

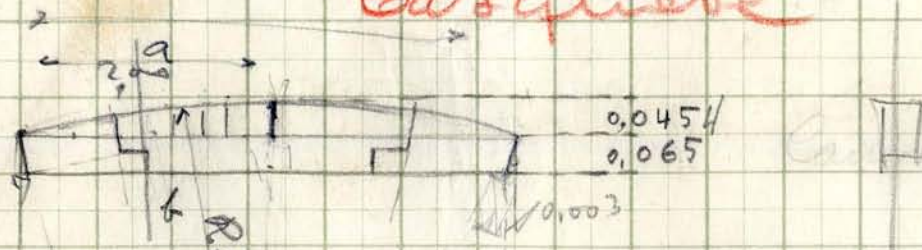
Calculo de la cumbre

158.518.

5-7-34

Camión de la parte esferica

Basquete



$$\sin \alpha \times 44,08 = 200 \text{ cm} = c$$

$$0,0654 - 44,08 - \cos \alpha \times 44,08 = f =$$

$$= 0,0454 - 44,08 (1 - \cos \alpha)$$

$$\cos \alpha = \sqrt{1 - \sin^2 \alpha}$$

$$\cos \alpha \times R = 0,065$$

$$R = \frac{0,065}{\cos \alpha}$$

$$\frac{200}{R} = \sin \alpha$$

$$R \sin \alpha = 200$$

$$\frac{0,0654}{0,00260} = 25,15$$

$$f = 0,0454 -$$

c	$\sin \alpha = \frac{c}{44,08}$	α	$\cos \alpha$	$1 - \cos \alpha$	$44,08(1 - \cos \alpha)$
200	0,045372	2° 36'	0,998997	0,001003	0,000
175	0,0397005	2° 16' 30"	0,999227	0,000773	0,0106
150	0,034029	1° 57'	0,99942	0,00058	0,020
125	0,028357	1° 37' 30"	0,99960	0,00040	0,028
100	0,022686	1° 18'	0,99974	0,00026	0,034
75	0,0170145	58' 30"	0,999860	0,000140	0,0392
50	0,011343	39'	0,999935	0,000065	0,0425
25	0,0056715	19' 30"	0,999984	0,000016	0,04469

Las maxima = 200 mts. Carga por m² = 200 Kg

Sección 7,5 x 11. $I = \frac{7,5 \times 11^3}{12} = 830 \text{ cm}^4$ $M = 200 \times \frac{2^2}{8} = 100 \text{ mkg}$

$$f = \frac{5}{384} \times \frac{200 \times 200}{85000 \times 850 \times 100} = \frac{16000000000000}{27000000000000} = 0,59 \text{ cm.}$$

$$H = \frac{10000 \times 55}{830} = 67 \text{ Kg en 2}$$

$$\text{Carga por espesor constante en la sección a-b} = \frac{100}{7,5 \times 6,5} = 2 \text{ Kg a 2}$$

Calculado Daza comprobado Bours

1° Canon de la forte total

Datos

$$R = 44.10$$

$$R' = 16.952$$

$$R'' = 16.952 - 0.02 = 16.932$$

$$R''' = 16.952 - 0.085 = 16.867$$

$$\alpha = 25^{\circ} 31'$$

$$l = \frac{360}{64} = 5^{\circ} 37' 30''$$

$$a = 0.80$$

$$f = de \text{ a } \frac{d}{2}$$

Formulas

$$\sin \frac{\beta \times R''}{2} = \frac{a}{2} = 0.40$$

$$\beta = 2^{\circ} 42' 30''$$

$$\gamma = 90 - \alpha - \beta = 61^{\circ} 46' 30''$$

$$b = \frac{19 \times (R - R''')}{R} = 11.705026$$

$$c = b + \cos \gamma R'' = 19.712778$$

$$d = 2 \sin \frac{l}{2} c = 1.934612$$

$$\sin l' c = f \quad \sin l' = \frac{f}{c}$$

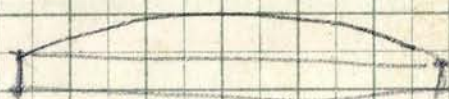
$$\cos \frac{l}{2} = 0.998797 \quad e = b - \cos \frac{l}{2} b = 0.014087$$

$$g = c - (b - \cos l' b) =$$

$$h = g \cos \gamma$$

f	$\sin l'$	l'	$\cos l'$	$b \cos l'$	$b - b \cos l'$	g	h
0	0	0	1	11.705026	0	0.014087	0.006621
0.20	0.0101457	0° 25'	0.999945	11.704382	0.000644	0.012433	0.0061528
0.40	0.0202914	1° 9' 45"	0.999799	11.702673	0.002347	0.011734	0.00554931
0.60	0.0304371	1° 44' 40"	0.999538	11.699618	0.005408	0.008679	0.00410452
0.80	0.0405828	2° 19' 30"	0.999176	11.695281	0.009745	0.004452	0.00210546
0.9673	0.0490696	2° 48' 45"	0.998797	11.690845	0.014081	0.000006	0

$$l = g \text{ maximo}$$



9.º Camos de la parte total

Datos

$$Q = 144,10$$

$$R' = 16,952$$

$$R'' = 16,952 - 0,02 = 16,932$$

$$R''' = 16,952 - 0,085 = 16,867$$

$$\alpha = 25^{\circ} 31'$$

$$L = \frac{360}{64} = 5^{\circ} 37' 30''$$

$$a = 1,60$$

$$f = \text{de } 0 \text{ a } \frac{d}{2}$$

$$\text{sen } \frac{L}{2} = 0,04907$$

Formulas

$$\text{sen } \frac{\beta}{2} \times R'' = \frac{a}{2} = 0,80$$

$$\text{sen } \frac{\beta}{2} = \frac{0,80}{R''} = 0,0472478; \beta = 5^{\circ} 25'$$

$$\gamma = 90 - \alpha - \beta = 59^{\circ} 4'; \cos \gamma = 0,51404$$

$$b = \frac{19 \times (R - R'')}{R} = 11,705026$$

$$c = b + \cos \gamma R'' = 20,408751$$

$$d = 2 \text{ sen } \frac{L}{2} c = 2,002915$$

$$\text{sen } L' c = f \quad \text{sen } L' = \frac{f}{c}$$

$$e = b - \cos \frac{L}{2} b = 0,014087$$

$$g = e - (b - \cos L' b) ; h = g \cos \gamma$$

f	sen L'	L'	cos L'	b cos L	b - b cos L'	g	h
0	0	0	1	11,7050	0	0,0141	0,0072
0,20	0,0097799	0° 33' 40"	0,99994	11,7043	0,0007	0,0134	0,0069
0,40	0,01960	1° 7' 0"	0,99983	11,7030	0,0020	0,0121	0,0062
0,60	0,02940	1° 41' 0"	0,99957	11,7000	0,0050	0,0091	0,0047
0,80	0,03920	2° 15' 0"	0,99923	11,6960	0,0090	0,0051	0,0026
1,0015	0,04907	2° 48' 0"	0,99882	11,6912	0,0138	0,0003	0,00015
1,005	0,04888						

3° Canon de la parte total

Datos

$$R = 44.10$$

$$R' = 16.952$$

$$R'' = 16.952 - 0.02 = 16.932$$

$$R''' = 16.952 - 0.085 = 16.867$$

$$\alpha = 25^\circ 31'$$

$$l = 5^\circ 37' 30''$$

$$a = 2.40$$

$$f = \frac{a}{2} \text{ o } \frac{d}{2}$$

$$\sin \frac{l}{2} = 0.04907$$

$$\cos \frac{l}{2} = 0.99880$$

Formulas

$$\text{sen } \frac{\beta}{2} R'' = \frac{a}{2} = 1.20$$

$$\text{sen } \frac{\beta}{2} = \frac{1.2}{R''} = 0.07087$$

$$\gamma = 90 - \alpha - \beta = 56^\circ 21' \text{ o } \gamma = 0.97368$$

$$b = \frac{19 \times (R - R')}{R} = 11.7050$$

$$c = b + \cos \gamma R'' = 2.0664$$

$$d = 2 \text{ sen } \frac{l}{2} c = 2.0695$$

$$\text{sen } l' c = f \quad \text{sen } l' = \frac{f}{c}$$

$$e = b - \cos \frac{l}{2} b = 0.014$$

$$g = e - (b - \cos l' b)$$

$$h = g \cos \gamma$$

f	$\text{sen } l'$	l'	$\cos l'$	$b \cos l'$	$b - b \cos l'$	g	h
0	0	0	1	11.705	0	0.014	0.0077
0.20	0.00997	$0^\circ 34' 20''$	0.99994	11.704	0.001	0.013	0.006
0.40	0.01994	$1^\circ 8' 40''$	0.99980	11.703	0.002	0.011	0.005
0.60	0.02990	$1^\circ 43' 0''$	0.99943	11.698	0.008	0.007	0.003
0.80	0.03987	$2^\circ 17' 0''$	0.99921	11.696	0.009	0.005	0.002
0.984	0.04904	$2^\circ 48' 45''$	0.99880	11.691	0.014	0	0
0.20	0.00948	$0^\circ 32' 35''$	0.999952	11.704	0.001	0.013	0.0072
0.40	0.01897	$1^\circ 5' 12''$	0.999819	11.703	0.002	0.012	0.0066
0.60	0.02845	$1^\circ 37' 50''$	0.999610	11.700	0.005	0.009	0.0050
0.80	0.03794	$2^\circ 10' 28''$	0.999284	11.697	0.008	0.006	0.0033
1.035	0.04908	$2^\circ 48' 45''$	0.99880	11.691	0.014	0	0

$$\frac{11405}{11691} \div 14$$

184

Daten

$$R = 44,10$$

$$R' = 16,952$$

$$R'' = 16,952 - 0,02 = 16,932$$

$$R''' = 16,952 - 0,085 = 16,867$$

$$\alpha = 25^{\circ} 31'$$

$$l = 5^{\circ} 37' 30''$$

$$\sin l = 0,04907$$

$$\cos \frac{l}{2} = 0,99880$$

$$a = 3,20$$

$$f = d \circ a \frac{d}{2}$$

Formulas

$$\sin \frac{\beta}{2} R'' = \frac{a}{2} = 1,60$$

$$\sin \frac{\beta}{2} = \frac{1,60}{16,932} = 0,094496 \quad \beta = 5^{\circ} 27' 30''$$

$$\gamma = 90 - \alpha - \beta = 53^{\circ} 34' \quad \cos \gamma = 0,59388$$

$$c = b + \cos \gamma R'' = 21,7606$$

$$b = \frac{19 \times (R - R')}{R} = 11,7050$$

$$d = 2 \sin \frac{l}{2} c = 2,1356$$

$$\sin l' = \frac{f}{c}$$

$$e = b - \cos \frac{l}{2} b = 0,01409$$

$$g = e - (b - \cos l' b)$$

$$h = g \cos \gamma$$

γ	$\sin l'$	l'	$\cos l'$	$b \cos l'$	$b - b \cos l'$	g	h
0	0	0	1	11,7050	0	0,0141	0,00837
0,20	0,00919	0^{\circ} 31' 35''	0,999955	11,7045	0,0005	0,0136	0,00807
0,40	0,01838	1^{\circ} 3' 12''	0,999831	11,7030	0,0020	0,0121	0,00718
0,60	0,02757	1^{\circ} 36' 30''	0,999608	11,7004	0,0046	0,0095	0,00564
0,80	0,03676	2^{\circ} 6' 30''	0,999355	11,6975	0,0085	0,0056	0,00332
1,068	0,04908	2^{\circ} 48' 45''	0,99880	11,69095	0,0140	0	0

5° Cálculo de la pte Total

Datos

$$R = 44.10$$

$$R' = 16.952$$

$$R'' = 16.952 - 0.02 = 16.932$$

$$R''' = 16.952 - 0.085 = 16.867$$

$$\alpha = 25^{\circ}31'$$

$$a = 4.00$$

$$l = 5^{\circ}37'30''$$

$$\frac{l}{2} = 2^{\circ}48'45''$$

$$\text{sen } \frac{l}{2} = 0.049070$$

$$\text{cos } \frac{l}{2} = 0.99880$$

$$f = d \text{ o } a \frac{d}{2}$$

Formulas

$$\text{sen } \frac{B}{2} R'' = \frac{a}{2} = 2.00 \quad 13^{\circ}34'$$

$$\text{sen } \frac{B}{2} = \frac{2.00}{16.932} = 0.118119 \quad B = 6^{\circ}47'$$

$$\gamma = 90 - \alpha - B = 50^{\circ}55' \text{ en } \gamma = 0.63045$$

$$c = b + \text{en } \gamma R'' = 22.3794$$

$$b = 11.7050$$

$$d = 2 \text{ sen } \frac{l}{2} c = 2.1963$$

$$\text{sen } l' = \frac{f}{c}$$

$$e = b - \text{en } \frac{l}{2} b = 0.01409$$

$$g = e - (b - \text{en } l' b)$$

$$h = g \text{ en } \gamma$$

f	sen l'	l'	cos l'	b en l'	b - b en l'	g	h
0.0	0	0	1	11.7050	0	0.0142	0.0090
0.2	0.00894	0^{\circ}37'20''	0.999938	11.7042	0.0008	0.0133	0.0084
0.4	0.01787	1^{\circ}14'35''	0.999763	11.7022	0.0028	0.0113	0.0071
0.6	0.02681	1^{\circ}32'12''	0.99964	11.7007	0.0043	0.0098	0.0062
0.8	0.03575	2^{\circ}2'56''	0.99936	11.6974	0.0076	0.0065	0.0048
1.098	0.04906	2^{\circ}48'45''	0.99880	11.6900	0.0140	0	0

6 = Camar de la forte Total

Dats

Formulas

$$R = 44,10$$

$$R' = 16,952$$

$$R'' = 16,952 - 0,02 = 16,932$$

$$R''' = 16,952 - 0,085 = 16,867$$

$$\alpha = 25^{\circ} 31'$$

$$l = 5^{\circ} 37' 30''$$

$$\frac{l}{2} = 2^{\circ} 48' 45''$$

$$\sin \frac{l}{2} = 0,049070$$

$$\cos \frac{l}{2} = 0,99880$$

$$f = \text{de } 0 \text{ à } \frac{d}{2}$$

$$a = 4,80$$

$$\sin \frac{A}{2} R'' = \frac{a}{2} = 2,40$$

$$\sin \frac{A}{2} = \frac{2,40}{16,932} = 0,141743 \quad A = 16^{\circ} 18'$$

$$Y = 90^{\circ} - \alpha - \beta = 48^{\circ} 11' \quad \cos Y = 0,666753$$

$$C = b + \cos Y R'' = 22,9945$$

$$b = 11,7050$$

$$d = 2 \sin \frac{l}{2} C = 2,25668$$

$$\sin l' = \frac{f}{C}$$

$$e = b - \cos \frac{l}{2} b = 0,0141$$

$$g = e - (b - \cos l' b)$$

$$h = g \cos Y$$

f	$\sin l'$	l'	$\cos l'$	b $\cos l'$	b - b $\cos l'$	g	h
0	0	0	1	11,7050	0	0,0141	0,0094
0,20	0,008698	0^{\circ} 30'	0,99996	11,7040	0,0010	0,0131	0,0087
0,40	0,017395	0^{\circ} 59' 50''	0,99985	11,7030	0,0020	0,0121	0,0081
0,60	0,026093	1^{\circ} 29' 45''	0,99966	11,7010	0,0040	0,0101	0,0067
0,80	0,034791	1^{\circ} 59' 45''	0,99939	11,6978	0,0072	0,0069	0,0046
1,128	0,049055	2^{\circ} 48' 45''	0,9988	11,6909	0,0141	0	0

5 87 30
15 116 90
22 20

16 52 30

137 24
54651
12945

137
387
7171
8411

2787
228
2153

$$\frac{a}{0.90} = \frac{8.411}{3.171}$$

$$a = \frac{0.9 \times 8.411}{3.171} = 2.3872$$

$$\tan \alpha = \frac{8.411}{a}$$

$$\tan \alpha = \frac{8.411}{2.3872}$$

$$\alpha =$$

$$c = 21.53 - a$$

$$\sin \beta R_1 = \sin \alpha r$$

$$\cos \beta R_1 - \cos \alpha r = c$$

$$\sin \beta R_1 = \sqrt{1 - \cos^2 \alpha} \frac{r}{R_1}$$

$$\sqrt{1 - \cos^2 \alpha} = \sqrt{1 - \cos^2 \alpha} \frac{r}{R_1}$$

$$\sqrt{1 - \cos^2 \alpha} = \sqrt{1 - \cos^2 \alpha} \frac{r}{R_1}$$

$$\cos \beta = \frac{c + \cos \alpha r}{R_1}$$

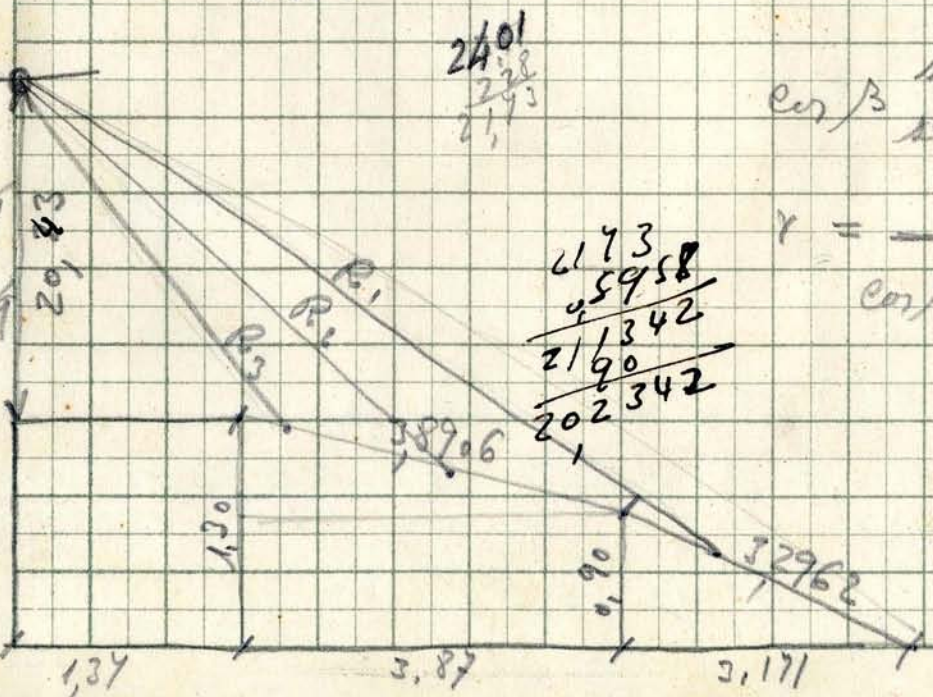
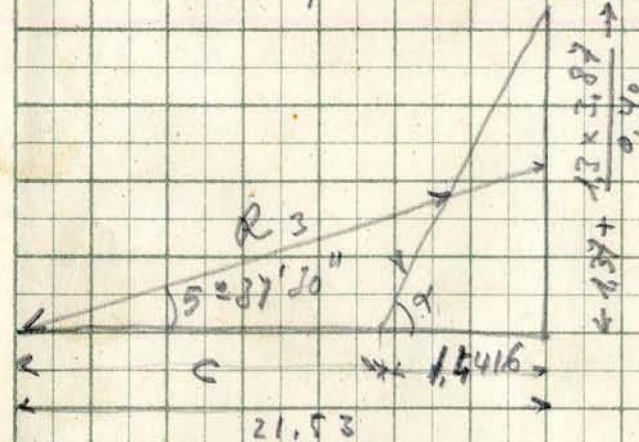
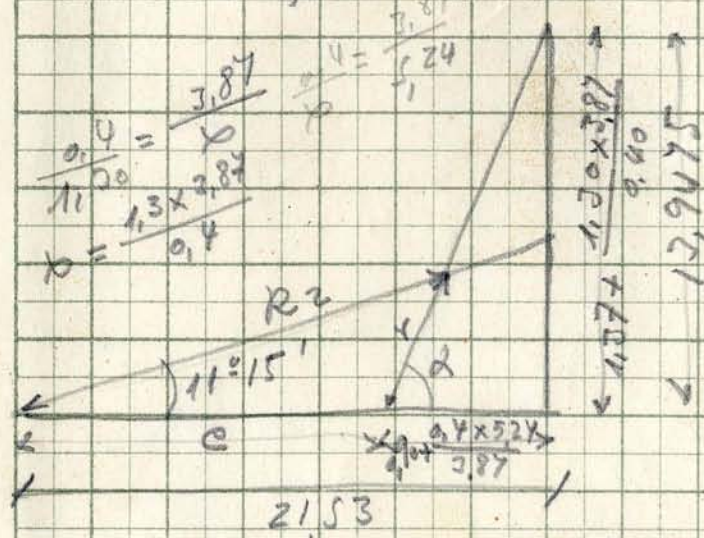
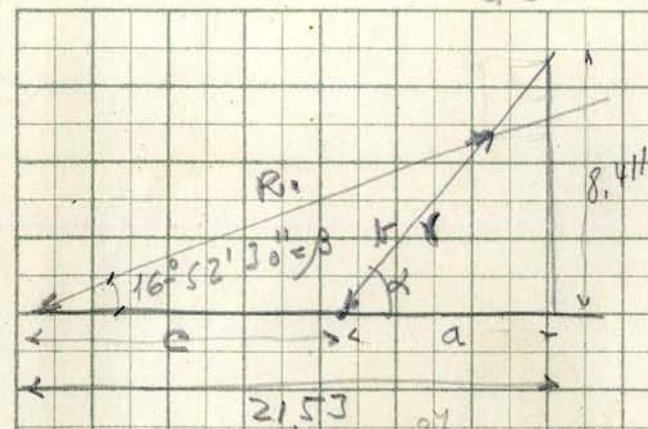
$$R_1 = \frac{\sin \alpha}{\sin \beta} r$$

$$\cos \beta \frac{\sin \alpha}{\sin \beta} r - \cos \alpha r = c$$

$$r = \frac{c}{\cos \beta \frac{\sin \alpha}{\sin \beta} - \cos \alpha}$$

0.16

0.81
10.05524
10.86524



130
1090
340

387
270
3096
1161
149769
116
151359

2401
228
2173

1173
45958
216342
2190
202342

$$R_0 = 22,475$$

18963
1,339
350
20,052
20,250
20 178
172
150

~~18963
18963
18963~~

Zapata de cimbra N° 3 (Cautín)

Parte de radio pequeño.

$$R = 8,667$$

α	$\frac{C}{R}$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha) R$	$f = 0,0792 - (1 - \cos \alpha) R$
0	0,0000		0	0	0	0,0792
0,25	0,028845	1° 39'	0,999588	0,000412	0,0036	0,0756
0,50	0,05769	3° 18' 30"	0,998334	0,001666	0,0144	0,0648
0,75	0,086535	4° 57' 50"	0,996244	0,003756	0,0326	0,0466
1,00	0,11538	6° 37' 30"	0,993323	0,006677	0,0579	0,0213
1,169	0,134879	7° 45'	0,990865	0,009135	0,0792	0

Zapata de cimbra N° 4 (Barrion)

Parte de radio pequeño.

$$R = 6,718$$

C	$\frac{C}{6,718}$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha) R$	$f = 0,1018 - (1 - \cos \alpha) R$
0	0	0	0	0	0	0,1018
0,25	0,037213	2° 8'	0,99931	0,00069	0,0046	0,0972
0,50	0,074427	4° 16'	0,997218	0,002782	0,0187	0,0831
0,75	0,111640	6° 24' 20"	0,993457	0,006543	0,0418	0,0600
1,00	0,148854	8° 33' 45"	0,98854	0,01146	0,0748	0,0270
1,166	0,173563	9° 59' 40"	0,984843	0,015157	0,1018	0
1,332	0,198272	11° 24'	0,980412	0,019588	0,1314	
1,498	0,222981	12° 54'	0,975157	0,024843	0,1609	0

1686
23,734

$$2 \sin \frac{\alpha'}{2} R = \frac{3803}{\sin \frac{\alpha'}{2}}$$

$$\sin \frac{\alpha'}{2} = \frac{3803}{2R} = \frac{3803}{2 \times 44.015} = 0.112735$$

$$R = 44.015$$

$$-\sin l R + \sin l + \gamma R = a$$

$$\cos l R - \cos l + \gamma R = b$$

$$\gamma = l + \gamma - \beta$$

$$P = 25^{\circ} 21' 21.4820'' =$$

$$= 2^{\circ} 42' 40''$$

$$\tan P = 0.0647214$$

$$B + P = 68^{\circ} 11' 40''$$

$$\tan B + P = 0.9284493$$

$$\cos B + P = 0.2587618$$

$$B = 90^{\circ} - 25^{\circ} 21' = 64^{\circ} 39'$$

$$\tan B = 0.902464 \quad \cos B = 0.420772$$

$$a = 27.148 \times \tan B = 24.50009$$

$$b = 27.148 \cos B = 11.694598$$

$$R \times \tan B + P = 40.865696 ; R \times \cos B + P = 16.2310506$$

$$\sin \alpha = 0.871447 \quad \cos \alpha = 0.49048 \quad \alpha = 47^{\circ} 41' + 12^{\circ} 56' 40'' = 60^{\circ} 37' 40''$$

$$f = R' \tan \alpha = 14.698696 \quad R' \cos \alpha = 8.272926 = c$$

$$l + c = 14.698696 + 8.272926 = 22.971622$$

$$b + c = 11.694598 + 8.272926 = 19.967524$$

$$g = \sqrt{22.971622^2 + 19.967524^2} = 43.99143$$

$$\angle = 62^{\circ} 0' 20''$$

6° 23' 20"
12° 56' 40"

$$d^2 = R^2 + q^2 - 2Rq \cos \gamma$$

$$\cos \gamma = \frac{d^2 - R^2 - q^2}{-2Rq} = \underline{0.995868} \text{ de donde } \gamma = \underline{5^\circ 13'}$$

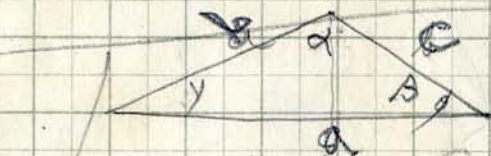
$$\sin \gamma = 0.09092 =$$

$$\frac{d}{q \sin \gamma} = \frac{R}{\sin \phi} \quad \tan \phi = \frac{R \sin \gamma}{d} = \underline{1.00046}$$

$$\frac{d}{\sin \gamma} = \frac{q}{\sin \Delta} \quad \tan \Delta = \frac{\sin \gamma \times q}{d} = \underline{0.999920}$$

$$Q^2 = d^2 + q^2 - 2dq \cos \rho$$

$$\cos \rho = \frac{Q^2 - d^2 - q^2}{-2dq} = 0.029569 \text{ de donde } \rho = \underline{87^\circ 43' 45''}$$



$Q =$



c B a

α

b

γ

α

$$\sin \gamma a = \sin \phi b$$

$$\sin \gamma a + \cos \phi b = c$$

$$\sqrt{1 - \sin^2 \gamma} a + \sqrt{1 - \sin^2 \phi} b = c$$

$$\alpha = \frac{b^2 + c^2 - a^2}{2bc} =$$

$$\frac{44.015 + 43.9914 - 4.2}{2 \times 44.015 \times 43.9914}$$

$$\beta = \rho = \frac{c^2 + a^2 - b^2}{2ca} =$$

$$\underline{0.99586}$$

$$\alpha \gamma = \frac{c^2 + a^2 - b^2}{2ca}$$

$$g^2 = d^2 + R^2 - 2dR \cos \Delta$$

$$\cos \Delta = \frac{g^2 - d^2 - R^2}{-2dR} = 0.051329 \text{ de donde } \Delta = 87^\circ 5' 15''$$

$$\sin \Delta = 0.9986787$$

$$\frac{h}{\sin \varphi} = \frac{R}{\sin 90^\circ 45' 55''} \quad h = \frac{g \sin \varphi}{\sin 90^\circ 45' 55''} = \frac{44.015 \times 0.0647214}{0.999906} = 2.84898$$

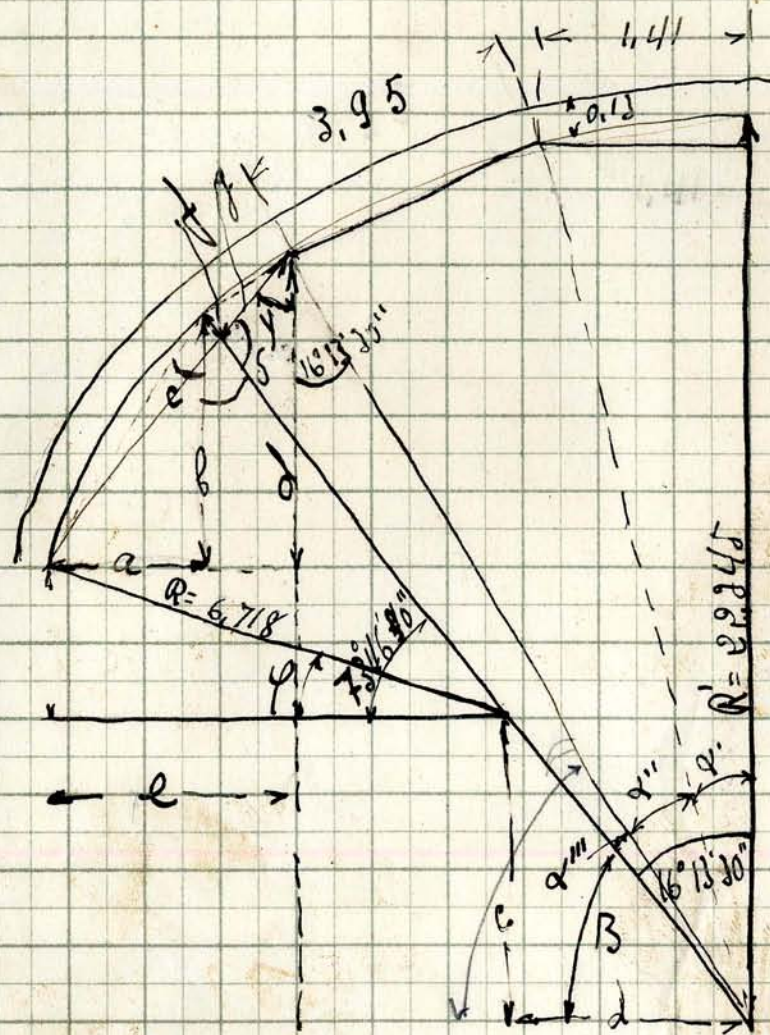
$$\frac{R-K}{\sin \Delta} = \frac{R}{\sin 90^\circ 45' 55''} \quad R-K = \frac{R \sin \Delta}{\sin 90^\circ 45' 55''} = \frac{44.015 \times 0.9986787}{0.999906} = 43.96086$$

$$K = 44.015 - 43.96086 = 0.05414 \text{ mts}$$

$$f+e - R \sin B+\varphi = 40.865695 - 39.198786 = 1.66691 \text{ mt}$$

$$b+e - R \cos B+\varphi = 19.967524 - 16.231050 = 3.736474$$

Linha nº 4 (Canal)



$$\begin{aligned}\varphi &= 53^{\circ} 47' 20'' \\ \sin \varphi &= 0.80687 \\ \cos \varphi &= 0.59071 \\ a &= 2.091 \\ b &= 1.03 \\ B &= 73^{\circ} 46' 20'' \\ \sin B &= 0.959691 \\ \cos B &= 0.279415 \\ B + \alpha''' &= 76^{\circ} 14' 40'' \\ \sin B + \alpha''' &= 0.971225 \\ \cos B + \alpha''' &= 0.22759 \\ \sin \alpha''' &= 0.04209 \\ \sin \delta &= 0.99722\end{aligned}$$

$$\frac{1.41}{22.345} = \sin \alpha' = 0.062101 \quad \text{de donde } \alpha' = 3.5650$$

$$\frac{3.95}{2 \times 22.345} = \sin \frac{\alpha''}{2} = 0.088286 \quad \text{de donde } \alpha'' = 10^{\circ} 8' 20''$$

$$16^{\circ} 13' 20'' - \alpha' + \alpha'' = \alpha''' = 2^{\circ} 28' 10''$$

$$(22.345 - 6.718) \sin 73^{\circ} 46' 20'' + 6.718 \times \sin \varphi - 22.345 \times \sin(B + \alpha''') = d = 1.38137$$

$$(22.345 - 6.718) \cos 73^{\circ} 46' 20'' + 6.718 \times \cos \varphi - 22.345 \times \cos(B + \alpha''') = e = 3.02599$$

$$22.345$$

$$c = \sqrt{d^2 + e^2} = 3.28815$$

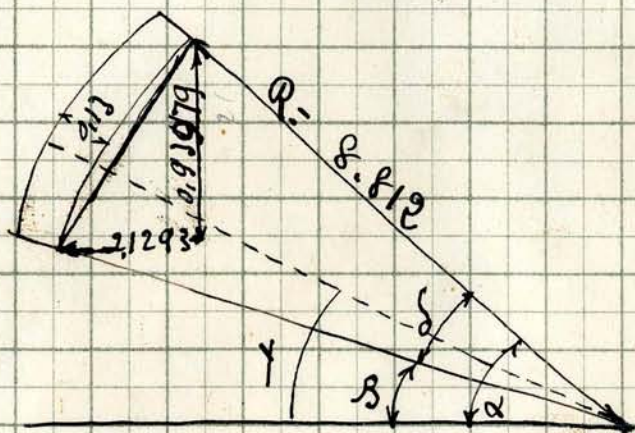
$$\sin \gamma = \frac{e}{c} = 0.920272 \quad \text{de donde } \gamma = 67^{\circ} 2' \quad \delta = 180 - \gamma - 16^{\circ} 13' 20'' - \alpha''' = 94^{\circ} 16' 20''$$

$$\frac{R'}{\sin \delta} = \frac{q}{\sin \alpha'''} \quad q = \frac{R' \sin \alpha'''}{\sin \delta} = 0.6553 \quad R' = \frac{R' \times \sin(16^{\circ} 13' 20'')}{\sin \delta} = 22.345 \quad \text{de donde } R' = 409.27$$

Ombra n° 2 (Camara)

(parte de radio pequeño)

Ombra de fondo del arco atirantado de fachada



$$\alpha = 73^{\circ} 46' 30''$$

$$\beta = 58^{\circ} 35' 50''$$

$$\delta = 15^{\circ} 10' 40''$$

$$R = 8.812$$

$$(\cos \gamma - \cos \beta) R = C$$

$$\cos \gamma = \frac{C}{R} - \cos \beta$$

$$f = (\sin \gamma - \sin \beta) R$$

$$\sin \beta = 0.853525$$

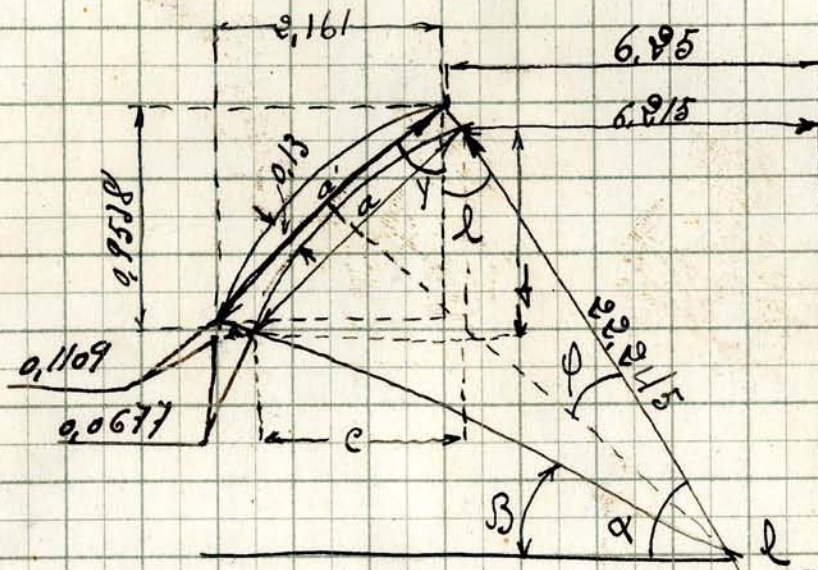
$$\cos \beta = 0.52105$$

C	$\frac{1}{R} C$	$\cos \gamma$	γ	$\sin \gamma$	$\sin \gamma - \sin \beta$	$(\sin \gamma - \sin \beta) R$
0	0	0.52105	58° 35' 50"	0.853525	0	0
0.25	0.02827	0.49268	60° 29'	0.870216	0.016681	0.146993
0.50	0.05674	0.46431	62° 20'	0.885660	0.032135	0.283173
0.75	0.08511	0.43594	64° 9' 45"	0.899974	0.046449	0.409208
1.00	0.11348	0.407569	65° 57'	0.913190	0.059665	0.525724
1.25	0.14185	0.379199	67° 42'	0.925220	0.071795	0.632654
1.50	0.17022	0.350829	69° 27' 40"	0.936440	0.082915	0.730647
1.75	0.19859	0.322459	71° 11' 20"	0.946585	0.093060	0.820044
2.00	0.226962	0.294088	72° 54'	0.955790	0.102265	0.901159
2.1293	0.241625	0.279415	73° 46' 30"	0.959693	0.106168	0.939799

Cimbra nº 3 (Cannon)

Cálculo del radio pequeño

$$\begin{array}{r} 3.285 \\ -1.109 \\ \hline 2.176 \\ -0.9398 \\ \hline 1.2362 \\ -0.8860 \\ \hline 0.3502 \\ -0.2300 \\ \hline 0.1202 \\ -0.023 \\ \hline 0.0972 \end{array}$$



$$l = 16^\circ 18' 20'' \quad \alpha = 73^\circ 46' 20''$$

$$d = \sqrt{2.161^2 + 0.9528^2} = 2.36212$$

$$\sin \gamma = \frac{2.161}{d} = 0.914856 \text{ de donde } \gamma = 66^\circ 11' 10''$$

$$\sin \alpha = 0.960175$$

$$\cos \alpha = 0.27941$$

$$\sin \beta = 0.855525$$

$$\cos \beta = 0.52105$$

$$\varphi = 90^\circ - \gamma - l = 7^\circ 55' 20''; \sin \varphi = 0.13208$$

$$\beta = \alpha - 2\varphi = 58^\circ 25' 50''$$

$$\sin \varphi \times R' = \frac{d}{2} \text{ de donde } R' = \frac{d}{2 \sin \varphi} = 8.94200$$

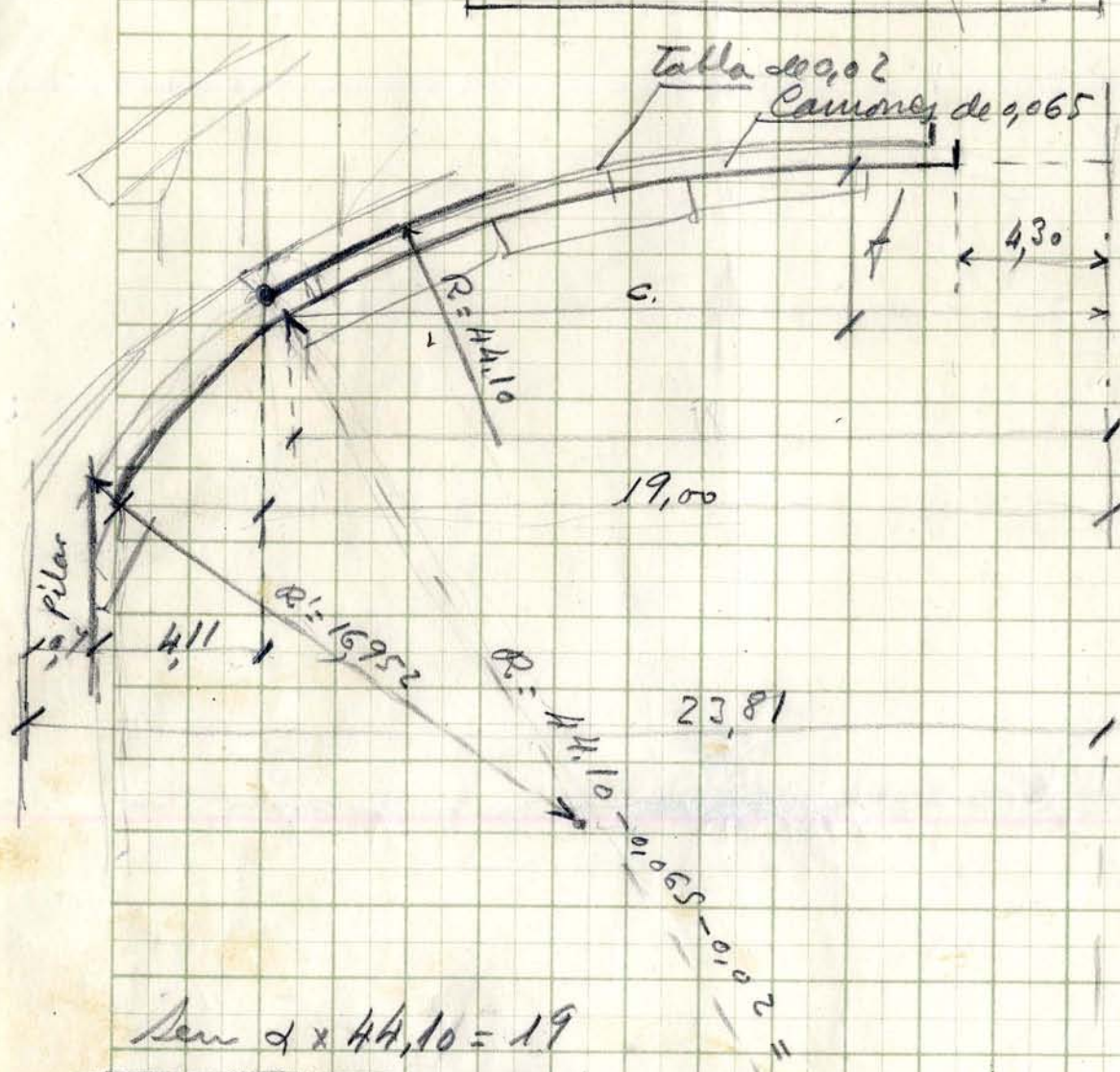
$$R = R' - 0.12 = 8.8200 \quad a = R \times 2 \sin \varphi = 2.32777$$

$$c = R (\cos \beta - \cos \alpha) = 2.129531$$

$$f = R (\sin \alpha - \sin \beta) = 0.929799$$

- x 1 Canon de la parte esferica
- x 2 Cercha de la parte esferica, parte de radio grande
- x 4 " " " " " " " " " pequeño
- x 6 " exterior de la bóveda en cañon
- x ~~12~~ " ~~interior de la bóveda en cañon (pequeño radio)~~
- x 13 " del fondo del arco de fachada (radio grande)
- x 14 " " " " " " " " (radio pequeño)
- 15 " interior de la bóveda en cañon punta al arco (")
- 16 Curva de intrados de la parte esferica de radio pequeño
- x 17 " " " de la bóveda en cañon en su parte exterior
- x 18 " " " de la parte interior de la bóveda en cañon. Pequeño radio
- " " " " " " " " " " " " " " " "
- x 20 Canon 1º de la parte total
- 21 " 2º " " " "
- 22 " 3º " " " "
- 23 " 4º " " " "
- 24 " 5º " " " "
- x 25 Proyeccion de la arista de union de la bóveda cañon
sobre el plano horizontal
- x 3 bis. Curva de zapatas de cercha principal en la parte de radio grande
- x 5 bis " " " " " " " " " " " pequeño
- x 6-2 bis " " " " " exterior de la bóveda en cañon

Cerchia principal de la parte esferica (parte de radio grande)



275
0,0025
0,0340

$$\text{Sen } \alpha \times 44,10 = 19$$

$$\text{Sen } \alpha \times 44,015 = c$$

$$c = \frac{19,00}{44,10} \times 44,015 = 18,963$$

$$a = 44,015(1 - \cos \alpha)$$

140
10
200
125
25
10
15
50
150
15
770

18,963
43
14663
29326

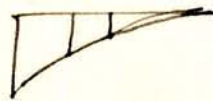
c	sen α	α	cos α	1 - cos α	a	f = 42932 - a
18,963	0,43083	25° 31'	0,90246	0,09754	42932	0
18,50	0,42031	24° 51'	0,90741	0,09259	4,0753	0,2179
18,00	0,40895	24° 8'	0,91260	0,08740	2,8469	0,4463
17,50	0,39759	23° 26'	0,91752	0,08248	3,6303	0,6629

0,3720
1785
2,652

(Continuación de Carcha principal)

C	sen α	α					
17.00	0,38623	22°43'	0,92242	0,07758	3,4147	0,8785	3514
16.50	0,37487	22° 1'	0,927071	0,072929	3,2100	1,0832	4,338
16.00	0,363512	21°19'	0,931585	0,068415	3,0113	1,2800	5,09 X
15.50	0,352153	20°37'	0,935956	0,064044	2,8189	1,4743	5,968 X
15.00	0,340793	19°55'30"	0,940136	0,059864	2635	1,6582	6,625
14.50	0,32943	19°14'	0,944186	0,055814	24568	1,8368	7,346
14.00	0,31807	18°33'	0,94804	0,05196	22870	2,0062	8,025
13.50	0,30671	17°52'	0,95177	0,04823	21228	2,1704	8,682
13.00	0,29535	17°11'	0,95536	0,04464	1,9648	2,3284	9,318
12.50	0,28399	16°30'	0,95882	0,04118	1,8125	2,4807	9,928
12.00	0,27263	15°49'	0,96214	0,03786	1,6664	2,6268	10,507
11.50	0,26127	15°9'	0,96525	0,03475	1,5295	2,7637	11,055
11.00	0,24991	14°29'	0,96822	0,03178	1,3988	2,8944	11,577
10.50	0,23855	13°48'	0,97114	0,02886	1,2703	3,0229	12,091
10.00	0,22719	13°8'	0,97384	0,02616	1,1514	3,1418	12,567
9.50	0,21583	12°28'	0,97642	0,02358	1,0379	3,2553	13,0212
9.00	0,20447	11°48'	0,97887	0,02113	0,9300	3,3632	13,4528
8.50	0,19311	11°7'	0,98124	0,01876	0,8257	3,4675	13,870
8.00	0,18176	10°27'	0,98341	0,01659	0,7302	3,5630	14,25
7.50	0,17040	9°48'	0,98541	0,01459	0,6422	3,6510	14,604
7.00	0,15904	9°9'	0,98728	0,01272	0,5549	3,7333	14,9077
6.5	0,14768	8°30'	0,98902	0,01098	0,4833	3,8099	15,239
6.00	0,13632	7°50'	0,99067	0,00933	0,4107	3,8825	15,53
5.5	0,12495	7°10'	0,99219	0,00781	0,3438	3,9494	15,7976
5.0	0,11360	6°21'	0,99387	0,00613	0,2698	4,0234	16,0936
4.30	0,09769	5°36'	0,99523	0,00477	0,2100	4,0832	16,3328

Continuarse el calculo desde 2.25 a 0, de 10 en 10 cm. ³/para Zapatas de cent.

388
194

13 hi

~~Curva~~ Curva de zapata de cercha principal en la parte de radio grande.

c	sen α	α	en α	1 - en α	a	$f = \frac{0,0603-a}{4,2932-a}$
2.30	0,05225	3°	0,99863	0,00937	0,0603	0
2.20	0,04983	2°51'30"	0,998758	0,001242	0,0547	0,0011 0,0056
2.10	0,04771	2°44'	0,99886	0,00994	0,0502	0,0101
2.00	0,04544	2°36'15"	0,998969	0,001031	0,0454	0,0149 0,0161
1.90	0,04317	2°28'	0,99907	0,00093	0,0409	0,0183 0,0194
1.80	0,04089	2°20'30"	0,999164	0,000836	0,0368	0,0235 0,0052
1.70	0,03862	2°13'	0,99925	0,00075	0,0330	0,0273
1.60	0,03635	2°5'	0,99934	0,00066	0,0296	0,0313 0,0130
1.50	0,03408	1°56'	0,99943	0,00057	0,0251	0,0352 0,05
1.40	0,03181					0,0372 0,0379 0,0196
1.30	0,02953	1°42'	0,99956	0,00044	0,0193	0,0407 0,06
1.20	0,02726					
1.10	0,02499	1°26'	0,99969	0,00031	0,0136	0,0437 0,0254 0,0443 0,0467
1.00	0,02272					0,0489 0,0306
0.90	0,02045	1°10'	0,99979	0,00021	0,0092	0,0511 0,064
0.80	0,01817					0,0528 0,0345
0.70	0,01590	0°55'	0,99987	0,00013	0,0057	0,0546 0,079
0.60	0,01363					0,0560 0,0371
0.50	0,01136	0°39'	0,99993	0,000057	0,0029	0,0574 0,015
0.40	0,00909					0,0579 0,0582 0,0388
0.30	0,00681	0°23'30"	0,99997	0,000027	0,0012	0,0594 0,043
0.20	0,00454					0,0597 0,0413
0.10	0,00227	0°8'	1,000	0		0,0603 0,056
0	0	0	1,000	0		0,0603 0,0420

Calculo de R'

Además viene la info 2764^2 es una dimensión μ
 $4,2016 + 2,764 = 7,0656$ multiplicar redondea

$$l = \sqrt{2764^2 + 4,11^2} = 4,9529$$

$$\sin a \cdot l = 4,11$$

$$\sin a = \frac{4,11}{l} = 0,829816 \checkmark$$

$$a = 56^\circ 5' \times$$

$$\text{sen } b \times 44,1 = 19 \quad \text{como } b = 25^\circ 31'$$

$$\text{se } b = \frac{19}{44,1} = 0,430839 \checkmark$$

$$b = 25^\circ 31' \times$$

$$c = 90 - a - b = 8^\circ 24' \checkmark$$

$$\text{se } c \times R' = \frac{l}{2}$$

$$R' = \frac{l}{2 \text{ sen } c} = 16,952 \checkmark$$

$$e = 90 - (b + 2c) = 47^\circ 41'$$

Comprobación: $\frac{R'}{\sin p} = \frac{l}{\sin 2c}$

$$\cos e \cdot R' - \cos (e + 2c) R' = 4,11$$

$$R' = \frac{4,11}{\cos e - \cos (e + 2c)} = 16,952$$

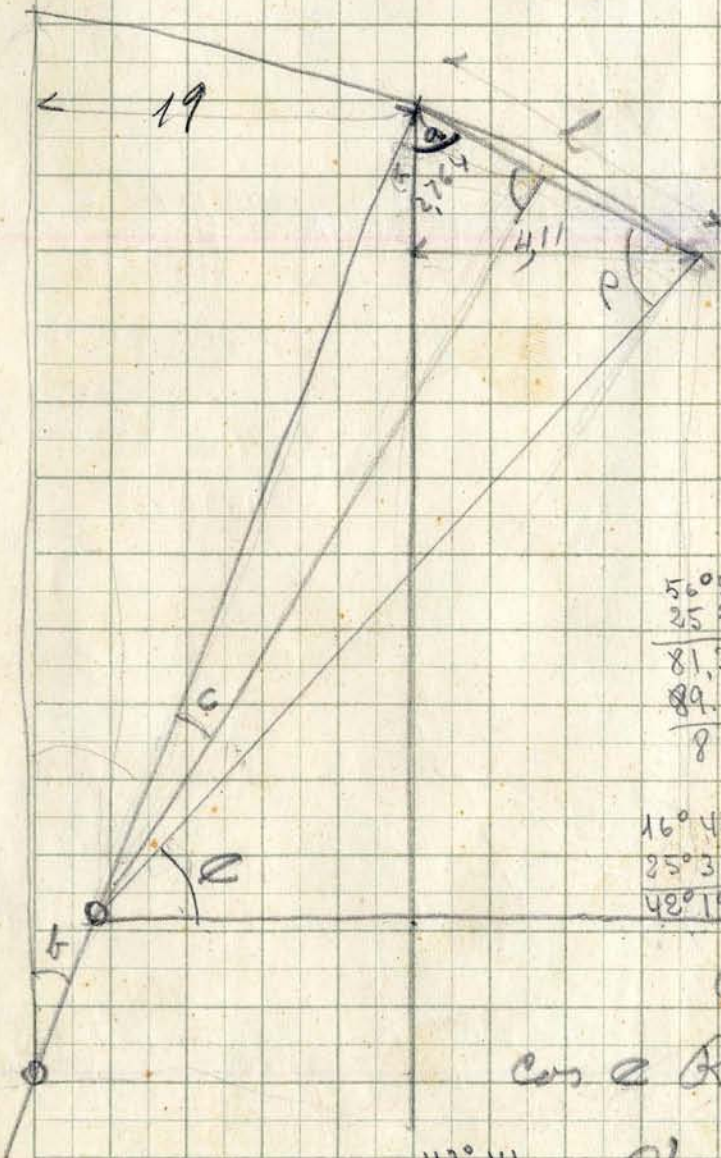
$$\begin{array}{r} 47^\circ 41' \\ 16^\circ 48' \\ \hline 64^\circ 29' \end{array}$$

$$R' = \frac{l \sin p}{\sin 2c} = \frac{4,9529 \times 0,88927}{0,989023} = 16,952$$

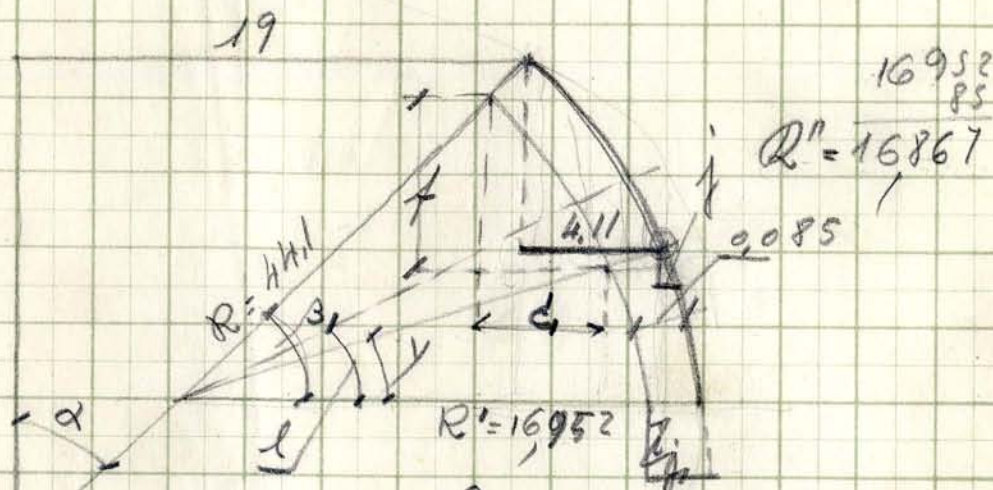
$$p = 81^\circ 26'$$

$$\text{sen } p = 0,98927$$

(14945)



Cercha principal de la parte esferica (parte de radio pequeño)



$$\sin \alpha = \frac{19}{16952} = 0,430839 \quad \alpha = 25^{\circ}31'$$

$$\beta = 90 - \alpha = 64^{\circ}29' \quad \cos \beta = 0,430839$$

$$\cos \gamma - \cos \beta = \frac{4,11}{16952} = 0,242449$$

$$\cos \gamma = \frac{4,11}{16952} + \cos \beta = 0,673288 \quad \sin \gamma = 0,739436$$

$$c = (\cos \gamma - \cos \beta) \times 16867 = 4,0894$$

$$(\cos \gamma - \cos l) R'' = c$$

$$\cos \gamma - \frac{c}{R''} = \cos l$$

$$f = (\sin \gamma - \sin l) / R''$$

Comprobación: $l = \gamma$

c	$\frac{c}{R''}$	$\cos l$	l	$\sin l$	$\sin \gamma - \sin l$	f
4,0894	0,242449	0,430839	64°29'	0,90246	0,16302	2750
4,00	0,237149	0,436139	64°8'30"	0,89988	0,16044	2706
3,75	0,222328	0,450960	63°12'	0,89206	0,15262	2574
3,50	0,207506	0,465782	62°14'	0,88485	0,14541	2453
3,25	0,192684	0,480604	61°17'	0,87701	0,13757	2320
3,00	0,177862	0,495426	60°18'	0,86863	0,12919	2179
2,75	0,16304	0,510248	59°19'	0,86000	0,12056	2033

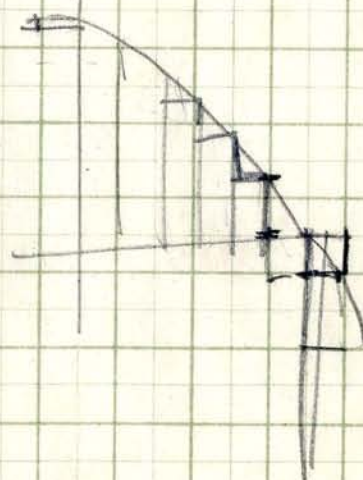
Calculado desde $c = 16,867$ a $c = 14,867$ de lo anterior, para las 2 partes de cercha

Continuación de cercha principal

2,50	0,148218	0,525070	58°19'30"	0,85105	0,11161	1,883	7,532
2,25	0,133394	0,539891	57°20'	0,84182	0,10238	1,727	6,908
2,00	0,118575	0,554713	56°18'30"	0,83204	0,09260	1,562	6,248
1,75	0,103753	0,569535	55°17'	0,82198	0,08254	1,392	5,568
1,50	0,088931	0,584357	54°14'30"	0,81148	0,07204	1,215	4,86
1,25	0,074109	0,599179	53°11'	0,80055	0,06111	1,031	4,124
1,00	0,059287	0,614001	52°7'	0,78926	0,04982	0,840	3,38
0,75	0,044466	0,628822	51°2'30"	0,77760	0,03816	0,644	2,576
0,50	0,029644	0,643644	49°56'	0,76529	0,02585	0,486	1,744
0,25	0,014822	0,658466	48°49'	0,75261	0,01317	0,222	
0	0	0,673288		0,739436	0	0	
-0,25	0,014822	0,688110	46°31'	0,72557	0,013866	-0,234	
-0,476	0,028231	0,701509	45°26'30"	0,712536	0,026900	-0,452	0,444

$$J = \cos = 0,058$$

$$\tan = 0,054$$



Curva de sapato de Canela, principal, e la forte
de radio pequeno

$$R'' = 16,867$$

α	$\frac{c}{R''} = \tan \alpha$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha) R''$	$y = a - R(1 - \cos \alpha)$
0	0	0	1	0	0	0,1192 _{0,0100}
0,20	0,01186	0° 40'	0,99993	0,00007	0,0012	0,1180 _{0,0088}
0,40	0,02371	1° 21'	0,99972	0,00028	0,0047	0,1145 _{0,0053}
0,60	0,03557	2° 2'	0,99937	0,00063	0,0106	0,1086 _{0,0092}
0,80	0,04743	2° 43'	0,99888	0,00112	0,0189	0,1003 _{0,0059}
1,00	0,05928	3° 24'	0,99823	0,00177	0,0298	0,0894 _{0,0092}
1,20	0,07114	4° 5'	0,99746	0,00254	0,0428	0,0764
1,40	0,08300	4° 46'	0,99654	0,00346	0,0584	0,0608
1,60	0,09486	5° 27'	0,99548	0,00452	0,0762	0,0430
1,80	0,10671	6° 8'	0,99427	0,00573	0,0966	0,0226 _{0,0050}
2,00	0,11857	6° 49'	0,99293	0,00707	0,1192	0

Handwritten calculations on grid paper, showing various arithmetic operations (addition, subtraction, multiplication, division) involving decimal numbers. The calculations are organized into several columns and rows, with some results underlined.

Column 1 (Leftmost):

- $0,0226$
- $0,0068$
- $0,0158$
- $0,0894$
- $0,0068$
- $0,0826$
- $0,118$
- $0,0068$
- $0,112$

Column 2:

- $0,0430$
- $0,0068$
- $0,0362$
- $0,1053$
- $0,0068$
- $0,0935$
- $0,1192$
- $0,0068$
- $0,1124$

Column 3:

- $0,0608$
- $0,0068$
- $0,0540$
- $0,1086$
- $0,068$
- $0,4018$

Column 4:

- $0,0464$
- $0,0068$
- $0,0696$
- $0,1145$
- $0,068$
- $0,1077$

Column 5:

- $0,00089$
- $0,00058$
- $0,1086$
- $0,1092$
- $0,1192$
- $0,0100$

Column 6 (Rightmost):

- $0,00178$
- $0,000888$
- $0,00178$
- $0,00890$
- $0,008$
- $0,0519$
- $0,118$
- $0,109$
- $0,009$
- $0,00118$
- $0,00648$

Percha de la bodega en cañon (parte de radio grande)



$$R = 22475 - 0,13 = 22,345 \text{ mts}$$

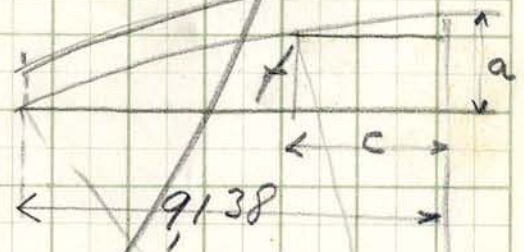
$$C = 6,25 \text{ mts}$$

$$\text{sen } \alpha R = C$$

$$a - (R - \cos \alpha R) = f$$

$$a = R - \cos \alpha R, \text{ siendo } C = 9,138$$

$$a = 1,953$$



C	sen $\alpha = \frac{C}{R}$	α	cos α	1 - cos α	R(1 - cos α)	f
9,138	0,408951	24° 2'	0,912598	0,087402	1,953	0
9,00	0,402775	23° 45'	0,91531	0,08469	1,892	0,061
8,50	0,380398	23° 21' 30"	0,924824	0,075176	1,680	0,273
8,00	0,358022	20° 59'	0,933684	0,066316	1,482	0,471
7,50	0,335646	19° 37'	0,94196	0,058039	1,297	0,656
7,00	0,313269	18° 15' 30"	0,94965	0,05035	1,125	0,828
6,50	0,290893	16° 55'	0,956725	0,043275	0,967	0,986 x
6,25	0,279705	16° 14' 30"	0,960011	0,039989	0,892	1,061 x
6,00	0,268516	15° 34' 30"	0,963279	0,036721	0,821	1,132 x
5,5	0,246140	14° 15'	0,96923	0,03077	0,688	1,265
5,0	0,223764	12° 56'	0,97463	0,02537	0,507	1,386
4,5	0,201387	11° 34'	0,979514	0,020486	0,458	1,495
4,0	0,179011	10° 49'	0,983832	0,016168	0,361	1,592
3,5	0,156634	9° 1'	0,987644	0,012356	0,276	1,677
3,0	0,134258	7° 43'	0,990957	0,009043	0,202	1,751
2,5	0,111882	6° 25' 30"	0,993719	0,006281	0,140	1,813
2,0	0,089505	5° 8'	0,99599	0,00401	0,090	1,863
1,5	0,067129	3° 51'	0,99774	0,00226	0,051	1,902
1,00	0,044753	2° 34'	0,998998	0,001002	0,022	1,931
0,50	0,022376	1° 14'	0,999748	0,000252	0,006	1,947
0,00						1,953

18276

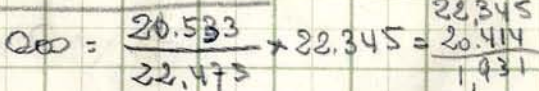
22475
14950

9138
18276

1953
13
2083

$$\begin{array}{r} 2.475 \\ -1.942 \\ \hline 0.533 \end{array}$$
$$\begin{array}{r} 22435 \\ 22345 \end{array}$$

6

$$\begin{array}{r} 22,345 \\ - 20,414 \\ \hline 1,931 \end{array}$$


$$\text{Ans } 72,475 = 6,279$$

$$\alpha = \frac{6,279}{22,475}$$

$$\text{sen } \alpha 22,345 = 6,243$$

$$\ln 2 \times 22745 = C$$

$$\ln 2 = \frac{C}{22,745} =$$

$$f = \cancel{1,242} - (1 - \cos \alpha) R$$

$$R = 22,345$$

C	$\frac{C}{22345}$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha)R$	δ
0	0	0	1	0	0	1,9312
0.50	0,02238	1° 17'	0,999748	0,000252	0,0006	1,925
1,00	0,04475	2° 34'	0,998998	0,001002	0,0022	1,909
1,50	0,06713	3° 51'	0,997744	0,002256	0,0050	1,881
1,995	0,089282	5° 7' 20"	0,996007	0,003993	0,0089	1,837
2,00	0,08950	5° 8' 30"	0,995978	0,004022	0,0090	1,841
2,50	0,11188	6° 25' 30"	0,993719	0,006281	0,0140	1,791
3,00	0,13426	7° 43'	0,990943	0,009057	0,0202	1,729
3,50	0,15663	9° 40"	0,987658	0,012342	0,0276	1,655
4,00	0,17900	10° 18' 45"	0,983845	0,016155	0,0361	1,570
4,077	0,182457	10° 30' 45"	0,98321	0,01679	0,0375	1,551
4,50	0,20138	11° 37'	0,980096	0,019904	0,0445	1,486
5,00	0,22376	12° 56'	0,97463	0,02537	0,0567	1,364
5,077	0,227592	13° 44' 40"	0,971268	0,028732	0,06297	1,20222 - 0,011
5,50	0,24613	14° 15'	0,96923	0,03077	0,0688	1,243
6,00	0,26851	15° 34' 30"	0,963279	0,036721	0,0821	1,110
6,243	0,27939	16° 13' 30"	0,960173	0,039827	0,0890	1,041
6,558	0,284314	16° 31'	0,958437	0,041563	0,0923	0,965
6,50	0,29089	16° 54' 30"	0,956768	0,043232	0,0966	0,957
6,58	0,29441		0,95566	0,04434	0,0990777	



Cuadra N° 2 (Canton)

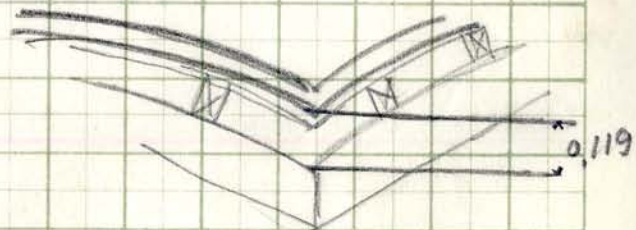
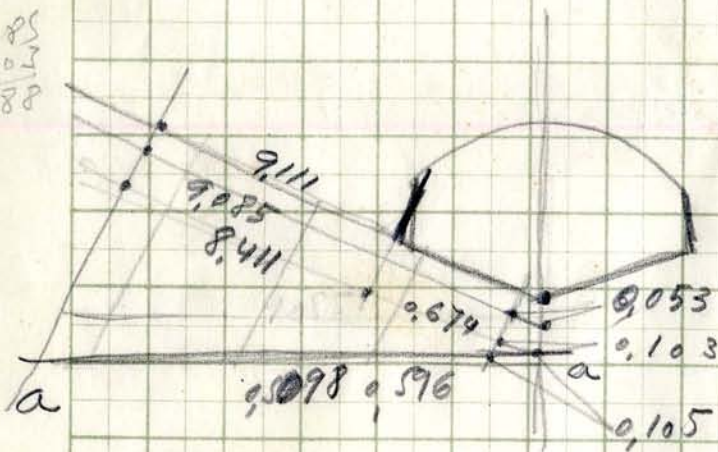
6 bis

7,00 0,31326	18°15'30"	0,94965	0,05035	1,125	0,806
7,50 0,33564	19°36'	0,942058	0,057942	1,295	0,636
8,00 0,35801	20°58'45"	0,93371	0,06629	1,481	0,450
8,50 0,38039	22°21'30"	0,924824	0,075176	1,680	0,251
9,085 0,40658	23°59'30"	0,913593	0,086407	1,931	0,00

$$\text{sen } 22^{\circ}30' \times 24,01 = 0,38268 \times 24,01 = 9,188$$

$$\text{sen } 22^{\circ}20' \times 24,01 =$$

$$2 \text{ sen } 11^{\circ}15' \times 24,01 = 2 \times 0,19509 \times 24,01 = 9,368$$



$$\frac{9,188}{9,368} = 0,103$$

$$x = \frac{9,368}{9,188} \times 0,103 =$$

Como la curva calculada, lo ha sido en proyección sobre la cuerda, para tenerla en proyección sobre el plano a-a, habrá que multiplicar sus ordenadas por $\frac{9,368}{9,188} = 1,01959$ y añadir una altura de 0,105 para tener la distancia al eje de pilar.

$$\begin{array}{r} 1397 \\ 3946 \\ 4025 \\ \hline 9368 \end{array}$$

$$\begin{array}{r} 5098 \\ 3032 \\ \hline 66 \end{array}$$

$$\begin{array}{r} 9177 \\ 103 \\ \hline 9188 \end{array}$$

$$\begin{array}{r} 3171 \\ 117 \\ \hline 3948 \end{array}$$

$$\begin{array}{r} 16 \\ 3 \\ \hline 32 \end{array}$$

Zapata de Cimbra N° 2

16-2 bis

Curva de Zapata de Cimbra
a teñir de la boveda en cañon

$$R = 22,345$$

255

19

C	$\frac{C}{22,345}$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha)R$	$f = 0,977 (1 - \cos \alpha)R$	
0	0	0	1	0	0	0,0977	1,0465
0,25	0,01119	38'30"	0,99994	0,00006	0,0013	0,0966	0,0452
0,474	0,021213	1°13'	0,99972	0,00028	0,0053	0,0913	0,0399
0,50	0,02238	1°14'	0,99915	0,00085	0,0056	0,0852	X 0,0338
0,75	0,033564	1°55'30"	0,99943	0,00057	0,0127	0,0756	X 0,0242
1,00	0,04475	2°34'	0,99900	0,00100	0,0223	0,0626	0,0112
1,25	0,05594	3°12'30"	0,99843	0,00157	0,0351	0,0533	0
1,44	0,06440	3°37'	0,99800	0,00200	0,0446	0,0475	
1,469		3°41'30"	0,99792	0,00208	0,0465		
1,50	0,06718	3°51'	0,99774	0,00226	0,0504		
1,95	0,08817	4°24'30"	0,99693	0,00307	0,0686	0,0293	
1,975		5°4'30"	0,99607	0,00393	0,0876	0,0103	
2,00	0,08950	5°8'	0,99599	0,00401	0,0896	0,0083	
1,861							
2,09	0,09353	5°22'	0,99562	0,00438	0,0979	0	

333
1000
35

$$\frac{163156}{217488} = \frac{23568}{6544}$$

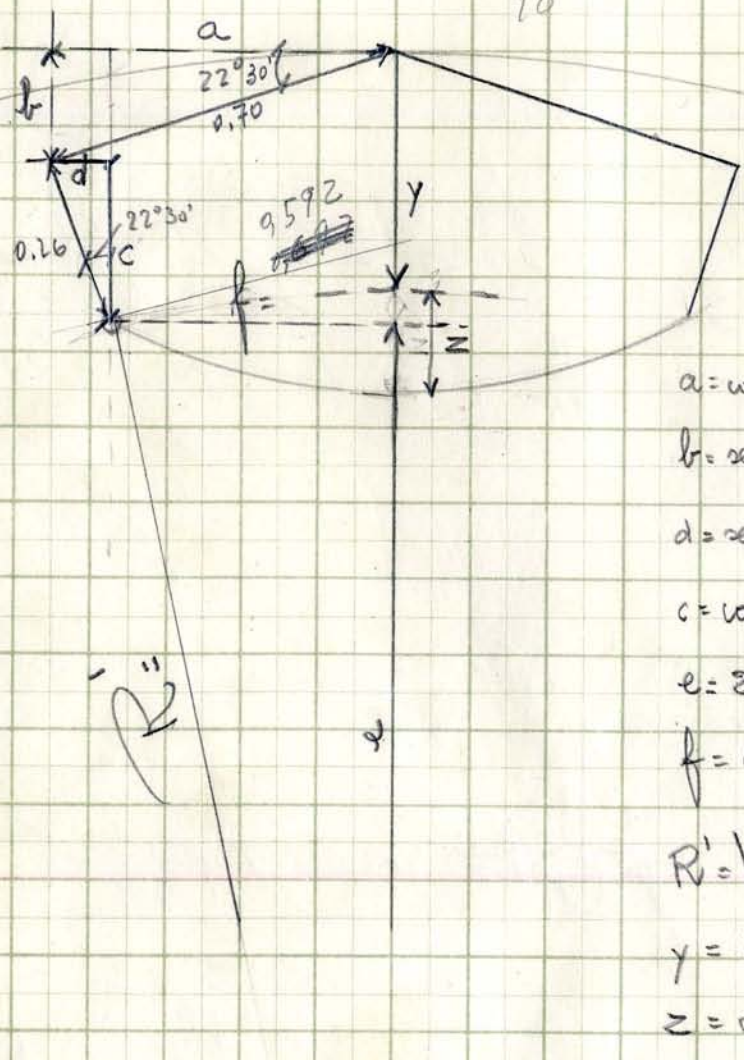
$$\frac{217}{215}$$

$$\frac{27108}{28} = \frac{27308}{70}$$

$$\frac{26}{23708} = \frac{23708}{1310}$$

$$\frac{23568}{0,70} = \frac{27308}{1}$$

7



$$\frac{23708}{26} = \frac{27308}{1,70}$$

$$e = 23,81 - 0,5472 = 23,2628$$

$$a = \cos 22^\circ 30' \times 0,70 = 0,92388 \times 0,70 = 0,6467$$

$$b = \sin 22^\circ 30' \times 0,70 = 0,38268 \times 0,70 = 0,2679$$

$$d = \sin 22^\circ 30' \times 0,26 = 0,38268 \times 0,26 = 0,0995$$

$$c = \cos 22^\circ 30' \times 0,26 = 0,92388 \times 0,26 = 0,2402$$

$$e = 23,81 - b - c = 23,3019$$

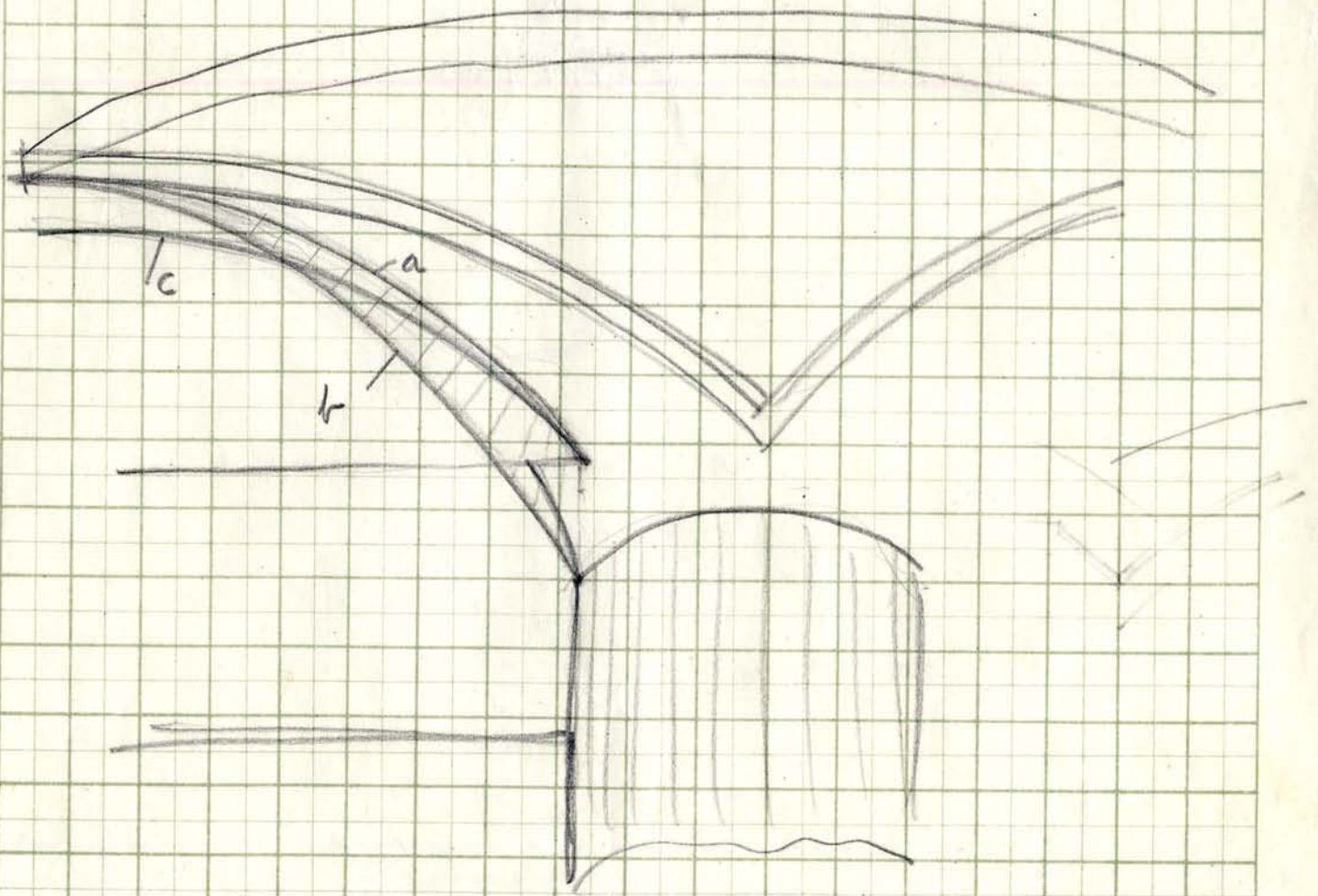
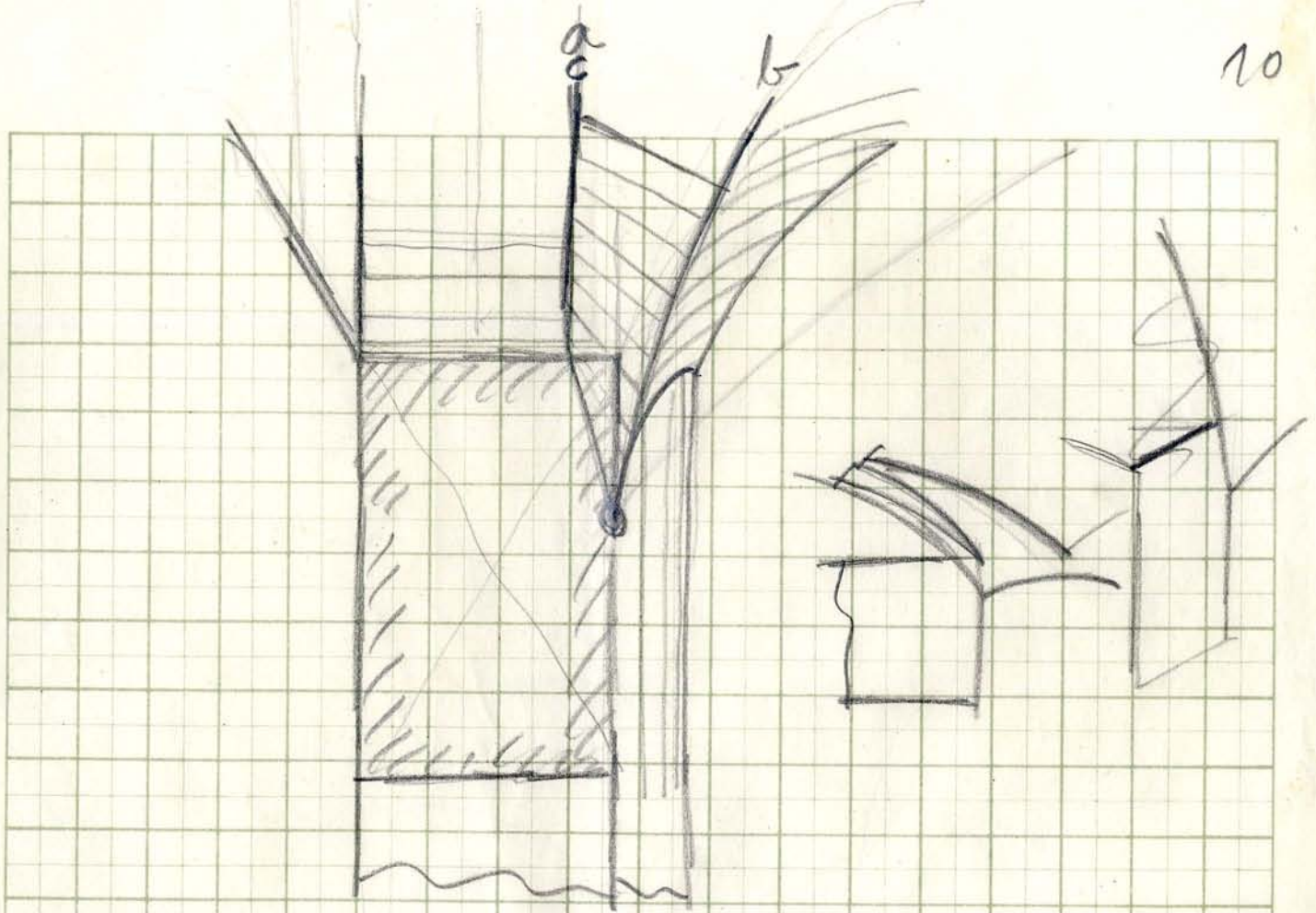
$$f = a - d = 0,6467 - 0,0995 = 0,5472$$

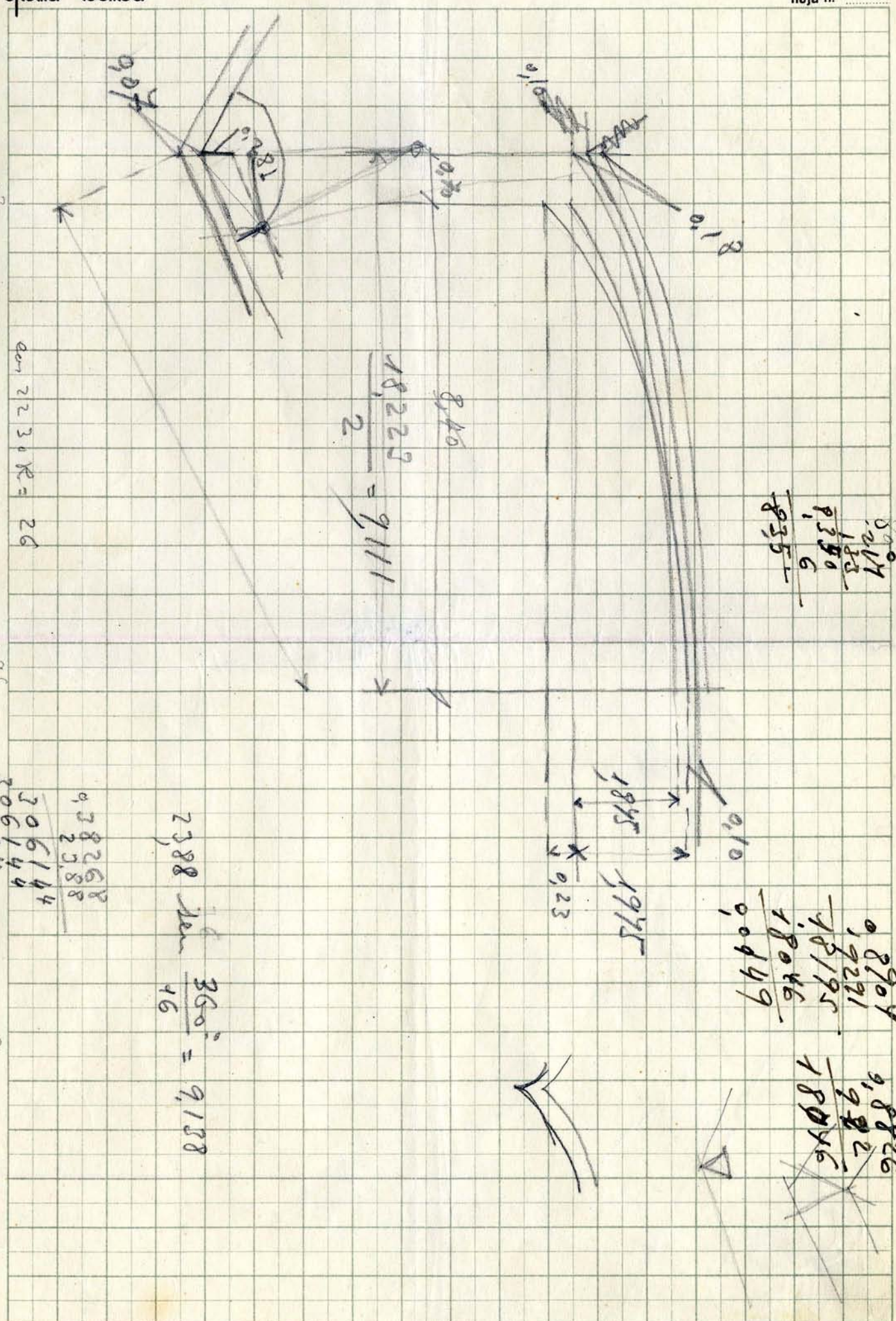
$$R' = \sqrt{23,3019^2 + 0,5472^2} = 23,308$$

$$y = 23,81 - 23,308 = 0,502$$

$$z = 0,70 - 0,502 = 0,198$$

$$\frac{127}{387} = \frac{3171}{8411}$$





$$\begin{array}{r} 890 \\ 1211 \\ 133 \\ \hline 9380 \\ 835 \end{array}$$

$$\begin{array}{r} 0.8704 \\ 1.9221 \\ 1.8195 \\ \hline 1.8046 \\ 0.0449 \end{array}$$

$$\begin{array}{r} 9.8826 \\ 1.9221 \\ \hline 1.8046 \end{array}$$

$$\begin{array}{r} 8.40 \\ 18222 \\ \hline 2 \\ 9111 \end{array}$$

$$2388 \text{ de } \frac{360}{16} = 9.138$$

$$2230R = 26$$

$$\begin{array}{r} 16952 \\ 33904 \end{array}$$

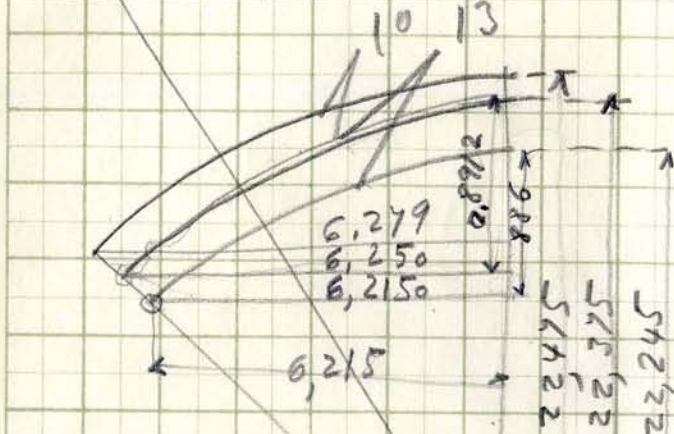
$$R = \frac{0.26}{0.92088} =$$

$$\begin{array}{r} 12695 \\ 25390 \\ \hline 25110 \end{array}$$

$$\begin{array}{r} 938268 \\ 306144 \\ 306144 \\ \hline 114864 \\ 165336 \\ \hline 91383984 \end{array}$$

$$\begin{array}{r} 12179 \\ 24278 \end{array}$$

Cercha de fondo del arco de fachada
(parte de radio grande)



$$\sin \alpha = \frac{6,279}{22,245} = 0,279377$$

$$\sin \alpha \times 22,245 = 6,215$$

$$\sin \alpha R = c$$

$$\sin \alpha = \frac{c}{R}$$

$$A = a - (1 - \cos \alpha) R$$

$$R = 22,245$$

c	$\frac{c}{22,245}$	α	$\cos \alpha$	$1 - \cos \alpha$	$(1 - \cos \alpha) R$	A
0	0		1	0	0	0,886018
0,50	0,02248	1° 14'	0,99975	0,00025	0,005561	0,880457
1,00	0,04495	2° 34' 30"	0,99912	0,00088	0,019575	0,866443
1,50	0,06743	3° 52'	0,99772	0,00228	0,050718	0,835300
2,00	0,08991	5° 9' 30"	0,99595	0,00405	0,090092	0,795926
2,50	0,11238	6° 27'	0,99367	0,00633	0,140810	0,745908
3,00	0,13486	7° 45'	0,99086	0,00914	0,203219	0,688699
3,50	0,15734	9° 3'	0,98755	0,01245	0,276950	0,609068
4,00	0,17981	10° 21' 30"	0,98370	0,01630	0,362593	0,523425
4,50	0,20229	11° 40'	0,97934	0,02066	0,459581	0,426437
5,00	0,22477	12° 59' 30"	0,97440	0,02560	0,569472	0,316546
5,3114	0,23856	13° 48' 50"	0,97108	0,02892	0,643225	0,242693
5,50	0,24725	14° 19'	0,96894	0,03106	0,690929	0,195089
6,00	0,26972	15° 39'	0,96293	0,03707	0,824622	0,061396
6,215	0,27939	16° 13' 36"	0,96017	0,03983	0,886018	0

Valle

15

de
p
3

(circular $N=2$ case)



$$\cos l = \cos \varphi - \frac{c}{R}$$

$$f = (\sec l - \sec \varphi) R$$

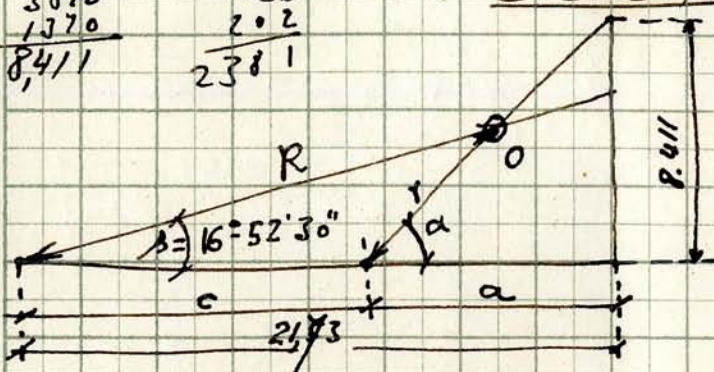
$$\gamma = 9^{\circ}59'30'' \times 2 = 19^{\circ}59'$$

$$\begin{array}{r} 2041 \\ 175 \\ \hline 0,341 \\ 1 \end{array}$$

Curva N° 5 (Encuentro del cañon y la esfera)

$$\begin{array}{r} 3171 \\ 3870 \\ 1370 \\ \hline 8411 \end{array}$$

$$\begin{array}{r} 2153 \\ 166 \\ 202 \\ \hline 2381 \end{array}$$



$$\begin{aligned} \text{sen } d &= 0,96206 \\ \text{cos } \alpha &= 0,27284 \end{aligned}$$

$$\begin{aligned} \text{sen } \beta &= 0,29028 \\ \text{cos } \beta &= 0,95694 \end{aligned}$$

Calculo del punto O.

$$\frac{a}{0,9} = \frac{8,411}{3,171} \quad a = \frac{0,9 \times 8,411}{3,171} = 2,38723$$

$$\text{tg } \alpha = \frac{8,411}{a} = 3,52333$$

$$\alpha = 74^{\circ} 10'$$

$$c = 2173 - a = 19,343 \text{ mts}$$

$$\text{sen } \beta R = \text{sen } \alpha r$$

$$\text{Cos } \beta R = c + \text{cos } \alpha r$$

$$r = \frac{c}{\text{cos } \beta \frac{\text{sen } \alpha}{\text{sen } \beta} - \text{cos } \alpha} = \frac{6,67298}{6,604}$$

$$R = \frac{\text{sen } d}{\text{sen } \beta} r = \frac{22,1159}{21,88751}$$

Calculo del punto O' en igual forma que el O

$$\text{tg } \alpha = \frac{5,24}{a} = 8,7955$$

$$\alpha = 83^{\circ} 31'$$

$$\beta = 11^{\circ} 15'$$

$$\begin{aligned} \text{sen } \alpha &= 0,99360 \\ \text{cos } \alpha &= 0,11291 \end{aligned}$$

$$\begin{aligned} \text{sen } \beta &= 0,19509 \\ \text{cos } \beta &= 0,98078 \end{aligned}$$

$$\frac{a}{0,40} = \frac{5,24}{3,87} \quad a = \frac{0,4 \times 5,24}{3,87} = 0,54556$$

$$c = 2173 - 0,90 - a = 20,234$$

$$r = \frac{20,234}{\frac{0,99360}{0,19509} \times 0,98078 - 0,11291} = \frac{4,1444}{4,10348}$$

$$R = \frac{0,99360}{0,19509} \times 4,1444 = 20,8989$$

Calculo del O'' en igual forma que el O

$$\alpha = 83^{\circ} 31'$$

$$\beta = 5^{\circ} 37' 30''$$

$$\begin{aligned} \text{sen } \alpha &= 0,99360 \\ \text{sen } \beta &= 0,09802 \end{aligned}$$

$$\text{cos } \alpha = 0,11291$$

$$\begin{aligned} \text{cos } \beta &= 0,99802 \\ &0,99518 \end{aligned}$$

$$a = 0,59576$$

$$c = 20,034 \quad 20,234$$

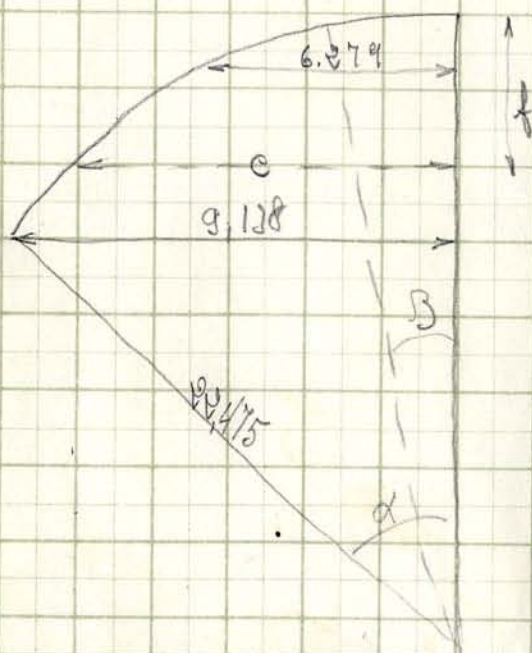
$$r = \frac{20,034}{\frac{0,99360}{0,09802} \times 0,99518 - 0,11291} = \frac{20,282}{2,0084}$$

$$R = \frac{0,99360}{0,09802} \times \frac{20,282}{2,0084} = 20,5592$$

32 47.10

Arista de encuentro
del Casquete y el Cañon

Curva de intrados de la bóveda en cañon en su parte exterior (Proyección ^{vertical} sobre la cuerda)



$$\text{sen } \alpha \cdot 22.475 = 9.138$$

$$\text{sen } \alpha = \frac{9.138}{22.475} = 0.406585$$

$$\cos \alpha = 0.912612$$

$$\text{sen } B \cdot R = c$$

$$\text{sen } B = \frac{c}{R}$$

$$(\cos B - \cos \alpha) R = f$$

$$\frac{1}{R} = 0.04449288$$

C	$\frac{C}{R} = \sin B$	B	$\cos B$	$\cos B - \cos \alpha$	$f = (\cos B - \cos \alpha) R$
0	0	0	1	0,086388	1,942
0,5	0,02224694	0,999802	0,08619	1,937	
1,0	0,04449288	0,999009	0,085397	1,919	
1,5	0,06674082	0,997777	0,084158	1,891	
2,0	0,08898776	0,99602	0,082418	1,852	
2,5	0,1112347	0,99279	0,080178	1,802	
3,0	0,1334816	0,99105	0,077438	1,740	
3,5	0,15572858	0,9878	0,074188	1,667	
4,0	0,17797552	0,98402	0,070418	1,583	
4,5	0,20022246	0,97975	0,066138	1,486	
5,0	0,2224694	0,97492	0,061318	1,378	
5,5	0,24471634	0,96959	0,055978	1,258	

$$\sin = \sqrt{1 - \cos^2}$$

$$\cos = \sqrt{1 - \sin^2}$$

(17 lis)

6.00	0,26696328		0,96370	0,050088	1,126.
6.20	0,2793770		0,96018	0,046568	1,047
6.50	0,289210	16°48'30"	0,957276	0,043664	0,981
7.00	0,21145716	18°9'	0,950241	0,036629	0,823
7.50	0,2327041	19°29'30"	0,942689	0,029077	0,654
8.00	0,25595104	20°51'	0,934516	0,020904	0,470
8.50	0,27819798	22°13'20"	0,92572	0,012108	0,272
9.00	0,40044892	23°36'20"	0,916324	0,002713	0,061
9.128	0,406585	23°59'20"	0,913608	0,000004	0

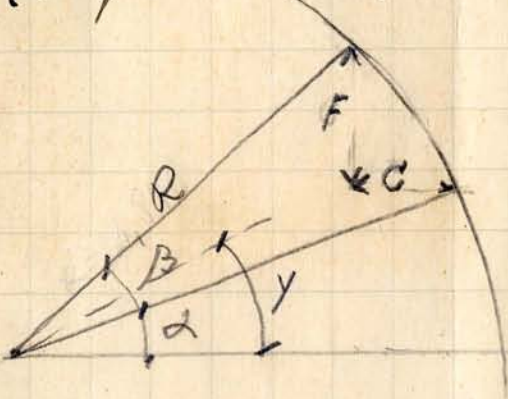
1942
1044
895

1942

Curva de entradas de la parte interior de la bveda en cañon
(Pequeño radio)

2132 (Proyección vertical sobre la cuerda)

2132
6277
8411
9111



$$\alpha = 43^{\circ} 59' 20''$$

$$\beta = 29^{\circ} 47' 0''$$

$$R = 4,846$$

$$F = 1,287 \text{ mts}$$

$$C = 2,132 \text{ ''}$$

$$C = (\cos \alpha - \cos \gamma) R$$

$$\cos \gamma = \cos \alpha - \frac{C}{R}$$

$$f = (\sin \gamma - \sin \alpha) R$$

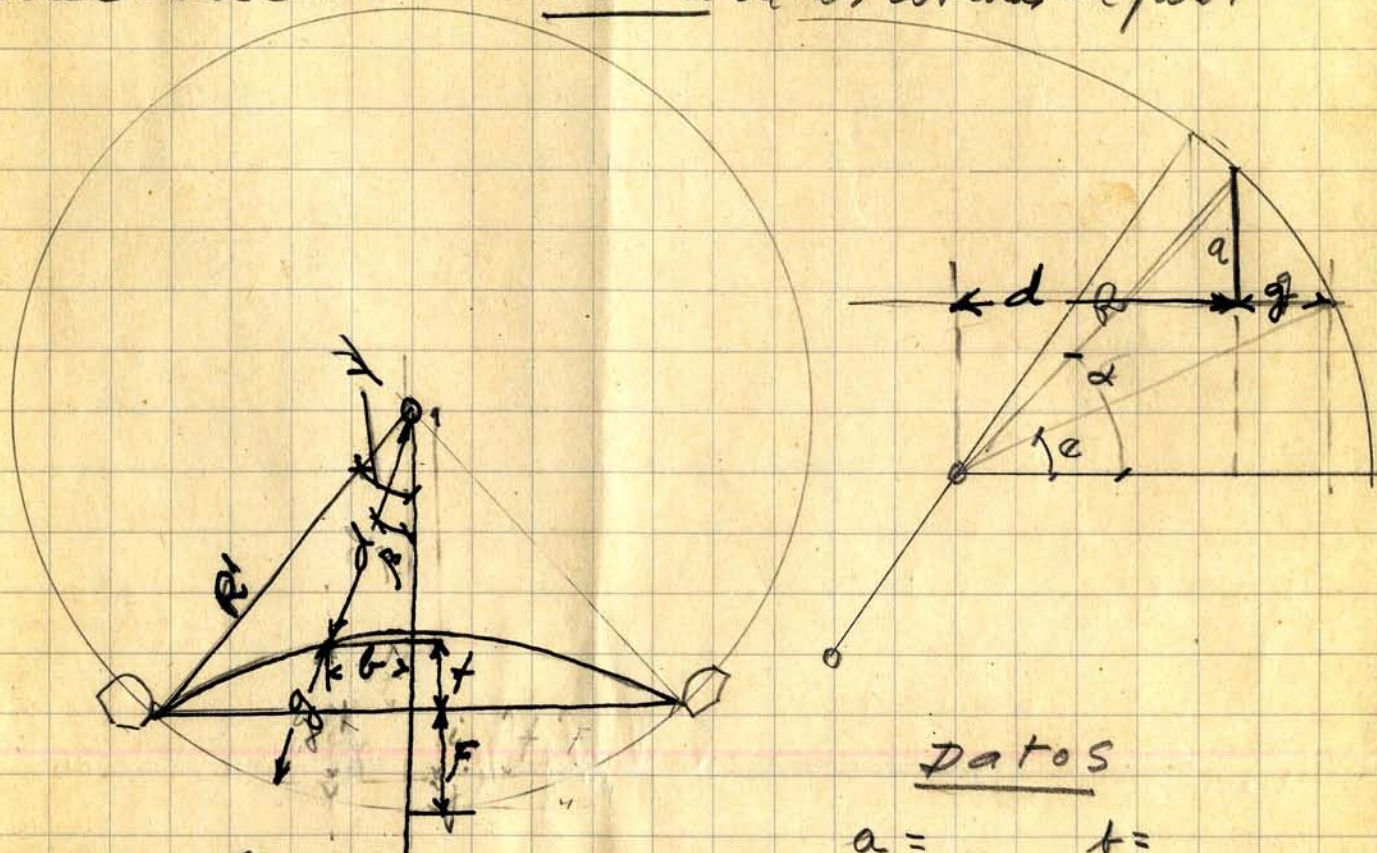
$$\cos \alpha = 0,71944$$

$$\sin \alpha = 0,69456$$

C	$\frac{1}{R} C$	$\cos \alpha \mp \frac{C}{R}$	γ	$\sin \gamma$	$\sin \gamma - \sin \alpha$	f
0	0	0,71944	43°59'30"	0,69456	0,00000	0
0,25	0,05159	0,66785	48°6'	0,74326	0,0487	0,236
0,50	0,10318	0,61626	51°57'	0,787473	0,092913	0,450
0,75	0,15477	0,56467	55°37'	0,82528	0,131	0,635
1,00	0,20636	0,51308	59°8'	0,85838	0,1638	0,994
1,25	0,25794	0,46150	62°31'	0,887144	0,192584	0,933
1,50	0,30953	0,40991	65°48'	0,91212	0,21756	1,054
1,75	0,36112	0,35832	69°0'	0,93358	0,239	1,158
2,00	0,41271	0,30673	72°8'	0,95177	0,25721	1,246
2,132	0,43995	0,27947	73°46'	0,960132	0,265572	1,287

1287
895
2182

Proyección de la arista de union de la bóveda en
Canton con la parte toral, sobre el plano horizontal,
medida desde la cuerda de los aristas de pilar



$$\sin \alpha = \frac{a}{R} + \sin \epsilon =$$

$$g = (\cos \epsilon - \cos \alpha) R$$

$$d = R' - g$$

$$\sin \beta = \frac{g}{d}$$

Datos

$$a = \quad t =$$

$$R = 16,952 \quad R' = 23,308$$

$$\alpha = 46^{\circ} 44' 30''$$

$$\gamma = 21^{\circ} 9'$$

$$F = R'(1 - \cos \gamma) = 1,57$$

$$f = R' - F - d \cos \beta$$

$$R' - F = 23,308 - 1,57 = 21,738$$

$$K = g \cos \beta$$

$$f = R' - F + K - d \cos \beta = R' - F + g \cos \beta - R' \cos \beta - F$$

$$f = R' - F + g \cos \beta - R' \cos \beta$$

$$R' - F + \cos \beta (g - R')$$

0,68529

(25)

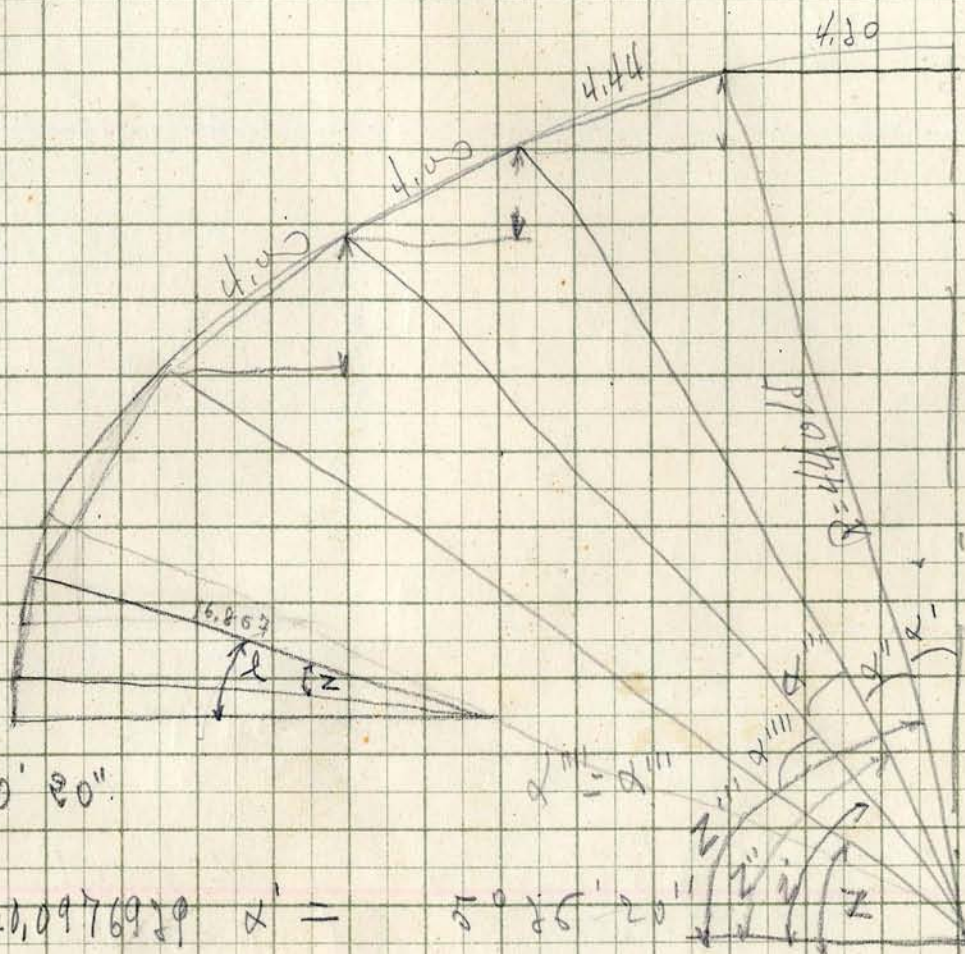
F = 1,57

a	a	per 2	α	Cor 2	conc-cord	lg	d	b	len B
2,182	0,128716	0,85699	58° 59'	0,51529	0,1700	2,882	20,426	0	
2,177	0,128421	0,85669	58° 57'	0,51579	0,1695	2,873	20,435	-0,50	1 2
2,159	0,127359	0,85563	58° 49'30"	0,51765	0,16764	2,842	20,466	-1,00	2 3
2,131	0,125707	0,85398	58° 39'	0,52025	0,16504	2,798	20,510	-1,50	3 4
2,092	0,123407	0,85168	58° 28'30"	0,52411	0,16118	2,732	20,576	-2,00	4 5
2,042	0,120457	0,84873	58° 17'30"	0,52880	0,15649	2,653	20,655	-2,50	5 6
x 1,980	0,116800	0,84507	57° 41'	0,53459	0,15070	2,555	20,753	-3,00	6 7
x 1,907	0,112494	0,84076	57° 13'30"	0,54185	0,14394	2,440	20,868	-3,50	7 8 16972
x 1,828	0,107538	0,83581	56° 42'	0,54902	0,13627	2,310	20,998	-4,00	8 9 x
1,726	0,101817	0,83007	56° 6'30"	0,55762	0,12767	2,164	21,144	-4,50	9 10 x
1,618	0,095446	0,82372	55° 27'30"	0,56700	0,11829	2,005	21,305	-5,00	10 11
1,498	0,088367	0,81664	54° 45'	0,57714	0,10815	1,833	21,465	-5,50	11 12
279 x 1,366	0,080580	0,80885	53° 59'	0,58807	0,09728	1,649	21,659	-6,00	12 13
1287	0,075920	0,80417		0,59437	0,09092	1,541	21,767	-6,279	12 14
1246	0,073502	0,80177		0,59763	0,08766	1,486	21,822	-6,411	14 15
1158	0,068310	0,79658		0,60453	0,08076	1,369	21,939	-6,661	15 16
1054	0,062175	0,79045		0,61252	0,07277	1,234	22,074	-6,911	16 17
x 933	0,055037	0,78331		0,62163	0,06366	1,077	22,229	-7,161	17 18
x 0,794	0,046838	0,77511		0,63182	0,05347	0,906	22,402	-7,411	18 19
0,635	0,037458	0,76573		0,64316	0,04213	0,714	22,594	-7,661	19 20
0,450	0,026545	0,75482		0,65593	0,02936	0,498	22,810	-7,911	20 x
5 { x 0,236	0,013220	0,74219		0,67018	0,01511	0,246	23,092	-8,161	21 x
5 { 0	0	0,72827		0,68529	0	0	23,308	-8,411	22 x

25-266

Sen B	B	cos A	d cos B	f = R' F - d cos B
0	0	1	20,426	1,312 1
0,024468	1° 24'	0,9997	20,429	1,309 2
0,048862	2° 48'	0,99881	20,442	1,296 3
0,073135	4° 12' 30"	0,99730	20,454	1,284 4
0,097201	5° 33' 30"	0,99530	20,479	1,259 5
0,12104	6° 57'	0,99280	20,506	1,232 6
0,14456	8° 19'	0,98948	20,535	1,203 7
0,16792	9° 39' 20"	0,985816	20,572	1,166 8
0,190474x	10° 59'	0,981685	20,613	1,125 9
0,21283	12° 17' 20"	0,977086	20,660	1,078 10
0,234686	13° 34' 20"	0,972076	20,710	1,028 11
0,25623	14° 50' 45"	0,966614	20,748	0,990 12x
0,27702	16° 5'	0,96086	20,811	0,927 13
0,288464	16° 46'	0,957486	20,842	0,896 14
0,293786	17° 5' 30"	0,955875	20,859	0,879 15
0,303615	17° 40' 30"	0,95280	20,903	0,835 16
0,313083	18° 14' 40"	0,949725	20,964	0,774 17
0,322147	18° 47' 30"	0,946895	21,042	0,694 18
0,330819	19° 19'	0,943706	21,144	0,597 19
0,339072	19° 49' 15"	0,940705	21,254	0,484 20
0,34684	20° 17' 30"	0,93794	21,394	0,344 21
0,35341	20° 42'	0,93544	21,601	0,137 22
0,36071	21° 8' 30"	0,93273	21,740	0 23

293786



$$l = 63^{\circ} 0' 20''$$

$$\sin \alpha' = \frac{4.80}{44.015} = 0.10976929 \quad \alpha' = 5^{\circ} 25' 20''$$

$$\sin \frac{\alpha''}{2} = \frac{2.22}{44.015} = 0.050437 \quad \alpha'' = 5^{\circ} 47'$$

$$\sin \frac{\alpha'''}{2} = \frac{2.00}{44.015} = 0.045439 \quad = \begin{matrix} 5^{\circ} 12' 20'' \\ 5^{\circ} 12' 20'' \end{matrix}$$

$$\begin{matrix} 21^{\circ} & 108 & 80 \\ & 48' & 20'' \end{matrix}$$

$$\begin{matrix} 29 & 59 & 60 \end{matrix}$$

$$\begin{matrix} 21 & 48 & 20 \end{matrix}$$

$$\begin{matrix} 68 & 11 & 40 \end{matrix}$$

$$Z = 90 - 21^{\circ} 48' 20'' = 68^{\circ} 11' 40'' \quad \sin Z = 0,928449$$

$$Z' = Z + \alpha''' = 72^{\circ} 24' 10'' \quad \sin Z' = 0,958155$$

$$Z'' = Z' + \alpha''' = 78^{\circ} 25' 40'' \quad \sin Z'' = 0,980206$$

$$Z''' = Z'' + \alpha''' = 84^{\circ} 27' 40'' \quad \sin Z''' = 0,995215$$

$$0,014910$$

$$R(\sin Z''' - \sin Z'') = 0,6562$$

$$R(\sin Z'' - \sin Z) = 0,9670$$

$$R(\sin Z' - \sin Z) = 1,2154$$

$$\sin \frac{Z}{2} =$$

$$0,6562$$

$$0,9670$$

$$1,2154$$

$$1,6669$$

$$4,6055$$

$$6,887$$

$$2,2815$$

$$\sin \beta = \frac{8,435}{44,015} = 0,191639 \quad \beta = 11^{\circ} 3'$$

$$\sin \frac{l}{2} = \frac{1,12}{44,015} = 0,025446 \quad \frac{l}{2} = 1^{\circ} 27' 30'' \quad l = 2^{\circ} 55'$$

$$\sin \frac{l'}{2} = \frac{1,98}{44,015} = 0,044985 \quad \frac{l'}{2} = 2^{\circ} 34' 40'' \quad l' = 5^{\circ} 9' 20''$$

$$l'' = l' = 5^{\circ} 9' 20''$$

$$\alpha = 25^{\circ} 31''$$

$$y'' = \beta + l + l' + l'' = \begin{array}{r} 11^{\circ} 3' \\ 2^{\circ} 55' \\ 5^{\circ} 9' 20'' \\ 5^{\circ} 9' 20'' \\ \hline 24^{\circ} 16' 40'' \end{array}$$

$$l''' = \alpha - y'' = 1^{\circ} 14' 20''$$

$$b = 2 \sin \frac{l'''}{2} R' = 0,021631 \times 44,015 = 0,952$$

$$\rho = 90^{\circ} - \alpha = 64^{\circ} 29'$$

$$\cos \varphi = \frac{a}{r'} + \cos \rho = \frac{1,642}{16,867} + 0,430772 = 0,528122$$

$$\varphi = 58^{\circ} 7' 15''$$

$$c = 2 \sin \left(\frac{\rho - \varphi}{2} \right) r' = 0,110984 \times 16,867 = 1,872$$

$$\sin \omega = \frac{a}{c} = \frac{1,642}{1,872} = 0,877134 \quad \omega = 61^{\circ} 18'$$

$$\omega' = 90^{\circ} - \rho = \alpha = 25^{\circ} 31'$$

$$\sigma = 90 - \omega - \omega' = 3^{\circ} 11' \quad \sigma' = 90 - \frac{l'''}{2} = 89^{\circ} 22' 50''$$

$$\sigma'' = 90 - \sigma' = 0^{\circ} 37' 10''$$

$$\sin \sigma \times c = 0,05553 \times 1,872 = 0,104 = x$$

$$\sin \sigma'' \times b = 0,0108155 \times 0,952 = 0,0103$$

$$\frac{0,0103}{0,0937} = h$$

$$f = \cos \sigma c = 0,998454 \times 1,872 = 1,869$$

$$g = \cos \sigma'' b = 0,9999385 \times 0,952 = 0,952$$

$$d = \frac{h}{1 + \frac{f}{g}} = \frac{0,0937}{1 + 1,9632} = 0,0316$$

$$e = \frac{f}{g} d = 1,9632 \times 0,0316 = 0,0620$$

$$\begin{array}{r} 0,104 \\ 0,062 \\ \hline 0,042 \end{array}$$

$$\bar{e} \alpha' = \frac{0,062}{1,869} = 0,033173$$

$$\sin \alpha' = 0,99945$$

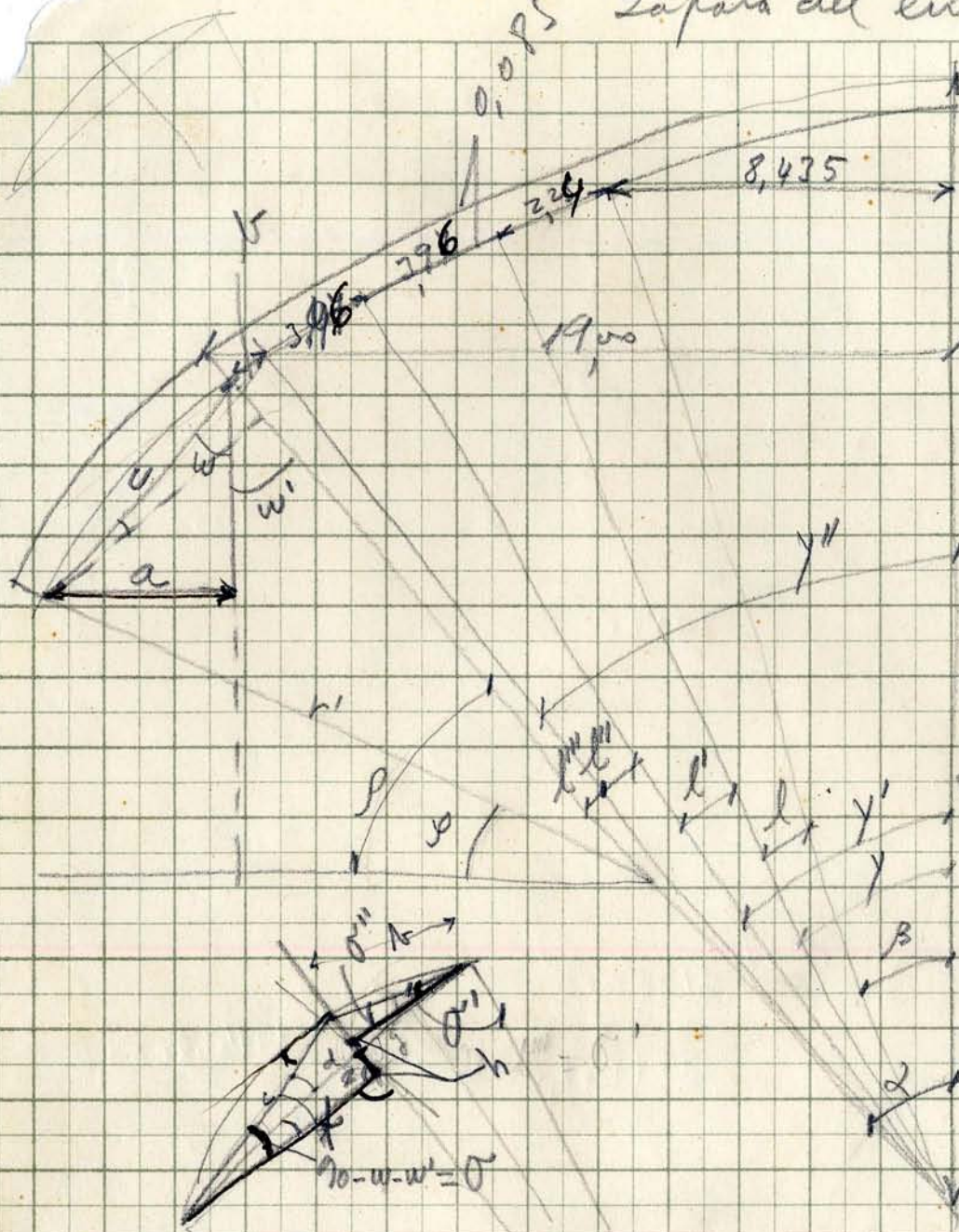
$$0,04198$$

h 0.0539

Curva N° 4 del Casagrate
zapata del empalme

396
198

839
1303
1642



$$R = 44.10$$

$$R' = 44.015$$

$$\alpha = 25^\circ 31'$$

$$r = 16952$$

$$r' = 16867$$

$$a = 1642$$

$$\sin \beta R' = 8.435$$

$$\sin \beta = \frac{8.435}{R'}$$

$$\beta =$$

$$y = \beta + \alpha$$

$$\sin \frac{y}{2} R' = \frac{224}{2}$$

$$l =$$

$$\sin \frac{l'}{2} R' = \frac{796}{2}$$

$$l' =$$

$$y' = y + l'$$

$$l''' = \alpha - y'$$

$$\sin \frac{l''}{2} R' = \frac{796}{2}$$

$$l'' =$$

$$y'' = y' + l''$$

~~$b = 2 \sin l'' R' =$~~

~~$l''' = \alpha - y''$~~

$$b = 2 \sin \frac{l'''}{2} R'$$

$$(\cos y - \cos p) r' = a$$

$$\cos y = \frac{a + \cos p}{r'}$$

$$y =$$

$$\frac{h}{e} = \frac{g}{d}$$

$$e + d = h$$

$$e = \frac{hd}{g}$$

$$d + d = h$$

$$(1 + \frac{h}{g})d = h$$

$$d = \frac{h}{1 + \frac{h}{g}}$$

~~$C = 2 \sin \frac{p-y}{2} R'$~~

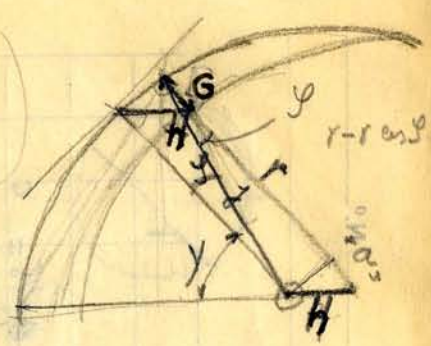
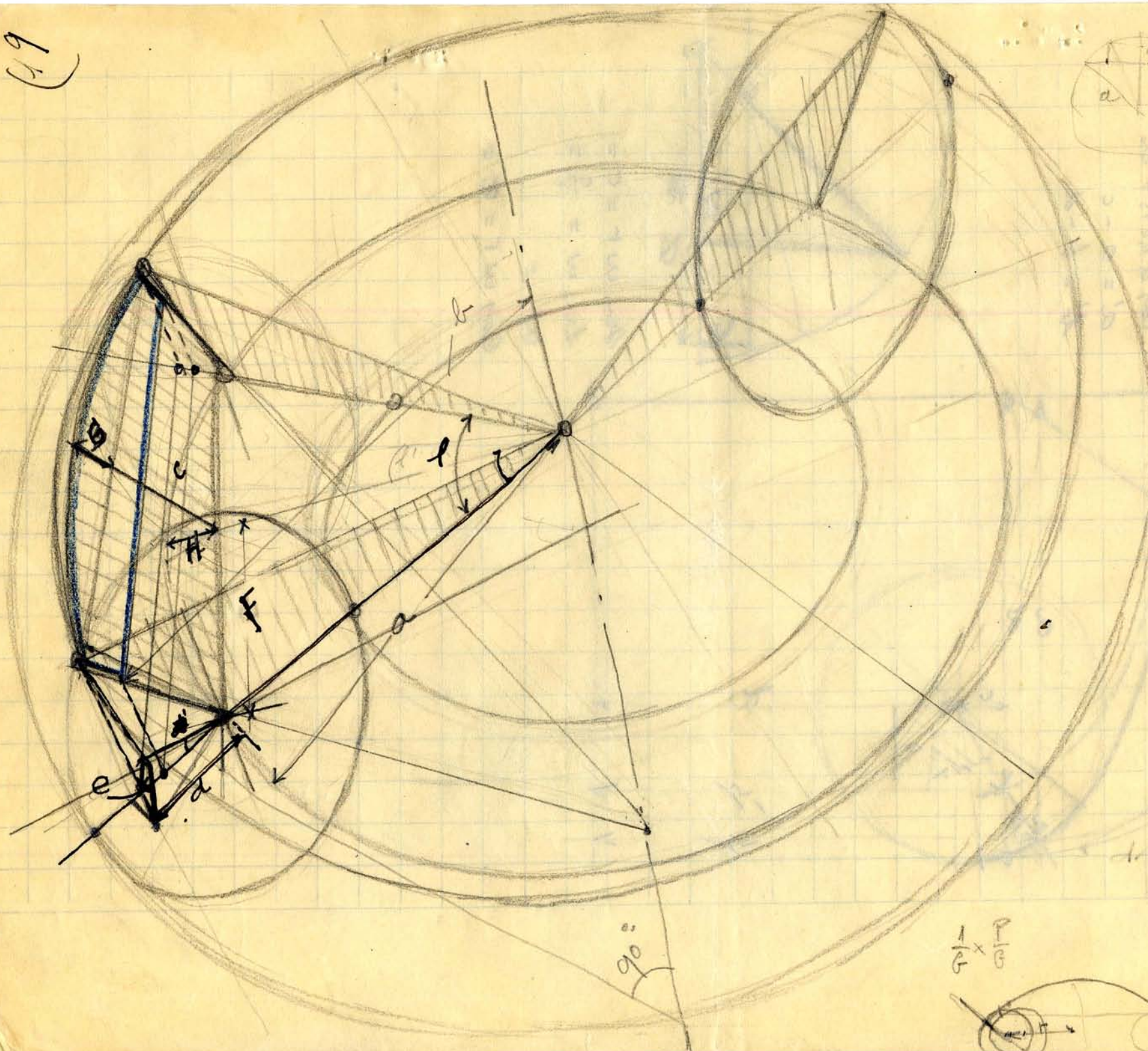
$$C = 2 \sin \left(\frac{p-y}{2} \right) r'$$

$$\sin w C = a$$

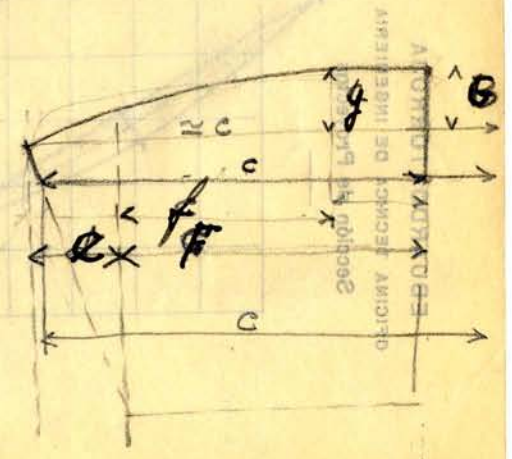
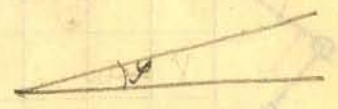
$$w =$$

$$w' = 90 - p$$

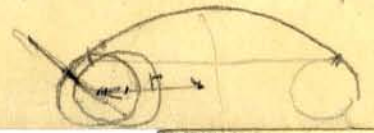
69

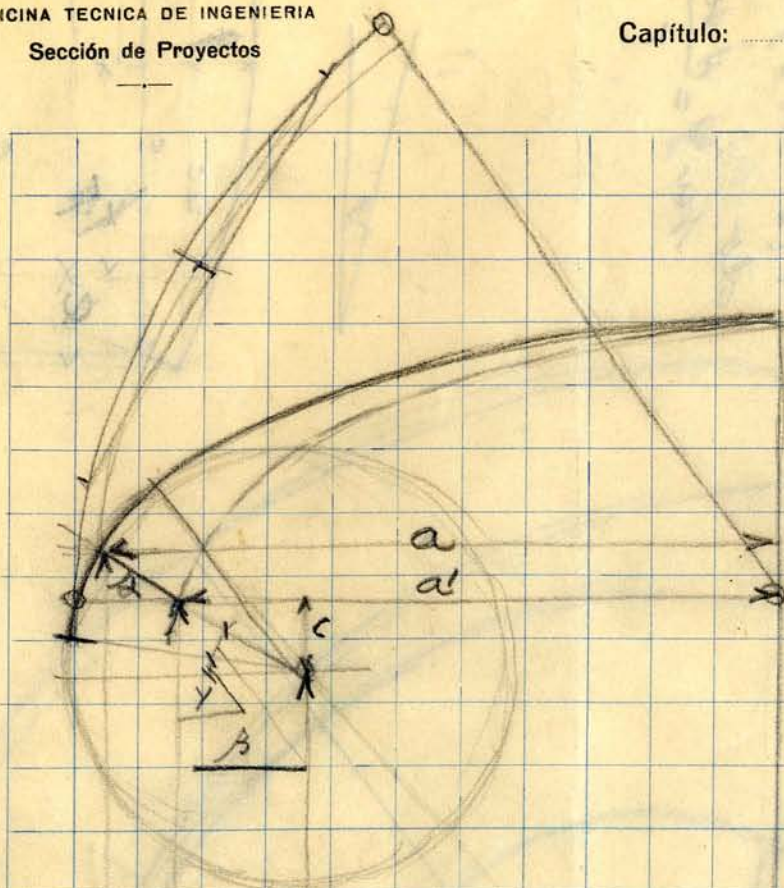


$G = H \cos y$ con un
 error menor de
 $r(1 - \cos y)$ siem-
 pre
 $\tan y = \frac{H \sin \alpha}{r}$



$$\frac{1}{G} \times \frac{P}{G}$$



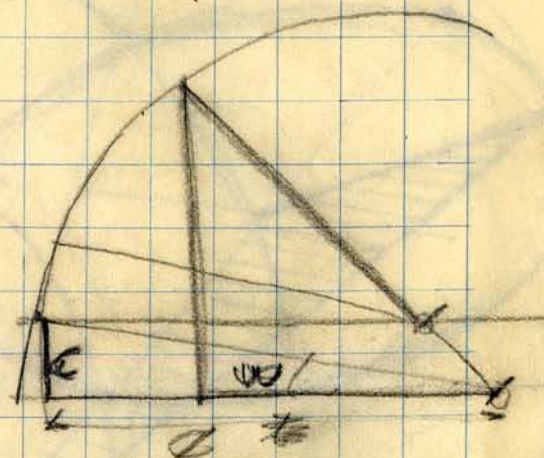


$$\text{sen } \alpha 045 = c$$

$$\text{cos } \alpha 045 = d$$

$$a' = a - c$$

$$b' = b - d$$



$$\text{sen } w r = c =$$

$$\text{sen } w = \frac{c}{r} =$$

$$w =$$

$$\text{cos } w r = e =$$

19 bis

$$\frac{44,10}{19} = \frac{27148}{a}$$

$$a = \frac{19 \times 27148}{44,10} =$$

$$\sin \frac{\beta}{2} 16.952 = 0.40$$

$B =$

$$y = y_0 - \beta - \alpha =$$

$$b = a + \cos \times 16.86\% =$$

$$c = 2 \sin \frac{1}{2} b =$$

$$d = \cos \gamma \times 16950 =$$

$$\tan \frac{l}{2} \times \frac{d}{\cos \frac{l}{2}} = e$$

$$F = m \frac{d}{dt} a$$

$$H = a - \cos \frac{1}{2} a$$

F-1: ser l'a

a - es l'a

$$h = H - (a - \cos l'a)$$

$$g = h \cos \gamma$$

27.148

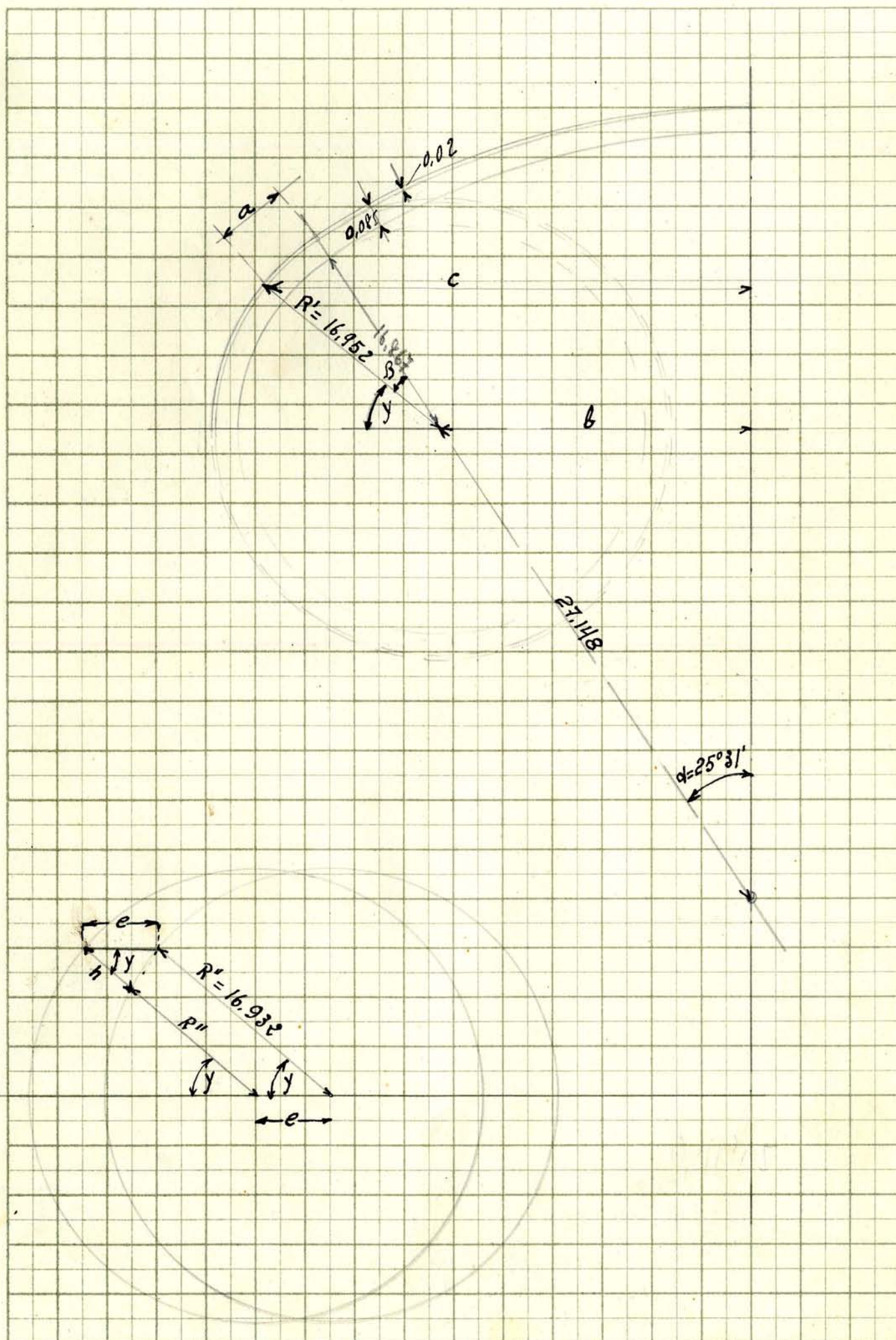
16952

44,100

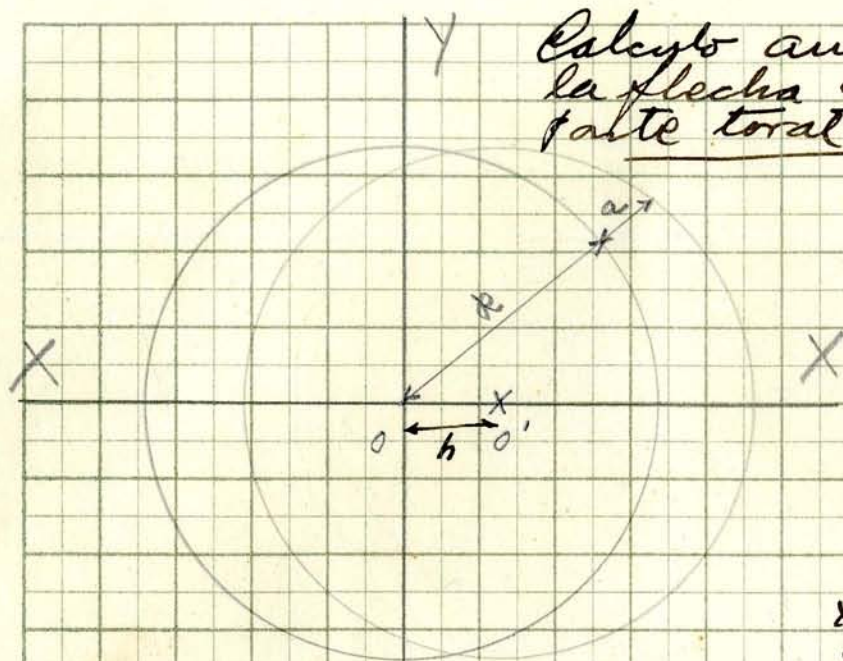
27.148

16867	
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44.015



Calculo analitico del valor de la flecha a del camion de la parte total. (primer camión)



$$x^2 + y^2 = R^2$$

$$\frac{y}{x} = c$$

$$(x' - h)^2 + y'^2 = R^2$$

$$\frac{y'}{x'} = c$$

$$a = \sqrt{(x' - x)^2 + (y' - y)^2} = 8,00665$$

$$y = cx$$

$$c = \frac{y}{x} = 1,86367$$

$$R = 16,982$$

$$h = 0,0142$$

$$x^2 + c^2 x^2 - R^2 = 0$$

$$(1 + c^2)x^2 - R^2 = 0$$

$$x = \sqrt{\frac{R^2}{1 + c^2}} = 8,00563$$

$$y = c \sqrt{\frac{R^2}{1 + c^2}} = 14,91985$$

$$y' = cx'$$

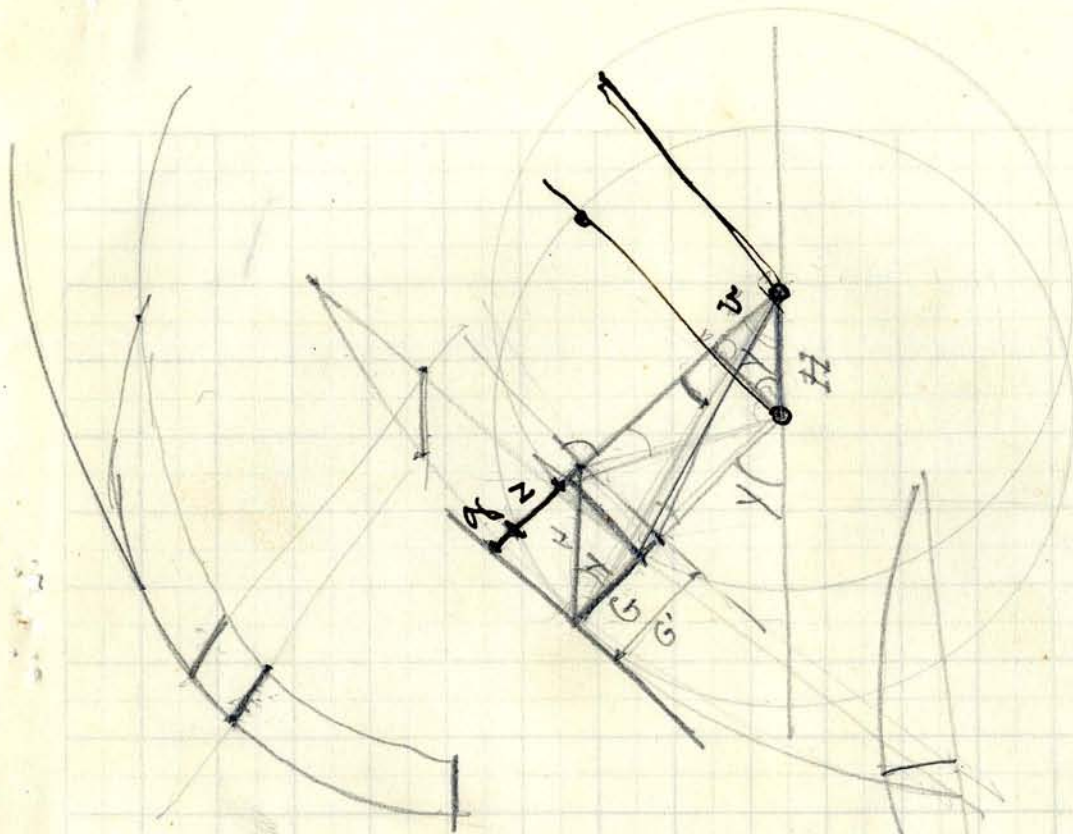
$$x'^2 + 2x'h + h^2 + c^2 x'^2 - R^2 = 0$$

$$(1 + c^2)x'^2 + 2hx' + h^2 - R^2 = 0$$

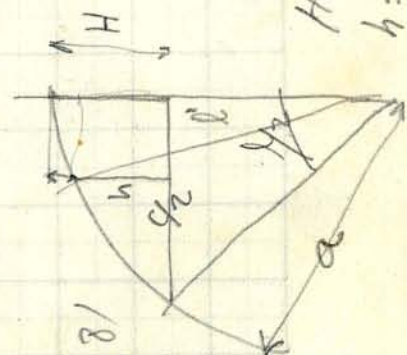
$$x' = \frac{-2h \pm \sqrt{4h^2 + 4(1 + c^2)(h^2 - R^2)}}{2(1 + c^2)} = \frac{-0,0284 \pm \sqrt{0,000865 + 5,18919898}}{2(1 + 3,4714)} = \frac{-0,0284 \pm 2,2998}{7,9428} = \frac{2,2714}{7,9428} = 0,286$$

$$= +0,0284 \pm 7,6326 = +8,0088 - 8,00246$$

$$8,94652$$



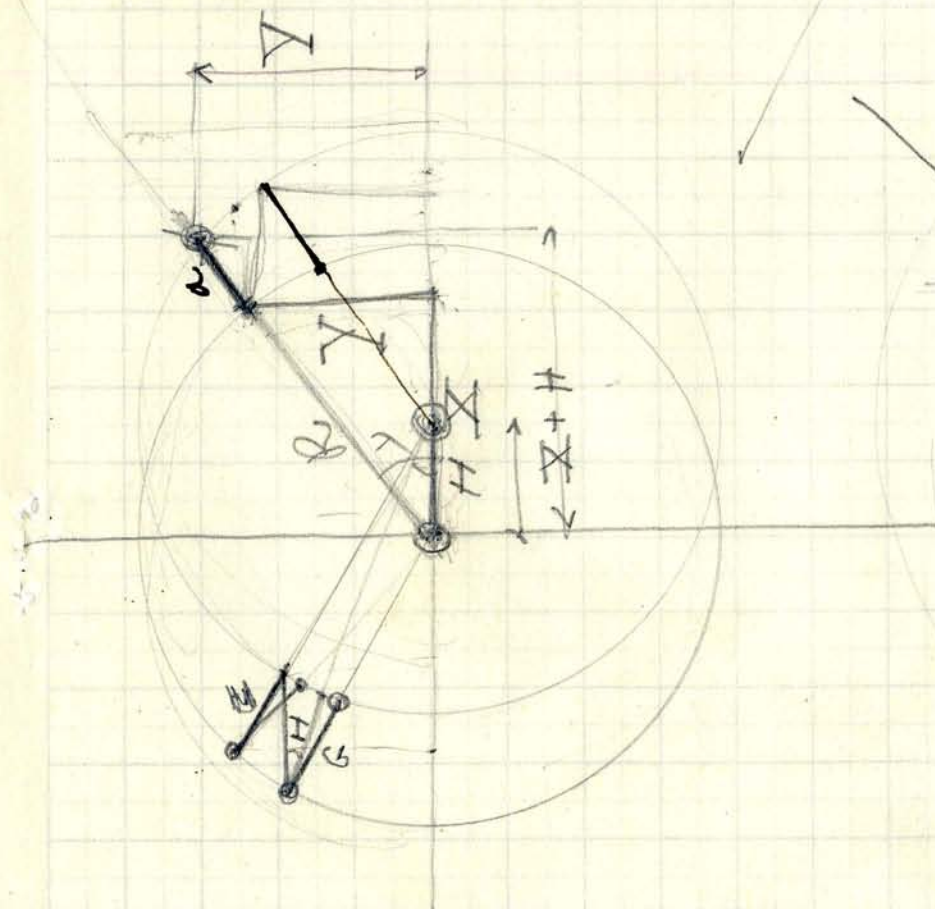
$R+a$



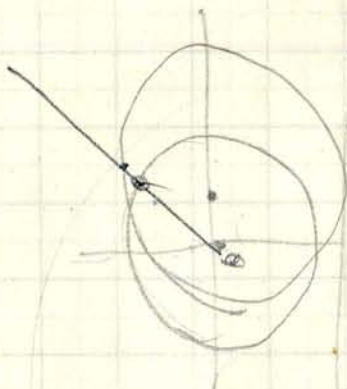
0,47281

$$H = a - \cos \frac{\pi}{2} a$$

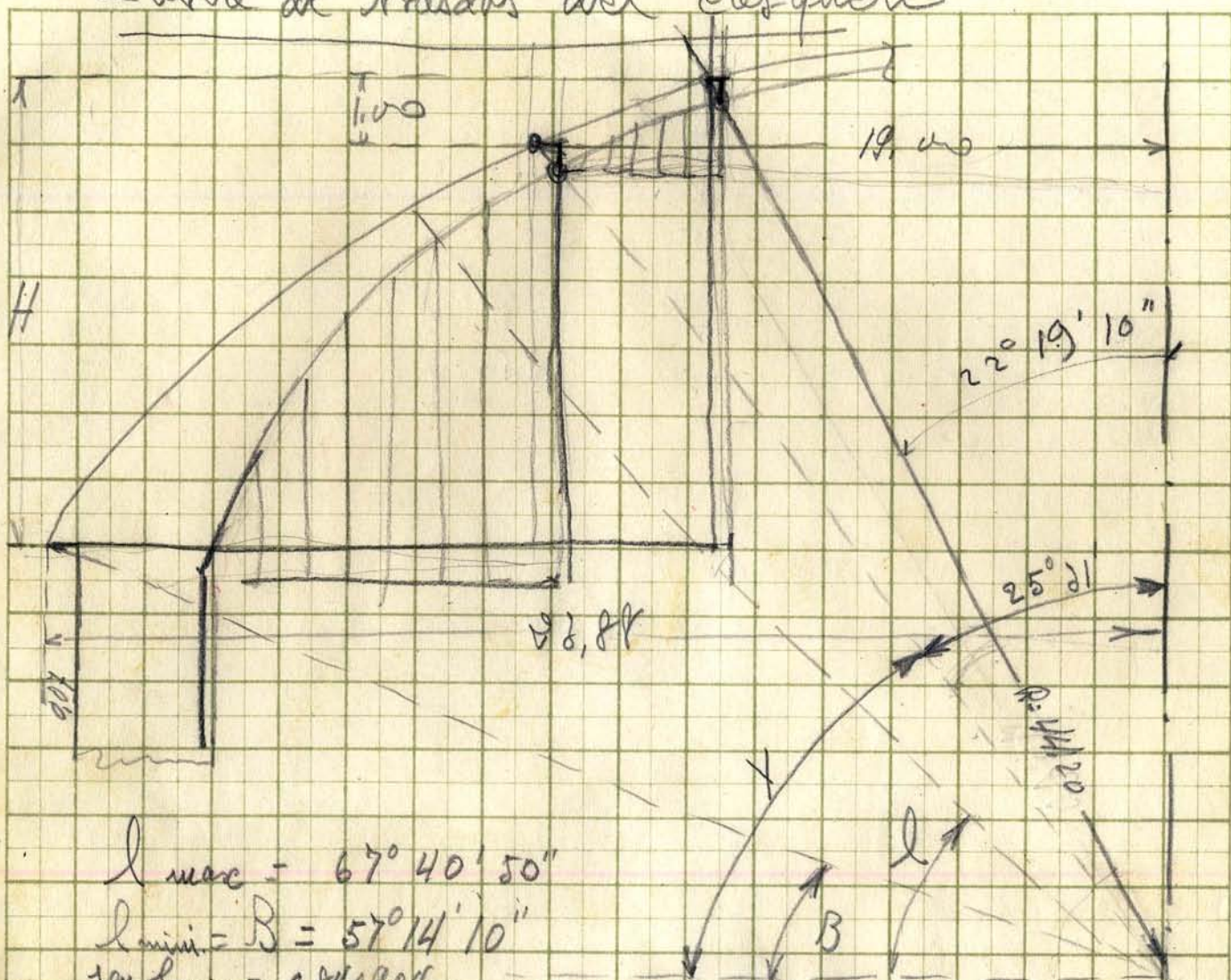
$$h = H - (a - \cos l'a)$$



$\rho =$



Curva de traidis del casquete



$$l_{max} = 67^{\circ} 40' 50''$$

$$l_{min} = B = 57^{\circ} 14' 10''$$

$$\sin l_{min} = 0.840904$$

$$(\cos l_{min} - \cos \gamma) R = 4.88$$

$$\cos l_{min} = \frac{4.88}{R} + \cos \gamma = 0.541179$$

$$H = (\sin \gamma - \sin B) R + 1 = 3.72095$$

$$\frac{H}{R} + \sin B = \sin l_{max} = 0.925088$$

$$(\cos B - \cos l_{max}) R = 4.88 \quad (\sin l_{max} - \sin B) R = h$$

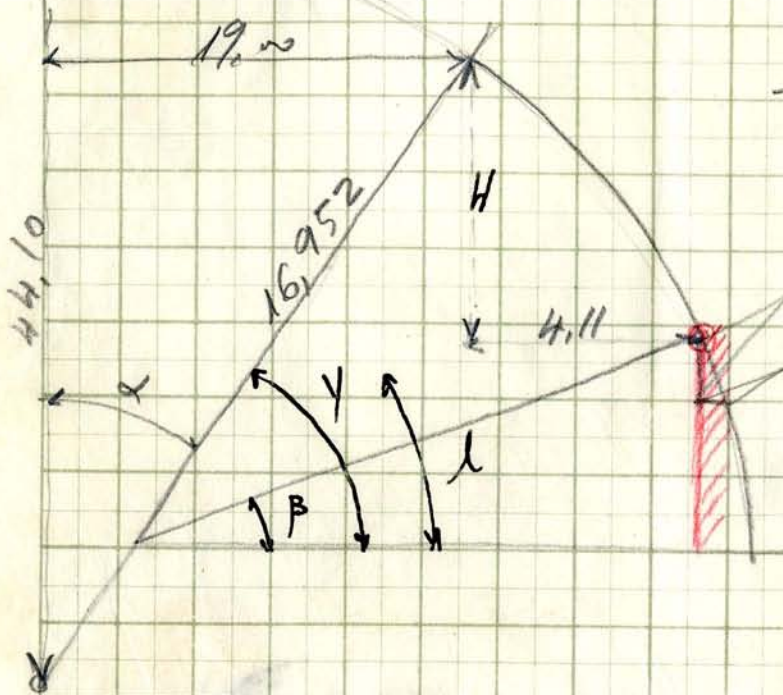
$$\sin \gamma = 0.902464 \quad \cos \gamma = 0.420772$$

e	$\frac{1}{R} \times e$	$\cos l$	l	$\sin l$	$\sin l - \sin B$	h
0	0	0.541179	$57^{\circ} 14' 10''$	0.840904	0	0
0.25	0.005656	0.525523	$57^{\circ} 27' 20''$	0.844540	0.003636	0.16071
0.50	0.011312	0.509867	$58^{\circ} 0' 10''$	0.848076	0.007172	0.31700
0.75	0.016968	0.494211	$58^{\circ} 23' 10''$	0.851602	0.010698	0.47285
1.00	0.022624	0.478555	$58^{\circ} 45' 50''$	0.855040	0.014136	0.62481

Curva de bridas del carguete

e	X _{ce}	en l	l	en l	en l	h
1.25	0,088980	0,512899	59° 8' 20"	0,858444	0,017536	0,77509
1.50	0,022926	0,507243	59° 21' 10"	0,861802	0,020898	0,92269
1.75	0,029592	0,501587	59° 53' 40"	0,865108	0,024204	1,06981
2.00	0,045249	0,495930	60° 16' 10"	0,868375	0,027471	1,21421
2.25	0,050905	0,490274	60° 28' 20"	0,871560	0,030656	1,35499
2.50	0,056561	0,484618	61° 0' 45"	0,874726	0,033823	1,49493
2.75	0,062217	0,478962	61° 22' 55"	0,877830	0,036926	1,62212
3.00	0,067873	0,473306	61° 45'	0,880890	0,039986	1,76728
3.25	0,073529	0,467650	62° 7' 5"	0,883920	0,043016	1,90120
3.50	0,079185	0,461994	62° 29' 5"	0,88689	0,045986	2,03258
3.75	0,084841	0,456338	62° 50' 55"	0,889802	0,048898	2,16129
4.00	0,090497	0,450682	63° 12' 45"	0,89268	0,051776	2,28850
4.25	0,096153	0,445026	63° 24' 30"	0,895515	0,054611	2,41280
4.50	0,101809	0,439370	63° 56' 10"	0,898220	0,057396	2,52690
4.75	0,107466	0,433713	64° 17' 45"	0,90105	0,060146	2,65845
5.00	0,113122	0,428057	64° 29' 20"	0,90374	0,062836	2,77725
5.25	0,118778	0,422401	65° 0' 10"	0,906271	0,065467	2,89264
5.50	0,124434	0,416745	65° 22' 15"	0,909022	0,068118	2,01081
5.75	0,130090	0,411089	65° 43' 15"	0,91159	0,070686	2,12432
6.00	0,135746	0,405433	66° 4' 55"	0,914125	0,073221	2,23227
6.25	0,141402	0,399777	66° 26' 10"	0,916620	0,075716	2,34664
6.50	0,147058	0,394121	66° 47' 20"	0,91906	0,078156	2,45449
6.75	0,152714	0,388465	67° 8' 20"	0,921475	0,080571	2,56124
7.00	0,158371	0,382808	67° 29' 20"	0,923820	0,082916	2,66488
7.1544	0,161411	0,379768	67° 40' 50"	0,925088	0,084184	2,72093

Curva de entradados de la parte
esférica de radio pequeño



$$\sin \alpha = \frac{19.00}{44.10} =$$

$$\alpha = 25^{\circ} 31'$$

$$\gamma = 64^{\circ} 29'$$

$$\sin \gamma = 90.2464 \text{ Vale}$$

$$\cos \gamma = 90.2464, 43077$$

$$(\cos \beta - \cos \gamma) R = 4.11$$

$$R = \frac{4.11}{\cos \beta - \cos \gamma} = 16.952$$

$$\cos \beta = \frac{4.11}{R} + \cos \gamma = 0.67322$$

$$\beta = 47^{\circ} 41'$$

$$H = (\sin \gamma - \sin \beta) R =$$

$$(\cos \beta - \cos \gamma) R = c$$

$$\cos \gamma = -\frac{c}{R} + \cos \beta$$

$$f = (\sin \gamma - \sin \beta) R$$

c	$\frac{c}{R}$	$\cos \beta - \frac{c}{R}$	β	$\sin \beta$	$\sin \gamma - \sin \beta$	$(\sin \gamma - \sin \beta) R = f$
0	0	0.67322	47° 41'	0.739425	0	0
0.25	0.01475	0.65847	48° 49'	0.752608	0.013172	0.222229
0.50	0.02950	0.64372	49° 55' 50"	0.765260	0.025824	0.437777
0.75	0.04424	0.62898	51° 1' 30"	0.777423	0.037987	0.642955
1.00	0.05899	0.61423	52° 6' 15"	0.789120	0.049694	0.842411
1.25	0.07374	0.59948	53° 10'	0.800280	0.060944	1.03212
1.50	0.08849	0.58473	54° 13'	0.81123	0.071794	1.21705
1.75	0.10323	0.56999	55° 15'	0.82170	0.082264	1.39454
2.00	0.11798	0.55524	56° 16' 20"	0.83168	0.092264	1.56272
2.25	0.13273	0.54049	57° 17' 20"	0.84127	0.101934	1.72798

según hasta 4.11

58143
25088

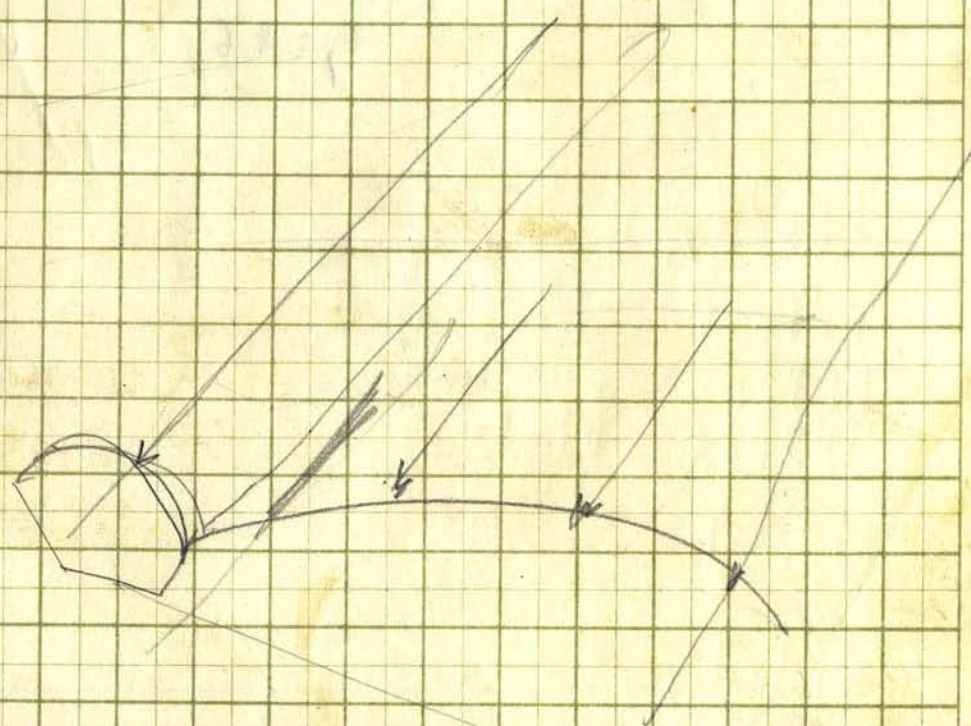
05507
25001

09913
25112

Curva de intrados de la parte cónica de radio pequeño

C	$\frac{C}{R}$	$\cos \beta - \frac{C}{R}$	β	$\sin \beta$	$\sin \beta - \sin \beta$	
2.50	0.14747	0.52575	58°16'50"	0.85063	0.111194	1.88496
2.75	0.16222	0.51100	59°16'10"	0.85958	0.120144	2.02668
3.00	0.17697	0.49625	60°14'50"	0.86818	0.128744	2.18947
3.25	0.19172	0.48150	61°12'	0.87655	0.137114	2.32425
3.50	0.20647	0.46675	62°10'25"	0.884389	0.144953	2.45724
3.75	0.22121	0.45201	62°47'40"	0.89202	0.152584	2.58660
4.00	0.23596	0.43726	64°4'15"	0.89924	0.159904	2.71069
4.11	0.24245	0.43077	64°29'	0.902464	0.163028	2.76265

4.11
11
10



Curva de intradas del casquete.

Parte comprendida entre los ángulos $22^{\circ}19'10''$ y $25^{\circ}21'$

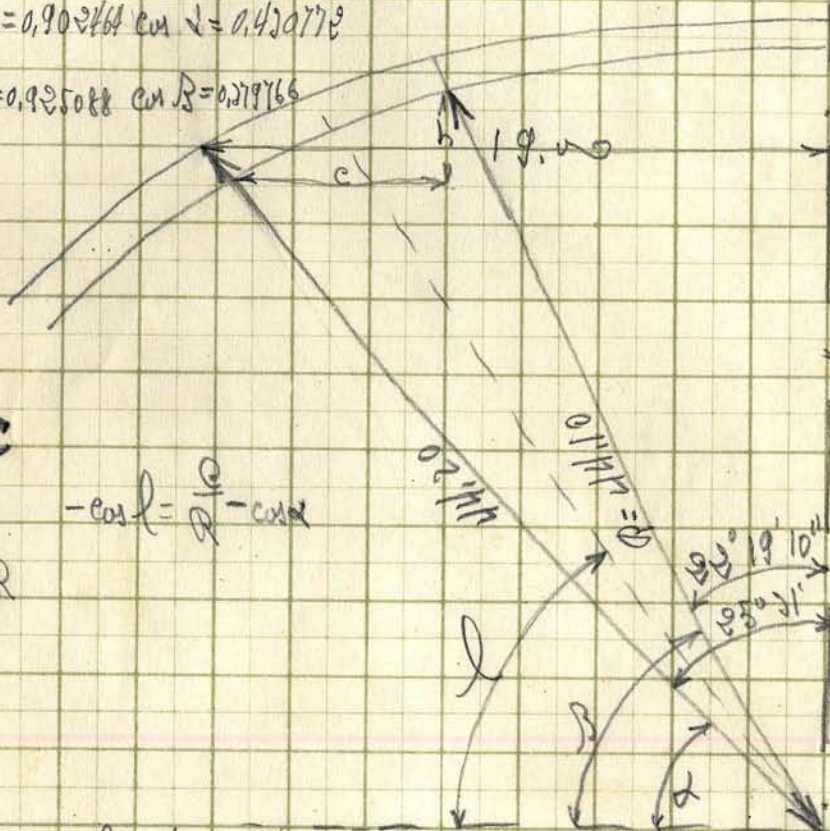
$\alpha = 64^{\circ}29'$ $\tan \alpha = 0.902464$ $\cos \alpha = 0.420772$

$\beta = 67^{\circ}40'50''$ $\tan \beta = 0.925088$ $\cos \beta = 0.379766$

$(\cos \alpha - \cos \beta) R = c$

$(\cos \alpha - \cos \beta) R = c$ $-\cos \beta = \frac{c}{R} - \cos \alpha$

$h = (r \sin l - \sin \alpha) R$



c	$\frac{1}{R} \times c$	$\cos l$	l	$\sin l$	$\sin l - \sin \alpha$	h
0	0	0.420772	$64^{\circ}29'$	0.902464	0	0
0.25	0.005669	0.425103	$64^{\circ}50'20''$	0.905122	0.002668	0.11766
0.50	0.011338	0.419234	$65^{\circ}12'5''$	0.907880	0.005416	0.22884
0.75	0.017007	0.413765	$65^{\circ}22'20''$	0.910280	0.007916	0.34909
1.00	0.022675	0.408097	$65^{\circ}54'50''$	0.912926	0.010422	0.46181
1.25	0.028344	0.402428	$66^{\circ}16'10''$	0.915455	0.012991	0.57290
1.50	0.034013	0.396759	$66^{\circ}37'20''$	0.91791	0.015446	0.68117
1.75	0.039682	0.391090	$66^{\circ}58'40''$	0.920255	0.017891	0.78899
2.00	0.045351	0.385421	$67^{\circ}19'50''$	0.92244	0.020276	0.894171
2.25	0.051004	0.379766	$67^{\circ}40'50''$	0.925088	0.022624	0.997718

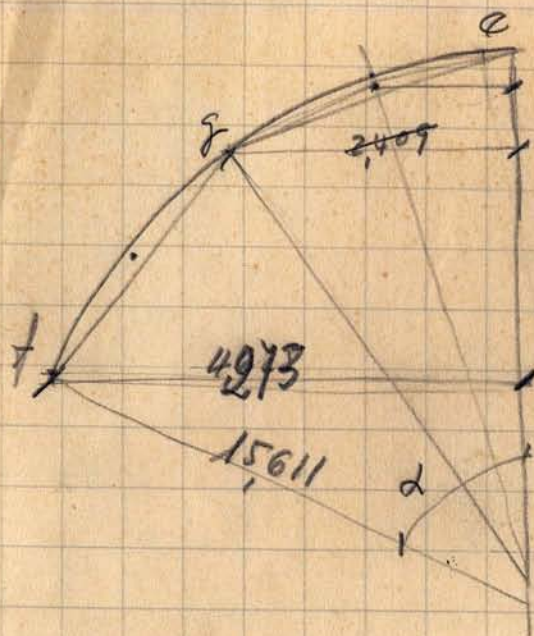
158.520.
12-3-35

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OFICINA TECNICA DE INGENIERIA
SECCION DE PROYECTOS

Proyecto de: N.º

Capítulo:

Calculo de la posicion de los puntos f y z



$$\text{sen } \alpha R = 4,273$$

$$\text{sen } \alpha = \frac{4,273}{15,611} = 0,273717$$

$$\alpha = 15^\circ 53' \quad \cos \alpha =$$

$$\frac{\alpha}{2} = 7^\circ 56' 30'' \quad \cos \frac{\alpha}{2} =$$

$$\text{sen } \alpha = 0,273717 \times R = 4,273$$

$$\text{sen } \frac{\alpha}{2} = 0,138162 \times R = 2,159$$

$$\cos \alpha = 0,96182$$

$$\cos \frac{\alpha}{2} = 0,99041$$

$$R - \cos \alpha R = 0,596$$

$$R - \cos \frac{\alpha}{2} R = 0,150$$

$$\text{sen } \alpha R = 4,625$$

$$\text{sen } \frac{\alpha}{2} R = 2,409$$

$$R - \text{sen } \alpha R = 0,701$$

$$R - \cos \frac{\alpha}{2} R = 0,176$$

$$\begin{array}{r} 0,701 \\ 0,15 \\ \hline 561 \end{array}$$

$$\begin{array}{r} 701 \\ 596 \\ \hline 105 \end{array}$$

Calculo de h

$$\text{sen } \alpha R = 4,36$$

$$\text{sen } \alpha = \frac{4,36}{15,611} = 0,27929$$

$$\alpha = 16^\circ 13'$$

$$\cos \alpha = 0,960204, R - \cos \alpha R = 0,621$$

$$\begin{array}{r} 701 \\ 596 \\ \hline 105 \end{array}$$

Calculo de i

$$\text{sen } \alpha R = 3,255$$

$$\text{sen } \alpha = \frac{3,255}{15,611} = 0,208504$$

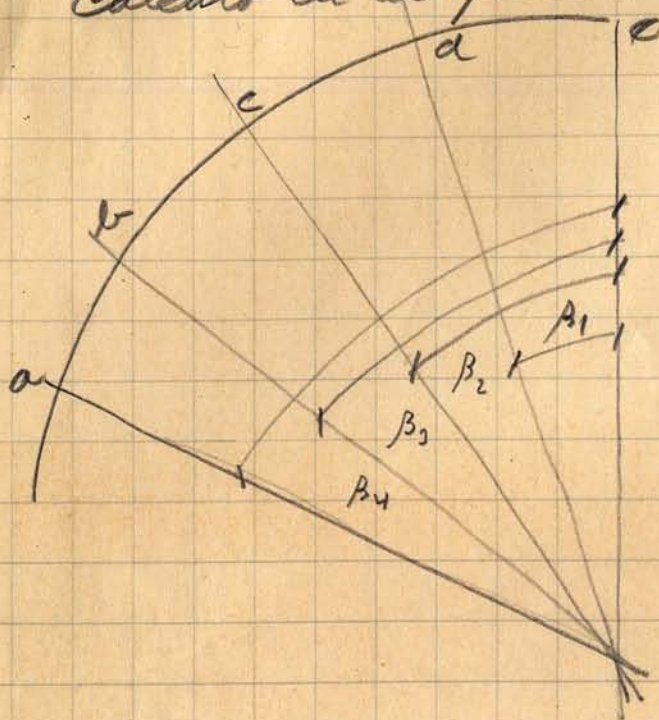
$$\alpha = 12^\circ 2'$$

$$\cos \alpha = 0,978628$$

$$R - \cos \alpha R = 0,343$$

$$\begin{array}{r} 701 \\ 358 \\ \hline 0,358 \end{array}$$

Calculo de la posición de los puntos a, b, c, d y e



$$\beta_1 = 4^\circ 18' 30''$$

$$\beta_2 = 8^\circ 37'$$

$$\beta_3 = 12^\circ 55' 30''$$

$$\beta_4 = 17^\circ 14'$$

$$R = 15,611$$

$$\text{sen } \beta_1 = 0,07513$$

$$\text{sen } \beta_2 = 0,14983$$

$$\text{sen } \beta_3 = 0,22367$$

$$\text{sen } \beta_4 = 0,29626$$

$$\text{cos } \beta_1 = 0,99717$$

$$\text{cos } \beta_2 = 0,98871$$

$$\text{cos } \beta_3 = 0,97466$$

$$\text{cos } \beta_4 = 0,95510 \times$$

$$\text{sen } \beta_1 R = 1,173$$

$$'' \beta_2 R = 2,339$$

$$'' \beta_3 R = 3,492$$

$$'' \beta_4 R = 4,625$$

$$\text{cos } \beta_1 R = 15,567 - 15,611 = 0,044$$

$$'' \beta_2 R = 15,435 - 15,611 = 0,176 \quad 0,657$$

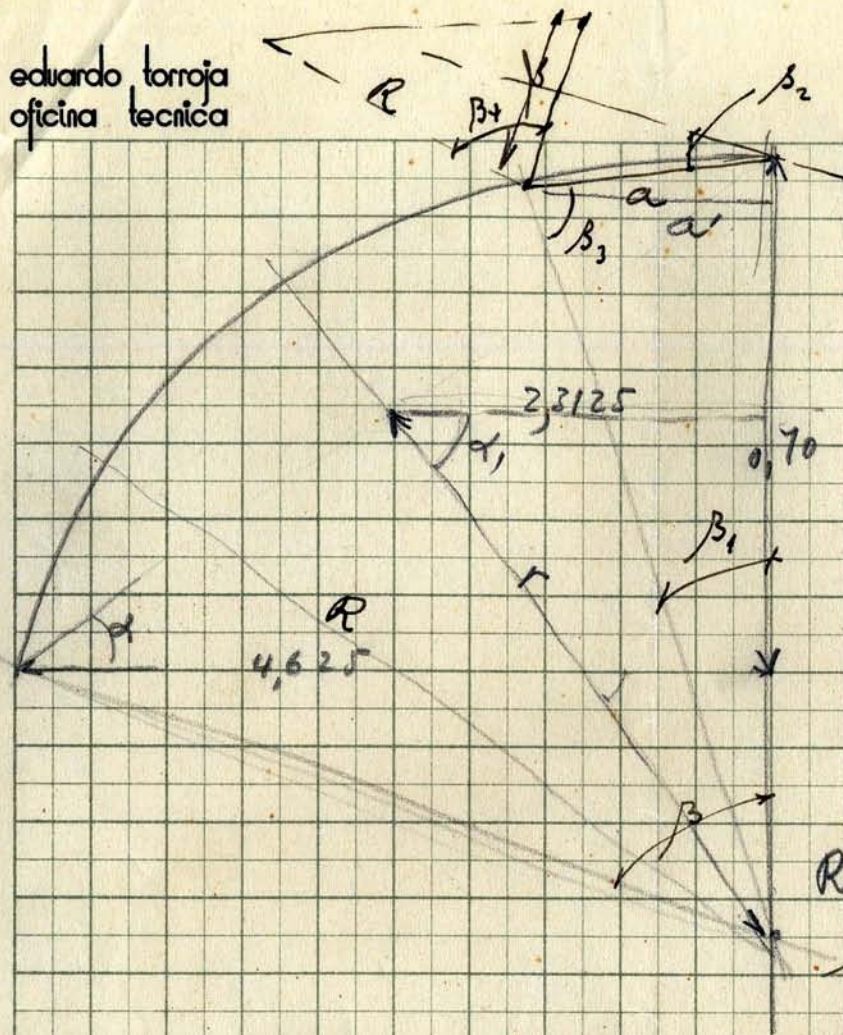
$$'' \beta_3 R = 15,215 - 15,611 = 0,396 \quad 525$$

$$'' \beta_4 R = 14,910 - 15,611 = 0,701 \quad 0,305$$

$$\text{sen } \frac{\beta_1}{2} = 0,03759, \quad \text{sen } \frac{\beta_1}{2} R = 0,58682$$

$$a = 2 \text{ sen } \frac{\beta_1}{2} R = 1,17364$$

$$\text{sen } b = 2 \text{ sen } 22^\circ 30' \times \text{sen } \beta_1 R = 2 \times 0,38268 \times 1,1728 = 0,8976$$



$$\text{Sen } \alpha = 4,625$$

$$\text{Cte } \alpha = 0,70$$

$$\text{Cte } \alpha = \frac{0,70}{4,625} = 0,15135$$

$$\alpha = 8^{\circ} 36' 20''$$

$$\alpha' = 81^{\circ} 23' 38''$$

$$\text{Cte } \alpha' r = 2,3125$$

$$r = \frac{2,3125}{0,14982} = 15,435$$

$$R = \frac{70}{2} + \text{Sen } \alpha, r = 15,611$$

$$\text{Sen } \beta \times 15,624 = 4,625$$

$$\text{Sen } \beta = \frac{4,625}{15,611} = 0,29607$$

$$\beta = 17^{\circ} 14'$$

$$\beta_1 = \frac{1}{4} \beta = 4^{\circ} 18' 30''$$

$$\text{Sen } \frac{\beta_1}{2} \times 15,624 = 0,03759 \times 15,611 = 0,5868$$

$$a = 2 \times 0,5868 = 1,1736$$

$$\beta_2 = 22^{\circ} 30'$$

$$b = 2 \text{ Sen } \beta_2 \times 1,1736 = 2 \times 0,38268 \times 1,1736 = 0,898$$

$$\beta_3 = 90 - \frac{1}{2} \beta_1 = 90^{\circ} - 2^{\circ} 9' 8'' = 87^{\circ} 50' 58''$$

$$\text{Cte } \beta_4 R = 0,38268$$

$$\text{Cte } \beta_4 = \frac{0,38268}{15,624} = 0,02449$$

$$\text{Cte } \beta_4 R = 0,4488$$

$$\text{Cte } \beta_4 = \frac{0,4488}{15,611} = 0,02875$$

$$\beta_4 = 88^{\circ} 21'$$

$$a' = a \times \text{Cte } \frac{\beta_1}{2} = 1,1728$$

$$b = 2 \text{ Sen } 22^{\circ} 30' \times 1,1728 = 0,8976$$

