laid over it and the type lines traced. Cruise data may be added to the map. Finally, white prints are made from the pencil tracing for use in logging planning.

230 PLANNING FOR SKYLINES

231 DEFLECTION AND TENSION

231.1 IMPORTANCE OF DEFLECTION. In planning for skylines the main problem is to obtain adequate deflection or sag in the skyline so that the tension in the cable will not exceed the desired factor of safety. The minimum factor of safety generally used by logging engineers is 3, although the tables in the wire rope manufacturers' handbooks use a factor of safety of 5. A factor of safety of 3 means that the tension is one-third of the breaking strength in the skyline. Tension is a maximum at the upper support when the load is at mid-span. The logger's rule of thumb is that deflection should not be less than 5 percent of the span, which is the horizontal distance between head tree and tail tree. Steep slopes require more deflecttion, and the tension should be computed.

Landings for skylines on steep slopes should be located well back from the bottom of the slope. In some cases it may be necessary to put the landing on the other side of the valley to obtain deflection. Where clearance for deflection is doubtful, draw a profile of the skyline road taken from a topographic map or from an Abney leveled and chained line over the proposed skyline road.

231.2 DEFLECTION CHART. Following is a graphic method of determining deflection:

1. Plot a profile of the ground between head and tail trees on 10 x 10 cross-section paper using a scale of 1 inch = 100 feet for both vertical and horizontal axes.

2. Fasten the paper to a wall with the horizontal lines level.

3. Put pins at the estimated elevations of the skyline supports (tree shoes) above the ground.

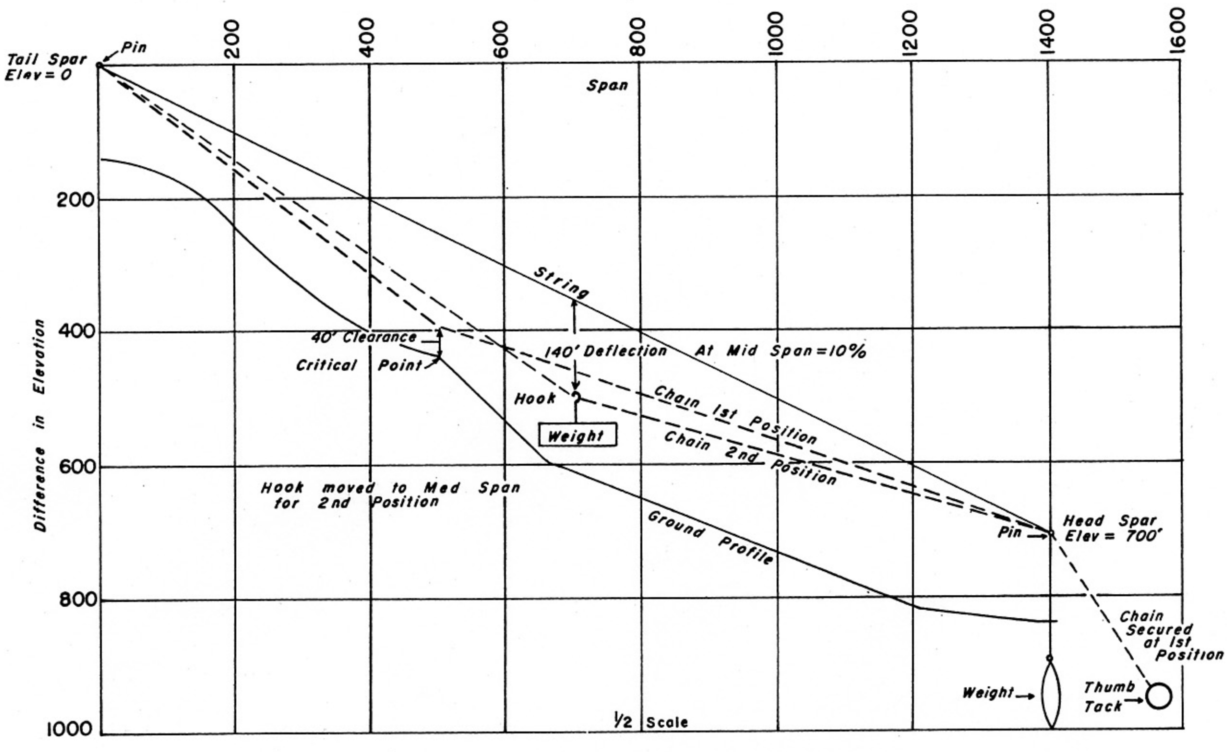
4. Stretch a string straight between pins and hang a light chain over the pins. The chain will assume the profile of the skyline, which is a catenary.

5. Hang a light weight with a wire hook on the chain to represent the load and adjust the sag in the chain to give a clearance of 20 to 30 feet from the ground at the critical point on the profile.

6. Anchor the chain with a thumb tack and move the load to mid-span. Scale off the vertical distance between the string and the chain at mid-span. This is the deflection in feet.

7. The maximum tension and the factor of safety may then be calculated by one of the methods given in Article 231.3. If the tension exceeds the desired factor of safety with a load of the largest log or the desired size turn, change the position of head tree or tail tree to increase the deflection. If adequate deflection cannot be obtained, the trial skyline location cannot be used.

FIGURE 231-1 DEFLECTION CHART



231.3 COMPUTING TENSION. The tension in skylines may be computed by using the formulas in the handbooks published by the wire rope manufacturers. They are available without charge from wire rope distributors. The quickest method is to use the following tables reproduced by permission of Professor William A. Davies, Forest Engineering Department, School of Forestry, Oregon State College. (1/) To facilitate computation, use units of Kips (1000 pounds) for loads and tensions and stations (100 feet) for spans. Span is horizontal distance between head and tail trees.

TENSION IN KIPS DUE TO 1 KIP OF LOAD

Slope %	Deflection in Per Cent of Span 5	6	7	8	10
0	5.02	4.15	3.60	3.15	2.54
10	5.00	4.12	3.56	3.11	2.50
20	5.02	4.13	3.57	3.10	2.49
30	5.09	4.17	3.60	3.12	2.50
40	5.22	4.26	3.68	3.17	2.54
50	5.39	4.40	3.79	3.27	2.60
60	5.58	4.57	3.92	3.38	2.68
70	5.81	4.77	4.08	3.51	2.79
80	6.10	5.00	4.27	3.68	2.91
90	6.40	5.25	4.48	3.87	3.04
100	6.72	5.52	4.70	4.07	3.19

BREAKING STRENGTH IN KIPS
1 W.R.C. Cable

Diam. Inches	Plow Steel	Improved Plow Steel
1-1/2	172	198
1-5/8	200	230
1-3/4	232	266
1-7/8	264	342

TENSION IN KIPS PER STATION OF SPAN DUE TO WEIGHT OF CABLE

Slope %	5	Deflection Per Cent 6	7	8	10	5	Deflection Per Cent 6	7	8	10
		1-1/2 Inch Cable					1-5/8 Inch Cable			
0	1.01	0.85	0.74	0.65	0.54	1.19	1.00	0.87	0.76	0.64
10	1.04	0.88	0.77	0.68	0.57	1.23	1.04	0.90	0.80	0.68
20	1.09	0.92	0.81	0.72	0.60	1.28	1.08	0.96	0.84	0.70
30	1.16	0.98	0.86	0.77	0.64	1.36	1.15	1.01	0.90	0.76
40	1.25	1.06	0.93	0.83	0.70	1.47	1.24	1.09	0.98	0.82
50	1.38	1.16	1.01	0.90	0.76	1.59	1.36	1.19	1.06	0.89
60	1.49	1.26	1.11	0.99	0.83	1.75	1.48	1.31	1.16	0.98
70	1.64	1.18	1.22	1.09	0.91	1.92	1.63	1.43	1.28	1.08
80	1.90	1.53	1.34	1.20	1.01	2.11	1.80	1.58	1.41	1.19
90	1.99	1.69	1.48	1.33	1.11	2.33	1.98	1.76	1.56	1.30
100	2.20	1.88	1.64	1.47	1.23	2.58	2.21	1.92	1.73	1.44
		1-3/4 Inch Cable					1-7/8 Inch Cable			
0	1.38	1.18	1.01	0.88	0.74	1.58	1.33	1.16	1.02	0.85
10	1.42	1.20	1.04	0.92	0.77	1.63	1.38	1.20	1.06	0.88
20	1.49	1.28	1.10	0.96	0.82	1.71	1.44	1.26	1.12	0.94
30	1.58	1.33	1.17	1.05	0.88	1.81	1.53	1.34	1.20	1.01
40	1.70	1.44	1.26	1.13	0.95	1.95	1.65	1.45	1.30	1.09
50	1.85	1.58	1.38	1.22	1.03	2.12	1.81	1.58	1.41	1.18
60	2.02	1.73	1.51	1.34	1.13	2.32	1.97	1.74	1.54	1.30
70	2.22	1.88	1.66	1.48	1.25	2.56	2.17	1.91	1.70	1.43
80	2.45	2.08	1.83	1.63	1.37	2.81	2.39	2.10	1.87	1.57
90	2.70	2.30	2.02	1.81	1.53	3.10	2.64	2.31	2.08	1.74
100	2.99	2.55	2.23	2.00	1.67	3.43	2.94	2.56	2.30	1.92

EXAMPLE: Given 1-7/8 inch I.P.S. cable, breaking strength 343 Kips, trial span 14 stations on 50 percent slope. To clear critical point, deflection at center, Dc = 70 feet = 5 percent of span. Loads in Kips: carriage 1.2, fall block and rigging 14.6, turn of logs 28.8. North Bend system so half the fall block and turn stresses the skyline.

Load, P, = 1.2 + 14.6/2 + 28.8/2 = 22.9 Kips;
Tension due to cable, Tw = 2.12 x 14 = 29.7 Kips;
Tension due to load, Tp = 5.39 x 22.9 = 124.5 Kips;
Total T = 154.2 Kips. Factor of Safety, FS = 342/154.2 = 2.22
Desired FS = 3.

By moving head tree 2 stations out from toe of slope, Dc reduces to 112 feet or 7 percent; slope reduces to 45 percent; span increases to 16 stations. Interpolate in table for Tw per station and Tp per Kip of P. Then,

Tw = 1.51 x 16 = 24.2;
Tp = 3.73 x 22.9 = 85.4;
T = 109.6;
FS = 342/109.6 = 3.12

Therefore, move landing and road 2 stations out from trial location.