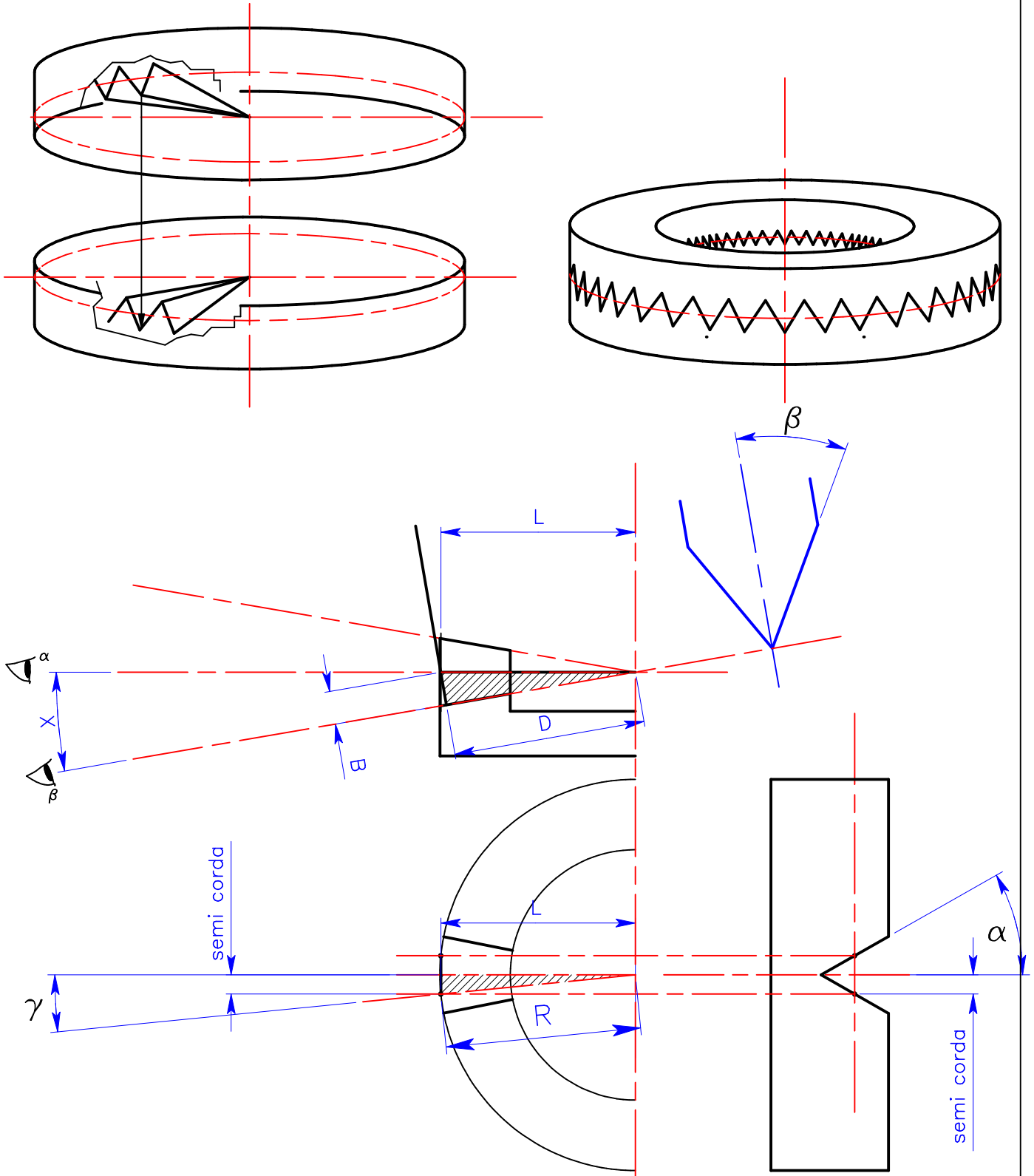


Se osserviamo il profilo del dente lungo la retta passante sull'angolo interno vedremo l'utensile che ha un angolo  $\beta$ .

Se lo osserviamo lungo la retta primitiva l'angolo del dente risulterà  $\alpha$ .

Questa dentatura prevede che tutte le facce dei denti convergano al centro in modo tale che accoppiando due corone piano-coniche il contatto sulle facce dei denti sia totale.



Generalmente le ruote "Hyr" vengono rettificate con mole di forma il cui angolo  $\beta$  è  $30^\circ$ , ne consegue che col variare del numero dei denti della ruota l'angolo alfa sarà diverso per tutte le coppie.

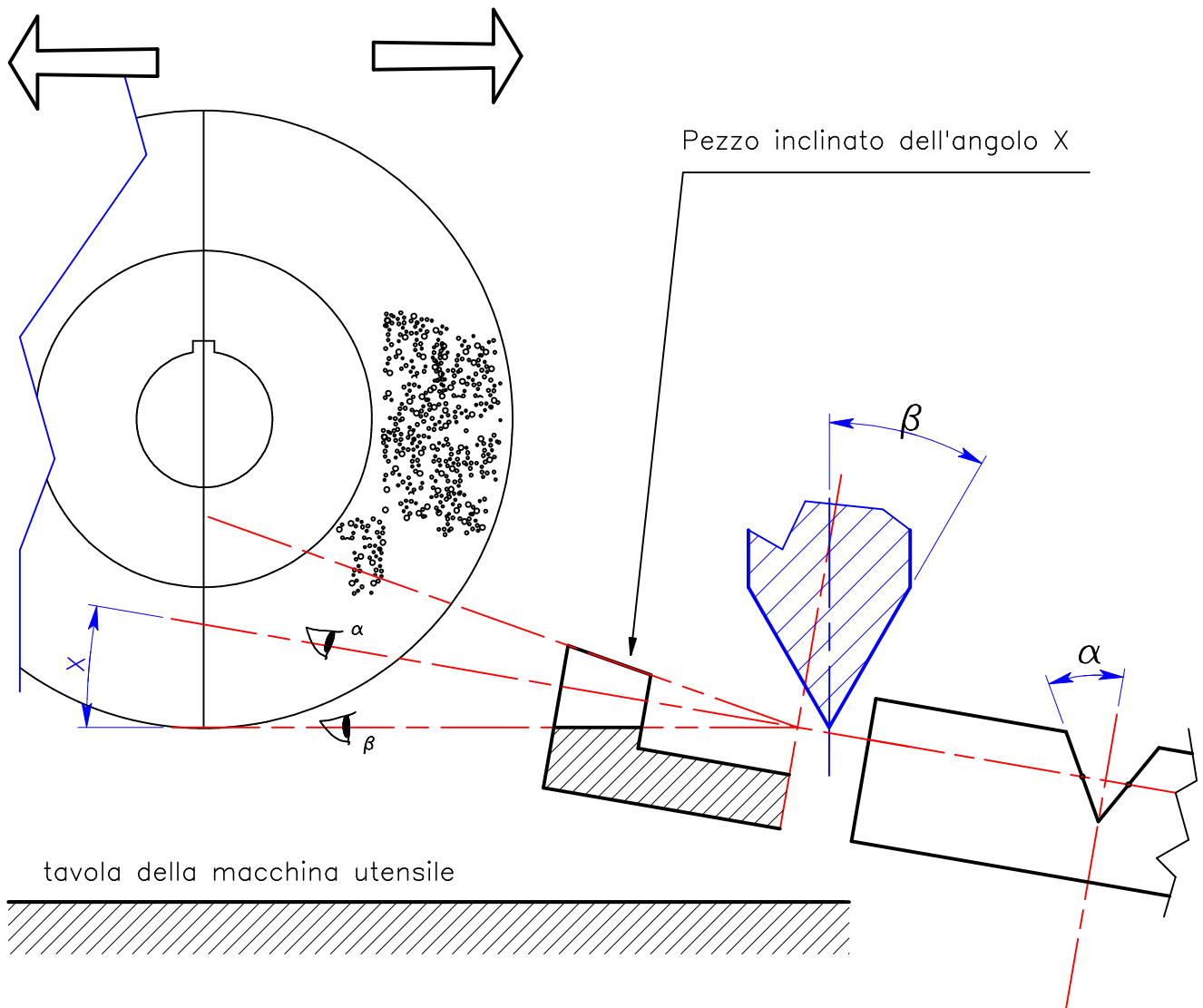
La coppia di anelli risultante sarà comunque perfettamente coniugata ed il funzionamento perfetto.

Non si può dire la stessa cosa per una ruota piano-conica che accoppia con un pignone secondo le dentature normalizzate nel campo degli ingranaggi.

In breve:

Fissando un angolo di pressione beta sull'utensile, le dentature avranno un angolo di pressione  $\alpha$  diverso al variare del n° dei denti.

Fissando l'angolo di pressione  $\alpha$  sulle ruote dentate, gli utensili avranno un angolo  $\beta$  sempre diverso con il variare del numero dei denti.



$\beta$  fisso,  $\alpha$  variabile

Z = numero dei denti

$$\gamma = \frac{90}{Z}$$

$$\text{Semicorda} = R * \sin \gamma$$

$$L = R * \cos \gamma$$

$$B = \frac{\text{Semicorda}}{\text{Tang. } \beta}$$

$$X = \text{Arcsin} \frac{B}{L}$$

Angolo effettivo de pezzo  $\alpha$

$$\text{Alfa} = \text{Arctang} \frac{\text{Tang } \beta}{\text{Cos } X}$$

Esempio:

$$R \ 50 \quad Z = 16 \quad \beta = 30^\circ$$

$$X = 9^\circ,82224763$$

$$\text{Alfa} = 29^\circ.63499$$

$\beta$  fisso,  $\alpha$  variabile

Semplificando e ponendo  $R=1$   
avremo:

$$\text{Semicorda} = \sin \gamma \quad L = \cos \gamma$$

$$B = \frac{\sin \gamma}{\text{Tang } \beta}$$

$$X = \text{Arcsin} \frac{B}{L}$$

$$X = \text{arcsin} \frac{\sin (90/z) / \text{tang } \beta}{\cos (90/z)} = \frac{\sin (90/z)}{\cos (90/z) * \text{tang } \beta}$$

Essendo  $\sin \gamma / \cos \gamma = \text{tang } \gamma$

nella forma più semplificata avremo:

$$X = \text{Arcsin} \left( \frac{\text{Tang} \left( \frac{90}{Z} \right)}{\text{Tang } \beta} \right)$$

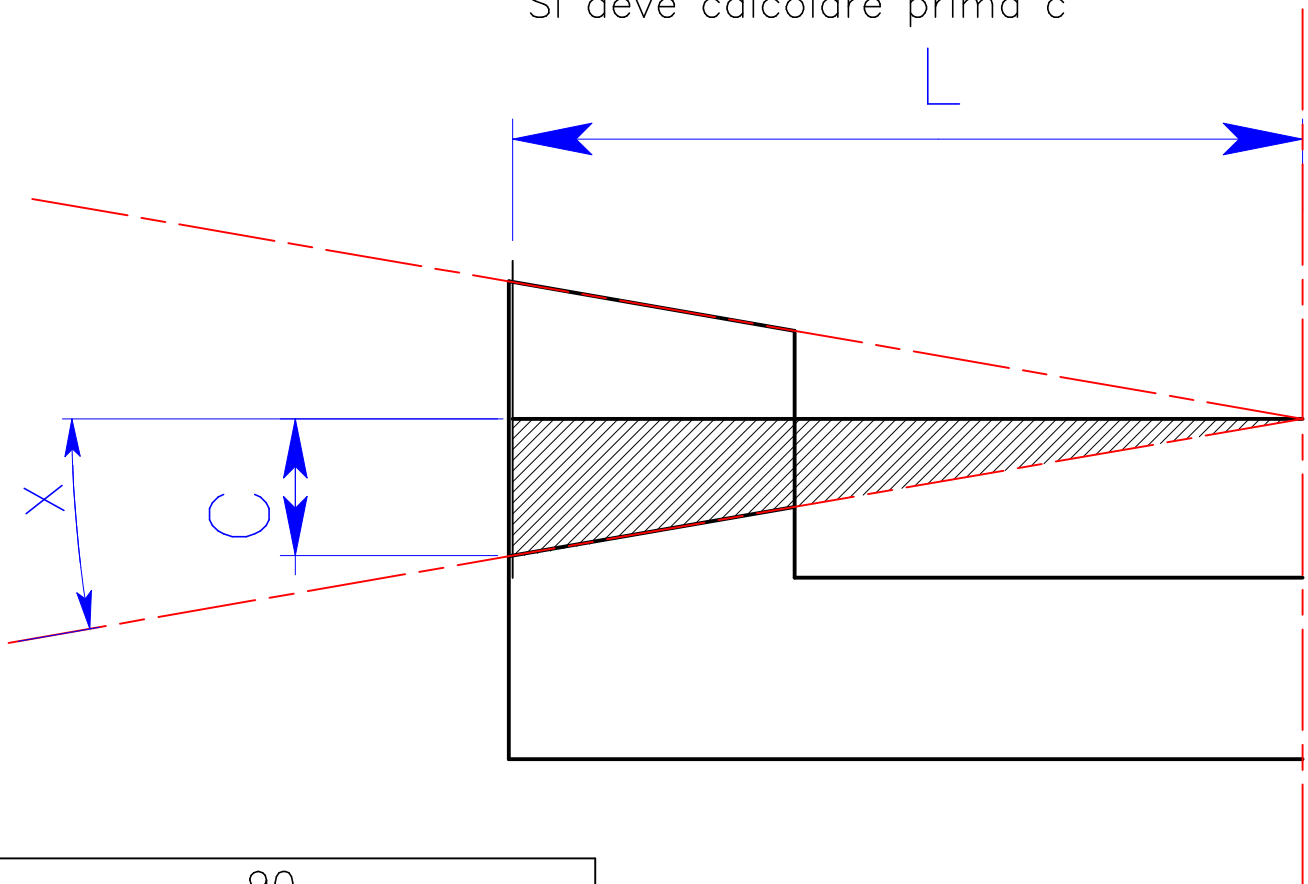
Quindi :

fissato  $\beta$  (l'angolo dell'utensile)

X è funzione del numero dei denti Z e non dei diametri

$\alpha$  fisso,  $\beta$  variabile

Calcolo dell'angolo dell'utensile  
conoscendo quello della ruota dentata  
Ma non conosciamo ancora  $x$   
Si deve calcolare prima  $c$



$$\gamma = \frac{90}{Z}$$

$$\text{Semicorda} = \sin \gamma$$

$$L = \cos \gamma$$

$$C = \frac{\text{Semicorda}}{\text{Tang. } \alpha}$$

$$X = \text{arctg} \frac{C}{L}$$

$$\beta = \text{arctg} \frac{\text{tg } \alpha}{\cos x}$$

Esempio:

$$R = 50$$

$$Z = 16$$

$$\alpha = 30^\circ$$

$$X = 9^\circ,82224763$$

$$\beta = 30^\circ,3575$$

► **possibilità di divisione con denture hirth**

Con denture su 360°	Incremento per dente	Divisioni possibili in 360°
48	7° 30'	2-3-4-6-8-12-16-24-48
56	6° 25' 43"	2-4-7-8-14-28-56
60	6°	2-3-4-5-6-10-12-15-20-30-60
63	5° 42' 51"	3-7-9-21-63
70	5° 8' 34"	2-5-7-10-14-35-70
72	5°	2-3-4-6-8-9-12-18-24-36-72
78	4° 36' 55"	2-3-6-13-26-39-78
80	4° 30'	2-4-5-8-10-16-20-40-80
84	4° 17' 9"	2-3-4-6-7-12-14-21-28-42-84
90	4°	2-3-5-6-9-10-15-18-30-45-90
96	3° 45'	2-3-4-6-8-12-16-24-32-48-96
100	3° 36'	2-4-5-10-20-25-50-100
108	3° 20'	2-3-4-6-9-12-18-27-36-54-108
110	3° 16' 22"	2-5-10-11-22-55-110
112	3° 12' 51"	2-4-7-8-14-16-28-56-112
120	3°	2-3-4-5-6-8-10-12-15-20-24-30-40-60-120
126	2° 51' 26"	2-3-6-7-9-14-18-21-42-63-126
140	2° 34' 17"	2-4-5-7-10-14-30-28-35-70-140
144	2° 30'	2-3-4-6-8-9-12-16-18-24-36-48-72-144
156	2° 18' 27"	2-3-4-6-12-13-26-39-52-78-156
180	2°	2-3-4-5-6-9-10-12-15-18-20-30-36-45-60-90-180
240	1° 30'	2-3-4-5-6-8-10-12-15-16-20-24-30-40-48-60-80-120-240
255	1° 24' 42"	3-5-15-17-51-85-255
360	1°	2-3-4-5-6-8-9-10-12-15-18-20-24-30-36-40-45-60-72-90-120-180-360
720	30'	2-3-4-5-6-8-9-10-12-15-16-18-20-24-30-36-40-45-48-60-72-80-90-120-144-180-240-360-720

Angolo interno anelli dentati e angolo di pressione risultante del dente eseguito con un utensile a 30°

In gradi decimali	in gradi, primi, secondi	
Z= 4		
45.843436979922	45° 50' 36"	angolo interno
21.909722734697	21° 54' 35"	angolo di pressione sul pezzo
5		
34.248093458379	34° 14' 53"	
25.51246572364	25° 30' 45"	
6		
27.652095607705	27° 39' 8"	
27.08549567346	27° 5' 8"	
7		
23.286512873674	23° 17' 11"	
27.937857317277	27° 56' 16"	
8		
20.152883667896	20° 9' 10"	
28.457823597436	28° 27' 28"	
9		
17.78266907924	17° 46' 58"	
28.800478250826	28° 48' 2"	
10		
15.922084434827	15° 55' 20"	
29.039060720043	29° 2' 21"	
11		
14.4201975286	14° 25' 13"	
29.212222628236	29° 12' 44"	
12		
13.181047559072	13° 10' 52"	
29.342065840098	29° 20' 31"	
13		
12.140463627373	12° 8' 26"	
29.442025469114	29° 26' 31"	
14		
11.253793387843	11° 15' 14"	
29.520673186477	29° 31' 14"	
15		
10.488949004124	10° 29' 20"	
29.583697379595	29° 35' 1"	
16		
9.822247632057	9° 49' 20"	
29.634998665897	29° 38' 6"	
17		
9.2358114129696	9° 14' 9"	
29.677326905039	29° 40' 38"	
18		
8.7158815423702	8° 42' 57"	
29.712667347269	29° 42' 46"	
19		
8.2516905239612	8° 15' 6"	
29.742483145114	29° 44' 33"	
20		
7.8346873618902	7° 50' 5"	
29.767872376179	29° 46' 4"	
21		
7.4579927098541	7° 27' 29"	
29.789672454378	29° 47' 23"	

22		
7.1160078167941	7° 6' 58"	
29.808531202772	29° 48' 31"	
23		
6.8041287263607	6° 48' 15"	
29.824956249634	29° 49' 30"	
24		
6.5185339947312	6° 31' 7"	
29.839350003266	29° 50' 22"	
25		
6.256024706015	6° 15' 22"	
29.852034833905	29° 51' 7"	
26		
6.0139023059646	6° 0' 50"	
29.863271481426	29° 51' 48"	
27		
5.7898741931296	5° 47' 24"	
29.873272697907	29° 52' 24"	
28		
5.5819799605053	5° 34' 55"	
29.882213486702	29° 52' 56"	
29		
5.388533191491	5° 23' 19"	
29.890238876438	29° 53' 25"	
30		
5.208075105254	5° 12' 29"	
29.897469886596	29° 53' 51"	
31		
5.0393373238987	5° 2' 22"	
29.904008150587	29° 54' 14"	
32		
4.8812117298761	4° 52' 52"	
29.909939531252	29° 54' 36"	
33		
4.7327258840899	4° 43' 58"	
29.915336972524	29° 54' 55"	
34		
4.5930228416125	4° 35' 35"	
29.920262766403	29° 55' 13"	
35		
4.4613444722993	4° 27' 41"	
29.924770368562	29° 55' 29"	
36		
4.3370175951777	4° 20' 13"	
29.928905862503	29° 55' 44"	
37		
4.2194423871816	4° 13' 10"	
29.932709148024	29° 55' 58"	
38		
4.1080826419901	4° 6' 29"	
29.936214911797	29° 56' 10"	
39		
4.002457542951	4° 0' 9"	
29.939453424608	29° 56' 22"	
40		
3.9021346821174	3° 54' 8"	
29.942451199765	29° 56' 33"	



41		
3.806724110373	3° 48' 24"	
29.945231539685	29° 56' 43"	
42		
3.715873245037	3° 42' 57"	
29.947814991814	29° 56' 52"	
43		
3.6292624940082	3° 37' 45"	
29.950219730728	29° 57' 1"	
44		
3.5466014813921	3° 32' 48"	
29.952461879787	29° 57' 9"	
45		
3.4676257802284	3° 28' 3"	
29.954555782964	29° 57' 16"	
46		
3.3920940744944	3° 23' 32"	
29.956514235566	29° 57' 23"	
47		
3.3197856859366	3° 19' 11"	
29.958348680756	29° 57' 30"	
48		
3.2504984121116	3° 15' 2"	
29.960069377555	29° 57' 36"	
49		
3.1840466308584	3° 11' 3"	
29.961685545006	29° 57' 42"	
50		
3.1202596336276	3° 7' 13"	
29.963205486218	29° 57' 48"	
51		
3.058980156045	3° 3' 32"	
29.964636695509	29° 57' 53"	
52		
3.0000630789868	3° 0' 0"	
29.965985951167	29° 57' 58"	
53		
2.9433742775066	2° 56' 36"	
29.967259396068	29° 58' 2"	
54		
2.8887895983234	2° 53' 20"	
29.968462607851	29° 58' 6"	
55		
2.836193949426	2° 50' 10"	
29.969600660234	29° 58' 11"	
56		
2.7854804876874	2° 47' 8"	
29.970678176711	29° 58' 14"	
. 4.86541		
57		
2.7365498923995	2° 44' 12"	
29.971699377666	29° 58' 18"	
58		
2.6893097142965	2° 41' 22"	
29.972668121847	29° 58' 22"	
59		
2.6436737910692	2° 38' 37"	
29.973587942939	29° 58' 25"	

60		
2.5995617215723	2° 35' 58"	
29.974462081886	29° 58' 28"	
61		
2.5568983919647	2° 33' 25"	
29.975293515546	29° 58' 31"	
62		
2.5156135478818	2° 30' 56"	
29.976084982087	29° 58' 34"	
63		
2.4756414075144	2° 28' 32"	
29.976839003609	29° 58' 37"	
64		
2.4369203110901	2° 26' 13"	
29.977557906298	29° 58' 39"	
65		
2.3993924028313	2° 23' 58"	
29.978243838404	29° 58' 42"	
66		
2.3630033419224	2° 21' 47"	
29.978898786335	29° 58' 44"	
67		
2.3277020394487	2° 19' 40"	
29.979524589087	29° 58' 46"	
68		
2.2934404186239	2° 17' 36"	
29.980122951169	29° 58' 48"	
69		
2.2601731959311	2° 15' 37"	
29.980695454241	29° 58' 51"	
70		
2.2278576810808	2° 13' 40"	
29.981243567592	29° 58' 52"	
71		
2.1964535939275	2° 11' 47"	
29.981768657597	29° 58' 54"	
72		
2.1659228966834	2° 9' 57"	
29.982271996245	29° 58' 56"	
73		
2.1362296399645	2° 8' 10"	
29.98275476884	29° 58' 58"	
74		
2.1073398213515	2° 6' 26"	
29.983218081026	29° 59' 0"	
75		
2.0792212552995	2° 4' 45"	
29.983662965118	29° 59' 1"	
76		
2.0518434533394	2° 3' 7"	
29.984090385844	29° 59' 3"	
77		
2.0251775136433	2° 1' 31"	
29.984501245613	29° 59' 4"	
78		
1.9991960191024	1° 59' 57"	
29.984896389276	29° 59' 6"	

79	1.9738729431653	1° 58' 26"
	29.985276608476	29° 59' 7"
80	1.9491835627557	1° 56' 57"
	29.98564264561	29° 59' 8"
81	1.9251043776528	1° 55' 30"
	29.985995197484	29° 59' 10"
82	1.9016130357883	1° 54' 6"
	29.986334918613	29° 59' 11"
83	1.87868826395	1° 52' 43"
	29.986662424266	29° 59' 12"
84	1.8563098034514	1° 51' 23"
	29.986978293271	29° 59' 13"
85	1.8344583503452	1° 50' 4"
	29.987283070569	29° 59' 14"
86	1.8131154998226	1° 48' 47"
	29.987577269555	29° 59' 15"
87	1.7922636944503	1° 47' 32"
	29.987861374256	29° 59' 16"
88	1.7718861759449	1° 46' 19"
	29.988135841332	29° 59' 17"
89	1.7519669402067	1° 45' 7"
	29.988401101888	29° 59' 18"
90	1.7324906953524	1° 43' 57"
	29.988657563202	29° 59' 19"
91	1.7134428225244	1° 42' 48"
	29.988905610271	29° 59' 20"
92	1.6948093392569	1° 41' 41"
	29.989145607247	29° 59' 21"
93	1.6765768652124	1° 40' 36"
	29.989377898807	29° 59' 22"
94	1.6587325901065	1° 39' 31"
	29.989602811358	29° 59' 23"
95	1.6412642436643	1° 38' 29"
	29.989820654215	29° 59' 23"
96	1.6241600674543	1° 37' 27"
	29.990031720646	29° 59' 24"

97	1.6074087884709	1° 36' 27"
	29.990236288863	29° 59' 25"
98	1.5909995943341	1° 35' 28"
	29.990434622946	29° 59' 26"
99	1.5749221099964	1° 34' 30"
	29.990626973695	29° 59' 26"
100	1.5591663758471	1° 33' 33"
	29.990813579424	29° 59' 27"
101	1.5437228271225	1° 32' 37"
	29.990994666683	29° 59' 28"
102	1.528582274525	1° 31' 43"
	29.991170450982	29° 59' 28"
103	1.5137358859762	1° 30' 49"
	29.991341137398	29° 59' 29"
104	1.4991751694233	1° 29' 57"
	29.99150692119	29° 59' 29"
105	1.4848919566269	1° 29' 6"
	29.991667988362	29° 59' 30"
106	1.4708783878713	1° 28' 15"
	29.991824516174	29° 59' 31"
107	1.4571268975312	1° 27' 26"
	29.991976673636	29° 59' 31"
108	1.4436302004409	1° 26' 37"
	29.992124621961	29° 59' 32"
109	1.4303812790167	1° 25' 49"
	29.992268515	29° 59' 32"
110	1.4173733710804	1° 25' 3"
	29.992408499639	29° 59' 33"
111	1.4045999583427	1° 24' 17"
	29.992544716166	29° 59' 33"
112	1.3920547555057	1° 23' 31"
	29.99267729863	29° 59' 34"
113	1.3797316999416	1° 22' 47"
	29.992806375178	29° 59' 34"
114	1.3676249419186	1° 22' 3"
	29.992932068356	29° 59' 35"
115	1.3557288353336	1° 21' 21"
	29.993054495397	29° 59' 35"

116		
1.3440379289294	1° 20' 39"	
29.993173768503	29° 59' 35"	
117		
1.3325469579587	1° 19' 57"	
29.993289995088	29° 59' 36"	
118		
1.3212508362742	1° 19' 17"	
29.993403278054	29° 59' 36"	
119		
1.3101446488178	1° 18' 37"	
29.993513715971	29° 59' 37"	
120		
1.2992236444859	1° 17' 57"	
29.993621403329	29° 59' 37"	
121		
1.2884832293481	1° 17' 19"	
29.993726430727	29° 59' 37"	
122		
1.2779189602013	1° 16' 41"	
29.993828885062	29° 59' 38"	
123		
1.2675265384353	1° 16' 3"	
29.993928849706	29° 59' 38"	
124		
1.2573018042002	1° 15' 26"	
29.994026404691	29° 59' 38"	
125		
1.2472407308499	1° 14' 50"	
29.994121626848	29° 59' 39"	
126		
1.2373394196527	1° 14' 14"	
29.994214589976	29° 59' 39"	
127		
1.2275940947509	1° 13' 39"	
29.994305364982	29° 59' 39"	
128		
1.2180010983575	1° 13' 5"	
29.994394020002	29° 59' 40"	
129		
1.2085568861771	1° 12' 31"	
29.994480620551	29° 59' 40"	
130		
1.1992580230364	1° 11' 57"	
29.994565229622	29° 59' 40"	
131		
1.1901011787167	1° 11' 24"	
29.994647907824	29° 59' 41"	
132		
1.181083123976	1° 10' 52"	
29.994728713464	29° 59' 41"	
133		
1.1722007267491	1° 10' 20"	
29.994807702675	29° 59' 41"	
134		
1.1634509485203	1° 9' 48"	
29.994884929495	29° 59' 42"	

135		
1.154830840855	1° 9' 17"	
29.994960445976	29° 59' 42"	
136		
1.1463375420865	1° 8' 47"	
29.99503430225	29° 59' 42"	
137		
1.1379682741464	1° 8' 17"	
29.995106546636	29° 59' 42"	
138		
1.1297203395354	1° 7' 47"	
29.995177225705	29° 59' 43"	
139		
1.1215911184201	1° 7' 18"	
29.995246384351	29° 59' 43"	
140		
1.1135780658613	1° 6' 49"	
29.99531406588	29° 59' 43"	
141		
1.105678709153	1° 6' 20"	
29.995380312065	29° 59' 43"	
142		
1.0978906452801	1° 5' 52"	
29.995445163203	29° 59' 44"	
143		
1.0902115384782	1° 5' 25"	
29.9955086582	29° 59' 44"	
144		
1.0826391178977	1° 4' 58"	
29.995570834609	29° 59' 44"	
145		
1.0751711753653	1° 4' 31"	
29.995631728685	29° 59' 44"	
146		
1.0678055632344	1° 4' 4"	
29.995691375459	29° 59' 44"	
147		
1.0605401923257	1° 3' 38"	
29.995749808769	29° 59' 45"	
148		
1.0533730299519	1° 3' 12"	
29.995807061306	29° 59' 45"	
149		
1.0463020980195	1° 2' 47"	
29.99586316467	29° 59' 45"	
150		
1.0393254712088	1° 2' 22"	
29.995918149417	29° 59' 45"	
151		
1.0324412752252	1° 1' 57"	
29.995972045091	29° 59' 45"	
152		
1.02564768512	1° 1' 32"	
29.996024880269	29° 59' 46"	
153		
1.0189429236767	1° 1' 8"	
29.99607668259	29° 59' 46"	

154	
1.0123252598606	1° 0' 44"
29.996127478803	29° 59' 46"
155	
1.0057930073281	1° 0' 21"
29.9961772948	29° 59' 46"
156	
.99934452299401	0° 59' 58"
29.996226155637	29° 59' 46"
157	
.99297820565286	0° 59' 35"
29.996274085579	29° 59' 47"
158	
.98669249465228	0° 59' 12"
29.996321108129	29° 59' 47"
159	
.98048586861853	0° 58' 50"
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29.996500569148	29° 59' 47"
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370	.42131598392855	0° 25' 17"
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371	.42018032735381	0° 25' 13"
	29.99933285473	29° 59' 58"
372	.41905077673249	0° 25' 9"
	29.999336436824	29° 59' 58"
373	.41792728295214	0° 25' 5"
	29.999339990148	29° 59' 58"
374	.41680979742559	0° 25' 1"
	29.999343515007	29° 59' 58"
375	.41569827208401	0° 24' 57"
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376	.41459265936992	0° 24' 53"
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377	.4134929122305	0° 24' 49"
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