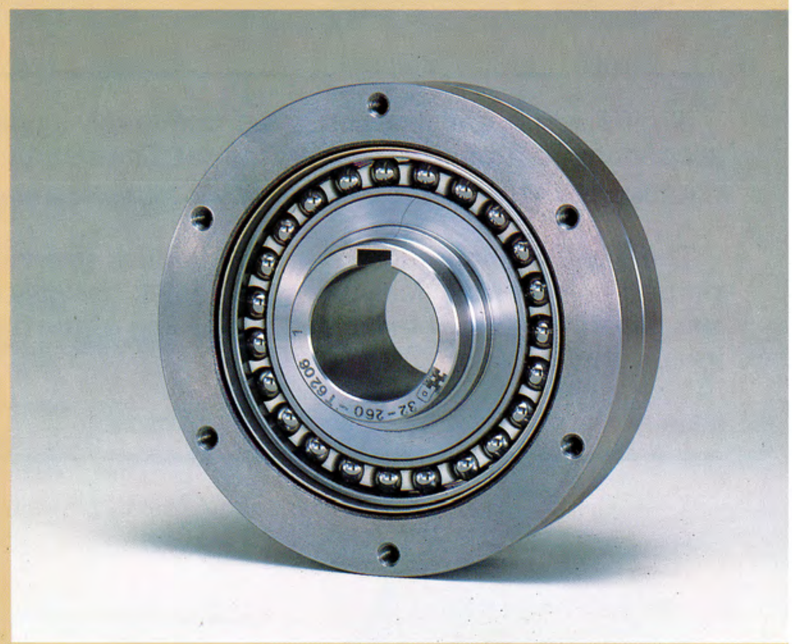
harmonic drive gearing

HDUA Differential Transmissions



CONTENTS

HARMONIC DRIVE DIFFERENTIAL TRANSMISSIONS

A differential transmission most commonly consists of a primary constant speed power input, a secondary control input, and an output. The output is varied in velocity or phase as a function of the control input speed or position.

The basic configuration of harmonic drive gearing permits two independent inputs with a common output, lending itself ideally to differential designs. HDUA DIFFERENTIAL TRANSMISSIONS provide this capability to vary the speed or phasing of the output in a very compact package with a convenient in-line configuration.

THE BASIC ASSEMBLY

The Dynamic Spline (DS) is a rigid ring having internal teeth of same number as the Flexspline. It rotates together with the Flexspline and can serve as either the input or output member.
It is identified by chamfered corners at its outside diameter.

The Wave Generator (WG) is a thin raced bearing assembly fitted onto an elliptical plug, and normally is the control input member.

The Flexspline (FS) is a non-rigid ring with external teeth on a slightly smaller pitch diameter than the Circular Spline. It is fitted over and elastically deflected by the Wave Generator.

The Circular Spline (CS) is a rigid ring with internal teeth, engaging the teeth of the Flexspline across the major axis of the Wave Generator.

Harmonic drive differential transmissions are available as a component set comprised of the Wave Generator, Flexspline, and Circular and Dynamic Splines, or as a housed unit. The housed unit is provided with grease lubrication.

Housing

Circular Spline

Wave Generator

Flexspline

Dynamic Spline

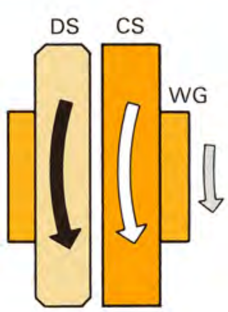
Housing

ORDERING INFORMATION

HDUA 20-80-2-GP

- HDUA — HDUA Series differential drive
- 20 — Size
- 80 — Nominal ratio
- 2 — O: Housed unit; 2: Component set
- GP — Suffix indicating grease lubrication

CONFIGURATIONS

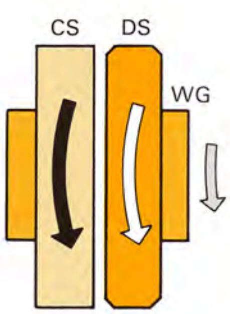


CS Input with N_S rpm
DS Output with N_D rpm
WG Control input with N_W rpm

DS output and CS input in same direction: $N_D = N_S \times \frac{R+1}{R}$

Output adjustment $\Delta N_D = -\frac{N_W}{R}$ when control input (N_W) and CS input (N_S) in same direction

or $\Delta N_D = +\frac{N_W}{R}$ when N_W and N_S in opposite direction



CS Output with N_S rpm
DS Input with N_D rpm
WG Control input with N_W rpm

CS output and DS input in same direction: $N_S = N_D \times \frac{R}{R+1}$

Output adjustment $\Delta N_S = +\frac{N_W}{R+1}$ when control input (N_W) and DS input (N_D) in same direction

or $\Delta N_S = -\frac{N_W}{R+1}$ when N_W and N_D in opposite direction

R as tabulated in PERFORMANCE RATING TABLE, page 6.

HDUA differential transmission offers many advantages not found in other forms of differentials.

Compact In-Line Configuration

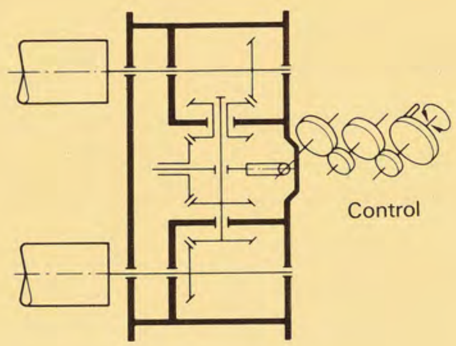
Concentric configuration of elements makes the overall differential drive small and simple, compared with conventional drives with multiple parts.

High Accuracy

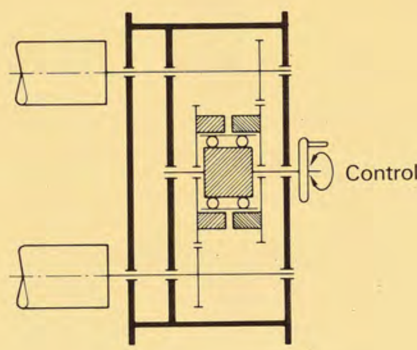
Extremely low backlash combined with high ratio makes it possible to precision control the output phasing or speed without precision trim input.

Bi-Directional Control

Phase or speed adjustment can be accomplished through 360° in either direction.



Schematic-typical differential gear train.



Schematic-harmonic drive differential.

Crosscutter and Overprinter

1. Intake control

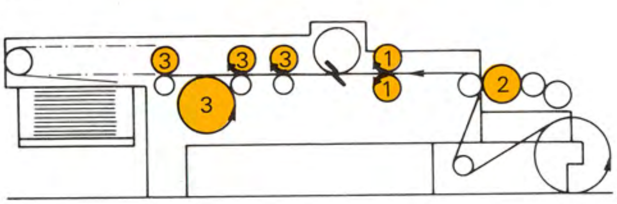
Harmonic drive differentials are used for precision web speed control so that the impression is accurately synchronized by photocells to the page size.

2. Overprinter

Harmonic drive differentials ensure that correct register is automatically held and the impression is correctly presented to the crosscutter.

3. Transfer and collation

Harmonic drive differentials continuously maintain justification and text presentation on the run.

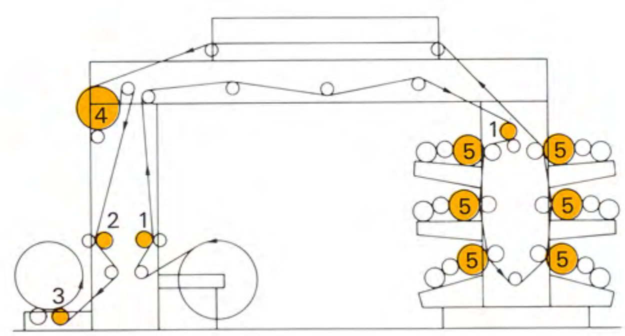


Flexo-Rotary Press

1. Fine web speed control using harmonic drive differentials and stepless speed controllers:
1) Intake control
2) Offtake control
3) Offtake reeler
4) Conditioner roll

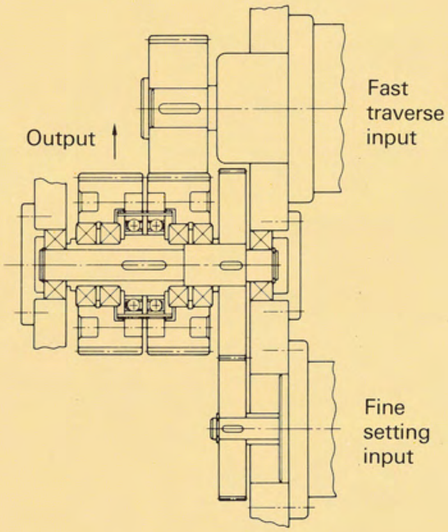
2. Register control

Harmonic drive differentials are used as register controls for the print roll (5). They may be set by hand or remotely from the print monitor console.



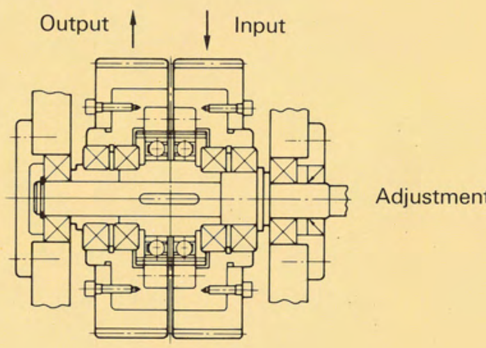
Positioning

Positioning with fast traverse and fine setting.



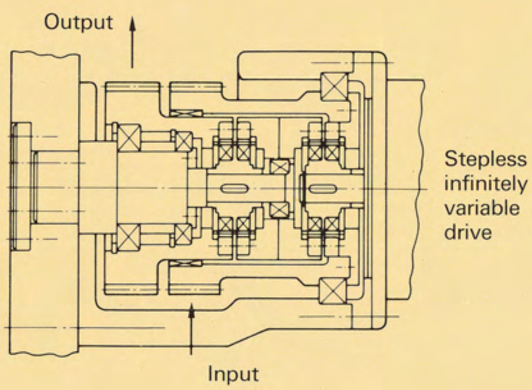
Phase Shifting

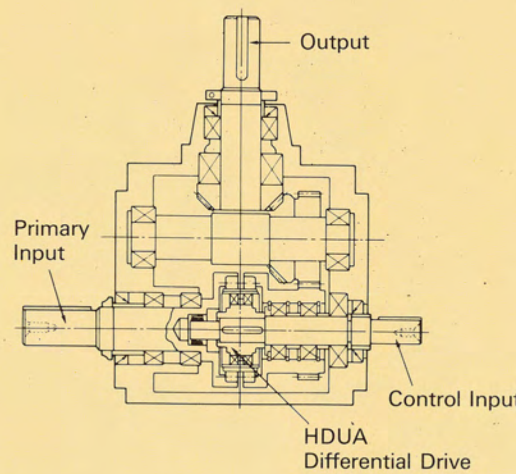
Continuous running phase adjustment of rotating parts.

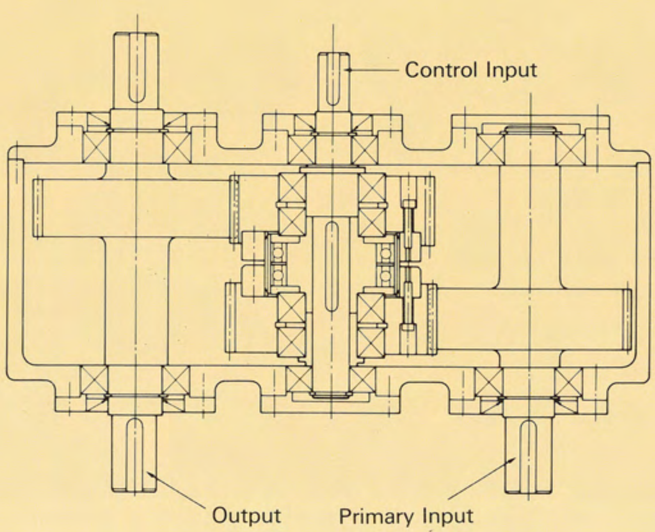


Register Control

at 1:1 overall ratio.

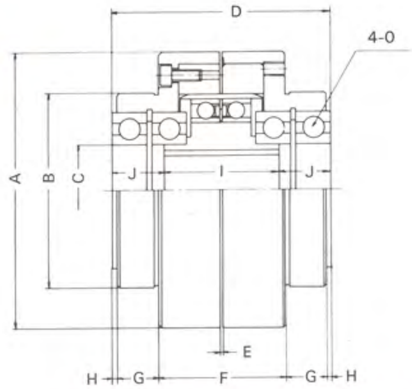


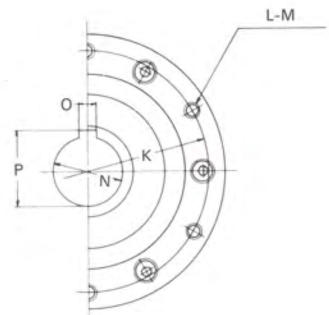




DIMENSIONS

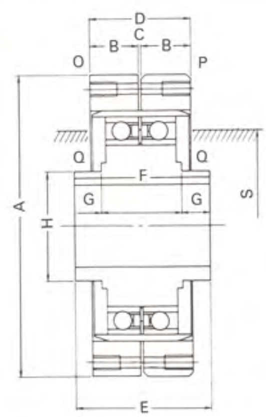
Type 0 Housed Unit

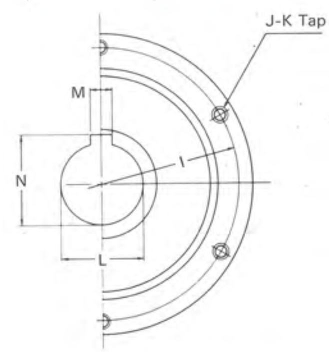




HDUA	A	B_{h7}	C	D	E	F	G	H	I	J	K	L	M	N_{H7}	O_{JS9}	P	Q	Weight kgf	Weight lb
20	85	$52^{\ 0}_{-0.030}$	20	73	1	44	12.5	2	38	17.5	70	6	M 4× 7	$14^{+0.018}_{\ 0}$	5 ±0.0150	16.3	#6004	2.0	4.4
25	95	$65^{\ 0}_{-0.030}$	30	81	1	45	16	2	40	20.5	80	6	M 5× 8	$20^{+0.021}_{\ 0}$	6 ±0.0150	22.8	#6006	2.6	5.7
32	120	$85^{\ 0}_{-0.035}$	40	95	1	55	18	2	50	22.5	105	6	M 6×10	$30^{+0.021}_{\ 0}$	8 ±0.0180	33.3	#6008	5.0	11
40	145	$100^{\ 0}_{-0.035}$	50	113	1	65	20	4	68	22.5	125	6	M 8×11	$35^{+0.025}_{\ 0}$	10 ±0.0180	38.3	#6010	8.3	18
50	185	$125^{\ 0}_{-0.040}$	60	132	1	80	22	4	78	27	155	6	M10×13.5	$40^{+0.025}_{\ 0}$	12 ±0.0215	43.3	#6012	17	37
65	235	$140^{\ 0}_{-0.040}$	70	147	1	117	12	3	87	30	195	6	M12×23	$50^{+0.025}_{\ 0}$	14 ±0.0215	53.8	#6014	34	75
80	290	$180^{\ 0}_{-0.040}$	90	178	1	129	21.5	3	106	36	240	8	M12×23	$65^{+0.030}_{\ 0}$	18 ±0.0215	69.4	#6018	59	130
100	360	$210^{\ 0}_{-0.046}$	110	212	1	155	25.5	3	130	41	290	8	M14×27	$80^{+0.030}_{\ 0}$	22 ±0.0260	85.4	#6022	118	260

Type 2 Component Set





HDUA	A_{g7}	B	C	D	E	F	G	H_{J6}	I	J	K	L_{H7}	M_{JS9}	N	O_C	P_C	Q_R	S*	Weight Kgf	Weight lb
20	$70^{-0.010}_{-0.040}$	12	1	25	38	21.5	8.25	$20^{+0.009}_{-0.004}$	60	6	M 3× 6	$14^{+0.018}_{\ 0}$	5 ±0.0150	16.3	0.2	1	0.5	42	0.6	1.3
25	$85^{-0.012}_{-0.047}$	14	1	29	40	25	7.5	$30^{+0.009}_{-0.004}$	75	6	M 4× 8	$20^{+0.021}_{\ 0}$	6 ±0.0150	22.8	0.2	1.5	1	53	1.0	2.2
32	$110^{-0.012}_{-0.047}$	18	1	37	50	30	10	$40^{+0.011}_{-0.005}$	100	6	M 5×10	$30^{+0.021}_{\ 0}$	8 ±0.0180	33.3	0.2	1.5	1	69	2.0	4.4
40	$135^{-0.014}_{-0.054}$	21	1	43	68	44	12	$50^{+0.011}_{-0.005}$	120	6	M 6×12	$35^{+0.025}_{\ 0}$	10 ±0.0180	38.3	0.4	1.5	1	84	3.6	7.9
50	$170^{-0.014}_{-0.054}$	26	1	53	78	54	12	$60^{+0.012}_{-0.007}$	150	6	M 8×16	$40^{+0.025}_{\ 0}$	12 ±0.0215	43.3	0.4	1.5	2	105	7.2	16
65	$215^{-0.015}_{-0.061}$	35	1	71	87	59	14	$70^{+0.012}_{-0.007}$	195	6	M10×20	$50^{+0.025}_{\ 0}$	14 ±0.0215	53.8	0.4	1.5	1	138	14	31
80	$265^{-0.017}_{-0.069}$	41	1	83	106	74	16	$90^{+0.013}_{-0.009}$	240	8	M10×20	$65^{+0.030}_{\ 0}$	18 ±0.0215	69.4	0.4	2	1.5	169	26	57
100	$330^{-0.018}_{-0.075}$	50	1	101	130	92	19	$110^{+0.013}_{-0.009}$	290	8	M12×24	$80^{+0.030}_{\ 0}$	22 ±0.0260	85.4	0.4	2	2	211	48	106

* The axial locaton surfaces at D width must extend radially inward to at least S for Flexspline containment. The surface hardness in the region where the Flexspline abuts is recommended to be RC29-34.

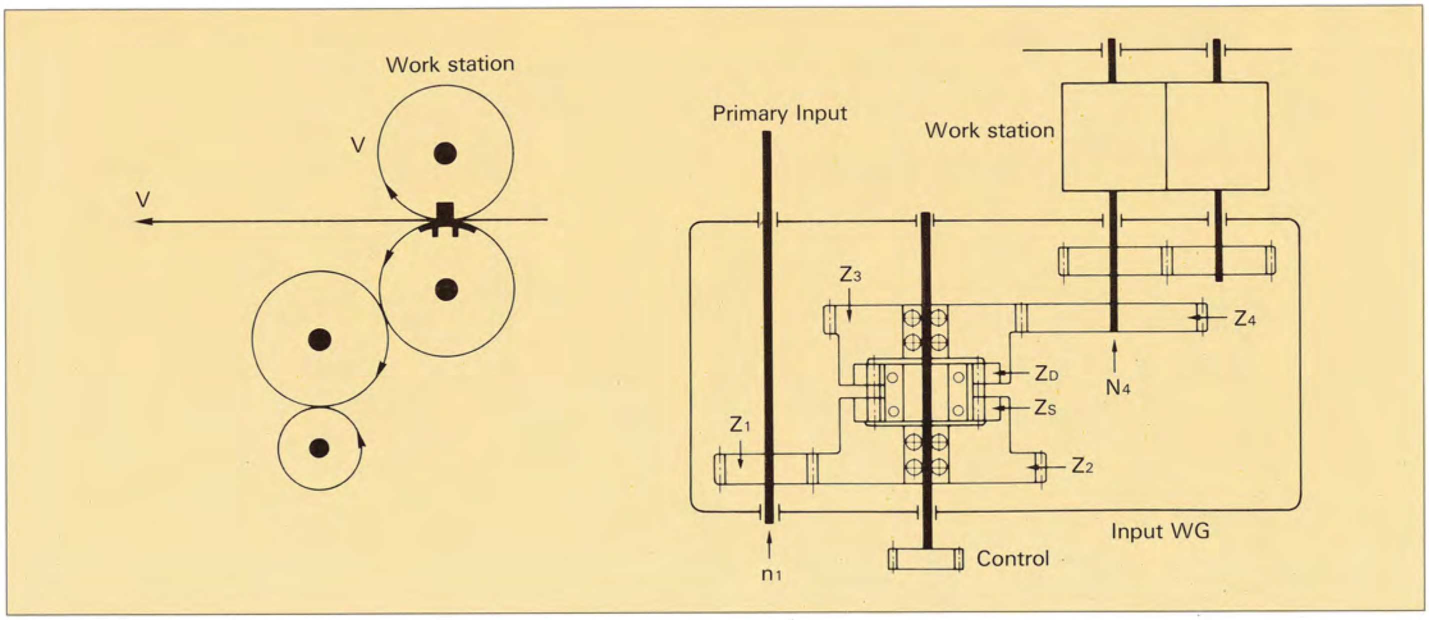
PERFORMANCE RATING

HDUA	Tabulated Ratio	Output Torque at CS or DS						Max. *Input Speed Oil Grease	Moment of Inertia $J(=\frac{GD^2}{4})$				Max. Back-lash at Output
		at 2000 rpm*		at 1450 rpm*		at 500 rpm*			1. WG Except Bearing Outer Race	2. CS, DS, FS and Bearing Outer Race	3. Comp. Set (1 + 2)	4. Housing incl. Support Bearings	
	R : 1	Nm	lb-in	Nm	lb-in	Nm	lb-in	rpm	kg m² lb-in²	kg m² lb-in²	kg m² lb-in²	kg m² lb-in²	Arc min.
20	80	33	295	31	274	31	274	6000	3.60×10^{-5}	3.43×10^{-4}	3.79×10^{-4}	1.39×10^{-3}	33
	100	40	355	37	327	37	327	3600	0.123	1.17	1.29	4.75	
	128	40	355	43	380	44	390						
	160	40	355	46	407	50	440						
25	80	55	490	58	513	58	513	5000	9.08×10^{-5}	8.45×10^{-4}	9.36×10^{-4}	1.95×10^{-3}	28
	100	66	580	68	600	81	717	3600	0.311	2.89	3.20	6.70	
	120	66	580	71	628	98	867						
	160	66	580	74	655	108	956						
	200	66	580	75	664	108	956						
32	78	108	955	108	956	108	956	4000	3.23×10^{-4}	3.13×10^{-3}	3.45×10^{-3}	5.69×10^{-3}	23
	100	137	1,215	150	1,328	160	1,417	3600	1.10	10.7	11.8	17.4	
	131	137	1,215	160	1,420	207	1,832						
	157	137	1,215	160	1,420	224	1,980						
	200	137	1,215	160	1,420	224	1,980						
	260	137	1,215	160	1,420	224	1,980						
40	80	196	1,735	196	1,735	196	1,735	4000	9.25×10^{-4}	8.15×10^{-3}	9.08×10^{-3}	2.34×10^{-2}	23
	100	255	2,255	265	2,345	265	2,345	3300	3.16	27.8	31.0	79.9	
	128	294	2,600	320	2,830	380	3,360						
	160	294	2,600	320	2,830	460	4,070						
	200	294	2,600	320	2,830	460	4,070						
	258	294	2,600	320	2,830	460	4,070						
50	80	363	3,210	357	3,160	360	3,190	3500	2.80×10^{-3}	2.55×10^{-2}	2.83×10^{-2}	4.41×10^{-2}	16
	100	470	4,165	565	5,000	565	5,000	3000	9.58	87.2	96.8	151	
	120	560	4,950	600	5,310	680	6,020						
	160	560	4,950	600	5,310	864	7,650						
	200	560	4,950	600	5,310	864	7,650						
	242	560	4,950	600	5,310	864	7,650						
65	78	745	6,590	780	6,900	780	6,900	3000	9.15×10^{-3}	8.60×10^{-2}	9.51×10^{-2}	1.56×10^{-1}	16
	104	1,060	9,370	1,120	9,910	1,210	10,700	2200	31.3	294	325	533	
	132	1,060	9,370	1,120	9,910	1,600	14,200						
	158	1,060	9,370	1,120	9,910	1,600	14,200						
	208	1,060	9,370	1,120	9,910	1,600	14,200						
	260	1,060	9,370	1,120	9,910	1,600	14,200						
80	80	1,320	11,700	1,400	12,400	1,400	12,400	2500	2.55×10^{-2}	2.32×10^{-1}	2.58×10^{-1}	4.09×10^{-1}	16
	96	1,660	14,700	1,840	16,300	1,840	16,300	2000	87.2	793	880	1400	
	128	2,360	20,800	2,220	19,600	2,770	24,500						
	160	2,360	20,800	2,220	19,600	3,190	28,200						
	194	2,360	20,800	2,220	19,600	3,190	28,200						
	258	2,360	20,800	2,220	19,600	3,190	28,200						
	320	2,360	20,800	2,220	19,600	3,190	28,200						
100	80	2,330	20,600	2,520	22,300	2,520	22,300	2000	7.63×10^{-2}	6.75×10^{-1}	7.51×10^{-1}	1.12	16
	100	3,210	28,400	3,800	33,600	3,800	33,600	1700	261	2310	2570	3830	
	120	3,210	28,400	4,060	35,900	4,840	42,800						
	160	3,210	28,400	4,060	35,900	5,840	51,700						
	200	3,210	28,400	4,060	35,900	5,840	51,700						
	242	3,210	28,400	4,060	35,900	5,840	51,700						
	320	3,210	28,400	4,060	35,900	5,840	51,700						

* Speed of Circular Spline, or Dynamic Spline — whichever the input element — relative to the control input speed at Wave Generator.

Ex. Main input speed = 500 rpm
Control speed at Wave Generator = 100 rpm in the same direction as Circular Spline
Relative speed of Circular Spline = 500 − 100 = 400 rpm

Below is an example of a typical application for the HDUA differential drive. Ratio selection, speeds, and required control torque are calculated.



The phasing of a pair of work rolls are adjusted while running, with the following operating condition:

Surface speed V	= 200 feet/min
Roll circumference ($d \cdot \pi$) U_W	= 20 inches
Working torque M_W	= 530 lb-in
Input shaft speed n_1	= 500 rpm
Work roll speed n_4	$= \frac{V}{U_W} = \frac{2400}{20} = 120$ rpm

Gearing Plan

An HDUA 25 with a tabulated ratio of 80/81 is **provisionally** selected from the rating chart. Using these data we obtain:

Internal ratio i_i	$= \frac{Z_D}{Z_S} = \frac{80}{81}$
Rated torque Md_{nom} (@1450 rpm)	= 513 lb-in
Main drive efficiency CS←→DS	n_1 = 90% approx.
Control efficiency	n_2 = 70% approx.

Ratio Selection

Through drive ratio:

$$ig = \frac{n_4}{n_1} = \frac{Z_1}{Z_2} \cdot \frac{Z_S}{Z_D} \cdot \frac{Z_3}{Z_4}$$

$$\frac{Z_1}{Z_2} \cdot \frac{Z_3}{Z_4} = \frac{Z_D}{Z_S} \cdot \frac{n_4}{n_1}$$

$$= \frac{80}{81} \cdot \frac{120}{500}$$

$$= \frac{2^4 \cdot 5}{3^4} \cdot \frac{2^3 \cdot 3 \cdot 5}{2^2 \cdot 5^3}$$

$$= \frac{2^5}{3^3 \cdot 5}$$

$$= \frac{2^3}{3 \cdot 5} \cdot \frac{2^2}{3^2}$$

$$= \frac{8}{15} \cdot \frac{4}{9}$$

$$= \frac{16}{30} \cdot \frac{16}{36}$$

$\underline{Z_1 = 16}$ $\underline{Z_2 = 30}$ $\underline{Z_3 = 16}$ $\underline{Z_4 = 36}$

Speeds

$$n_1 = 500 \text{ rpm}$$

$$n_2 = n_1 \frac{Z_1}{Z_2}$$

$$= 500 \cdot \frac{16}{30}$$

$$= 267 \text{ rpm}$$

$$n_3 = n_1 \cdot \frac{Z_1 \cdot Z_S}{Z_2 \cdot Z_D}$$

$$= 500 \cdot \frac{16}{30} \cdot \frac{81}{80}$$

$$= 270\text{rpm}$$

$$n_4 = n_1 \frac{Z_1}{Z_2} \cdot \frac{Z_S}{Z_D} \cdot \frac{Z_3}{Z_4}$$

$$= 500 \cdot \frac{16}{30} \cdot \frac{81}{80} \cdot \frac{16}{36}$$

$$= 120 \text{ rpm}$$

Control Input (WG) = Rotationaly fixed.

Torques

$$Md_1 = Md_4 \cdot \frac{Z_1}{Z_2} \cdot \frac{Z_S}{Z_D} \cdot \frac{Z_3}{Z_4} \cdot \frac{1}{n_1}$$

$$= 530 \cdot \frac{16}{30} \cdot \frac{81}{80} \cdot \frac{16}{36} \cdot \frac{1}{0.9} = 141 \text{ lb-in}$$

$$Md_2 = Md_4 \cdot \frac{Z_3}{Z_4} \cdot \frac{Z_S}{Z_D} \cdot \frac{1}{n_1}$$

$$= 530 \cdot \frac{16}{36} \cdot \frac{81}{80} \cdot \frac{1}{0.9} = 265 \text{ lb-in}$$

$$Md_3 = Md_4 \frac{Z_3}{Z_4}$$

$$= 530 \cdot \frac{16}{36} = 236 \text{ lb-in}$$

$$Md_4 = 530 \text{ lb-in}$$

Control Input

The angular displacement $\Delta\Theta$ at the work rolls when the control input(WG)is rotated by 360°, is calculated as follows:

$$|\Delta\Theta| = 360^0 \cdot \frac{Z_3}{Z_4} \cdot \frac{1}{80}$$

$$= 360^0 \cdot \frac{16}{36} \cdot \frac{1}{80} = 2^0$$

The resultant change of web register caused by one revolution of control input is

$$20 \cdot \frac{2^0}{360^0} = 0.11 \text{ inches}$$

Control Torque

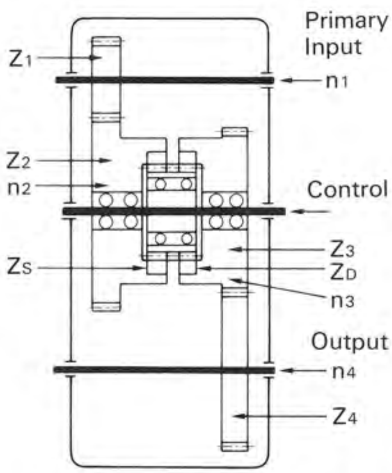
$$T = \text{Working Torque} \cdot \frac{Z_3}{Z_4} \cdot \frac{1}{R} \cdot \frac{1}{\eta_1}$$

$$= 530 \cdot \frac{16}{36} \cdot \frac{1}{80} \cdot \frac{1}{0.7}$$

$$= 4.2 \text{ lb-in}$$

COMPOUND GEAR RATIO

Favorable low number gear pairs for equal primary input and output speed are given in the table below.



Example : $i = \frac{n_1}{n_4} = \frac{\text{Input speed}}{\text{Output speed}} = 1$

$$i = \frac{n_1}{n_4} = \frac{Z_2}{Z_1} \cdot \frac{Z_D}{Z_S} \cdot \frac{Z_4}{Z_3}$$

$$= \frac{27}{26} \cdot \frac{80}{81} \cdot \frac{39}{40}$$

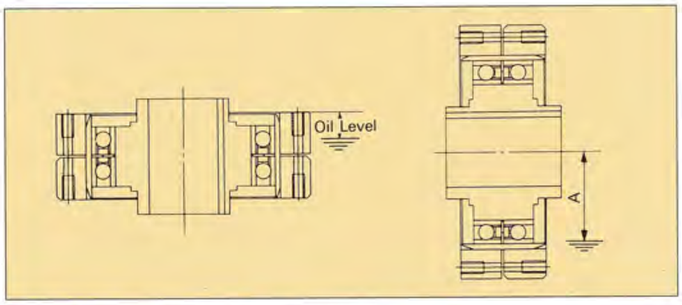
$$= 1$$

Compound ratio for equal peripheral speed $\frac{Z_D}{Z_S}$	$\frac{80}{81}$	$\frac{104}{105}$	$\frac{120}{121}$	$\frac{128}{129}$	$\frac{160}{161}$	$\frac{194}{195}$	$\frac{200}{201}$	$\frac{208}{209}$	$\frac{258}{259}$	$\frac{260}{261}$
Expression of internal ratio in prime numbers	$\frac{2^4 \cdot 5}{3^4}$	$\frac{2^3 \cdot 13}{3 \cdot 5 \cdot 7}$	$\frac{2^3 \cdot 3 \cdot 5}{11^2}$	$\frac{2^7}{3 \cdot 43}$	$\frac{2^5 \cdot 5}{7 \cdot 23}$	$\frac{2 \cdot 97}{3 \cdot 5 \cdot 13}$	$\frac{2^3 \cdot 5^2}{3 \cdot 67}$	$\frac{2^4 \cdot 13}{11 \cdot 19}$	$\frac{2 \cdot 3 \cdot 43}{7 \cdot 37}$	$\frac{2^2 \cdot 5 \cdot 13}{3^2 \cdot 29}$
	$\frac{16}{15} \cdot \frac{25}{27}$	$\frac{13}{14} \cdot \frac{16}{15}$	$\frac{25}{22} \cdot \frac{48}{55}$	$\frac{16}{15} \cdot \frac{40}{43}$	$\frac{16}{14} \cdot \frac{20}{23}$	$\frac{38}{39} \cdot \frac{97}{95}$	$\frac{20}{21} \cdot \frac{70}{67}$	$\frac{52}{55} \cdot \frac{20}{19}$	$\frac{36}{37} \cdot \frac{43}{42}$	$\frac{20}{18} \cdot \frac{26}{29}$
	$\frac{16}{18} \cdot \frac{20}{18}$	$\frac{13}{15} \cdot \frac{24}{21}$	$\frac{16}{22} \cdot \frac{30}{22}$	$\frac{32}{33} \cdot \frac{44}{43}$	$\frac{20}{21} \cdot \frac{24}{23}$	$\frac{64}{65} \cdot \frac{97}{96}$	$\frac{25}{24} \cdot \frac{64}{67}$			$\frac{65}{63} \cdot \frac{28}{29}$
$\frac{Z_1}{Z_2} \cdot \frac{Z_3}{Z_4}$	$\frac{20}{18} \cdot \frac{24}{27}$	$\frac{16}{15} \cdot \frac{26}{28}$	$\frac{18}{22} \cdot \frac{40}{33}$	$\frac{42}{43} \cdot \frac{64}{63}$	$\frac{22}{23} \cdot \frac{80}{77}$	$\frac{66}{65} \cdot \frac{97}{99}$	$\frac{40}{39} \cdot \frac{65}{67}$			$\frac{26}{27} \cdot \frac{30}{29}$
	$\frac{20}{21} \cdot \frac{28}{27}$	$\frac{20}{21} \cdot \frac{26}{25}$	$\frac{20}{22} \cdot \frac{24}{22}$		$\frac{25}{23} \cdot \frac{32}{35}$		$\frac{50}{51} \cdot \frac{68}{67}$			$\frac{52}{51} \cdot \frac{85}{87}$
Refer to example →	$\boxed{\frac{26}{27} \cdot \frac{40}{39}}$	$\frac{28}{27} \cdot \frac{36}{35}$								$\frac{65}{63} \cdot \frac{84}{87}$
		$\frac{34}{35} \cdot \frac{52}{51}$								$\frac{26}{27} \cdot \frac{90}{87}$
										$\frac{65}{66} \cdot \frac{88}{87}$

LUBRICATION

As with other harmonic drive transmissions oil lubrication is preferred. Although HDUA sets may be used in any attitude, it is essential that the Wave Generator bearing and gear teeth be properly lubricated. Minimum required oil amounts are tabulated below, but the actual amount will depend on the size of the housing.

In the case of a horizontal shaft installation, the appropriate oil level below the gear set center line must be maintained as tabulated. For vertical mounting, the recommended level is the center line of the upper Wave Generator bearing balls.



Oil Level and Minimum Oil Quantity

HDUA		20	25	32	40	50	65	80	100
A	mm	12	15	31	38	44	62	75	94
Qty	Liter	0.04	0.08	0.2	0.3	0.6	1.5	2.2	4.1
	Fl.oz.	1.4	2.8	7	10	20	50	75	140

Oil Temperature

In normal use, the oil temperature must not exceed 90°C, as oil loses its lubricating capability quickly above this limit.

Oil Change

The first change should be performed after 100 hours of operation. The need to perform subsequent oil changes will depend on operating conditions, but should take place at intervals of approximately 1,000 running hours.

Grease Lubrication

HDUA differential drives may be operated with grease lubrication at rated torque but at a reduced duty cycle. Imperial Molub Alloy No.2 is recommended.

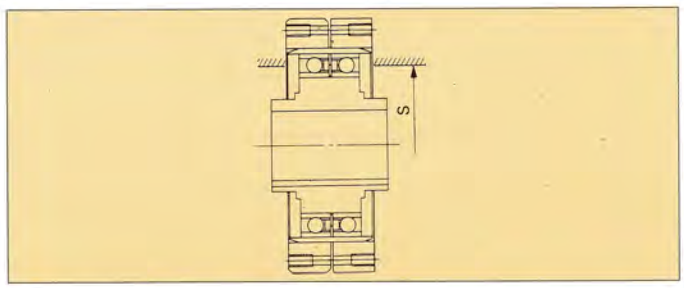
Grease lubrication may be used in applications where the doty cycle is less than 10 percent time-on and the length of time-on does not exceed 10 minutes of continuous operation. The maximum input speeds allowable for units lubricated by Molub Alloy No.2 are as follows:

HDUA	20	25	32	40	50	65	80	100
Max.rpm	2,800	2,200	1,700	1,400	1,100	850	700	550

Harmonic Grease HC-1

As a result of an extensive search for a grease that will render improved performance in harmonic drive component sets, a new grease, named Harmonic Grease HC-1, has been developed. With Harmonic Grease HC-1, UNITS MAY BE OPERATED CONTINUOUSLY.

An important consideration in grease lubrication is ensuring that as much grease as possible is retained where lubrication is needed. To achieve this, it is recommended that the axial location surfaces at D width extend radially inward to the dimension shown. However, such extension is not recommended for oil lubrication.



HDUA	20	25	32	40	50	65	80	100
S	38	48	63	76	95	126	152	190

Grease Changes

When operating the HDUA at rated torque, change grease after about 1,000 running hours. Light duty operation may permit longer service intervals. To change grease, completely disassemble and clean units before re-greasing. Apply grease generously inside the Flexspline, the Wave Generator bearing, and the teeth of both the Circular and Dynamic Splines and the Flexspline.

The approximate amount of grease needed for each harmonic drive HDUA component set is tabulated below:

HDUA		20	25	32	40	50	65	80	100
Grease Weight	gr.	18	30	60	100	150	320	570	1150
	oz.	0.6	1	2	3.5	5.5	11	20	40

Grease Packed HDUA Housed Unit (HDUA-O-GP)

HDUA Type O housed unit may be supplied with HC-1 grease packed at the factory. Specify GP.

EFFICIENCY

Efficiency varies depending on input speed, ratio, load level, temperature, and type of lubrication. The effects of these factors are illustrated in the curves shown.

Efficiency vs. Speed, Temperature, Reduction Ratio, and Lubrication

Chart 1

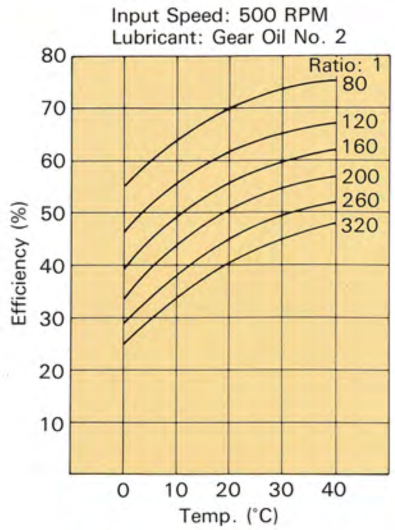


Chart 2

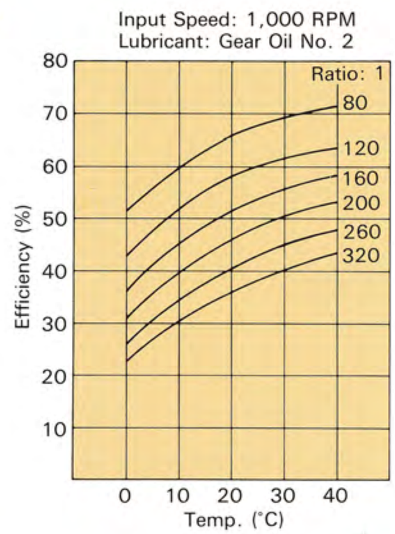


Chart 3

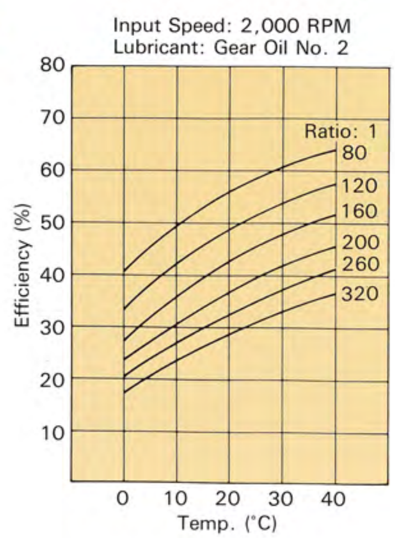


Chart 4

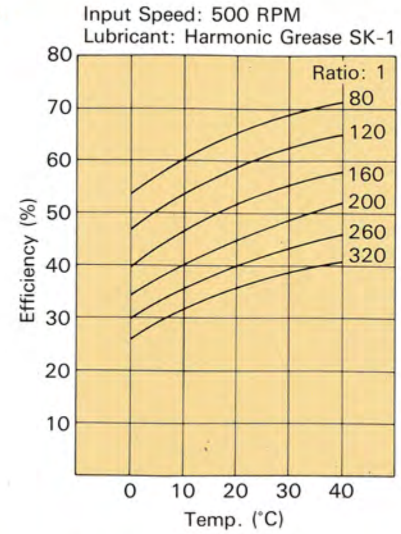


Chart 5

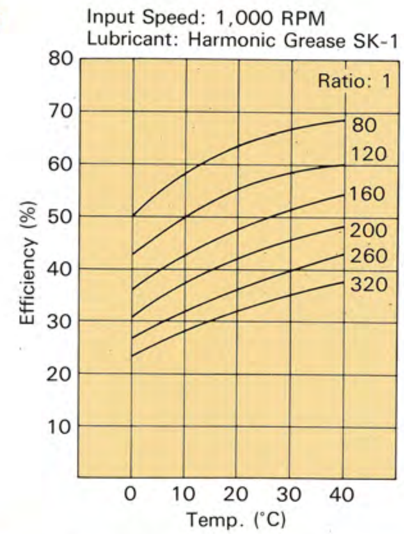


Chart 6