GLINT NO. 337
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WIND LOADS ON DECLINATION DRIVE REEXAMINED

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The basis of design was that stowing would be called for at a wind speed of 35 mph but that a 50 mph wind, though expected rarely, should be guarded against (Glint 225). Even though a 50 mph wind is expected here only once in 7.7 years, there is still one chance in 6 of it happening in any one year.

Now that the declination drive system has been installed in Tertio, its response under various wind conditions can be examined. Sample calculations can also be recorded.

Wind Data

Calculations are based on H. Hirst and K. E. McKee, "Wind Forces on Parabolic Antennas," Microwave Journal, Nov. 1965, vol. 8, pp. 43-47 (copy in RAI reprint file). These results apply to solid parabolic surfaces without associated structure, but the most critical situation, a north wind blowing when the dish is far to the south, is one where the structure would not appear to add to the load.

Data for 50 mph N Wind

Position	-	stow	zenith	37° above S	S horizon
α	0	37°	90°	143°	180°
Axial force, F_A	28 kip	28	0	11	20
Side force through vertex, F_S	0 kip	0	7	7	0
Moment, M	0 kip-ft	-50	150	110	0
Declination	-	90°	37	-16	-53°

Allowing 2820 sq. ft. for face on area of 60 ft. dish and a wind pressure of 10 lb. ft.$^{-2}$ we have 28,200 lb. expected, which agrees with the table for a wind blowing straight into the concave side ($\alpha = 0$). But for $\alpha = 180$ the table shows a smaller force than would result from the simple calculation based on projected area.

<u>Definition of Symbols</u>

M = wind moment on dish

F_A = axial wind force

F_S = side force through vertex

M_W = dead load moment on dish = $W_1 R_{CG} \sin(\text{dec} - 0.^\circ 7)$

W_1 = weight of No. 1 dish = 18,270 lbs (W_2 = 19,270, $W_3 = W_4 = W_5$ = 20,200, Glint 293, p. 2.)

R_{CG} = distance of CG from dec axis = 7.6 ft (Glint 293) = $\sqrt{y_3^2 + z_3^2}$

y_3 = 4.7 ft.

z_3 = 6 ft.

R = chain radius = 6.75 ft.

r = sprocket radius = 3.845 inches = 0.32 ft.

M_A = 4.7 F_A = moment of F_A about dec axis

M_S = 6 F_S = moment of F_S about dec axis

M_{tot} = total moment about dec axis

L_S = power loss in sprocket friction = 0.42 HP

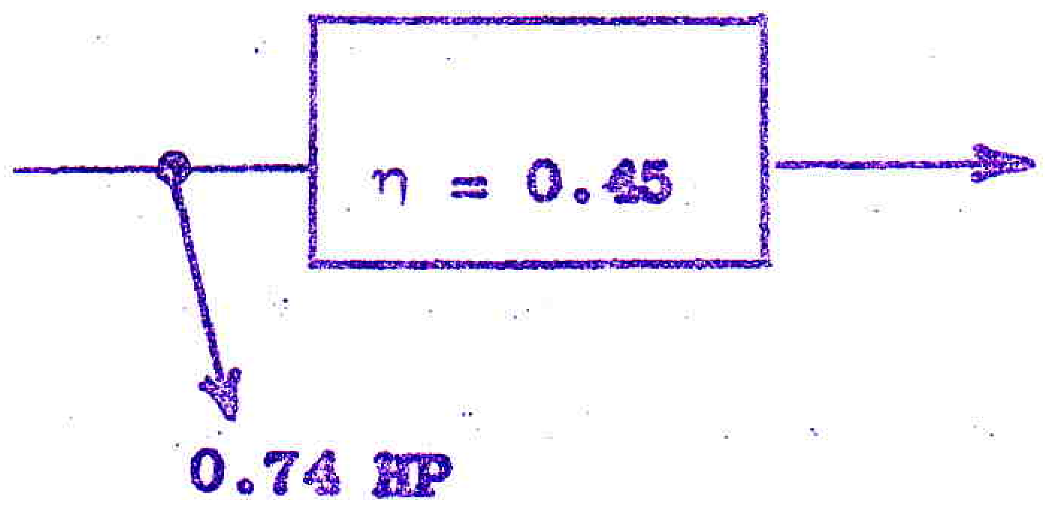
0.42 HP = 0.046 rpm × 7100 lb × 6.75 ft/5250

F = load on sprocket tooth = M_{tot}/R + 7100 lb.

T = sprocket torque = Fr

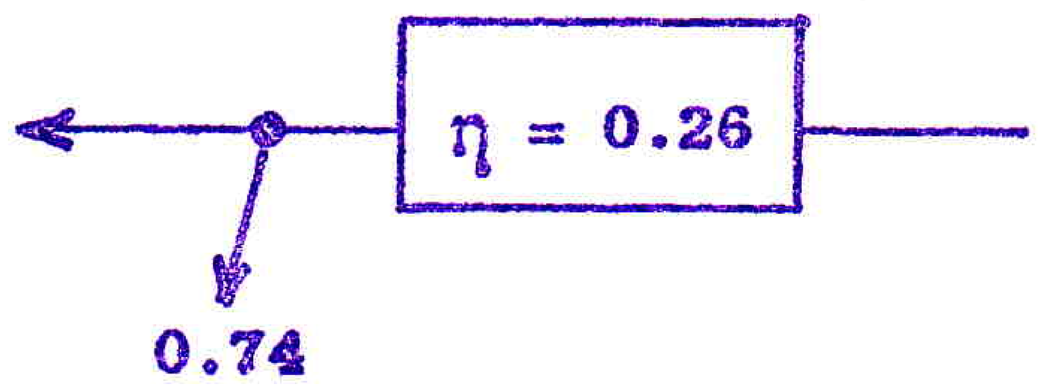
Chain tensions = 22,500 pretension $\pm \frac{1}{2} F$.

<u>Gear Box Model</u>



An oil churning loss of 0.74 HP is adopted, regardless of load, in accordance with measurements reported in Glint 330. More recent indications (of about 6 August 1969) are that this loss fell to 0.5 HP when the oil level was lowered to recommended level. Some further drop may possibly be expected from the use of a lighter grade of oil.

When power is flowing backward through the gears the model is



The oil churning loss is assumed to be the same because the gearing speeds are the same. The efficiency is calculated from $(2 - 1/\eta_1)(2 - 1/\eta_2)$ where $\eta_1 = 0.7$ and $\eta_2 = 0.64$ are the forward efficiencies of the two stages (Glint 330, App. 5).

The catalog efficiency of the DWB-1000 is 55% at rated load, no separate allowance being required for no-load loss.

Sample Calculation for the Worst Case

Dish at 37° elevation above South horizon (dec = -16°) driving North into a 50 mph North wind

Axial force	F_A = 11 kips (from data above)
Side force	F_S = 7 " " " "
Wind moment	M = 110 kip ft " "
	$M_A = 4.7\ F_A$ = 52 kip-ft
	$M_S = 6\ F_S$ = 42 kip-ft
	$M_W = 18{,}270 \times 7.6 \times \sin 16^\circ = 139 \times 0.275$ = 38 kip ft
	$M_{tot} = 110 + 52 + 42 + 38$ = 242 kip ft

$M_{tot}/R = 242/6.75 = 36$ kips

Load on sprocket, $F = 36 + 7.1 = 43$ kips

Sprocket torque, $T = 43 \times 0.32 = 13.5$ kip ft

$T/T_{rated} = 13.5/6.75 = 200$ % (300 % acceptable)

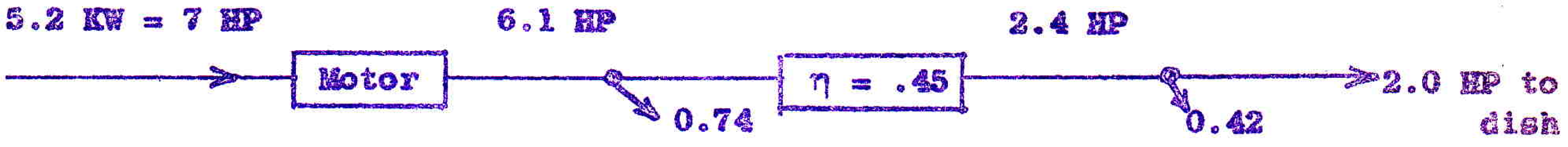
(Rated torque of Link Belt DWB 1000 is 81,000 lb in = 6.75 kip-ft at 2.35 input HP. Destruction torque is 550 to 600% - case breaks)

Chain tensions $22.5 \pm \frac{1}{2} F$ = 44 and 1 kip

Power to dish, $P_D = 0.043 \times 242/5250 = 2.0$ HP

Power to sprocket from gearbox, $P_S = 2.0 + 0.42 = 2.4$ HP $= \left(\frac{0.906 \text{ rpm} \times 13.5 \text{ kip-ft}}{5250}\right.$

Power to gearbox from motor, $P_G = 2.4/0.45 + 0.74 = 6.1$ HP (7.5 HP rated)



Note on speeds

	Motor	Sprocket	Dish
Synchronous rpm	1200	1200/1180 = 1.02	0.048
Rated (10% slip) rpm	1085 (90.4%)	0.906	0.043

In the above calculation rated speed was used, and the calculated power drain on the motor shows that this was about correct.

Typical Results Driving North Toward Stow

	50 mph North Wind				50 mph South Wind			
	South horiz	37° elev	Zenith	Stow	South horiz	37° elev	Zenith	Stow
Wind force F_A (kips)	20	11	0	28	28	28	0	11
" F_S "	0	7	7	0	0	0	7	7
Wind moment M (kip-ft)	0	110	150	-50	0	50	-150	-110
" M_A "	94	52	0	-132	-130	-130	0	+52
" M_S "	0	42	42	0	0	0	-42	-42
Gravity moment M_W "	110	38	-83	-138	110	38	-83	-138
M_{tot} "	204	242	109	-320	-20	-42	-275	-238
$M_{tot}/6.75$ (kips)	30	36	16	-47	-3	-6	-41	-35
Sprocket load F	37	43	23	-40	~0	0	-34	-28
Sprocket torque T	12	13.5	7	13	0	0	-11	- 9
T/T_{rated} (300% acceptable)	170%	200%	50%	-180%	0	0	-150%	-130%
Chain tensions (kips)	41&4	44&1	34&11	2&43	22.5	22.5	5&39	3&36
Power to dish P_D (HP)	1.7	2.0	0.9	-2.6	0	0	-2.5	-2.2
Power to sprocket P_S "	2.1	2.4	1.3	-2.2	0.4	0.4	-2.1	-1.8
Power to gearbox P_G "	5.4	6.1	3.6	0.1	1.6	1.6	0.2	0.2

In this table a minus sign means that the drive is being assisted by the wind as it moves the dish toward the stow position.

When P_G is negative it means that power is being fed to the motor. This would also entail the current going negative. The motor current is indicated at the control panel.

Typical Results for No Wind

	Driving North →				← Driving South			
	South horiz	37° elev	Zenith	Stow	South horiz	37° elev	Zenith	Stow
Gravity moment $M_W = M_{tot}$ (kip ft)	110	38	-83	-138	-110	-38	-83	-138
$M_{tot}/6.75$ (kips)	16	6	-12	-20	-16	-6	12	20
Sprocket load F $7.1 + M_{tot}/6.75$	23	13	-5	-13	-9	1	19	27
Sprocket torque T (kip-ft)	7	4	-2	-4	-3	0.3	6	8
T/T_{rated}	100%	60%	25%	60%	45%	5%	90%	120%
Chain tensions	34&11	29&16	20&25	16&29	18&27	23&22	32&13	36&9
Power to dish, P_D (HP)	1.0	0.3	-0.7	-1.23	-1.0	-0.3	0.7	1.23
Power to sprocket from G/B, P_S	1.4	0.7	-0.3	-0.8	-0.6	0.1	1.1	1.65
Power to G/B from motor, P_G	3.8	2.3	0.6	0.5	0.5	0.9	3.1	4.4