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QUARTERLY PROGRESS REPORT

PHASE IV

DESIGN AND DEVELOPMENT OF
A CONTINUOUSLY VARIABLE RATIO TRANSMISSION
FOR AN AUTOMOTIVE VEHICLE

May 31, 1978

Ref: ERDA-Orshansky Contract No. EY-76-C-03-1165,
Modification No. A004

Submitted to: Energy Research and Development Administration
Power Train & Vehicular Systems Branch
Office of Highway Vehicle Systems Energy Conservation
20 Massachusetts Avenue, N. W.
Washington, D. C. 20545

By: Orshansky Transmission Corporation
5141 Santa Fe Street
San Diego, California 92109

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I. INTRODUCTION

Under Modification A004 to Contract EY-76-C-03-1165 the following tasks had been funded up to March 31, 1978.

Task

- 6 Development of the hydraulic and electronic control sub-systems..
- 16B Measurement of response rate of advanced auxiliary circuit concept to changes in auxiliary hydraulic power demand.
- 17 Road testing of demonstration vehicle with installed First Generation Hydromechanical Transmission.
- 22 Testing of Co-Axial Hydrostatic Module for Second Generation Hydromechanical Transmission.
- 30 Reporting.
- 33 Evaluation of noise shield for the hydrostatic module.
- 41 Documentation of design changes.
- 42 Evaluation of clutch control modifications for improved shift quality.

The major automotive hydromechanical transmission development problem continues to be the reduction of hydrostatic noise and the project plan therefore concentrated on the new hydrostatic module. The potential for achieving acceptably low noise levels in the Second Generation hydromechanical transmission is to be assessed by comparing the noise levels of the hydrostatic modules for the first and second generation transmissions. A set of twelve test points were selected comprising of road load steady state and wide-open-throttle acceleration at 10, 20, 30, 40, 50 and 60 mph. The module operating conditions for the two transmissions at each of these twelve points were calculated. Table B-1 shows the conditions for the Second Generation Co-Axial Module designed under this contract. Baseline noise data was measured on the First Generation Module; the results are given in Appendix J.

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Schedule slippage and budget limitations indicated that all work should be concentrated on Task 22. Official notification of this decision was received on April 13 but re-orientation of effort had in fact started in early March. During the current reporting period, therefore, funded work was devoted to Task 22 - module development, and Task 30 - reporting.

On April 11, a project review meeting was held at the Orshansky Transmission facility, San Diego. A list of attendees and the agenda are given in Appendix K. The transmission development status was evaluated by N. Postma and T. Stockton of Ford Motor Company by test-driving the demonstration car in which a First Generation transmission prototype has been installed. The test ratings are given in Appendix K along with results for similar ratings in October 1976 and October 1977. It may be seen that the noise evaluation improved although noise for acceleration still is significantly below the acceptability rating of 5. The General Appraisal improved slightly from a rating of 3 in October 1977 to 3.5 in April 1978.

A final report from Ford Motor Company, as a subcontractor, is expected at the end of September, when noise data from the Second Generation hydrostatic module should be available for comment.

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II. TASK 22

A series of tests were conducted with the variable unit as a pump (H_{VP}) and the fixed unit as a motor (H_{FM}). With the H_{VP} set at maximum displacement, data was recorded at input speeds of zero to 1600 rpm in 400 rpm increments, while charge pressure was varied from 50 to 400 psi in 50 psi increments. These tests were conducted with the output drive shaft disconnected, such that pressure developed by the pump was only sufficient to overcome friction in the H_{FM} unit.

The same series of tests were conducted with the H_{VP} displacement set at zero, ($D_v = 0$). This removes both piston friction and cylinder block tipping moments. To further assure that the pump would do no effective work, (in case it was not set exactly to zero displacement), the low and high pressure ports were each connected to charge pressure.

All of the above data was cross-plotted, but did not divulge any specific solution to the valve plate scuffing, nor the excessive leakage problem. Data sheets and curves are included in Appendix A.

Road load noise tests were run, since this involved maximum speed of 1400 rpm on each unit, and a maximum pressure of about 650 psi. This was to be used for comparison to 1st generation unit, and as a base-line for noise reduction work to follow. See Appendix B for data.

First maximum power noise test point was for 50 mph conditions, with H_{FP} at 1168 rpm, H_{VM} at 3500 and pressure about 1900 psi. This test was completed successfully without valve plate damage. After running 40 mph maximum power point, H_{FP} at 2335 rpm, H_{VM} at 3500 rpm and pressure of 2250 psi, the variable valve plate (motor) was in good condition, but the fixed (pump) valve plate had been damaged.

Observation of the "blued" splines had led to the conclusion that they

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were not being properly loaded. A set of spare shafts had been checked and the crown center-line was in the center of the spline, approximately 0.25 inches from point specified. These were returned to the vendor for rework, which required removal of material and were returned undersize, which increased the backlash. Additional backlash was deemed more acceptable than loading in such a manner that a couple was created in the cylinder block, whose reaction was at the valve plate coincident with the nominal position of reaction for the piston centrifugal moment. These were installed and tested with a total torque loss reduction of about 100 lb-in. at 2500 psi total pressure as shown in Appendix C.

Further visual inspection of spline contact points did not appear to be as expected and several modifications were made, one at a time, and in general, to only one unit at a time. These included reducing O.D of spline by 0.010 in.; removal of 0.190 in. from swashplate end of cylinder barrel spline; removal of 0.45 in. of valve plate end of cylinder barrel spline; providing additional clearance for cylinder barrel spring; switching rotating groups in units; switching valve plates; and testing variable pump - fixed motor, then fixed pump - variable motor. Valve plate damage continued to occur and although slight improvement in torque loss and leakage were accomplished, it became significantly obvious that the high torque losses were always associated with the pumping unit, whether it be fixed or variable.

Up to this point, the high torque loss and excessive leakage was generally assumed to be associated with the same unit. This could occur with one side of the cylinder block lifting, causing leakage while driving the other side thru the oil film, creating friction. Minor modifications were made to the hardware to prevent inter-unit leakage, such that leakage rate of each unit could be observed.

Under laboratory conditions, a steady flow of charge oil was predictable,

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therefore the shoe hold-down plate was not required. This plate was removed during the next run only to ascertain whether or not this could possibly be contributing to the high torque loss. Results showed torque loss to be even higher without the hold-down plate. Oil was collected from each case drain, and weighed. With the variable unit as a pump leak was 140% of the fixed motor leakage, see Appendix D. Switching valve plates gave essentially the same results.

A fixture was made to check shaft deflection while assembled, see Appendix E. Predicted deflections were higher than those measured, and was due to the fact that spline teeth and shoulders were not used in calculations. Since even the predicted values were less than found in most production units, this was deemed to not be a contributor to torque loss or leakage problem.

65# springs were installed to replace the original 120# springs. This reduced the pump torque loss slightly, and pump leakage was now only some 70% of the motor leakage.

All tests to this point had been run with the high pressure kidney on the side opposite the actuators. It was reasoned that if case deflections were creating a problem, the results would be changed if the kidney on the same side as the actuator were pressurized. This was tested with no significant change in results.

Variable cylinder block bearing pads were relieved by 0.0005 in. which reduced the pump torque loss and improved the volumetric efficiency slightly. This same modification was then made to the fixed unit, and the variable unit was modified to give 22 tapered land pads as shown in Appendix F. This test gave essentially same results as earlier tests.

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Hardware inspections have never revealed any evidence of excessive piston friction, yet this too had to be thoroughly investigated. For the first test, the displacement of the variable unit was set at 1.835 in³/rev. Testing at the same input speed and pressure as the last test, the module will still have the same axial loads. Both units will have lower piston velocity, but for different reasons. The variable unit will have shorter stroke, and the fixed unit will have lower rotational speed. This resulted in a significant reduction of input torque loss and was tested to pressures of 4000 psi, without valve plate damage. When operating at pressures above 3500 psi, the fixed unit case drain was pulsating severely. This implied cylinder block/valve plate separation and re-seating, which could be attributed to the lighter springs. The 120# spring was installed in the fixed motor only and re-tested, with considerable reduction in motor leakage. Data and curves for this series of tests are included in Appendix G, and an inter-office memo discussing piston friction in greater detail. Relieving cylinder bores at T.D.C. had no significant effect on either leakage or motor torque loss.

Hardware was modified to permit moving the fixed unit cylinder barrel towards the swashplate to give more piston engagement at B.D.C. This change appeared to reduce motor torque loss, particularly at higher pressures. The variable pump displacement was set at 2.876 in³/rev., and a set of data points taken, then the unit was turned around to run the fixed unit as a pump. With the two units at essentially equal displacements, comparison of these two runs should permit better evaluation of the effect of more piston engagement at B.D.C. Input torque loss was definitely reduced with better piston engagement, so similar modifications were made to the variable unit, and with 120# springs in each unit, the total torque loss (including tare loss) was very close to the predicted value. The volumetric efficiency, however, was some 6% lower than predicted at 3500 psi. Although total torque loss looked quite good, the distribution between pump and motor losses does not appear as

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predicted. Results of this test are included in Appendix H.

Displacement of the variable unit was increased to 3.04 in³/rev., to increase the piston stroke, and retract more of the piston at B.D.C. Changes, if any, from previous run were very hard to detect. Input speed was increased to 2333 rpm and although torque losses were greater than at 1166 rpm, they were in very close agreement to the predicted value, and volumetric efficiency was still 5% low, as shown in Appendix I.

With units at maximum displacement, testing up to 4000 psi and 2333 input speed could be accomplished without severe damage to the valve plates. Tare losses were measured, and when these were accounted for, the module torque loss was slightly less than predicted.

FUTURE TEST PLANS

Investigate possibility of additional piston engagement at B.D.C.
Make new fixture to facilitate more accurate measurement of piston strokes, thus displacement of units, since these directly affect both torque loss and volumetric efficiency calculations. Test to see if module can be run at higher speeds and pressures so that noise data can be recorded for maximum power settings.

Module Test Data

DATE _____

3-1-78

[illegible]

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DATE

3-1

MODULE TEST DATA

REMARKS

FLOW

TEMPERATURE

PRESSURES

INPUT

TIME

OUT

IN

CASE

MANIFOLD
LO HI

IN

CASE

MANIFOLD
LO HI

IN

SPEED

TORQUE

TORQUE

SPEED

19	0950	1202	170	118	62	48	178	2.2	100	148	147	150	.41	
19		1202	132	178	114	100	250	2.2	100	152	152	139	.56	
20		1210	144	228	165	142	310	2.2	102	152	151	141	.70	
21		1199	154	286	213	197	375	2.5	103	152	152	141	.82	
22	1001	1195	164	344	265	248	440	2.8	105	152	152	141	.94	
23		1207	176	396	315	298	495	3.2	107	152	152	142	1.06	
24		1202	186	449	365	348	550	3.4	110	152	152	144	1.19	
25	1011	1208	196	508	420	400	617	3.8	112	153	152	145	1.32	

curve 1
2
4,5,6 & 7

Idle at 115 ~ 400 to road air

26	1020	430	154		427	408	560	3.9	104	123	123	120	1.13	
----	------	-----	-----	--	-----	-----	-----	-----	-----	-----	-----	-----	------	--

30 min

1A-2

DATE 3-1

[illegible]

102

८१

28

72

30

31

32

33

34

•

A-3

MODULE TEST DATA

DATE

3-1

TIME	INPUT		OUTPUT		PRESSURES				TEMPERATURE				FLOW		REMARKS
	SPEED	TORQUE	SPEED	TORQUE	P_{in}	P_c	P_s	P_e	IN	MANIFOLD		CASE	Q	OUT	
					IN	LO	HI	CASE		IN	LO		HI		CASE
1040					70	53	56	2.0	88	151	142	139	³² 33		54.5
					122	100	126	2.1	88	135	129	119	.48		113.
1043	0	0			172	150	155	2.2	88	126	122	111	.60		152.5
	S	S			220	200	204	2.5	87	121	116	104	.69		202.
				270	250	255	2.7	87	118	112	102	.77		252.5	
1045					320	303	304	3.0	87	114	108	98	.85		303.5
					368	347	353	3.2	87	111	105	97	.92		350.
	0	0			400	434	408	2.4	88	107	102	98	.99		416
1048															
Pick-up	PTC														
	1602	264			415	398	690	3.8	90	153	152	131	1.25		345
1053	1604	174			165	150	360	2.6	92	158	157	142	.76		255
1056	1204	192			420	398	620	3.9	94	141	140	131	1.22		509
	1400	222			420	398	650	3.8	98	149	147	133	1.24		524
1102	1003	178			420	398	602	3.8	100	136	136	129	1.20		301
	800	166			418	400	590	3.8	102	131	130	125	1.18		495
	600	156			420	400	565	3.6	103	127	127	123	1.17		482.5
	401	150			420	398	552	3.6	104	123	123	121	1.14		475
1110	1600	152			118	102	283	2.5	106	161	160	147	.67		192.5
1114	1600	152			137	123	302	2.5	106	165	165	153	.74		212.5
	1600	156			167	152	337	2.5	107	168	167	155	.82		244.5
1120	1600	164			190	177	372	2.5	106	166	166	153	.87		271.5

50 min

[illegible]

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SUBJECT

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MODULE TEST DATA

 DATE
 3-2-78

 HV = 1.5 in/g
 REMARKS
 Dv ~ 0

Engine warm-up

 ↓
 currol
 #8 line
 #13

0 Displacement on Pump; Output Shaft Disconnected.

TIME	INPUT		OUTPUT		PRESSURES			TEMPERATURE			FLOW		REMARKS
	SPEED	TORQUE	SPEED	TORQUE	IN	MANIFOLD LO HI	CASE	IN	MANIFOLD LO HI	CASE	IN	OUT	
1638	450	31	—	—	117	91 213	2.1	78	83 84	82	.45	—	
						(Common)							
0814	0	—			152	105		67	67		.36		
					393	368	3.9	73	73 73	76	.89		
	4100	MTL			COMMON ON LOW MTD GAUGE LINE								
0838	456	34			425	395	—	4.0	84 86 88	88	.98		
2	810	44			420	398	—	4.0	84 90 92	89	1.02		
3	1209	50			420	396	—	4.0	85 93 95	91	1.09		
4 0845	1600	54			417	395	—	4.2	87 99 100	96	1.17		
5	400	30			373	353	—	3.8	90 96 96	96	.94		
6	811	40			373	350	—	4.0	90 98 100	97	.97		
7	1197	46			373	350	—	3.9	92 102 103	99	1.04		
8 0854	1600	52			373	348	—	4.0	92 104 105	103	1.12		
9	400	26			320	300	—	3.5	93 102 102	100	.88		
10	800	36			320	300	—	3.5	94 102 103	100	.92		
11	1200	44			317	298	—	3.5	95 104 105	102	1.00		
12 0859	1600	50			315	297	—	3.7	95 106 107	105	1.06		

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MODULE TEST DATA

DATE 3-14-32-78

H₁ = Pump
D₁ = 0
REMARKS

TIME	INPUT		OUTPUT		PRESSURES				TEMPERATURE				FLOW		REMARKS
	SPEED	TORQUE	SPEED	TORQUE	IN	MANIFOLD		CASE	IN	MANIFOLD		CASE	IN	OUT	
						Lo	Hi			Lo	Hi				
0900	400	26			273	252	—	3.3	95	103	104	102	.81		
	800	34			273	253	—	3.3	96	104	105	102	.85		
	1200	42			270	250	—	3.3	96	107	108	104	.92		
	1600	48			268	250	—	3.5	97	107	110	109	.79		
	400	24			225	204	—	2.5	98	106	106	104	.73		
	800	34			223	203		3.0	98	106	107	105	.77		
	1200	42			222	202		3.0	99	108	109	107	.86		
0912	1600	48			222	200		3.2	99	109	110	109	.95		
0915	400	24			173	152		2.6	99	106	107	105	.63		
	800	34			173	150		2.7	99	107	108	106	.69		
	1200	40			173	150		2.7	99	108	109	107	.77		
0919	1600	48			170	148		2.8	99	110	111	110	.87		
0921	400	22			124	103		2.5	99	107	108	106	.53		
	800	32			123	103		2.5	99	107	109	106	.58		
	1200	40			120	100		2.5	99	109	110	109	.67		
	1600	48			120	100		2.5	99	110	111	112	.76		

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DATE

3-2-78

MODULE TEST DATA

 HV = Kemp
 D = 0
 REMARKS

FLOW

IN OUT

TEMPERATURE

IN MANIFOLD CASE

LO HI

PRESSURES

Common

MANIFOLD

LO HI

OUTPUT

SPEED TORQUE

INPUT

SPEED TORQUE

TIME

1329 Started Eng.

1335 2000 66 117 102 2.6 76 90 92 92 .70

 (Inlet Coupling?)
 RATTLES

1343 2000 60 115 98 2.8 88 99 100 103 .77

3000 76 112 92 3.4 88 103 103 112 1.01

1346 4000 94 108 87 3.9 88 107 108 121 1.20

2000 58 265 250 3.5 89 104 104 108 1.10

3000 74 260 244 4.4 90 108 106 115 1.35

4000 90 255 236 5.5 91 109 108 124 1.64

1350 2000 58 415 402 4.3 92 109 107 109 1.27

3000 74 410 395 5.0 93 110 109 115 1.56

1353 4000 92 403 388 6.5 95 111 111 125 1.85

1402

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DATE 3-3-78

MODULE TEST DATA

TIME	INPUT		OUTPUT		PRESSURES				TEMPERATURE				FLOW		REMARKS
	SPEED	TORQUE	SPEED	TORQUE	IN	MANIFOLD		CASE	IN	MANIFOLD		CASE	IN	OUT	
						LO	HI			LO	HI				
Oil Driveshaft disconnected - kidneys externally connected (common pressure).															
1327	0					389		4.5	74	74	74	77	91		Pressure tripped
1337	0					611		4.9	82	82	82	86	120		again
Blow filter -															
1349	restart														
	400	34				503		4.5	84	88	90	90	1.10		
	800	44				504		4.5	85	90	93	91	1.13		
	1200	52				503		4.6	86	95	96	93	1.18		
1359	1600	56				502		4.8	88	100	100	97	1.26		
	2000	64				501		5.0	84	100	100	101	1.34	1.35	
	3000	80				497		5.5	88	105	105	111	1.60		
1602	4000	98				493		6.6	90	108	108	120	1.90		

blew filter -

1327
1337
1338

1359

1602

INPUT TORQUE VS CHARGE PRESS. @ NO LOAD

$D_v = 3.04$
 $D_F = 2.867$

3-1-78

3-1-78

Leakage at Speed less Leakage at Zero Speed

3-1-78

Δ LEAKAGE VS INPUT SPEED @ CONSTANT PRESSURE

$D_v = 3.04$

$D_F = 2.867$

3-1-78

3-1-78

ΔP VS INPUT SPEED @ CONSTANT CHARGE PRESSURE

$D_v = 3.04$

$D_k = 2.867$

3-1-78

3-1-78

Δ LEAKAGE VS CHARGE PRESSURE @ CONSTANT SPEED

$D_v = 3.04$

$D_f = 2.867$

Δ LEAKAGE

.25

.20

.15

.10

.05

0

0

100

200

300

400

CHARGE PRESSURE P.S.I.

1600 RPM

1200 RPM

800 RPM

400 RPM

1000 RPM

.34

.32

3-1-78

3-1-78

ΔP VS CHARGE PRESSURE @ CONSTANT INPUT SPEED

$DV = 3.04$

$DF = 2.867$

3-1-78

3-2-78

2-2-78

3-2-78

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HYDRAULIC MODULE NOISE TESTING PARAMETERS

Test Conditions for Coaxial Hydrostatic Module for
Second Generation Automotive Hydromechanical Transmission

M A X I M U M P O W E R

Vehicle	Pump			Motor			
Speed	RPM	TORQUE	DISP.	RPM	TORQUE	DISP.	PR
10	3500	1103	1.13	1166	2500	2.88	5827
20	3500	1633	2.10	2333	1976	2.88	4535
30	3500	1633	3.02	3500	1329	2.88	3128
40	2334	1098	2.88	3500	569	1.83	2244
50	1168	922	2.88	3500	211	.91	1881
60	1	845	2.88	3500	58	.03	1993

R O A D L O A D

10	260	81	2.88	713	0	1.05	80
20	587	87	2.88	730	0	2.31	110
30	754	129	1.84	483	114	2.88	418
40	933	233	2.88	933	150	2.88	451
50	1166	277	2.88	1166	189	2.88	535
60	1400	327	2.88	1400	233	2.88	634

MODULE TEST DATA

DATE
4-1-78H_V = PumpD_V = 2.876

REMARKS.

N_V T_{LP} T_{LM}

FLOW

N_Q P_T

TEMPERATURE

MANIFOLD
LO HICASE
H_V/H_F

PRESSURES

CASE
H_V/H_F

OUTPUT

SPEED TORQUE

INPUT

SPEED TORQUE

TIME

1	No lube oil to inner sealing land															H _V /H _F											
2	Shoe hold-down plate omitted from H _V unit only - (I know retaining R).																										
3						177	165												0*								
4	* visual shows essential equal leakage both units.																										
5	1001	530	538	518	380	176	168	1180	1.6	92	97	103	90/45	.13	1348	97.4	74.8	81.8									
6	1006	699	698	689	75	176	166	495	1.6	90	121	122	107/116	.08+	661	98.3	47.4	75.1									
7	H _V has ~40% more leakage (visual)																										
8	1013	Shut-down - leakage ~ identical (visual)																									
9	1014	Start																									
10	1018	794	774	777	40	172	161	442	1.4/2	91	141	142	136/143	.145	603	97.6	45.4	88.2									
11	1022	880	454	751	285	170	157	985	2.4/22	102	143	145	147/152	.37	1142	93.6	75.0	92.8									
12	same leakage w/ maybe most @ H _V																										
13	1025	903	614	742	420	167	154	1292	1.6/2.4	112	146	148	153/157	.56	1446	92.1	95.1	99.3									
14	leakage - Some - Visual																										
15	1033	791	832	708	595	163	149	1670	2.4/3.0	120	149	152	163/163	.86	1819	89.2	135.8	99.1									
16	1038	806	908	702	650	160	145	1870	2.5/3.1	122	149	152	165/164	1.01	1965	86.8	141.3	114.4									
17	leakage - bucket -															H _F = 7#10, -1#9, H _V = 9#4, -1#1005,									(less bucket of)		
18																5#603,											
19																7#103											
20	1052	797	1262	634	940	146	114	2425	4.5/4.4	131	153	157	173/171	1.72	2539	79.3	204.2	114.6									
21	H _V 9 6															H _F 7-2											
22	1-10															1-9											
23	7-12															5-7											
24																L _{HV} /L _{HF} = 7.75/5.4375 = 1.425									Tip is higher		
25																No Valve R distress!!									It is worse		

see Curve 9

T_{LP} is higher } than previous
N_V is worse } than previous

VOL. EFFICIENCY
 η_v

COMPUTER PREDICTION

$$\eta_p = \eta_v = 800 \text{ RPM}$$

$$\frac{D_v}{D_F} = \frac{2.876}{2.8672} = 1.0031$$

4/1/78

300

200

Trans ~ 16. in.

100

$$T_{LM} = T_{LP}$$

higher $T_{LP} \neq$
lower η_v
than previous run

T_{LVP}
 η_v based on Q_v

T_{LFM}

4/1/78
Hv - w/o shoe hold-down
& retainers plate.

η_v

$\square T_{LP} = T_{LV}$

$\times T_{LM} = T_{LF}$

w/o Lube Oil to Either Unit

4000

5000

1000

2000

3000

$$P_T = P_L + P_H \sim \text{P.S.L.}$$

90

VOLUMETRIC EFF %

80

70

dial indicator

4-4-78

Deflection - Variable Shaft ~ inches

.0002

'P' pressure supplied to all eleven pistons
i.e. 2500 p.s.i. provides same shaft bending
as 5000 p.s.i. acting on 5 1/2 pistons.

MODS & REPAIRS

VALVE PLATES

Both lapped in order to aid in ^{visual} detection of damage after next run.

CYL. BLOCKS

H_F - .0005 removed from bearing pad surface to determine effect on motor

H_V - bearing pad surface modified to give 22 taper land pads

22

$H_v = \text{PUMP}$

$N_p = 1165$

$$\frac{D_p}{D_m} = \frac{2.876}{2.867} = 1.003$$

65# Springs - Both Units

Δ Vol. EFF.

$\circ$ T_{LO}

$\square$ T_{LIN}

4-19-78

$H_v = \text{PUMP}$
 $N_p = 1165$

$$\frac{D_p}{D_M} = \frac{2.876}{2.867} = 1.003$$

65# Springs - Both Units

- Q_{TOTAL}
- △ Q_{LP}/Q_{LM}
- Q_{LM}
- Q_{LP}

4-19-78

CHECKED BY

 ORSHANSKY TRANSMISSION CORPORATION
 ENGINEERING CALCULATION FORM

 PAGE 1 OF 2
 PROGRAM 48-22

SUBJECT

MODULE TEST DATA

DATE 4-20-78

TIME	INPUT		OUTPUT		w/accum. PRESSURES			TEMPERATURE	Q ₁ /Q _m		H ₀ = Pump FLOW	D ₁ = 1.875 D _F = 2.8672		REMARKS	T _{6A}				
	SPEED	TORQUE	SPEED	TORQUE	IN	MANIFOLD			IN	MANIFOLD		IN	P _T			T ₆	T _{LP}	T _{LM}	
						LO	HI			LO									HI
1003	1169	94	733	45	159	148	348	-	76	133	112	127/133	.05	496	98.0	35.6	46.3	30.0	
1049	1204	88	759	20	151	140	328		88	152	153	152/154	.09	468	97.7	33.1	65.8	14.2	
1052	Q ₁ = .9375 ^H = .06389pm		Q _m = 1.0625 (1.0723)					t = 2		Q ₁ /Q _m .8824		.1361							
1058	1166	82	729	20	149	138	312		92	155	155	155/157	.15	450	97.7	31.2	59.4	15.2	
1105	1191	154	734	115	186	173	578		100	149	150	152/154	.18	751	96.3	35.7	69.8	46.0	
		1.625	.1105		1.4375	.0978		2		1.1304 (2.1346)		.2083							
1111	1155	152	716	115	185	172	578		103	150	149	153/155	.18	750	96.9	33.4	70.3	46.9	
1114	1159	234	707	235	183	170	840		104	147	149	152/154	.25	1010	95.3	38.3	70.7	41.3	
1117		2.00	.1361		2.1875	.1488		2		.9143		.2849							
1119	1153	248	701	255	182	169	887		108	149	149	153/156	.28	1056	95.0	38.3	72.6	62.5	
1122	1183	314	708	355	181	167	1105		112	149	150	153/156	.36	1272	93.5	40.1	73.0	67.7	
1124		2.6875	.1828		2.875	.1956		2		.9348		.3784							
1129	1178	318	705	360	180	166	1122		115	151	153	156/159	.36	1288	93.5	38.8	76.3	67.8	
1131	1146	500	656	625	177	163	1718		120	149	153	157/161	.63	1881	89.4	45.9	84.6	71.6	
1135		4.1875	.2849		5.50	.3741		2		.7614		.6590							
1137	1068	588	599	760	174	160	7020		125	149	152	158/163	.78	2180	87.6	44.8	88.8	72.5	
1140	1165	662	632	865	173	158	2260		128	153	155	161/167	.90	2418	84.8	48.1	94.2	70.9	
1142		5.375	.3656		8.4375	.5740		2		.6370		.9396							
1146	1159	.666	631	870	172	156	2270		129	153	155	163/168	.96	2426	85.1	48.6	94.7	71.1	
1153	1169	1058	546	1405	154	115	3480		133	152	158	163/173	1.80	3595	79.0	75.3	130.5	620.78	
		3.875	.5272		10.625	1.4456		1		.3647		1.9728							
1158	1137	1202	4.4	585	4	132	3860		136	157	162	176/179	2.60	3992	638	113.2	116.2	53.8	

$H_v = \text{PUMP}$

$N_p = 1165$

$$\frac{D_p}{D_m} = \frac{1.835}{2.867} = .640$$

65# Springs - Both Units

Hv = Pump

Np = 1165

$$\frac{Dp}{Dm} = \frac{1.835}{2.867} = .640$$

65# Springs - both Units

LEAKAGE - ~ G.P.M.
2
00

Δ QLP/QLM

○ QLM

□ QLP

· QTOTAL

4-20-78

$$H_v = P_{\text{pump}}$$

See curve
26.427

$HV = \text{PUMP}$
 $N_P = 1165$
 $\frac{DP}{DM} = \frac{1.835}{2.867} = .640$
 65# Pump Spring
 120# Motor Spring

$H_v = \text{PUMP}$

$N_p = 1165$

$$\frac{D_p}{D_m} = \frac{1.835}{2.867} = .640$$

65# Pump Spring

120# Motor Spring

2

G.P.M.

LEAKAGE

6-9
00

4-20-78

5000

ORSHANSKY TRANSMISSION CORPORATION

April 24, 1978

To: Peter Huntley
 From: Ken Rudolph
 Subject: In-line Hydrostatic Module Development

REVIEW OF TEST STATUS

Test run on 4/19 was primarily to check individual leakage rates of pump and motor in addition to normal torque loss curves and volumetric efficiency. Torque loss curves include test set-up tare losses.

Curve 22 shows typical torque loss and volumetric efficiency for recent tests. Curve 23 shows excessive leakage at both units, with the fixed motor showing the greatest leakage. Since both units are physically the same, this difference in leakage could be attributed to piston friction. Piston friction 'seats' the pump valve block, and 'unseats' the motor valve block. This could also explain the pump valve plate scoring while motor valve plate is generally unmarked.

Piston friction consists of three types: 1) f1, normal 'sliding' friction, as a function of velocity; 2) f2, piston 'cocking' at B.D.C., as a function of torque, thus pressure; and 3) f3, piston 'sticking' at T.D.C. due to poor bores and/or piston swelling, as a function of pressure. At the present time, sliding friction (f1) is assumed to be minimal. To test for f2 and f3, the pump displacement was reduced from 2.876 to 1.835 CIPR. For the same pump speed, and same system pressure, this modification was expected to produce the following changes:

	<u>Expected Change</u>	
	<u>Variable</u> <u>Disp. Pump</u>	<u>Fixed</u> <u>Disp. Motor</u>
Axial load on housings and bolts	None	None
Shaft bending loads	Reduced (1)	None
Windage loss	None	Reduced (2)
Piston friction:		
f1 - sliding	Reduced (3)	Reduced (2)
f2 - cocking at B.D.C.	Reduced (4)	None
f3 - sticking at T.D.C.	Reduced (4)	None
Leakage	Reduced (5)	Reduced (6)

April 24, 1978
Page 2

To: Peter Huntley
From: Ken Rudolph
Subject: In-line Hydrostatic Module Development

NOTES:

- (1) Calculations and lab tests show this not to be a problem at full displacement and pressure, therefore affect should be minimal.
- (2) Torque loss improvements in motor will be a result of these two items.
- (3) Assumed to have only minor affect on pump torque loss, and could be estimated from motor torque loss improvements as noted in (2).
- (4) If either of these has been the problem, the shorter pump piston stroke should result in significant torque loss reduction.
- (5) Reduced pump leakage could be due to lower piston velocity and possibly more stable cylinder block/valve plate interface.
- (6) Reduced motor leakage would be a result of lower piston velocity. Lower piston velocity could also affect piston cocking (f2) and sticking (f3), and thus provide more stable cylinder block/valve plate interface.

Test results at reduced pump displacement are shown on curves 24 and 25. Comparison of these with previous curves shows minor improvements in motor torque loss and significant pump torque loss reduction. A portion of the motor torque loss improvement attributed to lower piston velocity was also present in the pump unit, as noted in Note 3, and is only a minor affect as assumed. This leads to conclusion that piston cocking at B.D.C. and/or piston sticking at T.D.C. has been the prime contributor to inefficiencies.

Comparison of curves 23 and 25 shows reduced leakage in both units, with the most significant change occurring in the pump. If the remarks in Note 5 are a valid explanation of this result, then the motor leakage should be reduced, if heavier springs were installed in the motor. Curves 22 thru 25 were for tests run with 65# springs in each unit, although original design was for 120# springs.

Curves 26 and 27 show results with the 120# springs installed only in the motor. This not only reduced motor leakage, as expected, but also reduced motor torque losses.

To: Peter Huntley
From: Ken Rudolph
Subject: In-line Hydrostatic Module Development

These tests lead to the conclusion that piston friction must be reduced. For the moment it is still assumed that normal sliding friction, f_1 , is not the primary problem. This leaves piston cocking, f_2 , and piston sticking, f_3 , to be resolved.

FUTURE TEST PLANS

The next test will be made with the cylinder barrel bores relieved at the bottom of the bores, (T.D.C.). This will reduce the possibility of bad bores as the cause of high torque losses and leakage, particularly at higher pressures. The results will show only in the motor, since the pump will still be at partial displacement.

During the past two tests, there has been no valve plate damage, therefore if the next test does show reduced motor leakage, the pump displacement will be returned to 2.876 CIPR without disassembly, and tested for pump leakage.

If piston bore reliefs show little or no improvement in performance, the conclusion will be that piston cocking at B.D.C. is the problem. If this proves to be true, the solution may well require some re-design and new hardware. The Sundstrand Series 18 pistons are being used in our units with a piston engagement at B.D.C. of approximately 0.78 inches, for an L/D ratio of 1.21. In the Sundstrand unit, 0.98 inches piston engagement for an L/D ratio of 1.52 exists at B.D.C. This is brought about by the fact that we have slightly longer piston strokes (.021 in fixed unit and .063 max. in variable unit), and that we have about .17 less piston entrance into cylinder bore at T.D.C., due to our hold-down mechanism. Our longer piston stroke combined with a larger pitch radius (1.49 vs. 1.196) to the pistons results in more cylinder block upsetting moments due to centrifugal force on pistons. This may have been a prime contributor to our early failures at higher speeds and low pressures.

KR:lw
Enclosures

curves 22 thru 27 included

*26 & 27 are only enclosures here to
show Computer pred. points which were
not on orig. curves.*

.357 thick Valve Pl. on each unit #120th springs H1 = Pump

TIME	INPUT		OUTPUT		PRESSURES				TEMPERATURE				FLOW		REMARKS				M _{OA}	T _{LT}	CHECKED BY	PREPARED BY
	SPEED	TORQUE	SPEED	TORQUE	IN	MANIFOLD		CASE V/F	IN	MANIFOLD		CASE V/F	IN	P _T	T _{LE}	T _{LP}	T _{LM}					
						LO	HI			LO	HI											
1441	1414	688	1329	515	160 150	150 144	1488	1.5/3.3	104	163	168	168/176	.44	1638	93.7	75.6	95.6	70.4	171.2	SUBJECT ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	DATE 5-24-79	PAGE 07
1450	1416	684	1328	505	157	147	1460		110	173	174	179/183	.51	1607	93.9	63.0	94.2	71.6	157.2			
1459	1399	656	1318	490	155	145	1430		114	174	176	181/184	.51	1575	93.9	67.8	96.4	70.4	164.2			
1504	1167	568	1102	425	154	144	1245	P/M	117	173	173	181/182	.48	1389	94.1	64.0	77.4	70.7	145.5	MODULE TEST DATA	DATE 5-24-79	PAGE 07
	1.125	.153	2.0	.272				.563					.425									
1510	1178	684	1102	530	153	143	1475		119	168	171	176/178	.52	1618	93.3	74.3	77.8	72.5	152.1			
1516	1164	806	1099	660	151	140	1750		122	169	171	179/180	.58	1890	92.4	69.1	74.7	75.9	143.7	MODULE TEST DATA	DATE 5-24-79	PAGE 07
1521	1.375	.187	2.75	.374				.500					.561									
1527	1166	840	1079	695	154	144	1830		116	166	168	176/177	.59	1974	92.3	68.3	74.4	76.6	142.6			
1531	1172	1018	1068	860	152	140	2200		118	164	168	176/177	.68	2340	90.8	75.1	80.0	77.0	155.1	MODULE TEST DATA	DATE 5-24-79	PAGE 07
	1.6875	.230	3.3125	.451				.509					.680	Eng. up to 2225								
1540	1151	1162	1031	1000	159	147	2480		122	168	170	188/181	.84	2627	89.3	94.1	64.6	77.1	158.7			
1545	1156	1256	1030	1060	158	146	2660 ⁺						.88	2796	88.8	109.8	82.6	75.2	152.5	MODULE TEST DATA	DATE 5-24-79	PAGE 07
1549	1171	1234	1042	1080	158	146	2660						.89	2806	88.7	83.3	67.2	77.9	150.5			
1555	1159	1582	992	1385	162	144	3320		125	170	171	188/185	1.27	3464	85.3	128.3	64.3	74.9	192.6			
	3.375	.459	6.4375	.976				.524					1.335							MODULE TEST DATA	DATE 5-24-79	PAGE 07
1601	1168	1596	1002	1405	164	147	3360		120	168	169	187/183	1.22	3507	85.5	125.3	61.2	75.5	195.5			
																(1)	(2)					
Avg 30	1159.33	1247.33	1034.33	1046.67		146.33	2596.67						.870	2743	88.9	95.7	71.5	76.7	147.2	MODULE TEST DATA	DATE 5-24-79	PAGE 07
1608	1746	1834	1502	1580	165	136	3810						1.72	3746	85.8	152.3	96.6	74.1	248.9			

See curves 42 & 43

last comparable run curve 34

(1) $f_{il} = 85\%$ $T_{LP} = 15.0072 + .0304 P_T$ (2) $f_{il} = 44\%$ $T_{LM} = 8.9.0380 + .0068 P_T$

ORSHANSKY TRANSMISSION CORPORATION
ENGINEERING CALCULATION FORM

PAGE 07

PROGRAM 48-22

DATE 5-24-70

$$\begin{aligned} \eta_v &= 1166 \\ H_v &= \text{PUMP} \\ \frac{D_v}{D_F} &= \frac{2.876}{2.3672} = \end{aligned}$$

LEAKAGE, G.P.M. & RATIO

$\frac{1}{V} = \text{Pump.}$

TIME	INPUT		OUTPUT		PRESSURES				TEMPERATURE				FLOW		REMARKS				Mo	JL	CHECKED BY	PREPARED BY					
	SPEED	TORQUE ±1	SPEED	TORQUE ±2.5	IN	MANIFOLD		CASE	IN	MANIFOLD		CASE V/F	IN	P _r	T _{in}	T _{oil}	T _{out}										
						Lo	Hi			Lo	Hi																
0945	~1160	530	1181	355	176	165	1130	-	96	152	159	158/166	.36	1295	96	63.1	85.4	68.2	148.5								
1027	2342	298	2438	95	149.1	160	620	74.7/45.3	112	202	205	205/214	.57	780	98.1	75.4	114.9	332	198.3								
1032	2344	462	2400	240	147	154	945	82.2/66.5	117	204	204	212/218	.76	1099	96.6	79.3	121.0	532	208.2								
1035	2354	564	2392	340	147	151	1170	87.4/73.1	122	201	202	211/216	.88	1321	95.8	71.0	125.0	61.3	196.5								
1038	2340	732	2353	470	146	146	1480	88.2/77.2	124	200	200	210/214	.98	1626	94.8	86.6	138.7	64.6	225.3								
1044	2344	852	2339	605	146	151	1720	89.1/84.6	123	198	198	209/213	1.07	1871	94.1	92.9	111.0	70.9	203.8								
1046	2348	972	2323	705	145	151	1960	90.1/85.4	120	195	195	208/210	1.16	2111	93.3	96.7	120.5	71.8	217.2								
1050	2343	1112	2295	840	147	147	2240	91.1/87.9	120	194	195	208/210	1.26	2387	92.4	99.3	115.1	74.0	224.4								
1054	2325	1212	2264	900	144	144	2400	90.1/87.4	122	195	195	209/211	1.35	2544	91.8	120.5	129.5	72.3	230.0								
1056	2329	1398	2236	1085	141	141	2475	91.2/90.3	123	195	195	211/212	1.56	2916	92.5	123.6	117.0	74.5	240.6								
1100	2353	1658	2214	1300	140	140	3295	92.1/90.3	126	197	197	214/217	1.89	3435	88.7	131.5	139.7	73.8	271.2								
1104	2332	1880	2154	1475	142	142	3690	91.3/91.1	125	196	195	218/217	2.18	3832	87.1	163.4	144.1	72.5	307.4								
1108	2251	1958	2064	1545	159	159	3850	91.2/91.7	125	195	193	219/216	2	4009	86.5	172.2	139.3	72.4	311.5								
recheck at lower power point																				124.2 138.2 w/ corrected displacement		75.5 w/o tare					
1112	2339	510	2386	295	151	151	1040	84.3/72.7	120	-	-	-	.76	1191	96.2	79.9	110.7	59.0	190.6								
																				DATE 5-26-79		PROGRAM 48-22		PAGE OF			

See curves 46 & 47

$$\eta_{in} = \frac{T_{in} - T_{oil}}{T_{in}}$$
$$\eta_{to} = \frac{T_o}{T_o + T_{to}}$$

See curves
46 & 47

$$\eta_{T_{in}} = \frac{T_{in} - T_{L_{in}}}{T_{in}}$$

$$N_{T_0} = \frac{T_0}{T_0 + T_{L0}}$$

46

46 0782

47

$\eta_v =$

$H_v = \text{PUMP}$

$\frac{D_v}{D_f} = 2.9672$

LEAKAGE, G.P.M. & RATIO

I-3

Q_{LT}

~~2~~ $2Q_{LM}$ per Computer Prediction

$\Delta Q_{LP}/Q_{LM}$

$\circ Q_{LM}$

$\square Q_{LP}$

$\triangle Q_{LT}$

5-16-78

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 1 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE NOISE TEST CONDITIONS	DATE 3-7-78

MAXIMUM ENGINE POWER

MPH	PUMP RPM	PUMP TORQUE IN-LB	MOTOR RPM	PRESSURE PSI	GRAPH CODE	LOG ENTRY	DB(A)
10	3177	1220	781	5300	461	108.14	102.1
20	3000	1632	1460	3950	463	108.8	99.6
30	2511	1326	2322	1920	449	106.19	104.9
40	1908	1312	3292	1950	451	106.18	97.4
50	3500	1006	1640	2880	465	108.12	107.9
60	3165	1022	1955	2333	467	108.13	108.7

ROAD LOAD

MPH	PUMP RPM	PUMP TORQUE IN-LB	MOTOR RPM	PRESSURE PSI	GRAPH CODE	LOG ENTRY	DB(A)
10	715	188	326	520	469	108.10	81.9
20	380	360	700	600	471	108.11	81.7
30	939	64	0	1250	453	107.7	84.8
40	1240	194	245	1200	455	106.14	85.8
50	1546	226	301	1430	457	106.13	86.4
60	1863	216	314	1410	459	106.16	90.8

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 2 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 10 MPH - FULL POWER	DATE 3-7-78

UNIT SPEED = 3200RPM

LOG SHEET 108.14

NO.	PEAK	FREQUENCY
1	103.0	1410.0
2	98.3	460.0
3	94.8	940.0
4	89.5	1150.0
5	89.5	1880.0
6	88.5	415.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	0.0	-3.0	-3.0	-8.5	-11.5
500	98.7	-2.5	96.2	-3.0	93.2
1000	103.8	-2.5	101.3	0.0	101.3
2000	89.5	-2.0	87.5	1.0	88.5
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	102.6		DBA = 102.1

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 3 OF 13
CHECKED BY		PROGRAM
		DATE 3-7-78
	SUBJECT 1ST GENERATION MODULE 20 MPH - FULL POWER.	

UNIT SPEED = 3100RPM

LOG SHEET 108.80

NO.	PEAK	FREQUENCY
1	100.8	460.0
2	96.5	1390.0
3	92.5	1430.0
4	91.0	410.0
5	88.8	260.0
6	88.0	510.0
7	87.6	910.0
8	88.0	1070.0
9	86.2	945.0
10	86.4	1320.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	88.8	-3.0	85.8	-8.5	77.3
500	101.4	-2.5	98.9	-3.0	95.9
1000	98.1	-2.5	95.6	0.0	95.6
2000	92.5	-2.0	90.5	1.0	91.5
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	101.1		DBA = 99.6

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 4. OF 13
CHECKED BY		PROGRAM
		DATE 3-7-78
	SUBJECT 1ST GENERATION MODULE 30 MPH - FULL POWER	

UNIT SPEED = 2500RPM
LOG SHEET 106.19

NO.	PEAK	FREQUENCY
1	104.0	380.0
2	99.5	750.0
3	98.0	1380.0
4	96.0	1510.0
5	95.0	1040.0
6	95.2	1740.0
7	94.4	1070.0
8	94.0	1580.0
9	93.3	700.0
10	93.5	1460.0
11	92.0	1130.0
12	91.5	350.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	91.5	-3.0	88.5	-8.5	80.0
500	104.4	-2.5	101.9	-3.0	98.9
1000	103.0	-2.5	100.5	0.0	100.5
2000	101.7	-2.0	99.7	1.0	100.7
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	105.6		DBA = 104.9

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 5 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 40 MPH - FULL POWER	DATE 3-7-78

UNIT SPEED = 1900RPM
LOG SHEET 106.18

NO.	PEAK	FREQUENCY
1	97.5	300.0
2	93.0	1490.0
3	92.5	500.0
4	92.4	585.0
5	89.0	1450.0
6	88.4	1160.0
7	88.0	1740.0
8	87.3	870.0
9	86.3	550.0
10	86.0	990.0
11	86.0	1360.0
12	84.5	1230.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	97.5	-3.0	94.5	-8.5	86.0
500	96.0	-2.5	93.5	-3.0	90.5
1000	93.6	-2.5	91.1	0.0	91.1
2000	95.3	-2.0	93.3	1.0	94.3
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	99.3	DBA =	97.4

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 6 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 50 MPH - FULL POWER	DATE 3-7-78

UNIT SPEED = 3600RPM

LOG SHEET 108.12

NO.	PEAK	FREQUENCY
1	105.0	1585.0
2	104.9	1210.0
3	103.0	525.0
4	98.2	1050.0
5	94.8	965.0
6	94.0	1250.0
7	94.1	1290.0
8	93.0	1480.0
9	92.7	1860.0
10	92.0	1340.0
11	91.0	1100.0
12	91.0	765.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	0.0	-3.0	-3.0	-8.5	-11.5
500	103.0	-2.5	100.5	-3.0	97.5
1000	107.0	-2.5	104.5	0.0	104.5
2000	105.5	-2.0	103.5	1.0	104.5
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	107.9	DBA =	107.9

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 7 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 60 MPH - FULL POWER	DATE 3-7-78

UNIT SPEED = 3200RPM
LOG SHEET 108.13

NO.	PEAK	FREQUENCY
1	107.2	1435.0
2	99.8	1920.0
3	99.2	955.0
4	97.5	1170.0
5	96.8	1245.0
6	96.0	1620.0
7	95.8	1380.0
8	95.7	480.0
9	95.5	1215.0
10	95.3	1490.0
11	94.0	1320.0
12	94.0	1725.0

OCTAVE BAND CENTER FREQUENCY HZ	MEASURED SOUND PRESSURE DB	ROOM CORRECTION DB	POWER LEVEL DB	A WEIGHT CORRECTION DB	CORRECTED LEVEL DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	0.0	-3.0	-3.0	-8.5	-11.5
500	95.7	-2.5	93.2	-3.0	90.2
1000	104.6	-2.5	102.1	0.0	102.1
2000	108.6	-2.0	106.6	1.0	107.6
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	108.0		
				DBA =	108.7

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 8 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 10 MPH - ROAD LOAD	DATE 3-7-78

UNIT SPEED = 750RPM
LOG SHEET 108.10

NO.	PEAK	FREQUENCY
1	79.2	400.0
2	77.6	1300.0
3	77.2	545.0
4	75.5	325.0
5	74.8	1200.0
6	74.2	435.0
7	73.4	870.0
8	72.2	645.0
9	72.2	1390.0
10	72.0	1415.0
11	71.0	1525.0
12	71.0	1820.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	75.5	-3.0	72.5	-8.5	64.0
500	82.5	-2.5	80.0	-3.0	77.0
1000	81.0	-2.5	78.5	0.0	78.5
2000	76.1	-2.0	74.1	1.0	75.1
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	83.3		DBA = 81.9

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 9 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 20 MPH - ROAD LOAD	DATE 3-7-78

UNIT SPEED = 400RPM

LOG SHEET 108.11

NO.	PEAK	FREQUENCY
1	79.0	545.0
2	78.2	400.0
3	75.0	1290.0
4	74.5	1200.0
5	74.5	325.0
6	74.2	1420.0
7	73.5	255.0
8	73.3	430.0
9	72.8	1525.0
10	73.0	1615.0
11	72.5	285.0
12	71.8	1810.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	78.3	-3.0	75.3	-8.5	66.8
500	82.2	-2.5	79.7	-3.0	76.7
1000	77.8	-2.5	75.3	0.0	75.3
2000	79.1	-2.0	77.1	1.0	78.1
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	83.3	DBA =	81.7

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 10 OF 13
CHECKED BY		PROGRAM
		DATE 3-7-78
	SUBJECT 1ST GENERATION MODULE 30 MPH - ROAD LOAD	

UNIT SPEED = 900RPM
LOG SHEET 107.70

NO.	PEAK	FREQUENCY
1	84.0	562.0
2	79.0	1540.0
3	78.5	985.0
4	77.8	835.0
5	75.3	710.0
6	74.5	1280.0
7	73.5	1575.0
8	72.8	425.0
9	72.0	285.0
10	72.0	870.0
11	72.0	1690.0
12	71.8	1960.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	72.0	-3.0	69.0	-8.5	60.5
500	84.3	-2.5	81.8	-3.0	78.8
1000	83.2	-2.5	80.7	0.0	80.7
2000	81.2	-2.0	79.2	1.0	80.2
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	85.6	DBA =	84.8

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 11 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 40 MPH - ROAD LOAD	DATE 3-7-78

UNIT SPEED = 1200RPM
LOG SHEET 106.14

NO.	PEAK	FREQUENCY
1	84.5	730.0
2	80.8	360.0
3	80.2	390.0
4	78.2	1290.0
5	78.2	1640.0
6	76.2	530.0
7	75.8	1250.0
8	75.0	260.0
9	74.8	280.0
10	74.5	870.0
11	74.0	930.0
12	73.8	150.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	73.8	-2.5	71.3	-16.0	55.3
250	77.9	-3.0	74.9	-8.5	66.4
500	84.3	-2.5	81.8	-3.0	78.8
1000	86.4	-2.5	83.9	0.0	83.9
2000	78.2	-2.0	76.2	1.0	77.2
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	86.8		DBA = 85.8

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 12 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 50 MPH - ROAD LOAD	DATE 3-7-78

UNIT SPEED = 1600RPM
LOG SHEET 106.13

NO.	PEAK	FREQUENCY
1	83.2	695.0
2	82.6	1160.0
3	82.5	470.0
4	81.8	410.0
5	80.8	1640.0
6	78.4	1390.0
7	78.2	235.0
8	76.0	930.0
9	75.5	290.0
10	73.8	10.0
11	73.0	520.0
12	73.0	1210.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ	DB	DB	DB	DB	DB
125	80.0	-2.5	-2.5	-16.0	-18.5
250	80.1	-3.0	77.1	-8.5	68.6
500	87.5	-2.5	85.0	-3.0	82.0
1000	84.9	-2.5	82.4	0.0	82.4
2000	80.8	-2.0	78.8	1.0	79.8
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	87.9	DBA =	86.4

PREPARED BY R. Millar	ORSHANSKY TRANSMISSION CORPORATION ENGINEERING CALCULATION FORM	PAGE 13 OF 13
CHECKED BY		PROGRAM
	SUBJECT 1ST GENERATION MODULE 60 MPH - ROAD LOAD	DATE 3-7-78

UNIT SPEED = 1900RPM

LOG SHEET 106.16

NO.	PEAK	FREQUENCY
1	94.4	550.0
2	86.6	1390.0
3	85.2	275.0
4	83.8	830.0

OCTAVE BAND CENTER FREQUENCY	MEASURED SOUND PRESSURE	ROOM CORRECTION	POWER LEVEL	A WEIGHT CORRECTION	CORRECTED LEVEL
HZ.	DB	DB	DB	DB	DB
125	0.0	-2.5	-2.5	-16.0	-18.5
250	85.2	-3.0	82.2	-8.5	73.7
500	94.4	-2.5	91.9	-3.0	88.9
1000	88.4	-2.5	85.9	0.0	85.9
2000	0.0	-2.0	-2.0	1.0	-1.0
4000	0.0	-0.5	-0.5	1.0	0.5
		DB =	93.2	DBA =	90.8

461

11

11

9

8

2K

463

3. 16/10

449

$$10 \frac{30}{10} = 120 \text{ DB}$$

Log 106-19

max power 30 mph

451

$$\frac{30}{10} = 110$$

Log 106-18 max POWER 40mph
110

465

467

465

by 108 line 10
10 MPH Road Road

2K

471

90

Log 108 line 11
20 MPH Road Road

2K

453

$$\frac{20}{10} = 100$$

ROAD LOAD _{30MPH} Log 107-7

455

Log 106-14

46 0782

457

RAW NOISE

100 - 13

1001

46 0782

$$\frac{12.20}{0.12} = 100$$

459

log 106-16

60 mph

ORSHANSKY TRANSMISSION CORPORATION

APRIL 11, 1978 PROJECT REVIEW MEETING

ATTENDEES:

P. Huntley

J. Pratt

W. Weseloh

B. Huffman

D. Connett

G. Olsen

K. Rudolph

Orshansky Transmission
Corporation

N. Postma

T. Stockton

Ford Motor Company

P. Manning

TARADCOM, Warren, MI

H. Themak

Dept. of Energy, Washington D.C.

R. Parker

NASA Lewis Research Center

ORSHANSKY TRANSMISSION CORPORATION

A G E N D A

April 11 and 12, 1978

Huntley's Office

8:00 A.M. - 8:30 A.M. Introduction, Huntley

Outline project, purpose of meeting.

Explain current status - no noise data.

What we hope to accomplish today without noise results.

Arrangements for Meeting

8:30 - 9:15

Review efficiency data on In-Line Hydrostatic Module for
Second Generation HMT, D. Connett

Summarize current status and problems.

Tests we have run.

Theories on nature of problem.

Design philosophy - comparison with other units.

Review efficiency results.

9:15 - 9:30

Review noise data for First and Second Generation
Modules, K. Rudolph

Definition of test points.

Results.

Further port-plate modifications.

9:30 - 10:15

Digital Controller, Description, B. Huffman

Review evolution of controllers.

Method of operation and special features of digital
controller.

10:15 - 10:30

Digital Controller Application, W. Weseloh

Examples of controller application.

10:30 - 12:00

Meeting divides into two groups, each group spending
45 minutes on each of the following topics:

ORSHANSKY TRANSMISSION CORPORATION

10:30 - 12:00 con't

(a) Acousting Test Cell

Instrumentation and measurement procedure, J. Pratt,

K. Rudolph.

Run Module.

Run tape recorder.

(b) Test Drive Demonstration Vehicle, B. Huffman,

W. Weseloh

Evaluation of control function and noise.

Illustration of controller capabilities.

12:30 - 1:30

Botsford's Restuarant, LaJolla

Buffet luncheon.

12:30 - 1:30

Review Second Generation Transmission Design

Require drawings, Design calculations, Hydraulic

controls, K. Rudolph, W. Weseloh

1:30 - 2:30

Projected efficiency of Second Generation HMT, P. Huntley

Printout.

May, 1977, Progress Report.

Test data on Gerotor.

2:30 - 3:30

Plans for completion of Second Generation HMT, W. Weseloh

Bar chart, man hours, major purchases.

3:30 - 4:30

Commentary by Ford

4:30

• Adjournment

Transmission Evaluation - Orshansky Hydromechanical

	1	2	3	4	5	6	7	8	9	10
Noise										
Idle			0		X					
Accel	0	X								
Decel			0	X						
Steady State				0	X					
Shift Quality										
Upshift										
Part Throttle	0	X								
W.O.T.	0	X								
Downshift										
Kickdown		0 X								
Decel		0			X					
Vibration										
Idle					0	X				
Accel				0 X						
Decel					0	X				
Steady State						0 X				
Engagement										
N-D Engagement		0							X	
N-R Engagement		0							X	
D-N Disengagement			0						X	
R-N Disengagement			0						X	
Fun to Drive		X								
General Appraisal		0	X							

October 1976 Assessment: 0
October 1977 Assessment: X

ORSHANSKY TRANSMISSION CORPORATION

Project Review Meeting - April 11, 1978

Vehicle: 1978 NOVA

Transmission Evaluation - Orshansky Hydromechanical

	1	2	3	4	5	6	7	8	9	10
Noise										
Idle				S P						
Accel		P	S							
Decel							S P			
Steady State							P	S		
Downshift			S	P						
Creep		S P								
Shift Quality										
Upshift										
Part Throttle				P S						
W.O.T.			P S							
Downshift										
Kickdown			S P							
Decel			P			S				
Vibration										
Idle						P	S			
Accel				P			S			
Decel						P			S	
Steady State						P			S	
Creep		P			S					
Engagement										
N-D Engagement								S P		
N-R Engagement								S P		
D-N Disengagement								S P		
R-N Disengagement								S P		
Hitching			P	S						
Fun to Drive				S						
General Appraisal			P	S						

S = Stockton

P = Postma