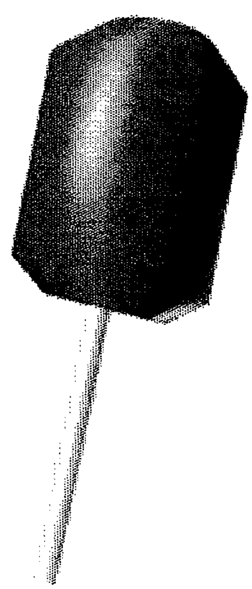
CONFIDENTIAL INFORMATION

THE JOYSTICK REPORT

SEPTEMBER 19, 1997



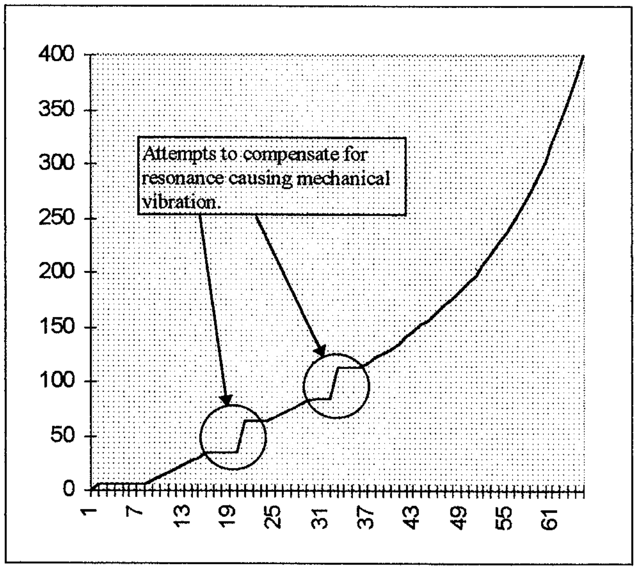
By Stephen L. Robinson

This report represents an effort to understand the esthetic effects of different speed profiles and their implementation in Pelco vector solving joysticks. The data was gathered directly from the programmed implementations of variable speed equipment and combined to obtain the net effect of the movement generated by the system.

For the purposes of this report, it is assumed that all joysticks are essentially linear and add no significant changes to the shape of the speed curve.

The following translation tables were obtained:

SPECTRA

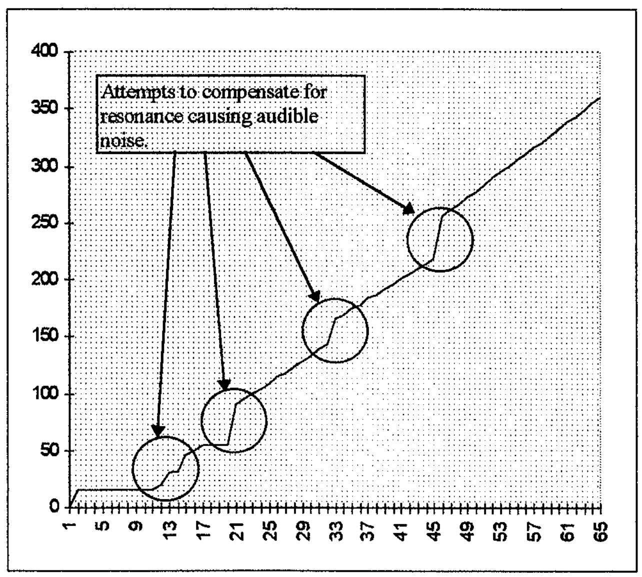


An attempt was made in a recent release of Spectra, to make the movement feel smoother. To this end, we adjusted the movement profile to have more precise control at the lower end speeds.

The "Y" axis on this chart represents movement in degrees per second times 10. The full range represented shows 0° to 40° per second.

The "X" axis represents the speed value received via protocol.

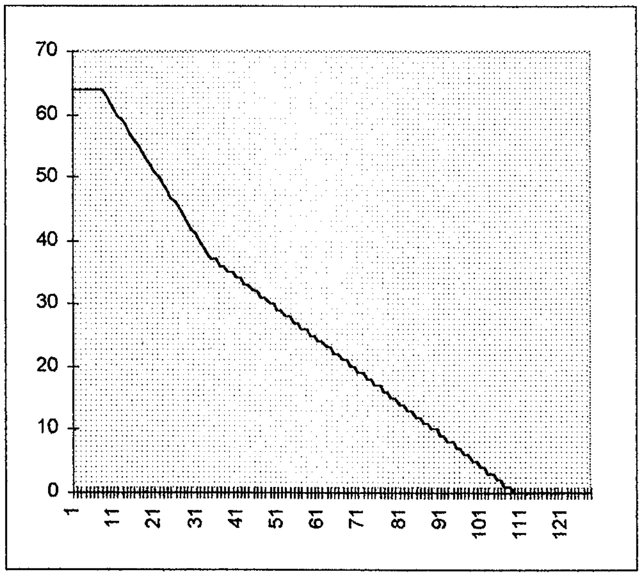
INTERCEPT



The chart at the right is the chart for Intercept. The noticeably choppy nature of the chart is due to an attempt to skip speeds that were causing significant noise problems in the Intercept dome.

As with Spectra, the speeds shown (on the "Y" axis) reflect ten times the speed in degrees per second.

KBD300



The information here shows the profile for the new 6700 system variable speed joystick.

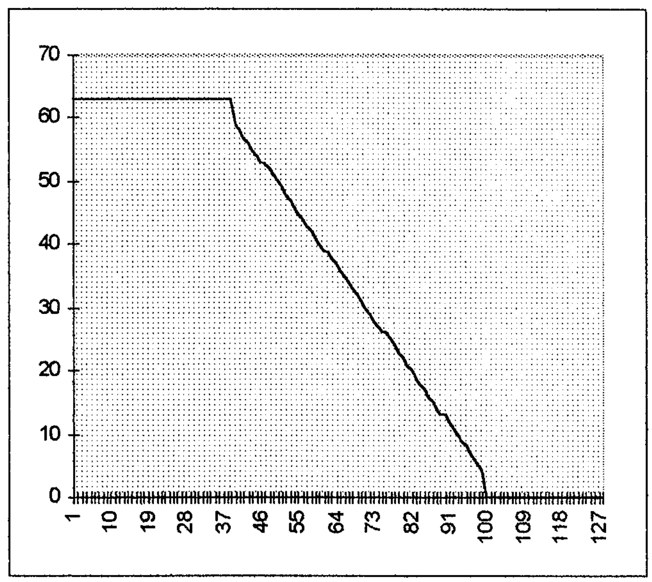
The KBD300 was given a fairly wide dead zone followed by a linear section with a slope of ½. For the higher speed, where detailed control is less critical, the slope is 1 and there is a plateau at the top representing turbo speed.

MPT9500

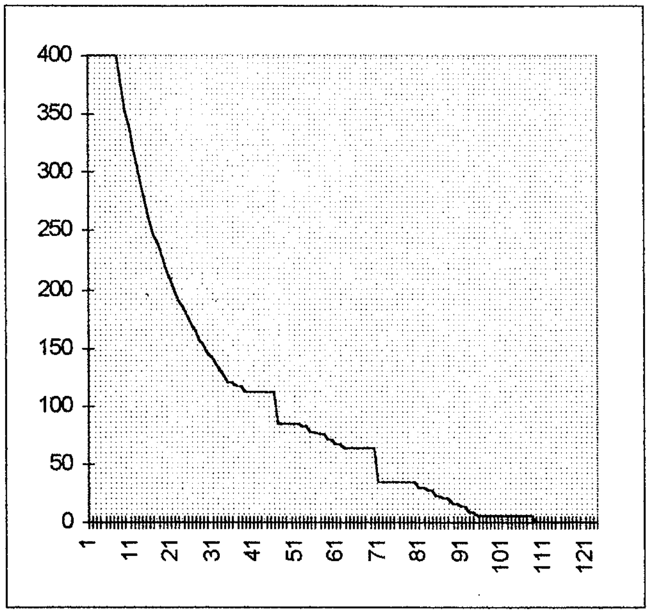
The MPT9500 joystick function was designed to give a very linear response. It has a wide dead zone (speed zero when the joystick is idle), and a wide zone at top speed.

It should be noted that the MPT9500 has a turbo button so the top speed shown here represents speed value 63, the highest speed not including turbo.

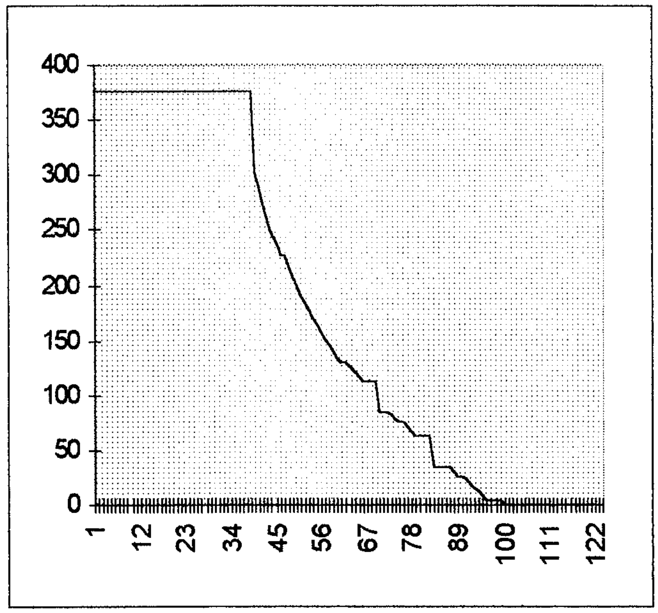
In the charts on the following page, I have taken and combined the profiles of the keyboards with the profiles of the Spectra and Intercept domes. The resulting profile shows the perceived motion as it relates to joystick movement.



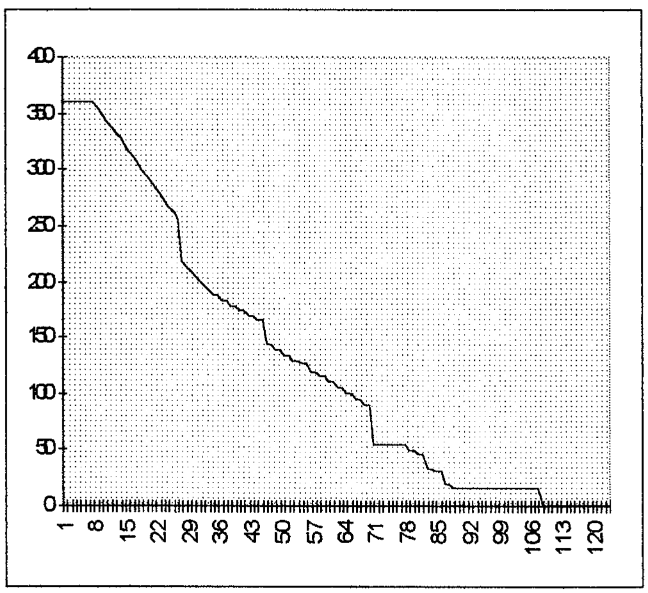
Spectra / KBD300



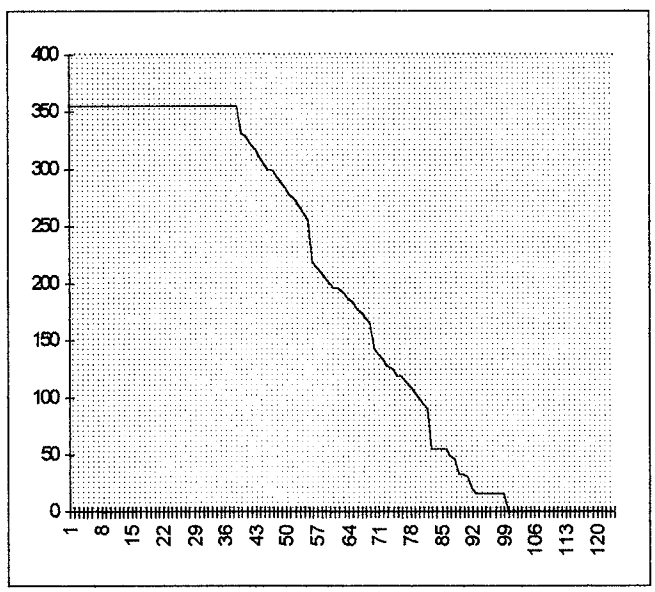
Spectra / MPT9500



Intercept / KBD300

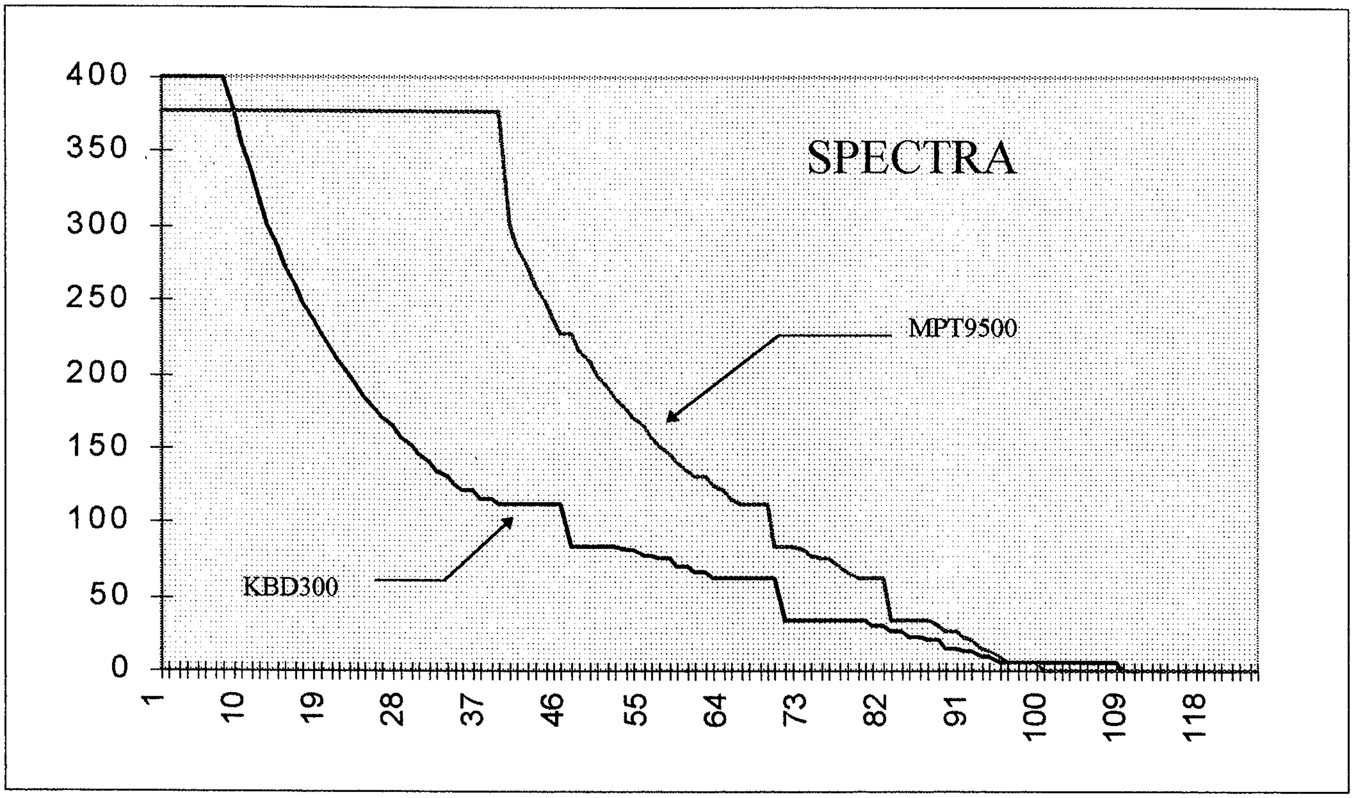


Intercept / MPT9500



In a recent test, several people were asked to evaluate the feel of the KBD300 used in association with the 6700 matrix and Spectra. One of the comments was that the MPT9500 drove Spectra better than the KBD300. This is not surprising since the engineer working on Spectra used the MPT9500 extensively in testing and tuning Spectra's performance.

The chart below contrasts the speed output of Spectra against the joystick positions for the two keyboards.

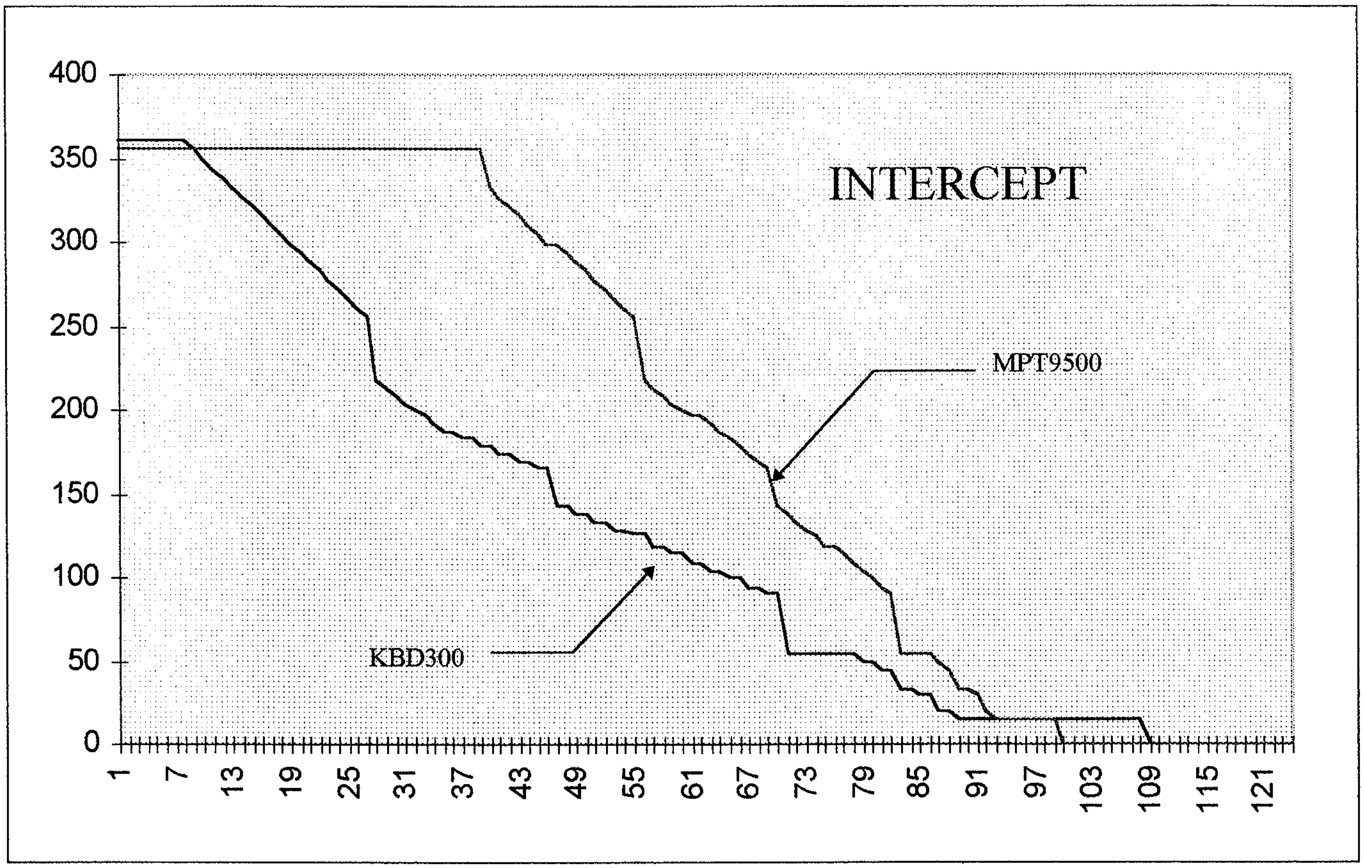


It's apparent, from this diagram, that the KBD300 is loaded much more toward the low end and will provide excellent low speed control. At many of the useful higher speeds (when tracking someone walking or running) there is less control.

At the lower part of the curve, there is very little change in speed for a relatively large joystick movement. At the upper part of the curve, speed changes much more rapidly. This seems to result in a perceived loss of control at the upper speeds.

The MPT9500, on the other hand, has a much more even distribution of speeds throughout the range. Very little low speed control is lost. All the same speeds are there, they just don't occupy the same range of motion on the joystick.

Notice, in the above graphs, that the low end loading aggravates the skipped speeds. The keyboard creates a longer horizontal sweep so you spend more time at a single speed to avoid some speeds… then, suddenly, it changes speeds.



These charts clearly show how choppy the motion control on Intercept really is. The efforts to reduce the noise in Intercept have introduced a bunch of "no go" zones. It was discovered that operating the Intercept dome at speeds in this range produced unacceptable noise and those speeds were removed from the speed tables. You can see others (of varying size) on the chart as indicated by the vertical lines showing a jump from one speed to another.

While the MPT9500 makes these smaller, I doubt that the difference is noticeable. The speed jumps are so large that no amount of fine adjustment in the behavior of the keyboard will be able to compensate and make the system operate smoothly.

Theory and Ideal Curves

A family of curves, with equal percentage change between each step, can be generated with a simple algorithm that meet the criteria of smooth perceived operation. The algorithm is:

Find the value for X where:

T = Top value required
L = Lowest value required $X = \sqrt[S]{T/L}$
S = Number of steps

Now the speed for any given step = $L(X)^S$

If, for example, you want to go from .5 to 40 in 10 steps then:

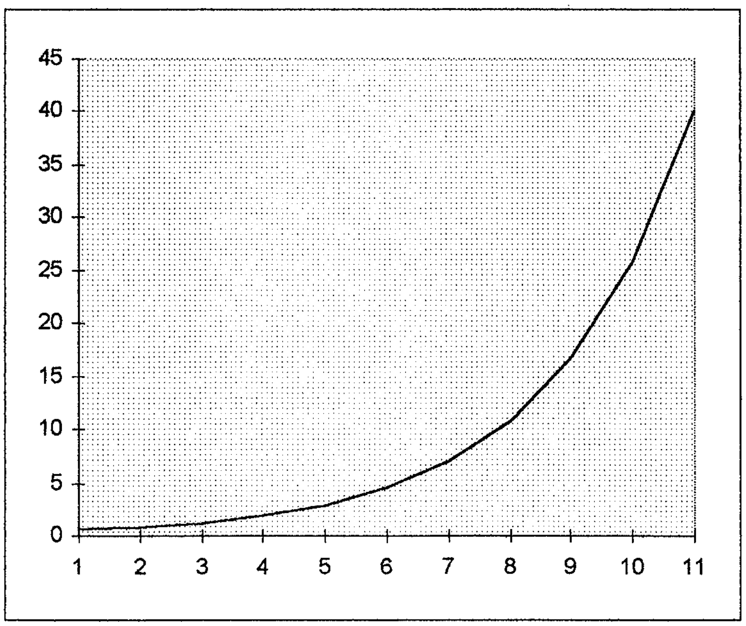
$X = \sqrt[10]{40/.5}$ which is 1.549918988

and the table of these speeds is:

Step	Value
1	0.5000
2	0.7750
3	1.2011
4	1.8616
5	2.8854
6	4.4721
7	6.9314
8	10.7432
9	16.6511
10	25.8078
11	40.0000

This curve, as it turns out, is an exponential curve and can be represented as a straight line on a graph using a log scale.

and the graph looks like this



This can be turned into a family of curves by weighting the curve with a straight line with the same start and end points. The values for the straight line are calculated as follows:

Where:

T = Top value
L = Lowest value
S = Number of steps

Step size X = (T-L)/S   in our example, X = (40-.5)/10 = 3.95

The table looks like this:

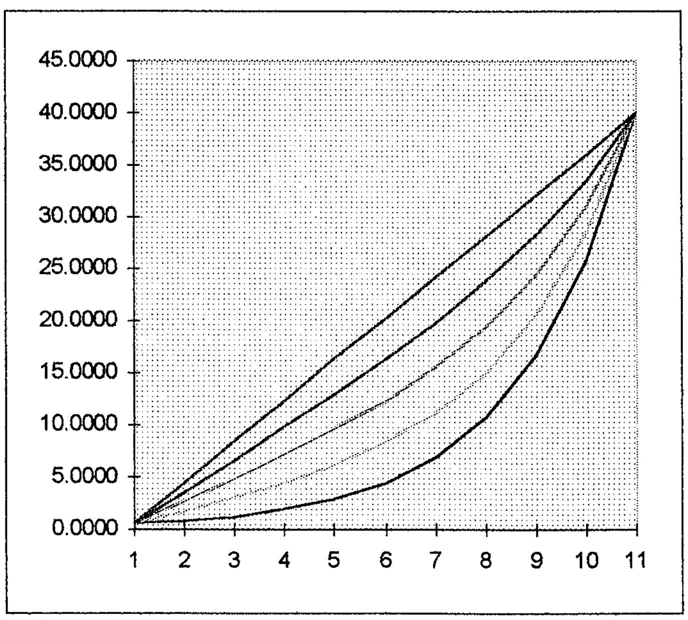
Step	Curve	Straight	¾ Curve	½ Curve	¼ Curve
1	0.5000	0.50	0.50	0.50	0.50
2	0.7750	4.45	1.69	2.61	3.53
3	1.2011	8.40	3.00	4.80	6.60
4	1.8616	12.35	4.48	7.11	9.73
5	2.8854	16.30	6.24	9.59	12.95
6	4.4721	20.25	8.42	12.36	16.31
7	6.9314	24.20	11.25	15.57	19.88
8	10.7432	28.15	15.09	19.45	23.80
9	16.6511	32.10	20.51	24.38	28.24
10	25.8078	36.05	28.37	30.93	33.49
11	40.0000	40.00	40.00	40.00	40.00

The ¾ curve value is calculated by:

(3*Curve + Straight) / 4

This gives us points that are ¾ of the way between the curve and a the straight line.

and the graphs look like this:



What is implemented in Spectra is the ½ curve and ½ straight member from the family. This was chosen without experimentation based on recommendations only.

The theory is, if you choose the straight line, you won't be happy with the low end control (it moves to fast to be able to make fine adjustments). In conjuction with this, you can't really "see" things that well when the horizon is passing by at 40° per second.

Therefore, you need a curve that is weighted to give more fine, low end control and less high speed control.

Having equal percentage change between steps gives a predictable, smooth feel.

DOME / PAN & TILT

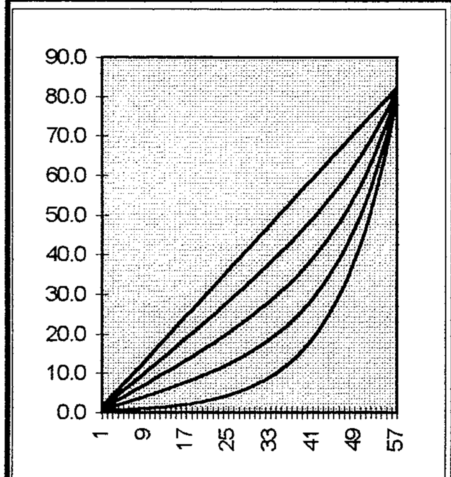
Using the formula

(low speed)*(X^steps)=top speed

X = (TOP / LOW)^(1/STEPS)

Low	Steps	Top
0.5	56	80

X = 1.094861755



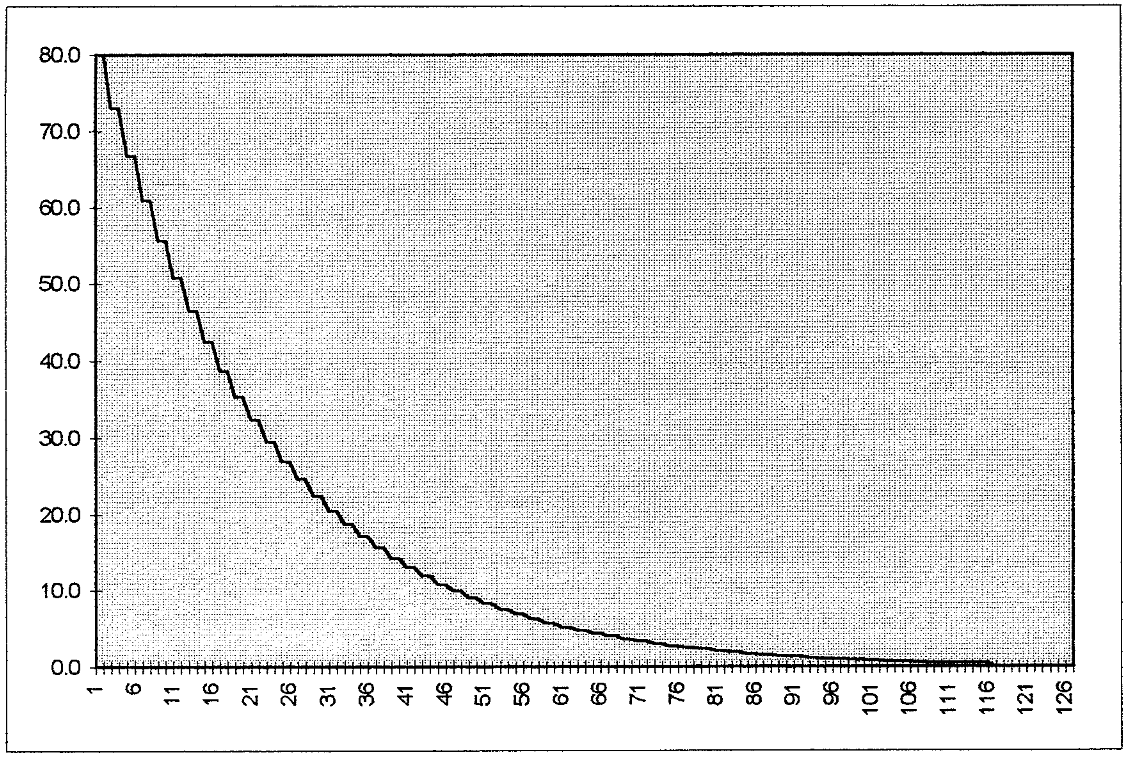
Step	Curve	Straight Line	Relaxed Curves		
	A	B	C	D	E
			(C+3S)/4	(C+S)/4	(3C+S)/4
1	0.5	1.445454545	1.20909	0.9727	0.73636
2	0.5	2.890909091	2.30504	1.7192	1.1333
3	0.6	4.336363636	3.40211	2.4679	1.53361
4	0.7	5.781818182	4.50042	3.219	1.93762
5	0.7	7.227272727	5.60007	3.9729	2.34567
6	0.8	8.672727273	6.7012	4.7297	2.75815
7	0.9	10.11818182	7.80395	5.4897	3.17548
8	0.9	11.56363636	8.90846	6.2533	3.59812
9	1.0	13.00909091	10.0149	7.0207	4.02657
10	1.1	14.45454545	11.1235	7.7924	4.46138
11	1.2	15.9	12.2344	8.5688	4.90316
12	1.4	17.34545455	13.3478	9.3502	5.35257
13	1.5	18.79090909	14.4641	10.137	5.81034
14	1.6	20.23636364	15.5833	10.93	6.27724
15	1.8	21.68181818	16.7059	11.73	6.75416
16	1.9	23.12727273	17.8322	12.537	7.24205
17	2.1	24.57272727	18.9625	13.352	7.74193
18	2.3	26.01818182	20.0971	14.176	8.25495
19	2.6	27.46363636	21.2365	15.009	8.78236
20	2.8	28.90909091	22.3812	15.853	9.32552
21	3.1	30.35454545	23.5317	16.709	9.88593
22	3.4	31.8	24.6884	17.577	10.4652
23	3.7	33.24545455	25.852	18.459	11.0652
24	4.0	34.69090909	27.0232	19.355	11.6878
25	4.4	36.13636364	28.2026	20.269	12.3352
26	4.8	37.58181818	29.3911	21.2	13.0097
27	5.3	39.02727273	30.5895	22.152	13.7139
28	5.8	40.47272727	31.7987	23.125	14.4506
29	6.3	41.91818182	33.0198	24.121	15.223
30	6.9	43.36363636	34.2539	25.144	16.0343
.31	7.6	44.80909091	35.5022	26.195	16.8883
32	8.3	46.25454545	36.7661	27.278	17.7891
33	9.1	47.7	38.047	28.394	18.741

KEYBOARD

A to D			Result	Speed
Left	Right	Xmit	Result	Speed
0	255	64	Turbo	200.0
1	254	63	800	80.0
2	253	63	800	80.0
3	252	62	730	73.0
4	251	62	730	73.0
5	250	61	667	66.7
6	249	61	667	66.7
7	248	60	609	60.9
8	247	60	609	60.9
9	246	59	556	55.6
10	245	59	556	55.6
11	244	58	508	50.8
12	243	58	508	50.8
13	242	57	464	46.4
14	241	57	464	46.4
15	240	56	424	42.4
16	239	56	424	42.4
17	238	55	387	38.7
18	237	55	387	38.7
19	236	54	353	35.3
20	235	54	353	35.3
21	234	53	323	32.3
22	233	53	323	32.3
23	232	52	295	29.5
24	231	52	295	29.5
25	230	51	269	26.9
26	229	51	269	26.9
27	228	50	246	24.6
28	227	50	246	24.6
29	226	49	224	22.4
30	225	49	224	22.4
31	224	48	205	20.5
32	223	48	205	20.5
33	222	47	187	18.7

34	10.0	49.14545455	39.3466	29.548	19.7489
35	10.9	50.59090909	40.6667	30.742	20.8182
36	11.9	52.03636364	42.0091	31.982	21.9546
37	13.1	53.48181818	43.3761	33.27	23.1646
38	14.3	54.92727273	44.7699	34.612	24.455
39	15.7	56.37272727	46.193	36.013	25.8336
40	17.1	57.81818182	47.6484	37.479	27.3087
41	18.8	59.26363636	49.1389	39.014	28.8894
42	20.5	60.70909091	50.668	40.627	30.5858
43	22.5	62.15454545	52.2393	42.324	32.4089
44	24.6	63.6	53.8569	44.114	34.3706
45	27.0	65.04545455	55.525	46.005	36.4841
46	29.5	66.49090909	57.2485	48.006	38.7638
47	32.3	67.93636364	59.0328	50.129	41.2255
48	35.4	69.38181818	60.8834	52.385	43.8865
49	38.7	70.82727273	62.8067	54.786	46.7656
50	42.4	72.27272727	64.8097	57.347	49.8835
51	46.4	73.71818182	66.8998	60.081	53.2629
52	50.9	75.16363636	69.0853	63.007	56.9286
53	55.7	76.60909091	71.3753	66.142	60.9078
54	61.0	78.05454545	73.7798	69.505	65.2302
55	66.7	79.5	76.3094	73.119	69.9283
56	73.1	80.94545455	78.9762	77.007	75.0378
57	80.0	82.39090909	81.7932	81.195	80.5977

34	221	47	187	18.7
35	220	46	171	17.1
36	219	46	171	17.1
37	218	45	156	15.6
38	217	45	156	15.6
39	216	44	142	14.2
40	215	44	142	14.2
41	214	43	130	13.0
42	213	43	130	13.0
43	212	42	119	11.9
44	211	42	119	11.9
45	210	41	108	10.8
46	209	41	108	10.8
47	208	40	99	9.9
48	207	40	99	9.9
49	206	39	90	9.0
50	205	39	90	9.0
51	204	38	83	8.3
52	203	38	83	8.3
53	202	37	75	7.5
54	201	37	75	7.5
55	200	36	69	6.9
56	199	36	69	6.9
57	198	35	63	6.3
58	197	35	63	6.3
59	196	34	57	5.7
60	195	34	57	5.7
61	194	33	52	5.2
62	193	33	52	5.2
63	192	32	48	4.8
64	191	32	48	4.8
65	190	31	44	4.4
66	189	31	44	4.4
67	188	30	40	4.0
68	187	30	40	4.0
69	186	29	36	3.6
70	185	29	36	3.6



71	184	28	33	3.3
72	183	28	33	3.3
73	182	27	30	3.0
74	181	27	30	3.0
75	180	26	27	2.7
76	179	26	27	2.7
77	178	25	25	2.5
78	177	25	25	2.5
79	176	24	23	2.3
80	175	24	23	2.3
81	174	23	21	2.1
82	173	23	21	2.1
83	172	22	19	1.9
84	171	22	19	1.9
85	170	21	17	1.7
86	169	21	17	1.7
87	168	20	16	1.6
88	167	20	16	1.6
89	166	19	14	1.4
90	165	19	14	1.4
91	164	18	13	1.3
92	163	18	13	1.3
93	162	17	12	1.2
94	161	17	12	1.2
95	160	16	11	1.1
96	159	16	11	1.1
97	158	15	10	1.0
98	157	15	10	1.0
99	156	14	9	0.9
100	155	14	9	0.9
101	154	13	8	0.8
102	153	13	8	0.8
103	152	12	7	0.7
104	151	12	7	0.7
105	150	11	7	0.7
106	149	11	7	0.7
107	148	10	6	0.6

108	147	10	6	0.6
109	146	9	5	0.5
110	145	9	5	0.5
111	144	8	5	0.5
112	143	8	5	0.5
113	142	7	5	0.5
114	141	7	5	0.5
115	140	7	5	0.5
116	139	7	5	0.5
117	138	0	0	0.0
118	137	0	0	0.0
119	136	0	0	0.0
120	135	0	0	0.0
121	134	0	0	0.0
122	133	0	0	0.0
123	132	0	0	0.0
124	131	0	0	0.0
125	130	0	0	0.0
126	129	0	0	0.0
127	128	0	0	0.0

Joystick				Dome Motion Control					0	0
Motion Control			Average	Distance	Adjustment	Adjusted	Motion	Step	0	0
Left	Right	Sent	Step Size	From Mid.	To Step	Step	Profile	No.	0	0
0	255	64	1.445455	-28	-1.4	0.045455	0.5	7	0	0
1	254	63	1.445455	-27	-1.35	0.095455	0.5	8	0	0
2	253	63	1.445455	-26	-1.3	0.145455	0.6	9	0	0
3	252	63	1.445455	-25	-1.25	0.195455	0.8	10	0	0
4	251	63	1.445455	-24	-1.2	0.245455	1.0	11	0	0
5	250	62	1.445455	-23	-1.15	0.295455	1.2	12	0	0
6	249	62	1.445455	-22	-1.1	0.345455	1.5	13	0	0
7	248	61	1.445455	-21	-1.05	0.395455	1.9	14	0	0
8	247	61	1.445455	-20	-1	0.445455	2.3	15	7	0.5
9	246	60	1.445455	-19	-0.95	0.495455	2.7	16	7	0.5
10	245	60	1.445455	-18	-0.9	0.545455	3.2	17	8	0.5
11	244	59	1.445455	-17	-0.85	0.595455	3.8	18	8	0.5
12	243	59	1.445455	-16	-0.8	0.645455	4.3	19	9	0.6
13	242	58	1.445455	-15	-0.75	0.695455	5.0	20	9	0.6
14	241	58	1.445455	-14	-0.7	0.745455	5.7	21	10	0.8
15	240	57	1.445455	-13	-0.65	0.795455	6.4	22	10	0.8
16	239	57	1.445455	-12	-0.6	0.845455	7.2	23	11	1
17	238	56	1.445455	-11	-0.55	0.895455	8.1	24	11	1
18	237	56	1.445455	-10	-0.5	0.945455	9.0	25	12	1.2
19	236	55	1.445455	-9	-0.45	0.995455	9.9	26	12	1.2
20	235	55	1.445455	-8	-0.4	1.045455	10.9	27	13	1.5
21	234	54	1.445455	-7	-0.35	1.095455	12.0	28	13	1.5
22	233	54	1.445455	-6	-0.3	1.145455	13.1	29	14	1.9
23	232	53	1.445455	-5	-0.25	1.195455	14.2	30	14	1.9
24	231	53	1.445455	-4	-0.2	1.245455	15.4	31	15	2.3
25	230	52	1.445455	-3	-0.15	1.295455	16.6	32	15	2.3
26	229	52	1.445455	-2	-0.1	1.345455	17.9	33	16	2.7
27	228	51	1.445455	-1	-0.05	1.395455	19.3	34	16	2.7
28	227	51	1.445455	0	0	1.445455	20.7	35	17	3.2
29	226	50	1.445455	1	0.05	1.495455	22.1	36	17	3.2
30	225	50	1.445455	2	0.1	1.545455	23.6	37	18	3.8
31	224	49	1.445455	3	0.15	1.595455	25.2	38	18	3.8
32	223	49	1.445455	4	0.2	1.645455	26.8	39	19	4.3
33	222	48	1.445455	5	0.25	1.695455	28.4	40	19	4.3
34	221	48	1.445455	6	0.3	1.745455	30.1	41	20	5
35	220	47	1.445455	7	0.35	1.795455	31.8	42	20	5
36	219	47	1.445455	8	0.4	1.845455	33.6	43	21	5.7
37	218	46	1.445455	9	0.45	1.895455	35.5	44	21	5.7
38	217	46	1.445455	10	0.5	1.945455	37.4	45	22	6.4
39	216	45	1.445455	11	0.55	1.995455	39.3	46	22	6.4
40	215	45	1.445455	12	0.6	2.045455	41.3	47	23	7.2
41	214	44	1.445455	13	0.65	2.095455	43.4	48	23	7.2
42	213	44	1.445455	14	0.7	2.145455	45.5	49	24	8.1
43	212	43	1.445455	15	0.75	2.195455	47.6	50	24	8.1
44	211	43	1.445455	16	0.8	2.245455	49.8	51	25	9
45	210	42	1.445455	17	0.85	2.295455	52.0	52	25	9
46	209	42	1.445455	18	0.9	2.345455	54.3	53	26	9.9
47	208	41	1.445455	19	0.95	2.395455	56.7	54	26	9.9

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98	157	16

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1.445455	21	1.05	2.495455	61.5	56
1.445455	22	1.1	2.545455	64.0	57
1.445455	23	1.15	2.595455	66.6	58
1.445455	24	1.2	2.645455	69.2	59
1.445455	25	1.25	2.695455	71.8	60
1.445455	26	1.3	2.745455	74.5	61
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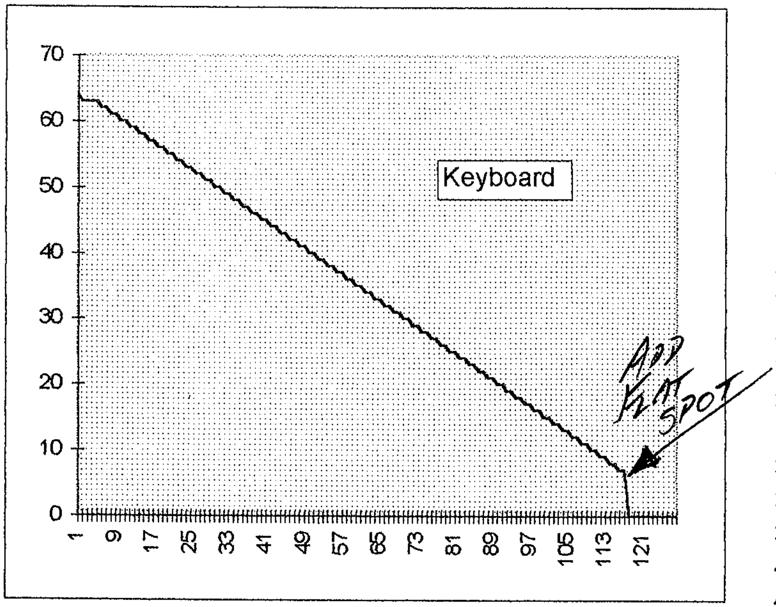

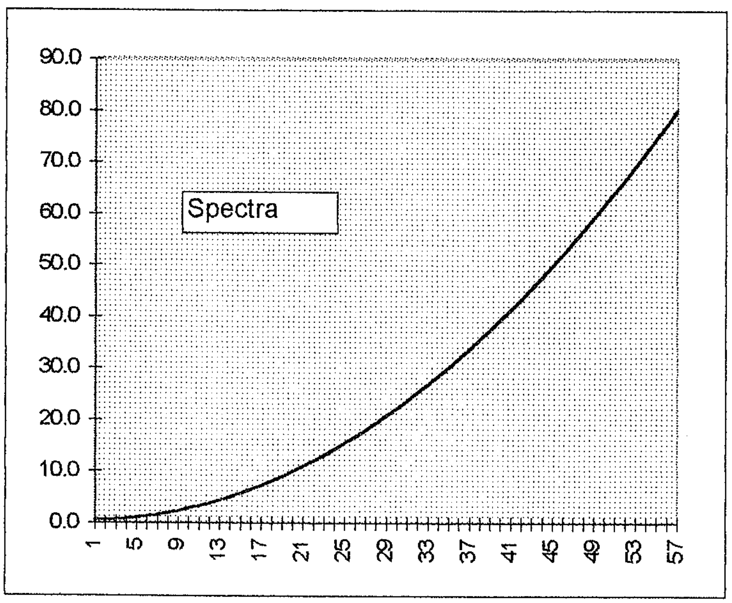

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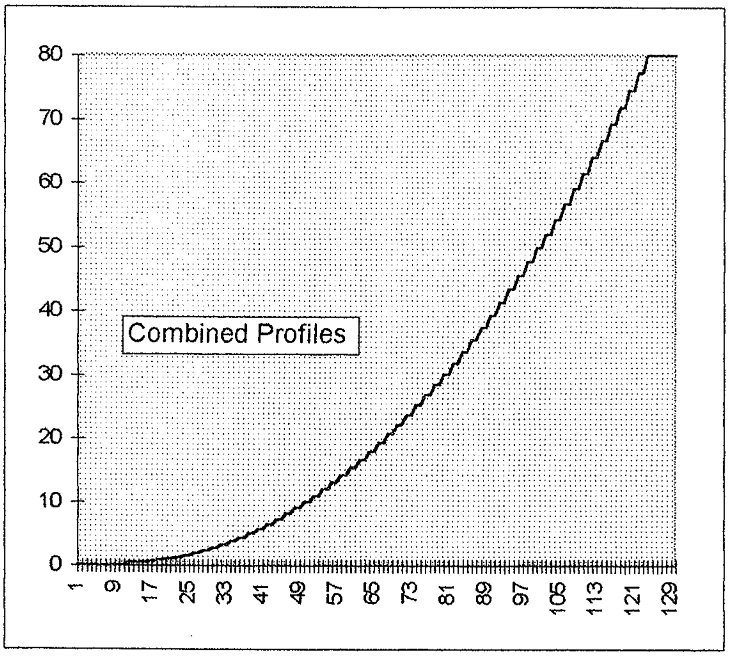

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