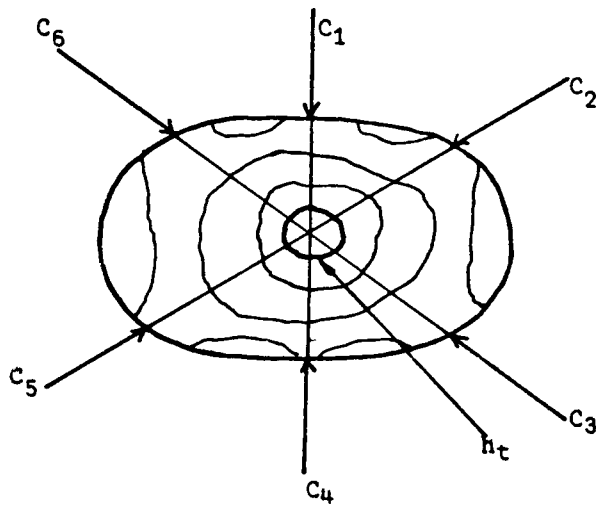


Fig.IX-1

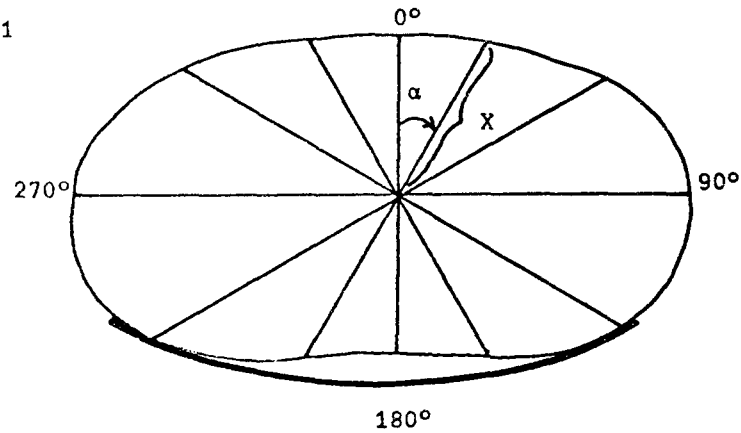


Fig.IX-2

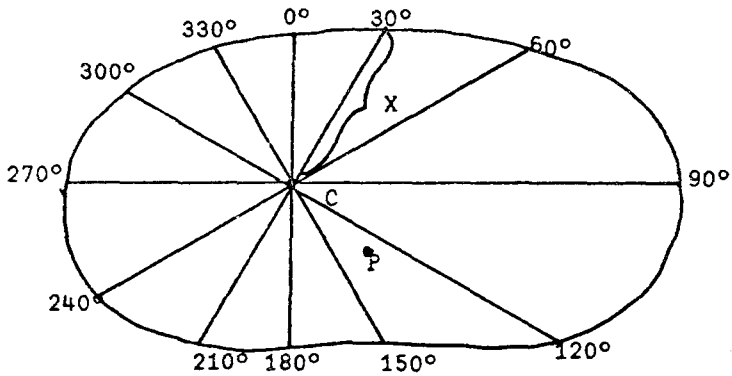


Fig. IX-3

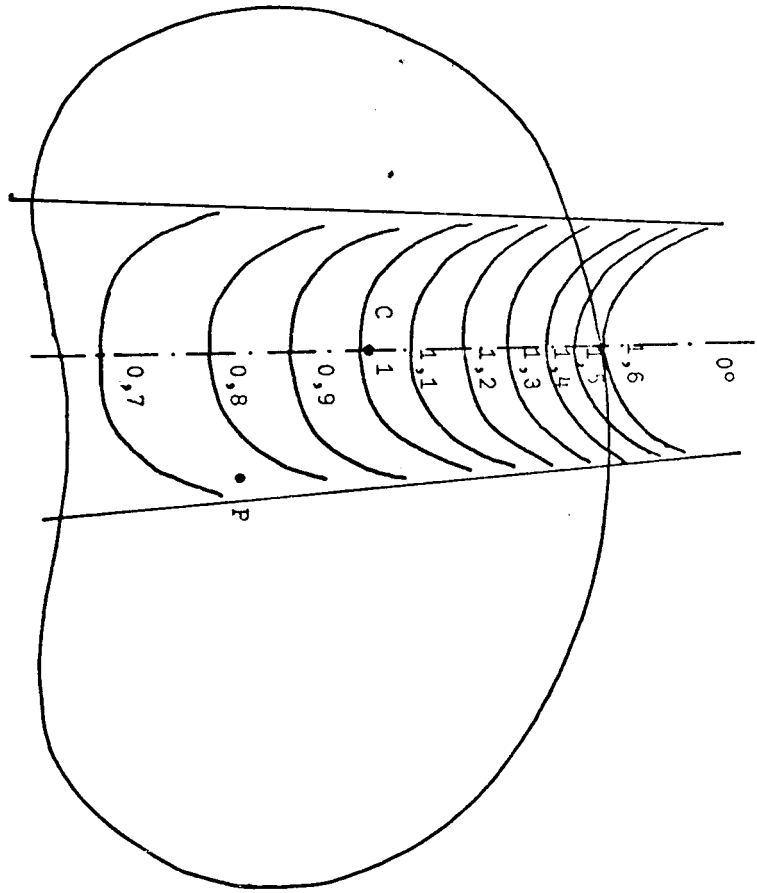


Fig. IX-4

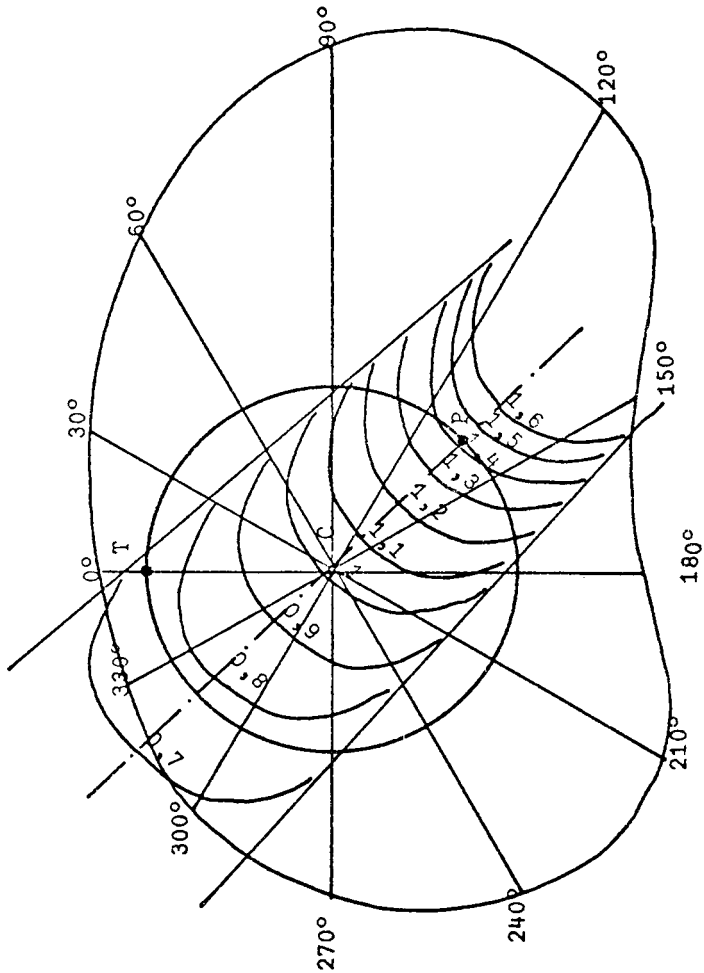

90°
120°
60°
150°
30°
180°
0°
T
330°
210°
300°
240°
270°
0,9
0,8
0,7
1,1
1,2
1,3
1,4
1,5
1,6

Fig. IX-5

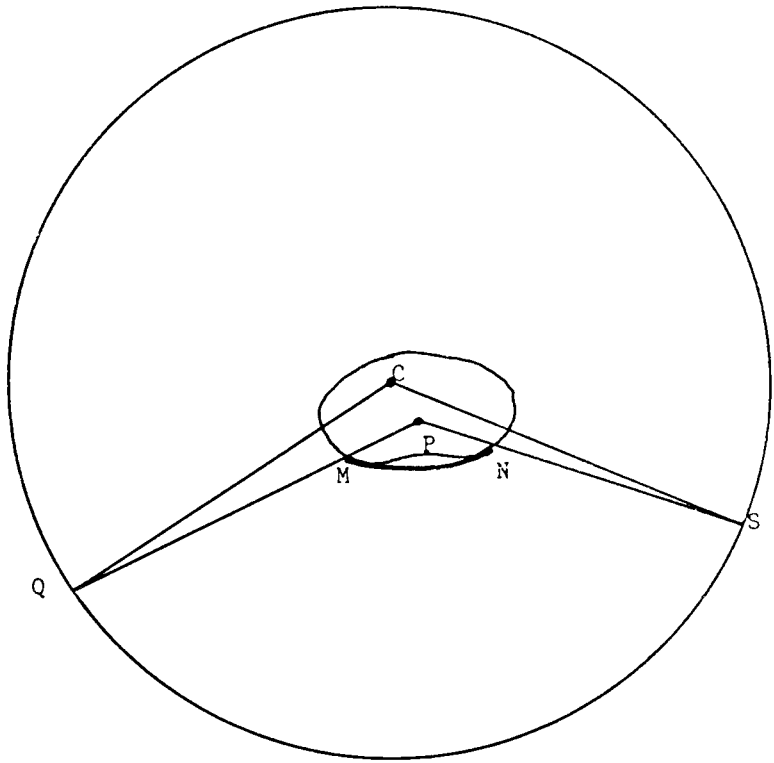
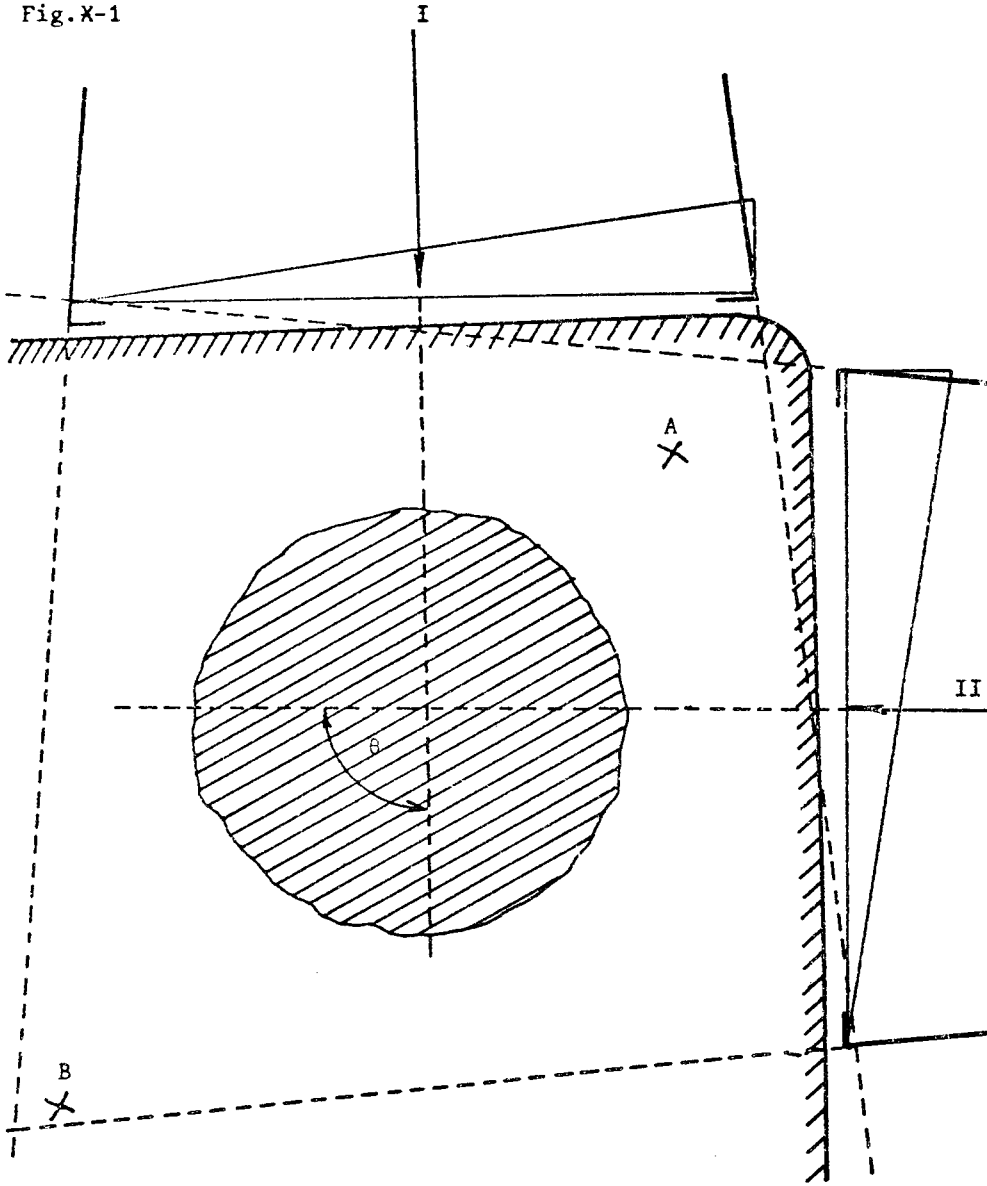
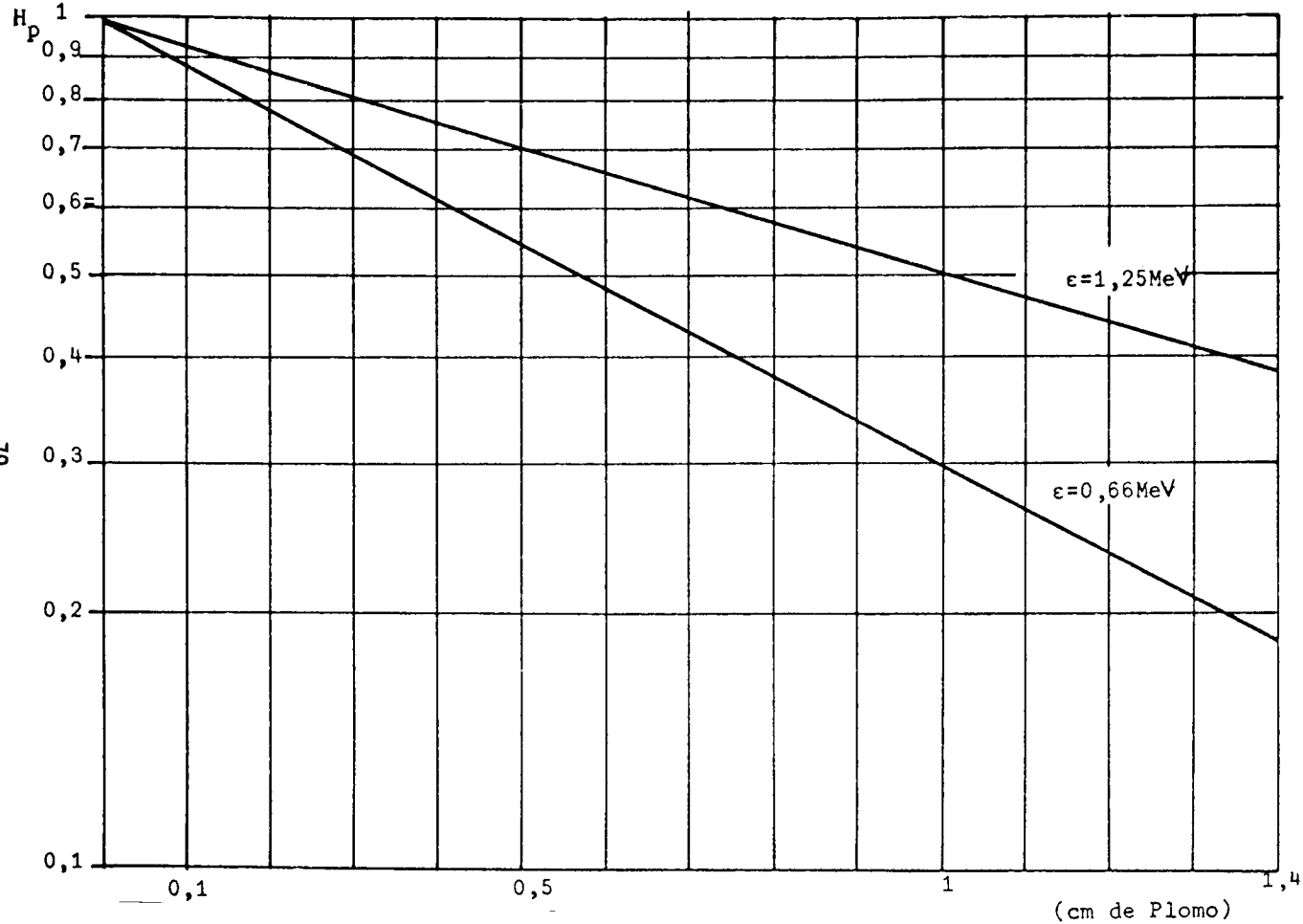
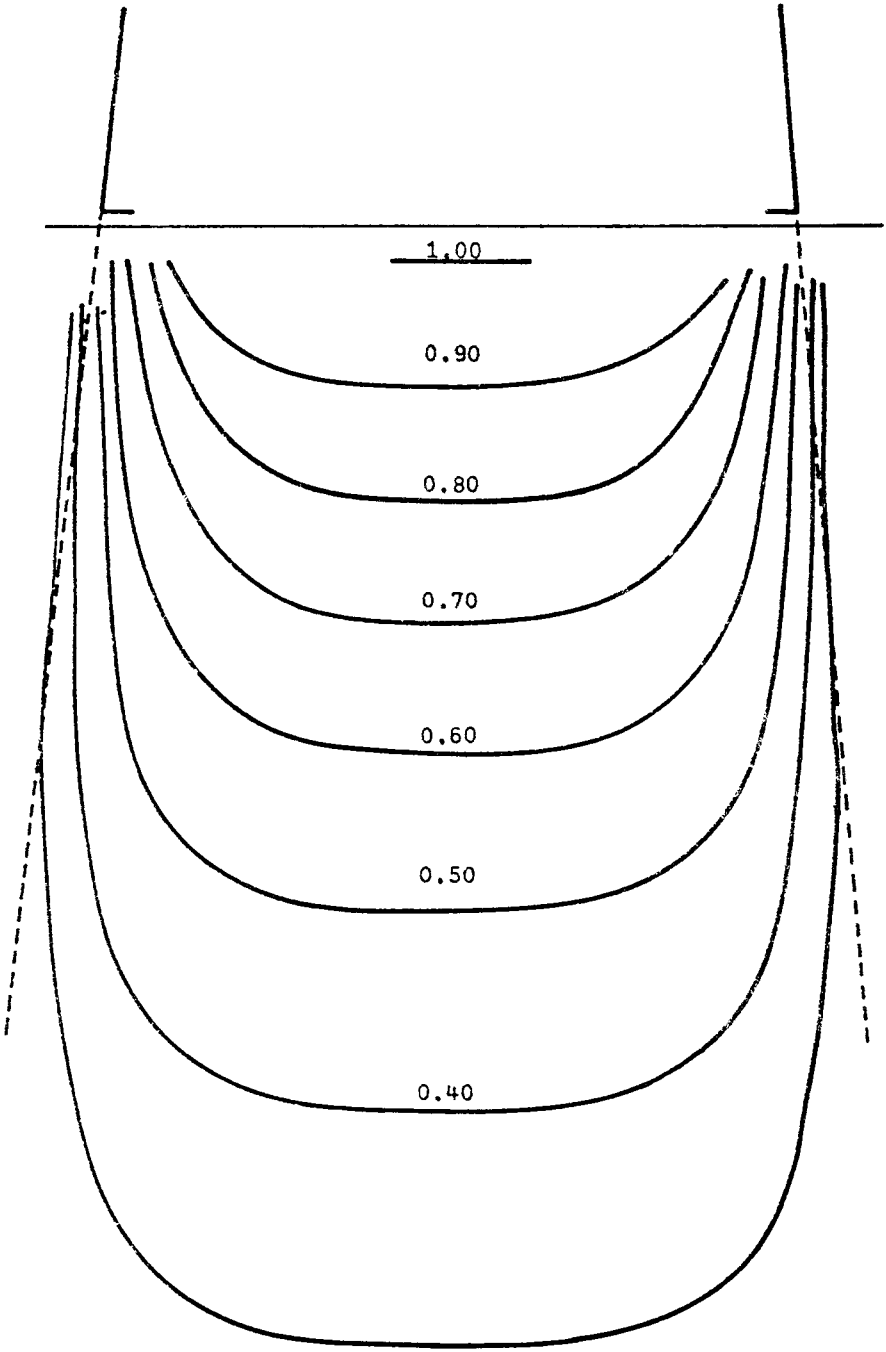


Fig.X-1




H_p
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,1
0,5
1
1,4
(cm de Plomo)
ε=1,25MeV
ε=0,66MeV


1.00
0.90
0.80
0.70
0.60
0.50
0.40

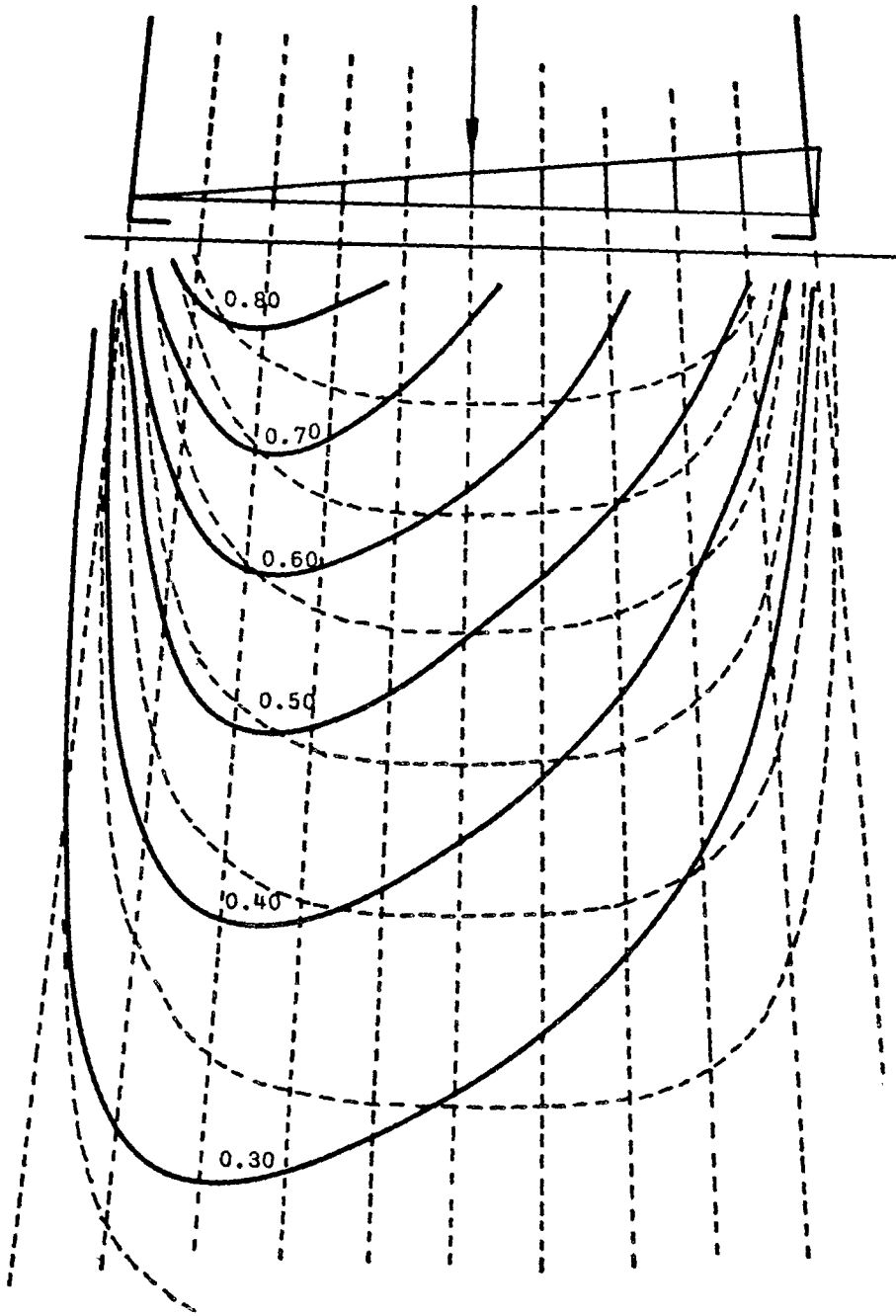

0.80
0.70
0.60
0.50
0.40
0.30

Fig.X-5

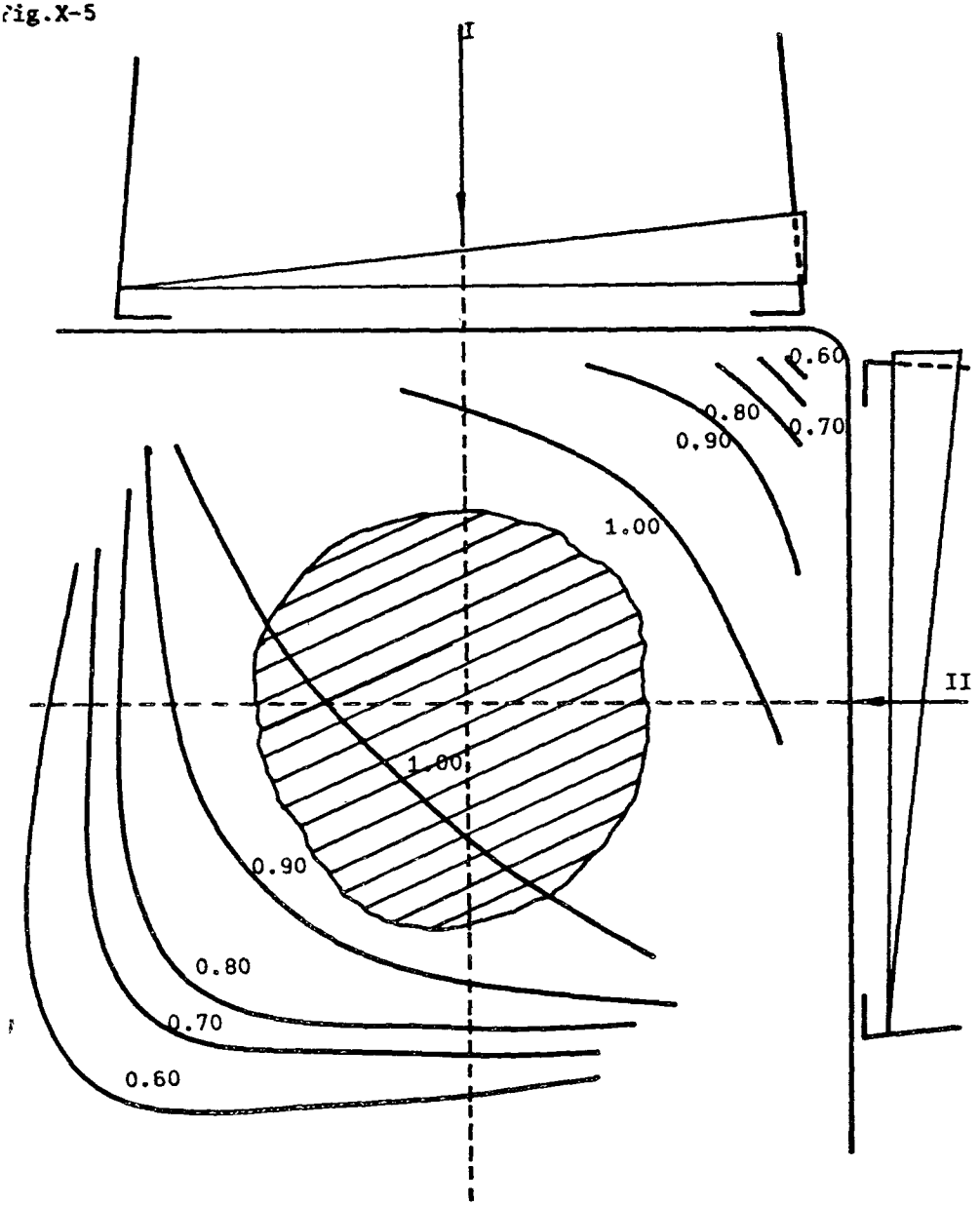


Fig. X-6

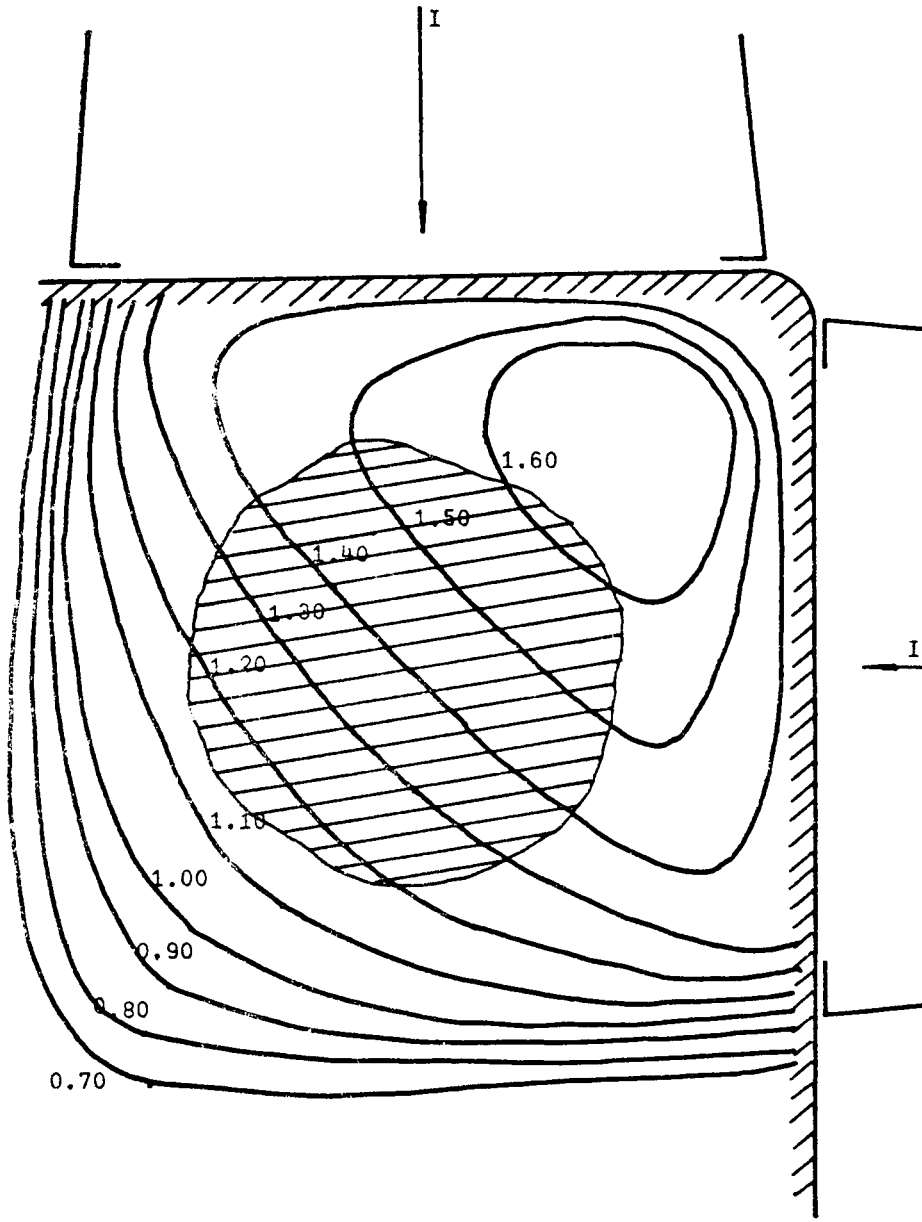


Fig.X-7

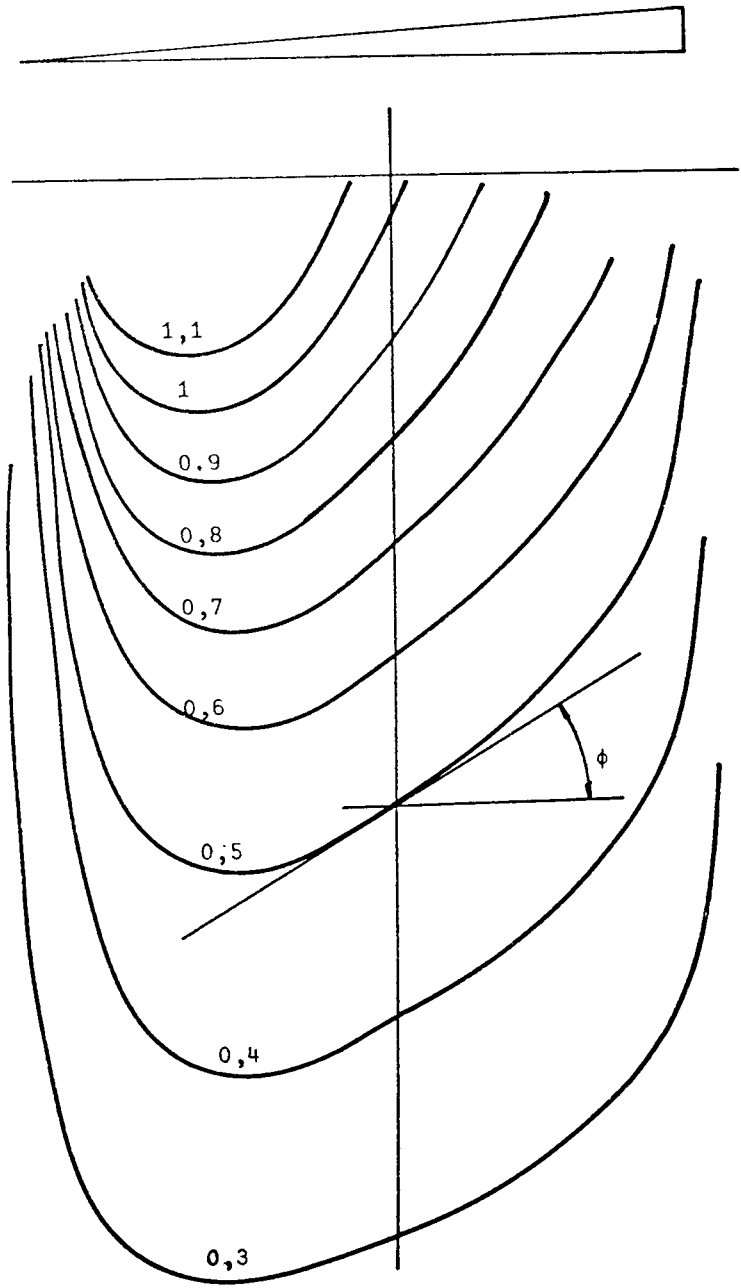


Fig. XI-1

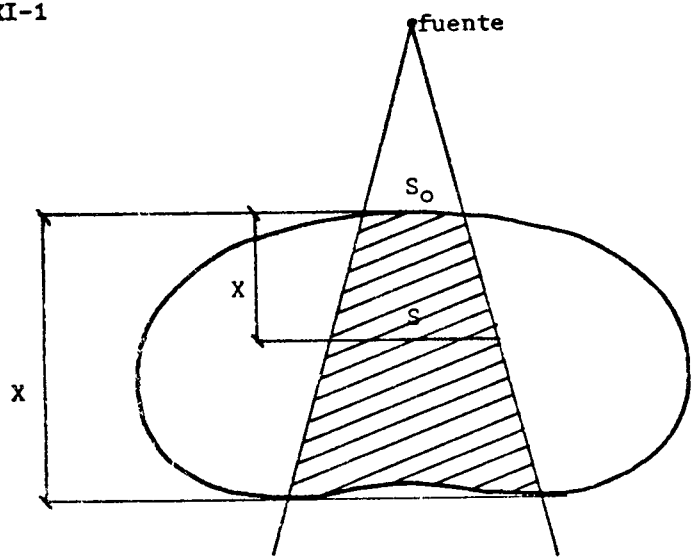


Fig.XI-3

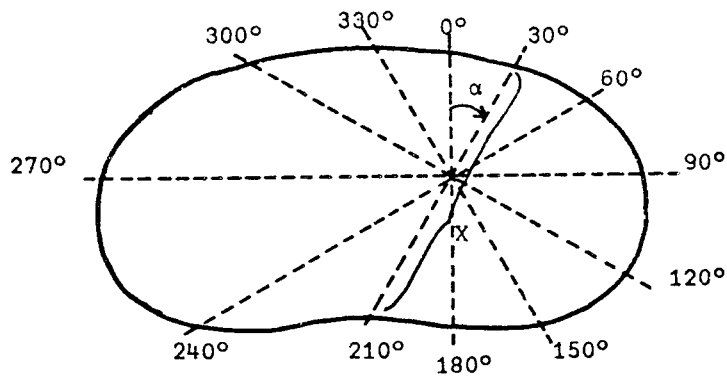


Fig.XI-2 $F = \frac{\delta(1-e^{-\mu x})}{\mu}$

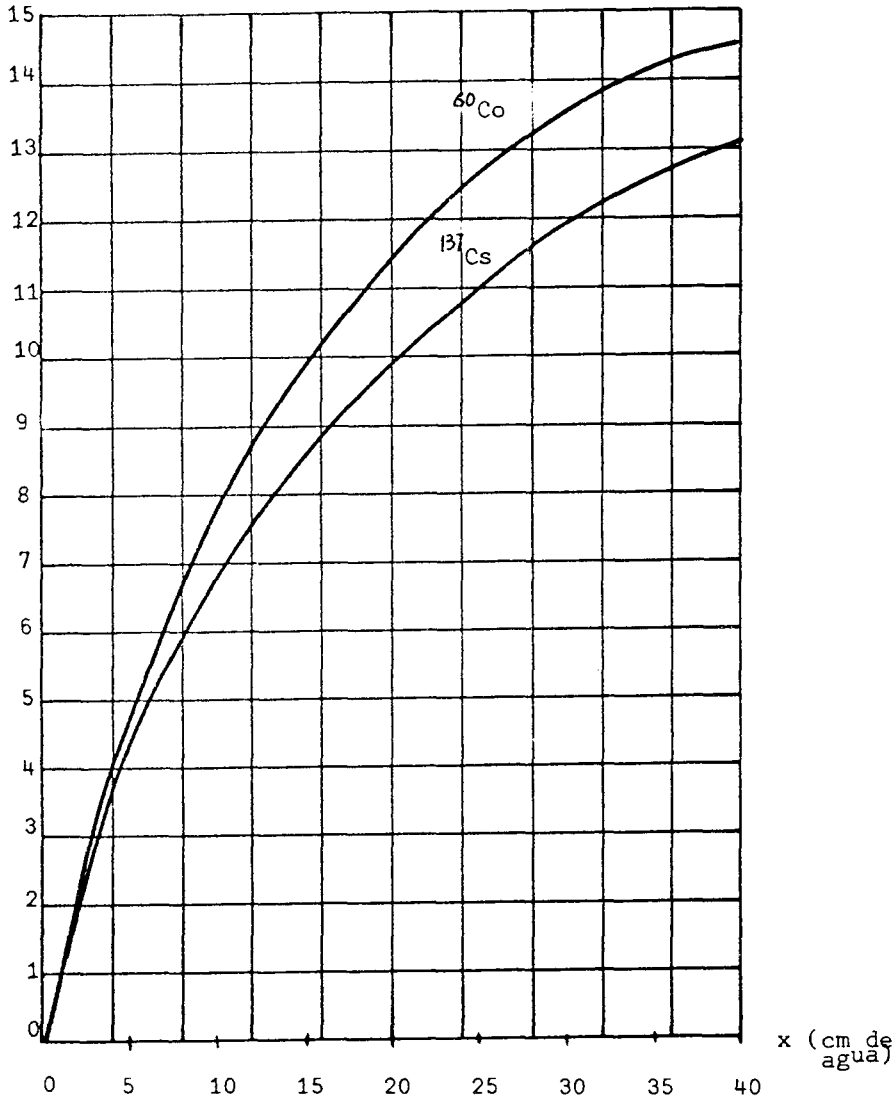


Fig.XI-4

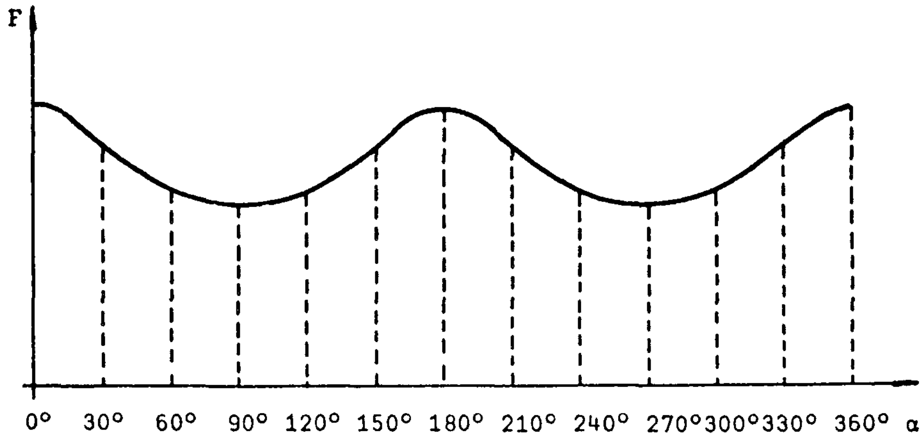
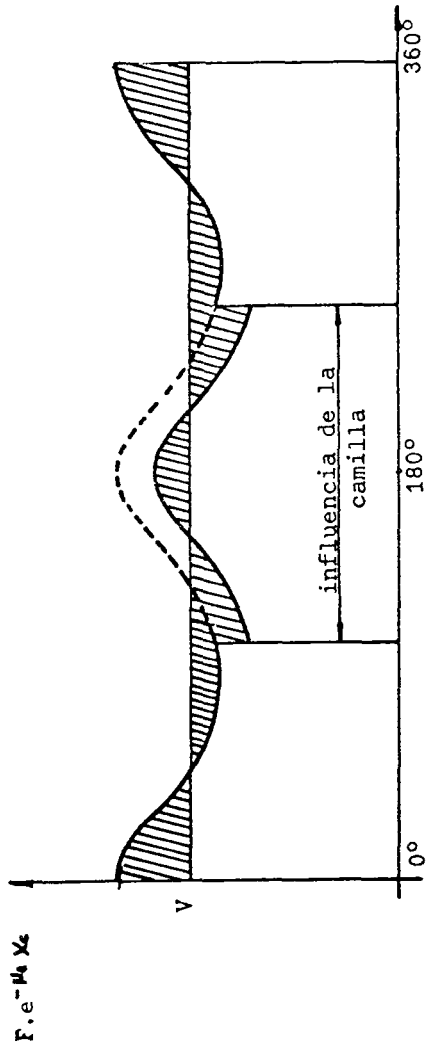


Fig. XI-5



Blindaje hacia adentro

Fig. XII-1

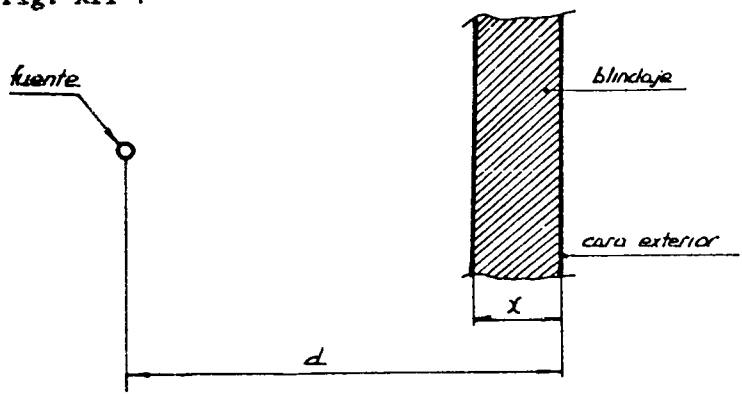


Fig. XII-2

Blindaje hacia afuera

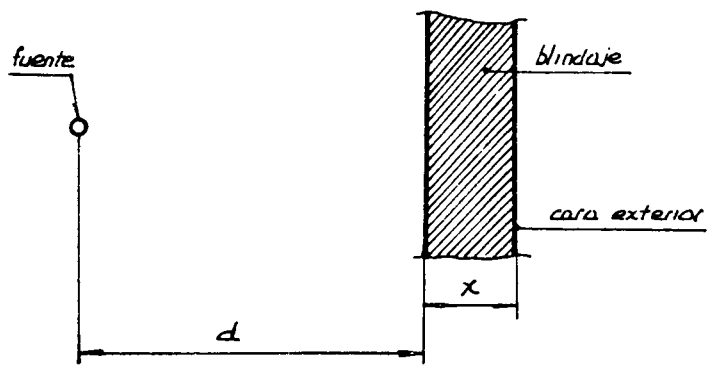


Fig. XII-3

BLINDAJE	
hacia alusera.	hacia exterior
$f = \frac{E \cdot (\alpha t x)^2}{A \cdot \Gamma \cdot B}$	$f = \frac{E \cdot d^2}{A \cdot \Gamma \cdot B}$

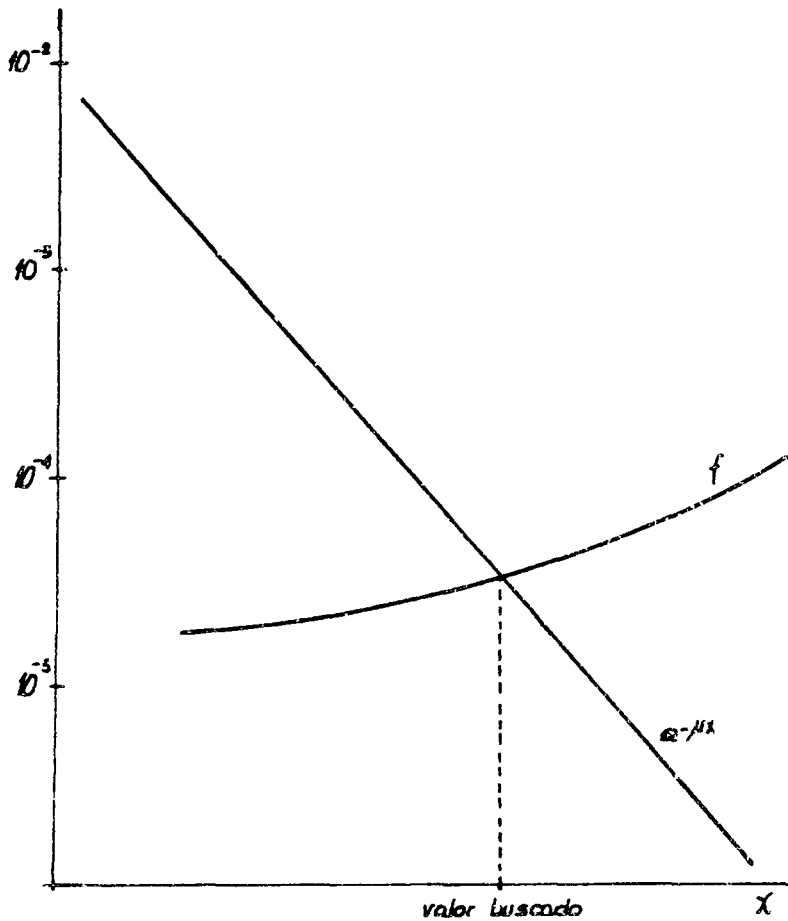


Fig. XII-4

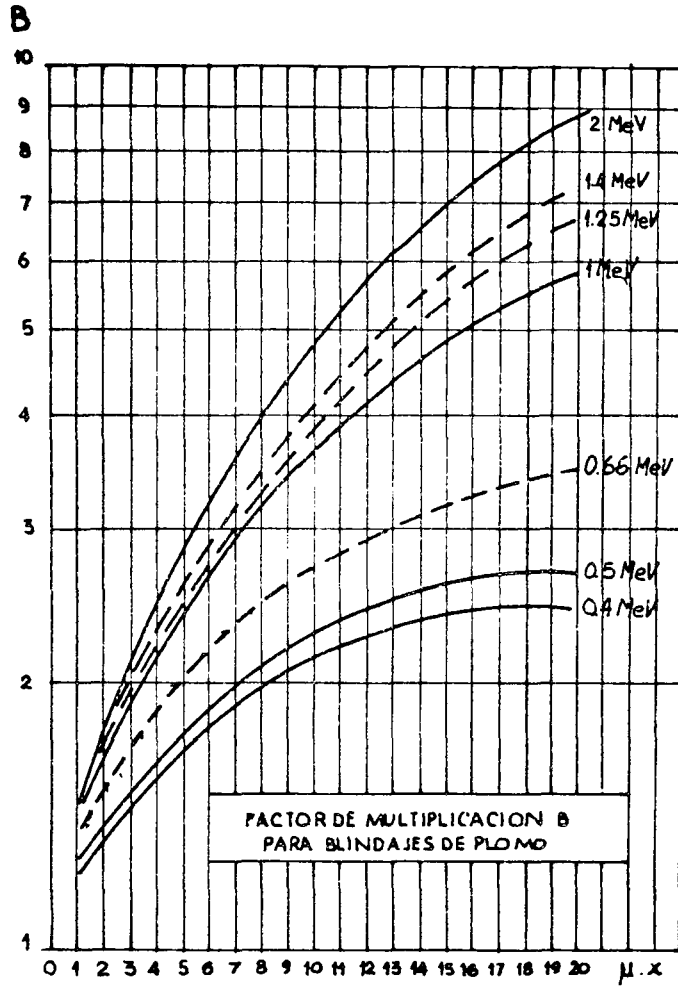

B
10
9
8
7
6
5
4
3
2
1
2 MeV
1.4 MeV
1.25 MeV
1 MeV
0.66 MeV
0.5 MeV
0.4 MeV
FACTOR DE MULTIPLICACION B
PARA BLINDAJES DE PLOMO
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 μ.x

Fig. XII-5

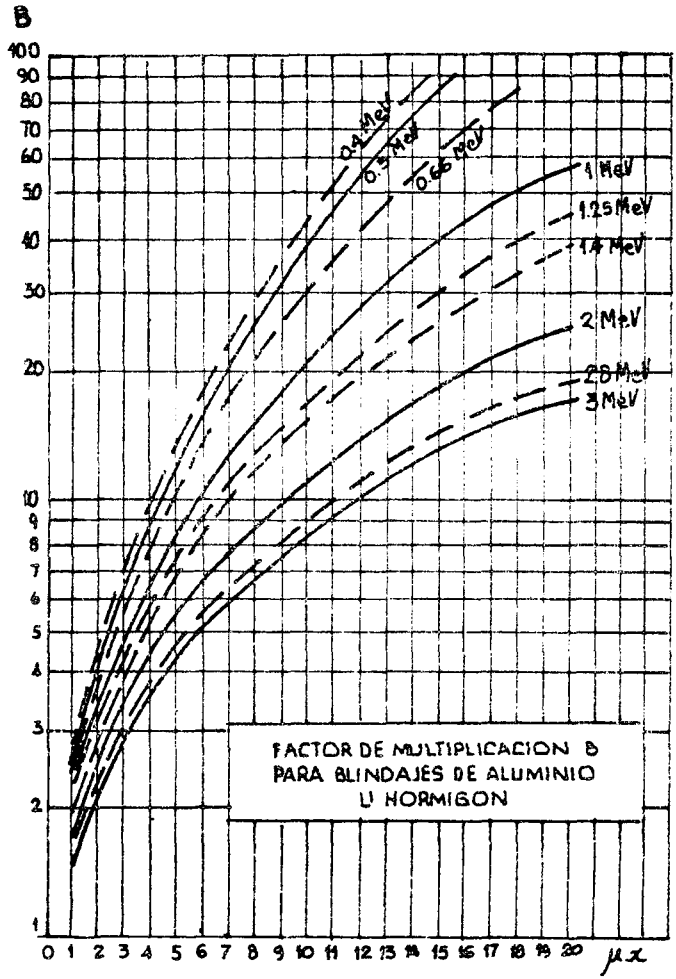

B
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
μx
0,4 MeV
0,5 MeV
0,66 MeV
1 MeV
1,25 MeV
1,4 MeV
2 MeV
2,8 MeV
3 MeV
FACTOR DE MULTIPLICACION B
PARA BLINDAJES DE ALUMINIO
Y HORMIGON

Fig. XII-6

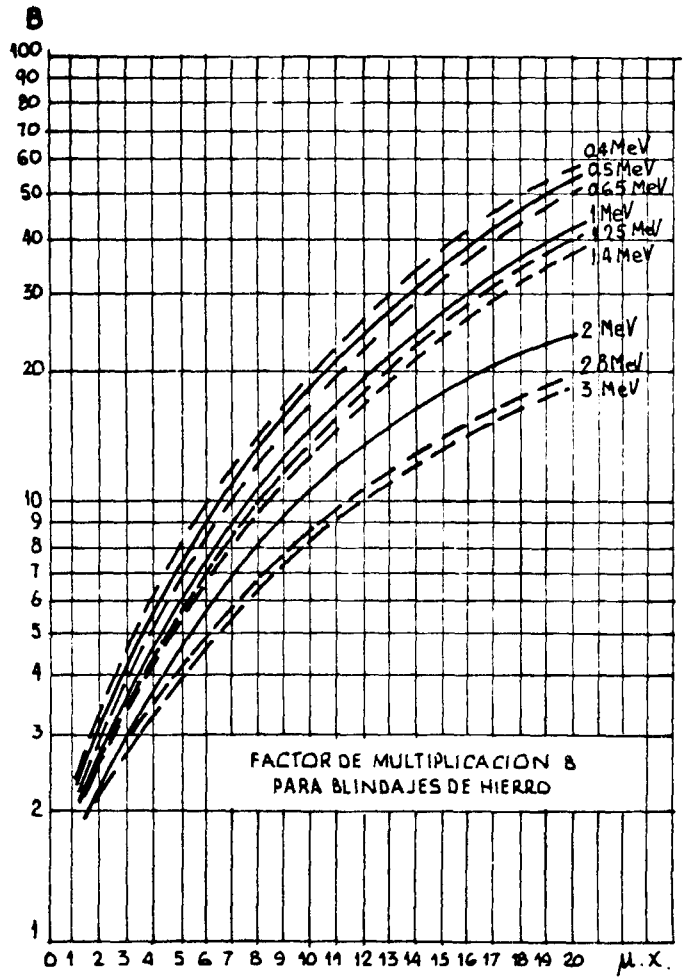

B
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
μ.X.
0.4 MeV
0.5 MeV
0.65 MeV
1 MeV
1.25 MeV
1.4 MeV
2 MeV
2.8 MeV
3 MeV
FACTOR DE MULTIPLICACION B
PARA BLINDAJES DE HIERRO

Fig. XII-7

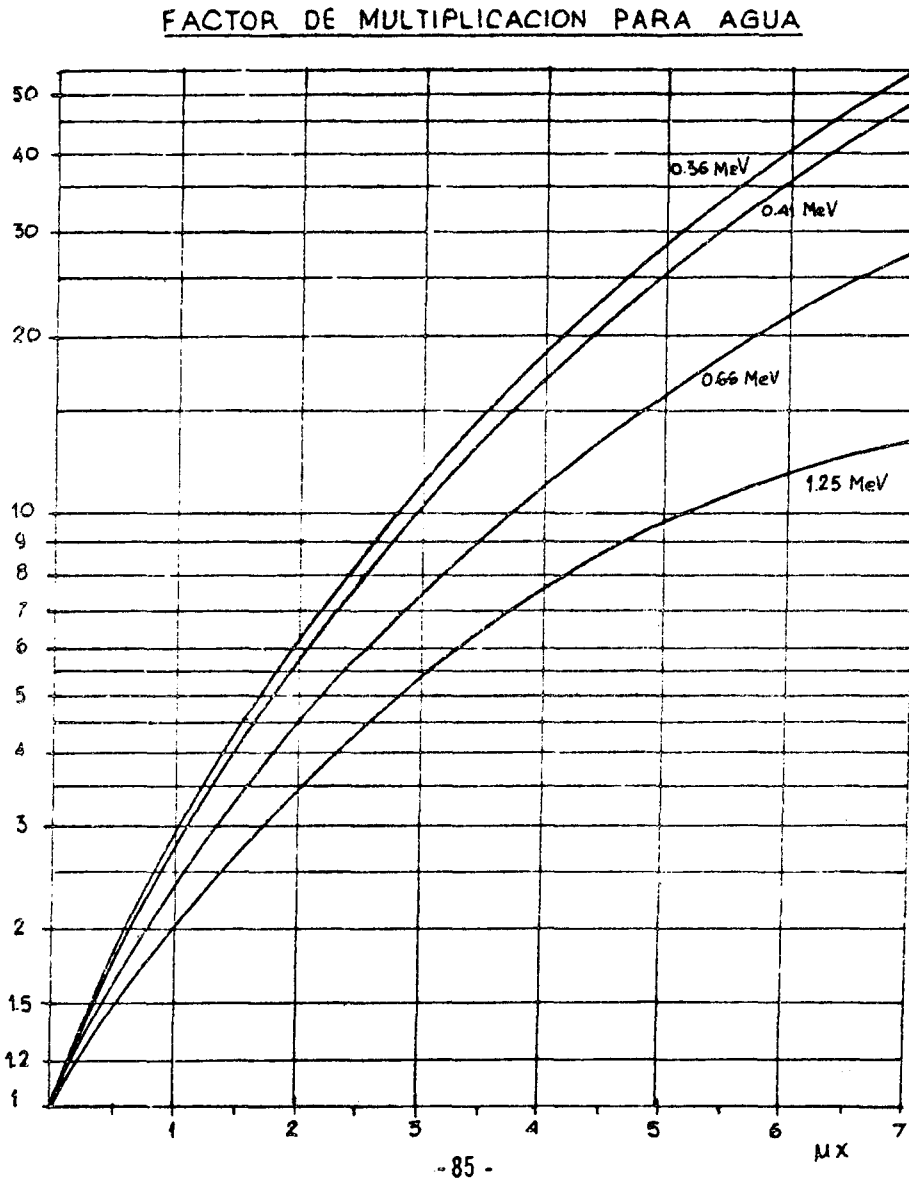

FACTOR DE MULTIPLICACION PARA AGUA
50
40
30
20
10
9
8
7
6
5
4
3
2
1.5
1.2
1
0.36 MeV
0.4 MeV
0.66 MeV
1.25 MeV
1
2
3
4
5
6
7
μx

Fig. XII-8

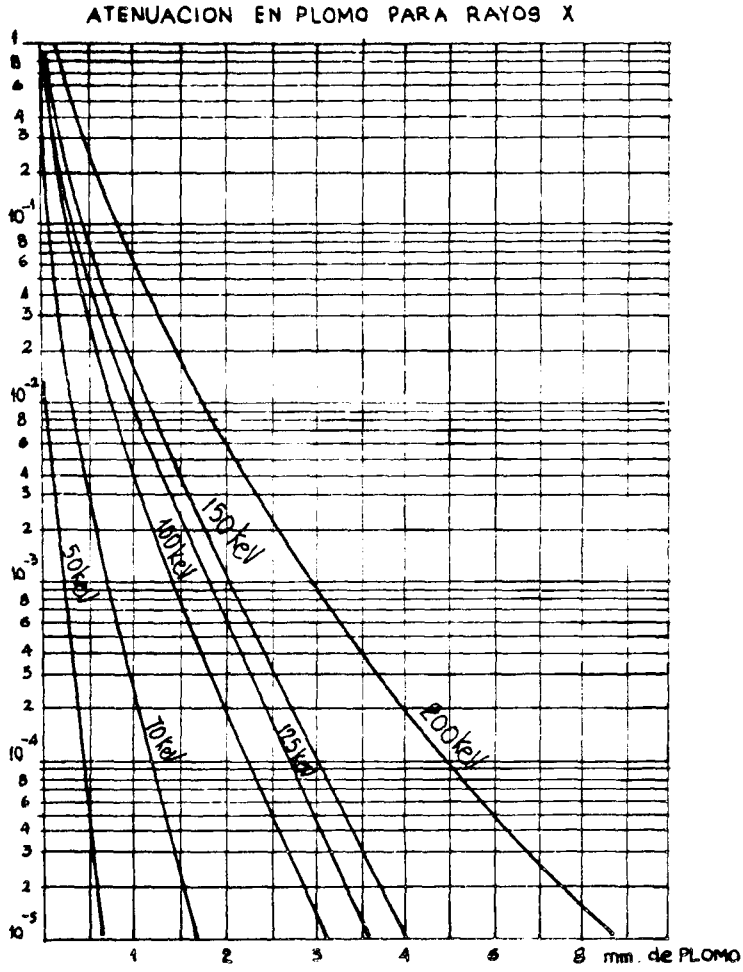

ATENUACION EN PLOMO PARA RAYOS X
1
8
6
4
3
2
10^{-1}
8
6
4
3
2
10^{-2}
8
6
4
3
2
10^{-3}
8
6
4
3
2
10^{-4}
8
6
4
3
2
10^{-5}
1
2
3
4
5
6 mm. de PLOMO
50 kev
70 kev
100 kev
125 kev
150 kev
200 kev

Fig. XII-9

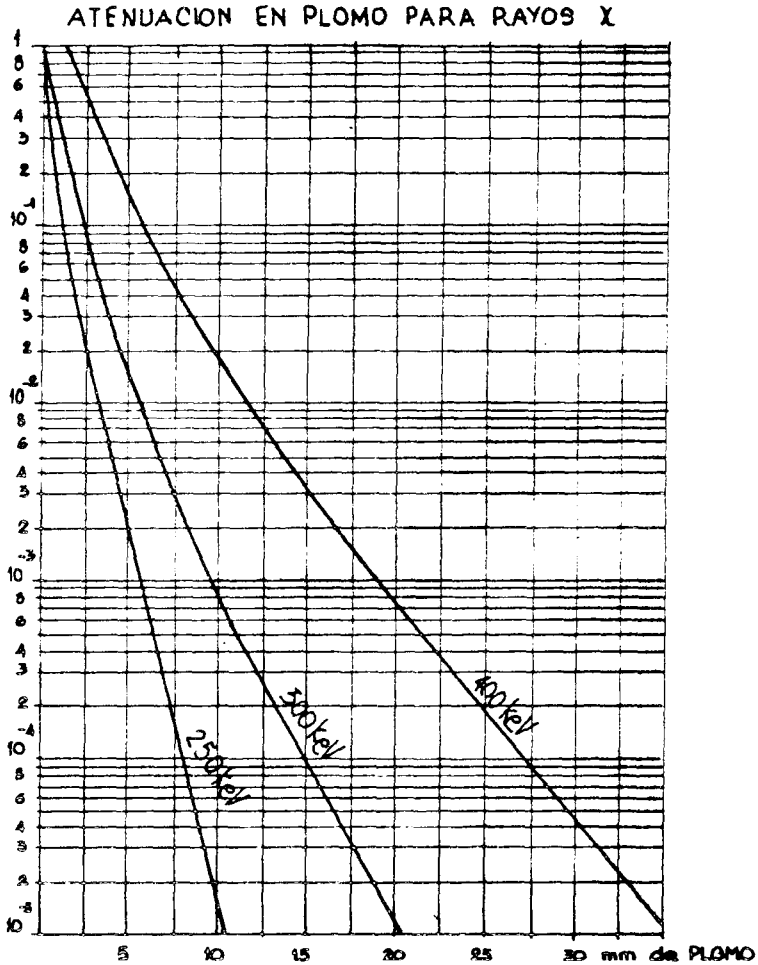

ATENUACION EN PLOMO PARA RAYOS X
400 keV
300 keV
250 keV
5
10
15
20
25
30 mm de PLOMO

Fig. XII-10

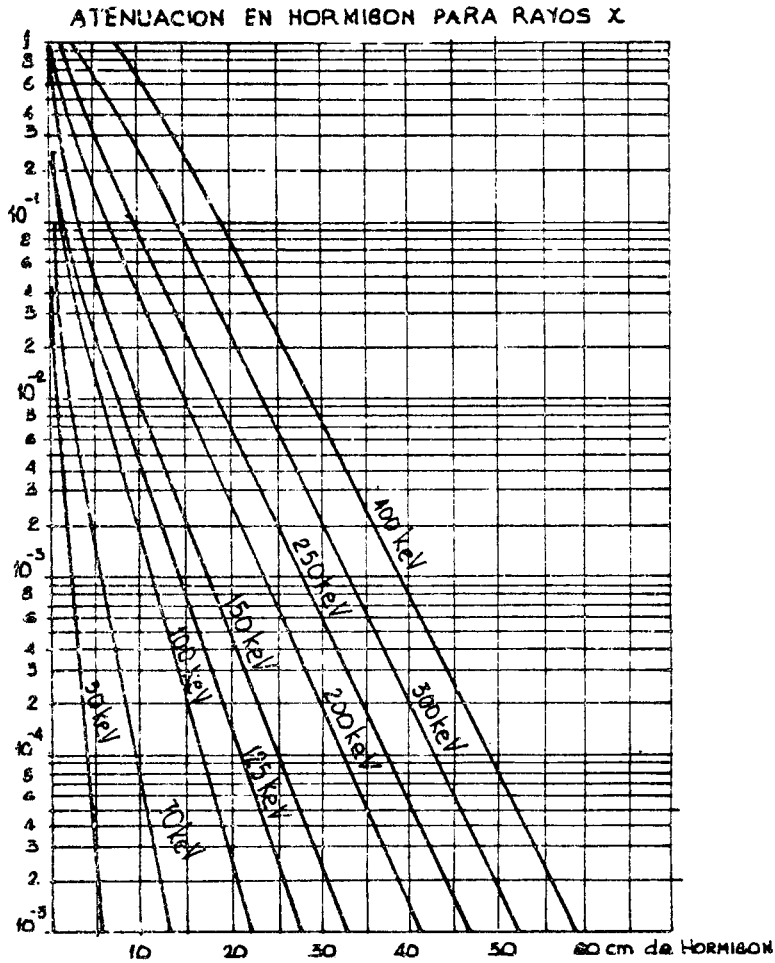
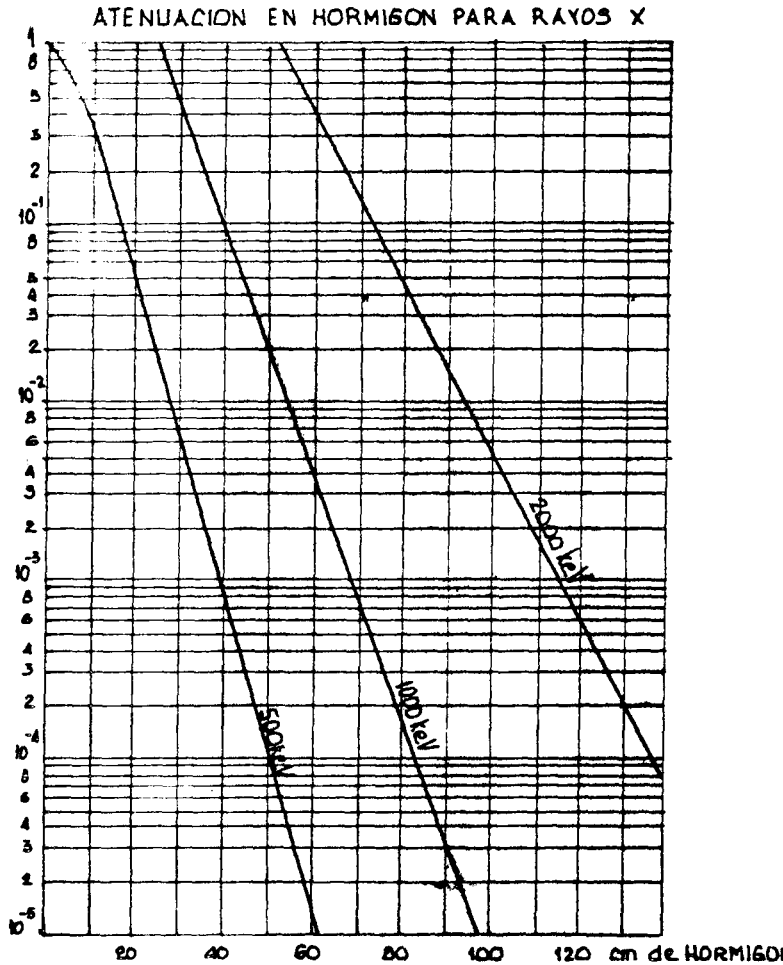
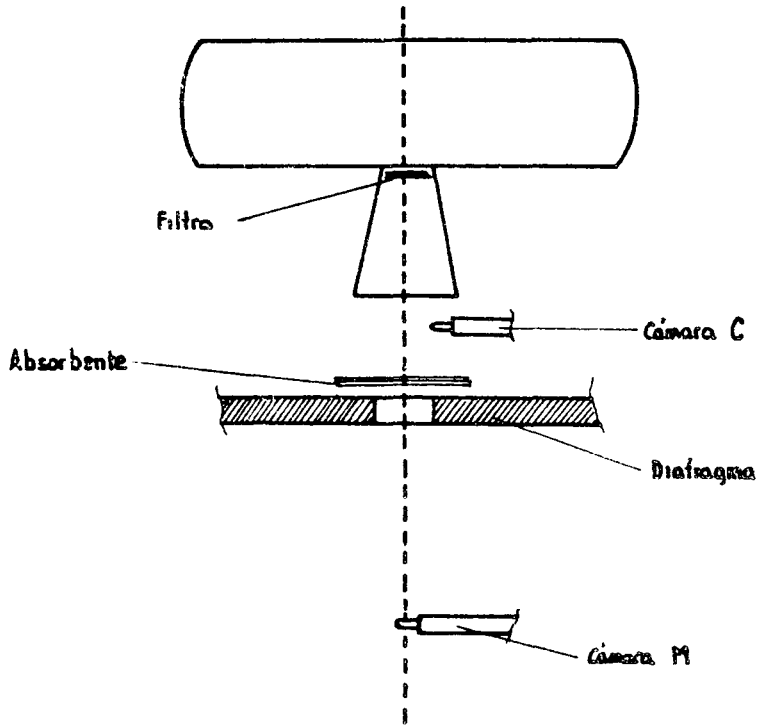

ATENUACION EN HORMIGON PARA RAYOS X
400 keV
250 keV
150 keV
100 keV
90 keV
200 keV
300 keV
125 keV
70 keV
10
20
30
40
50
60 cm de HORMIGON

Fig. XII-11


ATENUACION EN HORMIGON PARA RAYOS X
1
8
5
3
2
10^{-1}
8
5
4
3
2
10^{-2}
8
6
4
3
2
10^{-3}
8
6
4
3
2
10^{-4}
8
6
4
3
2
10^{-5}
500 kV
1000 kV
2000 kV
20
40
60
80
100
120 cm de HORMIGON

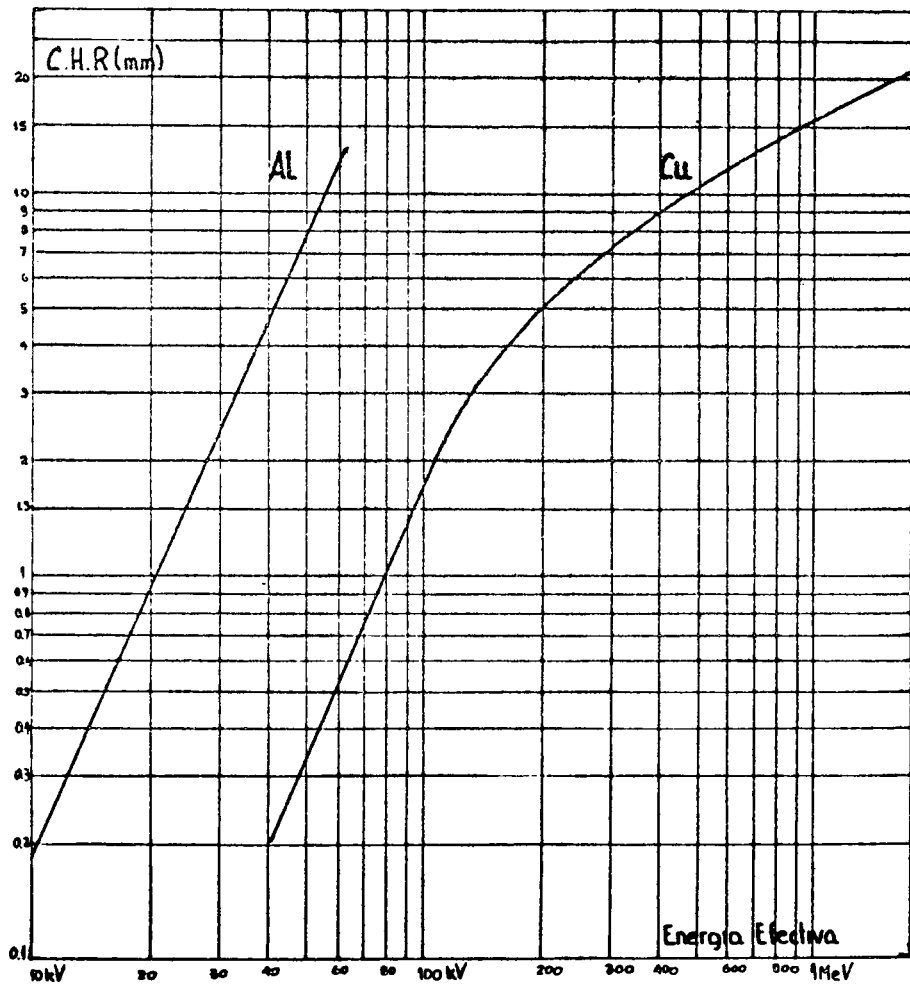
A1



Determinación de C.H.R.

A2

Curva de C.H.R. en función de la energía efectiva



IMPRESO EN CNEA - AGOSTO 1973