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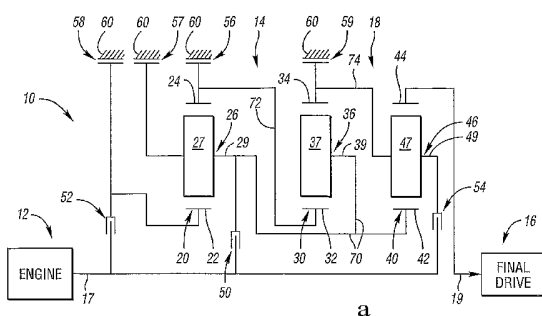
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[Continued on next page]

(54) Title: PLANETARY TRANSMISSIONS HAVING THREE INTERCONNECTING MEMBERS AND CLUTCHED INPUT MEMBERS



a

(57) Abstract: The family of transmissions has a plurality of members that can be utilized in powertrains to provide at least eight forward speed ratios and one reverse speed ration. The transmission family members include three planetary gear sets having seven torque-transmitting mechanisms and three interconnecting members. The powertrain includes an engine that is selectively connectable to at least one of the planetary gear members and an output member that is continuously connected with another one of the planetary gear members. The seven torque-transmitting mechanism provide interconnections between various gear member, the input shaft and the transmission housing, and are operated in combinations of two to establish at least eight forward speed ratios and at least one reverse speed ratio.

	RATIOS	50	52	54	56	57	58	59
REVERSE	-2.25	X						X
NEUTRAL	0.00							X
1	5.38		X					X
2	2.35		X			X		
3	1.74	X					X	
3'	1.66		X		X			
4	1.23			X			X	
5	1.00	X		X				
6	0.85			X	X			
7	0.69			X		X		
8	0.51	X			X			

(X = ENGAGED CLUTCH)

b

RING GEAR	TOOTH RATIO:	$\frac{N_{R1}}{N_{S1}} = 2.25$,	$\frac{N_{R2}}{N_{S2}} = 1.51$,	$\frac{N_{R3}}{N_{S3}} = 2.25$
SUN GEAR				

RATIO SPREAD	10.55
RATIO STEPS	
REV/1	-0.42
1/2	2.29
2/3	1.35
3/4	1.41
4/5	1.23
5/6	1.18
6/7	1.23
7/8	1.35

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PLANETARY TRANSMISSIONS HAVING THREE INTERCONNECTING MEMBERS AND CLUTCHED INPUT MEMBERS

TECHNICAL FIELD

[0001] The present invention relates to a family of power transmissions having three planetary gear sets that are controlled by seven torque-transmitting devices to provide at least eight forward speed ratios and at least one reverse speed ratio.

BACKGROUND OF THE INVENTION

[0002] Passenger vehicles include a powertrain that is comprised of an engine, multi-speed transmission, and a differential or final drive. The multi-speed transmission increases the overall operating range of the vehicle by permitting the engine to operate through its torque range a number of times. The number of forward speed ratios that are available in the transmission determines the number of times the engine torque range is repeated. Early automatic transmissions had two speed ranges. This severely limited the overall speed range of the vehicle and therefore required a relatively large engine that could produce a wide speed and torque range. This resulted in the engine operating at a specific fuel consumption point during cruising, other than the most efficient point. Therefore, manually-shifted (countershaft transmissions) were the most popular.

[0003] With the advent of three- and four-speed automatic transmissions, the automatic shifting (planetary gear) transmission increased in popularity with the motoring public. These transmissions improved the operating performance and fuel economy of the vehicle. The increased number of speed ratios reduces the step size between ratios and therefore improves the shift quality of the transmission by making the ratio interchanges substantially imperceptible to the operator under normal vehicle acceleration.

[0004] It has been suggested that the number of forward speed ratios be increased to six or more. Six-speed transmissions are disclosed in U.S. Patent No.

4,070,927 issued to Polak on January 31, 1978; and U.S. Patent No. 6,422,969 issued to Raghavan and Usoro on July 23, 2002.

[0005] Six-speed transmissions offer several advantages over four- and five-speed transmissions, including improved vehicle acceleration and improved fuel economy. While many trucks employ power transmissions having six or more forward speed ratios, passenger cars are still manufactured with three- and four-speed automatic transmissions and relatively few five or six-speed devices due to the size and complexity of these transmissions.

[0006] Seven-speed transmissions are disclosed in U.S. Patent No. 6,623,397 issued to Raghavan, Bucknor and Usoro. Eight speed transmissions are disclosed in U.S. Patent No. 6,425,841 issued to Haka. The Haka transmission utilizes three planetary gear sets and six torque transmitting devices, including two brakes and two clutches, to provide eight forward speed ratios and a reverse speed ratio. One of the planetary gear sets is positioned and operated to establish two fixed speed input members for the remaining two planetary gear sets. Seven-, eight- and nine-speed transmissions provide further improvements in acceleration and fuel economy over six-speed transmissions. However, like the six-speed transmissions discussed above, the development of seven-, eight- and nine-speed transmissions has been precluded because of complexity, size and cost.

SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to provide an improved family of transmissions having three planetary gear sets controlled to provide at least eight forward speed ratios and at least one reverse speed ratio.

[0008] In one aspect of the present invention, the family of transmissions has three planetary gear sets, each of which includes a first, second and third member, which members may comprise a sun gear, a ring gear, a planet carrier assembly member, or a pinion, in any order.

[0009] In referring to the first, second and third gear sets in this description and in the claims, these sets may be counted "first" to "third" in any order in the drawings (i.e., left to right, right to left, etc.).

[0010] In another aspect of the present invention, the planetary gear sets may be of the single pinion-type or of the double pinion-type.

[0011] In yet another aspect of the present invention, a first member of the first planetary gear set is continuously interconnected with a first member of the second planetary gear set and with a first member of the third planetary gear set through a first interconnecting member.

[0012] In yet another aspect of the present invention, a second member of the first planetary gear set is continuously interconnected with a second member of the second planetary gear set through a second interconnecting member.

[0013] In yet another aspect of the present invention, a third member of the second planetary gear set is continuously interconnected with a second member of the third planetary gear set through a third interconnecting member.

[0014] The interconnecting members may be multi-piece rigid connections, single piece rigid connections, shared ring gears, shared carriers, shared sun gears, long pinions, such as in a Ravigneax gear set, or other suitable devices.

[0015] In yet a further aspect of the invention, each family member incorporates an output shaft which is continuously connected with at least one member of the planetary gear sets, and an input shaft which is not continuously connected with any member of the planetary gear sets but is selectively connectable with at least one member of the planetary gear sets through at least one of seven torque-transmitting mechanisms (torque transfer devices).

[0016] In still a further aspect of the invention, a first torque-transmitting mechanism, such as a clutch, selectively interconnects a member of the first planetary gear set with the input shaft.

[0017] In another aspect of the invention, a second torque-transmitting mechanism, such as a clutch, selectively interconnects another member of the second planetary gear set with the input shaft.

[0018] In a still further aspect of the invention, a third torque-transmitting mechanism, such as a clutch, selectively interconnects a member of the first or third planetary gear set with the input shaft.

[0019] In a still further aspect of the invention, a fourth torque-transmitting mechanism, such as a brake, selectively interconnects a member of the first planetary gear set with a stationary member (ground/transmission case).

[0020] In a still further aspect of the invention, a fifth torque-transmitting mechanism, such as a brake, selectively connects a member of the second planetary gear set with the stationary member (ground/transmission case).

[0021] In still another aspect of the invention, a sixth torque-transmitting mechanism, such as a brake, selectively connects a member of the first or third planetary gear set with the stationary member (ground/transmission case).

[0022] In still another aspect of the invention, a seventh torque-transmitting mechanism, such as a clutch, selectively interconnects a member of the first, second or third planetary gear set with another member of the first, second or third planetary gear set. Alternatively, the seventh torque-transmitting mechanism, such as a brake, selectively connects a member of the first, second or third planetary gear set with the stationary member (ground/transmission case).

[0023] In still another aspect of the invention, the seven torque-transmitting mechanisms are selectively engageable in combinations of two to yield at least eight forward speed ratios and at least one reverse speed ratio.

[0024] The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIGURE 1a is a schematic representation of a powertrain including a planetary transmission incorporating a family member of the present invention;

[0026] FIGURE 1b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 1a;

[0027] FIGURE 2a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0028] FIGURE 2b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 2a;

[0029] FIGURE 3a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0030] FIGURE 3b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 3a;

[0031] FIGURE 4a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0032] FIGURE 4b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 4a;

[0033] FIGURE 5a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0034] FIGURE 5b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 5a;

[0035] FIGURE 6a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0036] FIGURE 6b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 6a;

[0037] FIGURE 7a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0038] FIGURE 7b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 7a;

[0039] FIGURE 8a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0040] FIGURE 8b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 8a;

[0041] FIGURE 9a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0042] FIGURE 9b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 9a;

[0043] FIGURE 10a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention;

[0044] FIGURE 10b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 10a;

[0045] FIGURE 11a is a schematic representation of a powertrain having a planetary transmission incorporating another family member of the present invention; and

[0046] FIGURE 11b is a truth table and chart depicting some of the operating characteristics of the powertrain shown in Figure 11a.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0047] Referring to the drawings, wherein like characters represent the same or corresponding parts throughout the several views, there is shown in Figure 1a a powertrain 10 having a conventional engine 12, a planetary transmission 14, and a conventional final drive mechanism 16.

[0048] The planetary transmission 14 includes an input shaft 17 connected with the engine 12, a planetary gear arrangement 18, and an output shaft 19 continuously connected with the final drive mechanism 16. The planetary gear arrangement 18 includes three planetary gear sets 20, 30 and 40.

[0049] The planetary gear set 20 includes a sun gear member 22, a ring gear member 24, and a planet carrier assembly 26. The planet carrier assembly 26 includes a plurality of pinion gears 27 rotatably mounted on a carrier member 29 and disposed

in meshing relationship with both the sun gear member 22 and the ring gear member 24.

[0050] The planetary gear set 30 includes a sun gear member 32, a ring gear member 34, and a planet carrier assembly member 36. The planet carrier assembly member 36 includes a plurality of pinion gears 37 rotatably mounted on a carrier member 39 and disposed in meshing relationship with both the sun gear member 32 and the ring gear member 34.

[0051] The planetary gear set 40 includes a sun gear member 42, a ring gear member 44, and a planet carrier assembly member 46. The planet carrier assembly member 46 includes a plurality of pinion gears 47 rotatably mounted on a carrier member 49, wherein the pinion gears 47 are disposed in meshing relationship with both the sun gear member 42 and the ring gear member 44.

[0052] The planetary gear arrangement also includes seven torque-transmitting mechanisms 50, 52, 54, 56, 57, 58 and 59. The torque-transmitting mechanisms 50, 52, and 54 are rotating-type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 56, 57, 58 and 59 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[0053] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the ring gear member 44. The planet carrier assembly member 26 is continuously connected with the planet carrier assembly member 36 and with the sun gear member 42 through the interconnecting member 70. The ring gear member 24 is continuously connected with the sun gear member 32 through the interconnecting member 72. The ring gear member 34 is continuously connected with the planet carrier assembly member 46 through the interconnecting member 74.

[0054] The planet carrier assembly member 26 is selectively connectable with the input shaft 17 through the clutch 50. The sun gear member 22 is selectively connectable with the input shaft 17 through the clutch 52. The planet carrier assembly member 46 is selectively connectable with the input shaft 17 through the

clutch 54. The ring gear member 24 is selectively connectable with the transmission housing 60 through the brake 56. The planet carrier assembly member 26 is selectively connectable with the transmission housing 60 through the brake 57. The sun gear member 22 is selectively connectable with the transmission housing 60 through the brake 58. The ring gear member 34 is selectively connectable with the transmission housing through the brake 59.

[0055] As shown in Figure 1b, and in particular the truth table disclosed therein, the torque-transmitting mechanisms are selectively engaged in combinations of two to provide eight forward speed ratios and one reverse speed ratio, as well as an extra third forward speed ratio.

[0056] The reverse speed ratio is established with the engagement of the clutch 50 and the brake 59. The clutch 50 connects the input shaft 17 with the planet carrier assembly member 26. The brake 59 connects the ring gear member 34 with the transmission housing 60. The planet carrier assembly members 26, 36 and sun gear member 42 rotate at the same speed as the input shaft 17. The ring gear member 24 rotates at the same speed as the sun gear member 32. The ring gear member 34 and planet carrier assembly member 46 do not rotate. The speed of the sun gear member 32 is determined from the speed of the planet carrier assembly member 36 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the sun gear member 42 and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the reverse speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 30 and 40.

[0057] The first forward speed ratio is established with the engagement of the clutch 52 and the brake 59. The clutch 52 connects the sun gear member 22 with the input shaft 17. The brake 59 connects the ring gear member 34 with the transmission housing 60. The sun gear member 22 rotates at the same speed as the input shaft 17. The planet carrier assembly member 26 rotates at the same speed as the planet carrier assembly member 36 and the sun gear member 42. The ring gear member 24 rotates

at the same speed as the sun gear member 32. The speed of the planet carrier assembly member 26 is determined from the speed of the ring gear member 24, the speed of the sun member 22, and the ring gear/sun gear tooth ratio of the planetary gear set 20. The ring gear member 34 and planet carrier assembly member 46 do not rotate. The speed of the planet carrier assembly member 36 is determined from the speed of the sun gear member 32 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at the speed determined from the speed of the sun gear member 42 and ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the first forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 20, 30 and 40.

[0058] The second forward speed ratio is established with the engagement of the clutch 52 and brake 57. The clutch 52 connects the sun gear member 22 with the input shaft 17. The brake 57 connects the planet carrier assembly member 26 with the transmission housing 60. The ring gear member 24 rotates at the same speed as the sun gear member 32. The planet carrier assembly members 26, 36 and the sun gear member 42 do not rotate. The sun gear member 22 rotates at the speed as the input shaft 17. The speed of the ring gear member 24 is determined from the speed of the sun gear member 22 and the ring gear/sun gear tooth ratio of planetary gear set 20. The ring gear member 34 rotates at the same speed as the planet carrier assembly member 46. The ring gear member 34 rotates at a speed determined from the speed of the sun gear member 32 of the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed of the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the planet carrier assembly member 46 and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the second forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 20, 30 and 40.

[0059] The third forward speed ratio is established with the engagement of the clutch 50 and the brake 58. The clutch 50 connects the planet carrier assembly member 26 with input shaft 17. The brake 58 connects the sun gear member 22 with the transmission housing 60. The sun gear member 22 does not rotate. The planet carrier assembly members 26, 36 and the sun gear member 42 rotate at the same speed as the input shaft 17. The ring gear member 24 rotates at the same speed as the sun gear member 32. The speed of the ring gear member 24 is determined from the speed of the planet carrier assembly member 26 and the ring gear/sun gear tooth ratio of the planetary gear set 20. The ring gear member 34 rotates at the same speed as the planet carrier assembly member 46. The speed of the ring gear member 34 is determined from the speed of the planet carrier assembly member 36, the speed of the sun gear member 32, and ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the planet carrier assembly member 46, the speed of the sun gear member 42, and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical of the third forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 20, 30 and 40.

[0060] The extra third forward speed ratio (3') is established with the engagement of the clutch 52 and the brake 56. The clutch 52 connects the sun gear member 22 with input shaft 17. The brake 56 connects the ring gear member 24 with the transmission housing 60. The sun gear member 22 rotates at the same speed as the input shaft 17. The planet carrier assembly member 26 rotates at the same speed as the planet carrier assembly member 36 and the sun gear member 42. The ring gear member 24 and sun gear member 32 do not rotate. The speed of the planet carrier assembly member 26 is determined from the speed of the sun gear member 22 and the ring gear/sun gear tooth ratio of the planetary gear set 20. The ring gear member 34 rotates at the same speed of the planet carrier assembly member 46. The speed of the ring gear member 34 is determined from the speed of the planet carrier assembly member 36 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The

ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed from the planet carrier assembly member 46, the speed of the sun gear member 42, and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the extra third forward speed ratio (3') is determined utilizing the ring gear/sun gear tooth ratio of the planetary gear sets 20, 30 and 40.

[0061] The fourth forward speed ratio is established with the engagement of the clutch 54 and the brake 58. The clutch 54 connects the planet carrier assembly member 46 with the input shaft 17. The brake 58 connects the sun gear member 22 with the transmission housing 60. The sun gear member 22 does not rotate. The planet carrier assembly member 26 rotates at the same speed as the planet carrier assembly member 36 and the sun gear member 42. The ring gear member 24 rotates at the same speed as the sun gear member 32. The speed of the planet carrier assembly member 26 is determined from the speed of the ring gear member 24 and the ring gear/sun gear tooth ratio of the planetary gear set 20. The ring gear member 34 and the planet carrier assembly member 46 rotate at the same speed as the input shaft 17. The speed of the planet carrier assembly member 36 is determined from the speed of the ring gear member 34, the speed of the sun gear member 32, and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the planet carrier assembly member 46, the speed of the sun gear member 42 and ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the fourth forward speed is determined utilizing the ring gear/sun gear tooth ratios of the planetary gears set 20, 30 and 40.

[0062] The fifth forward speed ratio is established with the engagement of the clutches 50, 54. In this configuration, the input shaft 17 is connected in a direct drive relationship with the output shaft 19. The numerical value of the fifth forward ratio is 1.

[0063] The sixth forward speed ratio is established with the engagement with the clutch 54 and the brake 56. The clutch 54 connects the planet carrier assembly member 46 with the input shaft 17. The brake 56 connects the ring gear member 24 with transmission housing 60. The ring gear member 24 and sun gear member 32 do not rotate. The planet carrier assembly member 26 rotates at the same speed as the planet carrier assembly member 36 and the sun gear member 42. The ring gear member 34 and planet carrier assembly member 46 rotate at the same speed as the input shaft 17. The speed of the planet carrier assembly member 36 is determined from the speed of the ring gear member 34 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the planet carrier assembly member 46, the speed of the sun gear 42, and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the sixth forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 30 and 40.

[0064] The seventh forward speed ratio is established with the engagement of the clutch 54 and the brake 57. The clutch 54 connects the planet carrier assembly member 46 with the input shaft 17. The brake 57 connects the planet carrier assembly member 26 with the transmission housing 60. The planet carrier assembly members 26, 36 and the sun gear member 42 do not rotate. The ring gear member 24 rotates at the same speed as the sun gear member 32. The ring gear member 34 and planet carrier assembly member 46 rotate at the same speed as the input shaft 17. The speed of the sun gear member 32 is determined from the speed of the ring gear member 34 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates at a speed determined from the speed of the planet carrier assembly member 46 and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the seventh forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gears sets 30 and 40.

[0065] The eighth forward speed ratio is established with the engagement of the clutch 50 and the brake 56. The clutch 50 connects the planet carrier assembly member 26 with the input shaft 17. The brake 56 connects the ring gear member 24 with the transmission housing 60. The ring gear member 24 and the sun gear member 32 do not rotate. The planet carrier assembly members 26, 36 and the sun gear member 42 rotate at the same speed as the input shaft 17. The ring gear member 34 rotates at the same speed as the planet carrier assembly member 46. The speed of the ring gear member 34 is determined from the speed of the planet carrier assembly member 36 and the ring gear/sun gear tooth ratio of the planetary gear set 30. The ring gear member 44 rotates at the same speed as the output shaft 19. The ring gear member 44, and therefore the output shaft 19, rotates as a speed determined from the speed of the planet carrier assembly member 46, the speed of the sun gear member 42, and the ring gear/sun gear tooth ratio of the planetary gear set 40. The numerical value of the eighth forward speed ratio is determined utilizing the ring gear/sun gear tooth ratios of the planetary gear sets 30 and 40.

[0066] As set forth above, the engagement schedule for the torque-transmitting mechanisms is shown in the truth table of Figure 1b. This truth table also provides an example of speed ratios that are available utilizing the ring gear/sun gear tooth ratios given by way of example in Figure 1b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 20; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 30; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 40. Also, the chart of Figure 1b describes the ratio steps that are attained utilizing the sample of tooth ratios given. For example, the step ratio between the first and second forward speed ratios is 2.29, while the step ratio between the reverse and first forward ratio is -0.42.

[0067] Figure 2a shows a powertrain 110 having a conventional engine 12, a planetary transmission 114, and a conventional final drive mechanism 16.

[0068] The planetary transmission 114 includes an input shaft 17 continuously connected with the engine 12, a planetary gear arrangement 118, and an output shaft

19 continuously connected with the final drive mechanism 16. The planetary gear arrangement 118 includes three planetary gear sets 120, 130 and 140.

[0069] The planetary gear set 120 includes a sun gear member 122, a ring gear member 124, and a planet carrier assembly 126. The planet carrier assembly 126 includes a plurality of pinion gears 127, 128 rotatably mounted on a carrier member 129. The pinion gears 128 are disposed in meshing relationship with the ring gear member 124, and the pinion gears 127 are disposed in meshing relationship with the sun gear member 122.

[0070] The planetary gear set 130 includes a sun gear member 132, a ring gear member 134, and a planet carrier assembly member 136. The planet carrier assembly member 136 includes a plurality of pinion gears 137 rotatably mounted on a carrier member 139 and disposed in meshing relationship with both the sun gear member 132 and the ring gear member 134.

[0071] The planetary gear set 140 includes a sun gear member 142, a ring gear member 144, and a planet carrier assembly member 146. The planet carrier assembly member 146 includes a plurality of pinion gears 147 rotatably mounted on a carrier member 149 and disposed in meshing relationship with both the sun gear member 142 and the ring gear member 144.

[0072] The planetary gear arrangement 118 also includes seven torque-transmitting mechanisms 150, 152, 154, 156, 157, 158 and 159. The torque-transmitting mechanisms 150, 152 and 154 are rotating-type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 156, 157, 158 and 159 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[0073] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the sun gear member 122. The ring gear member 124 is continuously connected with the ring gear member 144 and with the planet carrier assembly member 136 through the interconnecting member 170. The planet carrier assembly member 126 is continuously connected with the ring gear member 134 through the interconnecting

member 172. The sun gear member 132 is continuously connected with the planet carrier assembly member 146 through the interconnecting member 174.

[0074] The planet carrier assembly member 126 is selectively connectable with the input shaft 17 through the clutch 150. The planet carrier assembly member 146 is selectively connectable with the input shaft 17 through the clutch 152. The sun gear member 142 is selectively connectable with the input shaft 17 through the clutch 154. The planet carrier assembly member 126 is selectively connectable with the transmission housing 160 through the brake 156. The ring gear member 124 is selectively connectable with the transmission housing 160 through the brake 157. The planet carrier assembly member 146 is selectively connectable with the transmission housing 160 through the brake 158. The sun gear member 142 is selectively connectable with the transmission housing 160 through the brake 159.

[0075] The truth table of Figure 2b describes the engagement sequence utilized to provide eight forward speed ratios and two reverse speed ratios in the planetary gear arrangement 118 shown in Figure 2a.

[0076] The truth tables given in Figures 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b, 10b and 11b show the engagement sequences for the torque-transmitting mechanisms to provide at least eight forward speed ratios and at least one reverse ratio. As shown and described above for the configuration in Figure 1a, those skilled in the art will understand from the respective truth tables how the speed ratios are established through the planetary gear sets identified in the written description.

[0077] As set forth above, the truth table of Figure 2b describes the engagement sequence of the torque-transmitting mechanisms utilized to provide the reverse drive ratios and eight forward speed ratios. The truth table also provides an example of the ratios that can be attained with the family members shown in Figure 2a utilizing the sample tooth ratios given in Figure 2b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 120; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 130; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 140. Also shown in Figure 2b are the ratio steps between single step ratios in the forward

direction as well as the reverse to first step ratio. For example, the first to second step ratio is 1.54.

[0078] Turning to Figure 3a, a powertrain 210 includes the engine 12, a planetary transmission 214, and a final drive mechanism 16. The planetary transmission 214 includes an input shaft 17 continuously connected with the engine 12, a planetary gear arrangement 218, and an output shaft 19 continuously connected with the final drive mechanism 16. The planetary gear arrangement 218 includes three planetary gear sets 220, 230 and 240.

[0079] The planetary gear set 220 includes a sun gear member 222, a ring gear member 224, and a planet carrier assembly 226. The planet carrier assembly 226 includes a plurality of pinion gears 227, 228 rotatably mounted on a carrier member 229. The pinion gears 227 are disposed in meshing relationship with the sun gear member 222 and the pinion gears 228 are disposed in meshing relationship with the ring gear member 224, and with the pinion gears 227.

[0080] The planetary gear set 230 includes a sun gear member 232, a ring gear member 234, and a planet carrier assembly member 236. The planet carrier assembly member 236 includes a plurality of pinion gears 237 rotatably mounted on a carrier member 239 and disposed in meshing relationship with both the sun gear member 232 and the ring gear member 234.

[0081] The planetary gear set 240 includes a sun gear member 242, a ring gear member 244, and a planet carrier assembly member 246. The planet carrier assembly member 246 includes a plurality of pinion gears 247 rotatably mounted on a carrier member 249 and disposed in meshing relationship with both the sun gear member 242 and with the ring gear member 244.

[0082] The planetary gear arrangement 218 also includes seven torque-transmitting mechanisms 250, 252, 254, 256, 257, 258 and 259. The torque-transmitting mechanisms 250, 252, 254 and 256 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 257, 258 and 259 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[0083] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the ring gear member 224. The sun gear member 222 is continuously connected with the planet carrier assembly member 236 and with the ring gear member 244 through the interconnecting member 270. The planet carrier assembly member 226 is continuously connected with the sun gear member 232 through the interconnecting member 272. The ring gear member 234 is continuously connected with the planet carrier assembly member 246 through the interconnecting member 274.

[0084] The sun gear member 232 is selectively connectable with the input shaft 17 through the clutch 250. The planet carrier assembly member 236 is selectively connectable with the input shaft 17 through the clutch 252. The planet carrier assembly member 246 is selectively connectable with the input shaft 17 through the clutch 254. The sun gear member 242 is selectively connectable with the transmission housing 260 through the brake 256. The planet carrier assembly member 226 is selectively connectable with the transmission housing 260 through the brake 257. The sun gear member 222 is selectively connectable with the transmission 260 through the brake 258. The sun gear member 242 is selective connectable with the transmission housing 260 through the brake 259.

[0085] As shown in the truth table in Figure 3b, the torque-transmitting mechanisms are engaged in combinations of two to establish eight forward speed ratios and two reverse speed ratios.

[0086] As previously set forth, the truth table of Figure 3b describes the combinations of engagements utilized for the forward and reverse speed ratios. The truth table also provides an example of speed ratios that are available with the family member described above. These examples of speed ratios are determined utilizing the tooth ratios given in Figure 3b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 220; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 230; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 240. Also depicted in Figure 3b is a chart representing the ratio steps between adjacent forward speed ratios and

between the first and reverse speed ratio. For example, the first to second ratio interchange has a step of 2.19.

[0087] A powertrain 310, shown in Figure 4a, includes the engine 12, a planetary transmission 314, and the final drive mechanism 16. The planetary transmission 314 includes an input shaft 17 continuously connected with the engine 12, a planetary gear arrangement 318, and an output shaft 19 continuously connected with the final drive mechanism 16. The planetary gear arrangement 318 includes three planetary gear sets 320, 330 and 340.

[0088] The planetary gear set 320 includes a sun gear member 322, a ring gear member 324, and a planet carrier assembly member 326. The planet carrier assembly member 326 includes a plurality of pinion gears 327, 328 rotatably mounted on a carrier member 329. The pinion gears 327 are disposed in meshing relationship with the sun gear member 322. The pinion gears 328 are disposed in meshing relationship with the ring gear member 324 and with the pinion gears 327.

[0089] The planetary gear set 330 includes a sun gear member 332, a ring gear member 334, and a planet carrier assembly member 336. The planet carrier assembly member 336 includes a plurality of pinion gears 337 rotatably mounted on a carrier member 339 and disposed in meshing relationship with both the sun gear member 332 and the ring gear member 334.

[0090] The planetary gear set 340 includes a sun gear member 342, a ring gear member 344, and a planet carrier assembly member 346. The planet carrier assembly member 346 includes a plurality of pinion gears 347 rotatably mounted on a carrier member 349 and disposed in meshing relationship with both the sun gear member 342 and the ring gear member 344.

[0091] The planetary gear arrangement 318 also includes seven torque-transmitting mechanisms 350, 352, 354, 356, 357, 358 and 359. The torque-transmitting mechanisms 350, 352, 354 and 356 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 357, 358 and 359 are stationary type torque transfer devices commonly termed brakes or reaction clutches.

[0092] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the sun gear member 322. The ring gear member 324 is continuously connected with the planet carrier assembly member 336 and with the sun gear member 342 through the interconnecting member 370. The planet carrier assembly member 326 is continuously connected with the ring gear member 334 through the interconnecting member 372. The sun gear member 332 is continuously connected with the planet carrier assembly member 346 through the interconnecting member 374.

[0093] The ring gear member 334 is selectively connectable with the input shaft 17 through the clutch 350. The planet carrier assembly member 336 is selectively connectable with the input shaft 17 through the clutch 352. The planet carrier assembly member 346 is selectively connectable with the input shaft 17 through the clutch 354. The ring gear member 344 is selectively connectable with the input shaft 17 through the clutch 356. The planet carrier assembly member 326 is selectively connectable with the transmission housing 360 through the brake 357. The planet carrier assembly member 346 is selectively connectable with the transmission housing 360 through the brake 358. The ring gear member 344 is selectively connectable with the transmission housing 360 through the brake 359.

[0094] The truth table shown in Figure 4b describes the engagement combination and the engagement sequence necessary to provide the reverse drive ratio and eight forward speed ratios, as well as the extra eighth forward speed ratio. A sample of the numerical values for the ratios is also provided in the truth table of Figure 4b. These values are determined utilizing the ring gear/sun gear tooth ratios also given in Figure 4b. The N_{R1}/N_{S1} value is the tooth ratio for the planetary gear set 320; the N_{R2}/N_{S2} value is the tooth ratio for the planetary gear set 330; and the N_{R3}/N_{S3} value is the tooth ratio for the planetary gear set 340. Also given in Figure 4b is a chart describing the step ratios between the adjacent forward speed ratios and the reverse to first forward speed ratio. For example, the first to second forward speed ratio step is 1.56.

[0095] A powertrain 410, shown in Figure 5a, includes the engine 12, a planetary transmission 414 and the final drive mechanism 16. The planetary transmission 414 includes a planetary gear arrangement 418, input shaft 17 and output shaft 19. The planetary gear arrangement 418 includes three simple planetary gear sets 420, 430 and 440.

[0096] The planetary gear set 420 includes a sun gear member 422, a ring gear member 424, and a planet carrier assembly 426. The planet carrier assembly 426 includes a plurality of pinion gears 427 rotatably mounted on a carrier member 429 and disposed in meshing relationship with both the sun gear member 422 and the ring gear member 424.

[0097] The planetary gear set 430 includes a sun gear member 432, a ring gear member 434, and a planet carrier assembly member 436. The planet carrier assembly member 436 includes a plurality of pinion gears 437 rotatably mounted on a carrier member 439 and disposed in meshing relationship with both the ring gear member 434 and the sun gear member 432.

[0098] The planetary gear set 440 includes a sun gear member 442, a ring gear member 444, and a planet carrier assembly member 446. The planet carrier assembly member 446 includes a plurality of pinion gears 447, 448 rotatably mounted on a carrier member 449 and disposed in meshing relationship with each other. The pinion gears 447 are engaged with the sun gear member 442, and the pinion gears 448 are engaged with the ring gear member 444.

[0099] The planetary gear arrangement 418 also includes seven torque-transmitting mechanisms 450, 452, 454, 456, 457, 458 and 459. The torque-transmitting mechanisms 450, 452, 454 and 456 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 457, 458 and 459 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[00100] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the ring gear member 444. The ring gear member 424 is continuously connected with the planet

carrier assembly member 436 and the sun gear member 442 through the interconnecting member 470. The planet carrier assembly member 426 is continuously connected with the ring gear member 434 through the interconnecting member 472. The sun gear member 432 is continuously connected with the planet carrier assembly member 446 through the interconnecting member 474.

[00101] The planet carrier assembly member 426 is selectively connectable with the input shaft 17 through the clutch 450. The ring gear member 424 is selectively connectable with the input shaft 17 through the clutch 452. The sun gear member 422 is selectively connectable with the input shaft 17 through the clutch 454. The sun gear member 432 is selectively connectable with the input shaft 17 through the clutch 456. The planet carrier assembly member 436 is selectively connectable with the transmission housing 460 through the brake 457. The sun gear member 422 is selectively connectable with the transmission housing 460 through the brake 458. The planet carrier assembly member 446 is selectively connectable with the transmission housing 460 through the brake 459.

[00102] The truth table shown in Figure 5b describes the engagement combination and sequence of the torque-transmitting mechanisms 450, 452, 454, 456, 457, 458 and 459 that are employed to provide the forward and reverse drive ratios.

[00103] Also given in the truth table of Figure 5b is a set of numerical values that are attainable with the present invention utilizing the ring gear/sun gear tooth ratios shown. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 420; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 430; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 440.

[00104] Figure 5b also provides a chart of the ratio steps between adjacent forward ratios and between the reverse and first forward ratio. For example, the ratio step between the first and second forward ratios is 2.01.

[00105] A powertrain 510, shown in Figure 6a, includes an engine 12, a planetary gear transmission 514 and the final drive mechanism 16. The planetary transmission 514 includes the input shaft 17, a planetary gear arrangement 518 and

the output shaft 19. The planetary gear arrangement 518 includes three planetary gear sets 520, 530 and 540.

[00106] The planetary gear set 520 includes a sun gear member 522, a ring gear member 524, and a planet carrier assembly 526. The planet carrier assembly 526 includes a plurality of pinion gears 527 rotatably mounted on a carrier member 529 and disposed in meshing relationship with both the sun gear member 522 and the ring gear member 524.

[00107] The planetary gear set 530 includes a sun gear member 532, a ring gear member 534, and a planet carrier assembly member 536. The planet carrier assembly member 536 includes a plurality of pinion gears 537 rotatably mounted on a carrier member 539 and disposed in meshing relationship with both the sun gear member 532 and the ring gear member 534.

[00108] The planetary gear set 540 includes a sun gear member 542, a ring gear member 544, and a planet carrier assembly member 546. The planet carrier assembly member 546 includes a plurality of pinion gears 547 rotatably mounted on a carrier member 549 and disposed in meshing relationship with both the sun gear member 542 and the ring gear member 544.

[00109] The planetary gear arrangement 518 also includes seven torque-transmitting mechanisms 550, 552, 554, 556, 557, 558 and 559. The torque-transmitting mechanisms 550, 552, 554 and 556 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 557, 558 and 559 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[00110] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the planet carrier assembly member 526. The planet carrier assembly member 526 is continuously connected with the sun gear member 532 and the ring gear member 544 through the interconnecting member 570. The sun gear member 522 is continuously connected with the ring gear member 534 through the interconnecting member 572. The planet

carrier assembly member 536 is continuously connected with the planet carrier assembly member 546 through the interconnecting member 574.

[00111] The ring gear member 534 is selectively connectable with the input shaft 17 through the clutch 550. The ring gear member 524 is selectively connectable with the input shaft 17 through the clutch 552. The planet carrier assembly member 546 is selectively connectable with the input shaft 17 through the clutch 554. The sun gear member 542 is selectively connectable with the input shaft 17 through the clutch 556. The ring gear member 524 is selectively connectable with the transmission housing 560 through the brake 557. The planet carrier assembly member 546 is selectively connectable with the transmission housing 560 through the brake 558. The sun gear member 542 is selectively connectable with the transmission housing 560 through the brake 559.

[00112] The truth table shown in Figure 6b describes the engagement sequence and combination of the torque-transmitting mechanisms to provide two reverse speed ratios and eight forward speed ratios. The chart of Figure 6b describes the ratio steps between adjacent forward speed ratios and the ratio step between the reverse and first forward speed ratio.

[00113] The sample speed ratios given in the truth table are determined utilizing the tooth ratio values also given in Figure 6b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 520; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 530; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 540.

[00114] A powertrain 610, shown in Figure 7a, has the engine 12, a planetary transmission 614 and the final drive mechanism 16. The planetary transmission 614 includes the input shaft 17, a planetary gear arrangement 618 and the output shaft 19. The planetary gear arrangement 618 includes three planetary gear sets 620, 630 and 640.

[00115] The planetary gear set 620 includes a sun gear member 622, a ring gear member 624, and a planet carrier assembly 626. The planet carrier assembly 626 includes a plurality of pinion gears 627 rotatably mounted on a carrier member 629

and disposed in meshing relationship with both the sun gear member 622 and the ring gear member 624.

[00116] The planetary gear set 630 includes a sun gear member 632, a ring gear member 634, and a planet carrier assembly member 636. The planet carrier assembly member 636 includes a plurality of pinion gears 637 rotatably mounted on a carrier member 639 and disposed in meshing relationship with both the sun gear member 632 and the ring gear member 634.

[00117] The planetary gear set 640 includes a sun gear member 642, a ring gear member 644, and a planet carrier assembly member 646. The planet carrier assembly member 646 includes a plurality of pinion gears 647 rotatably mounted on a carrier member 649 and disposed in meshing relationship with both the sun gear member 642 and the ring gear member 644.

[00118] The planetary gear arrangement 618 also includes seven torque-transmitting mechanisms 650, 652, 654, 656, 657, 658 and 659. The torque-transmitting mechanisms 650, 652, 654 and 656 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 657, 658 and 659 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[00119] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the planet carrier assembly member 646. The planet carrier assembly member 626 is continuously connected with the planet carrier assembly member 636 and with the ring gear member 644 through the interconnecting member 670. The ring gear member 624 is continuously connected with the ring gear member 634 through the interconnecting member 672. The sun gear member 632 is continuously connected with the planet carrier assembly member 646 through the interconnecting member 674.

[00120] The ring gear member 624 is selectively connectable with the input shaft 17 through the clutch 650. The planet carrier assembly member 626 is selectively connectable with the input shaft 17 through the clutch 652. The sun gear member 622 is selectively connectable with the input shaft 17 through the clutch 654.

The sun gear member 642 is selectively connectable with the input shaft 17 through the clutch 656. The planet carrier assembly member 626 is selectively connectable with the transmission housing 660 through the brake 657. The sun gear member 622 is selectively connectable with the transmission housing 660 through the brake 658. The sun gear member 642 is selectively connectable with the transmission housing 660 through the brake 659.

[00121] The truth table shown in Figure 7b describes the combination of torque-transmitting mechanism engagements that will provide two reverse drive ratios and eight forward speed ratios, as well as the sequence of these engagements and interchanges.

[00122] The ratio values given are by way of example and are established utilizing the ring gear/sun gear tooth ratios given in Figure 7b. For example, the N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 620; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 630; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 640. The ratio steps between adjacent forward ratios and the reverse to first ratio are also given in Figure 7b.

[00123] A powertrain 710, shown in Figure 8a, has the conventional engine 12, a planetary transmission 714, and the conventional final drive mechanism 16. The engine 12 is drivingly connected with the planetary transmission 714 through the input shaft 17. The planetary transmission 714 is drivingly connected with the final drive mechanism 16 through the output shaft 19. The planetary transmission 714 includes a planetary gear arrangement 718 that has a first planetary gear set 720, a second planetary gear set 730, and a third planetary gear set 740.

[00124] The planetary gear set 720 includes a sun gear member 722, a ring gear member 724, and a planet carrier assembly 726. The planet carrier assembly 726 includes a plurality of pinion gears 727 rotatably mounted on a carrier member 729 and disposed in meshing relationship with both the sun gear member 722 and the ring gear member 724.

[00125] The planetary gear set 730 includes a sun gear member 732, a ring gear member 734, and a planet carrier assembly member 736. The planet carrier assembly

member 736 includes a plurality of pinion gears 737 rotatably mounted on a carrier member 739 and disposed in meshing relationship with both the sun gear member 732 and the ring gear member 734.

[00126] The planetary gear set 740 includes a sun gear member 742, a ring gear member 744, and a planet carrier assembly member 746. The planet carrier assembly member 746 includes a plurality of pinion gears 747 rotatably mounted on a carrier member 749 and engaged with both the sun gear member 742 and the ring gear member 744.

[00127] The planetary gear arrangement 718 also includes seven torque-transmitting mechanisms 750, 752, 754, 756, 757, 758 and 759. The torque-transmitting mechanisms 750, 752 and 754 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 756, 757, 758 and 759 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[00128] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the ring gear member 724. The sun gear member 722 is continuously connected with the sun gear member 732 and the sun gear member 742 through the interconnecting member 770. The planet carrier assembly member 726 is continuously connected with planet carrier assembly member 736 through the interconnecting member 772. The ring gear member 734 is continuously connected with the planet carrier assembly member 746 through the interconnecting member 774.

[00129] The sun gear member 742 is selectively connectable with the input shaft 17 through the clutch 750. The planet carrier assembly member 746 is selectively connectable with the input shaft 17 through the clutch 752. The ring gear member 744 is selectively connectable with the input shaft 17 through the clutch 754. The planet carrier assembly member 726 is selectively connectable with the transmission housing 760 through the brake 756. The sun gear member 742 is selectively connectable with the transmission housing 760 through the brake 757. The ring gear member 734 is selectively connectable with the transmission housing

760 through the brake 758. The ring gear member 744 is selectively connectable with the transmission housing 760 through the brake 759.

[00130] The truth table of Figure 8b defines the torque-transmitting mechanism engagement sequence utilized for each of the forward and reverse speed ratios. Also given in the truth table is a set of numerical values that are attainable with the present invention utilizing the ring gear/sun gear tooth ratios given in Figure 8b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 720; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 730; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 740.

[00131] Figure 8b also provides a chart of the ratio steps between adjacent forward ratios and between the reverse and first forward ratio. For example, the ratio step between the first and second forward ratios is 2.11.

[00132] A powertrain 810, shown in Figure 9a, has the conventional engine 12, a planetary transmission 814, and the final drive mechanism 16. The engine 12 is drivingly connected with the planetary transmission 814 through the input shaft 17. The planetary transmission 814 is drivingly connected with the final drive mechanism 16 through the output shaft 19. The planetary transmission 814 includes a planetary gear arrangement 818 that has a first planetary gear set 820, a second planetary gear set 830, and a third planetary gear set 840.

[00133] The planetary gear set 820 includes a sun gear member 822, a ring gear member 824, and a planet carrier assembly 826. The planet carrier assembly 826 includes a plurality of pinion gears 827 rotatably mounted on a carrier member 829 and disposed in meshing relationship with both the sun gear member 822 and the ring gear member 824.

[00134] The planetary gear set 830 includes a sun gear member 832, a ring gear member 834, and a planet carrier assembly member 836. The planet carrier assembly member 836 includes a plurality of pinion gears 837 rotatably mounted on a carrier member 839 and disposed in meshing relationship with both the sun gear member 832 and the ring gear member 834.

[00135] The planetary gear set 840 includes a sun gear member 842, a ring gear member 844, and a planet carrier assembly member 846. The planet carrier assembly member 846 includes a plurality of pinion gears 847 rotatably mounted on a carrier member 849 and disposed in meshing relationship with both the ring gear member 844, and the sun gear member 842.

[00136] The planetary gear arrangement 818 also includes seven torque-transmitting mechanisms 850, 852, 854, 856, 857, 858 and 859. The torque-transmitting mechanisms 850, 852 and 854 are rotating type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 856, 857, 858 and 859 are stationary-type torque transmitting mechanisms, commonly termed brakes or reaction clutches.

[00137] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the planet carrier assembly member 826. The ring gear member 824 is continuously connected with the planet carrier assembly members 836 and 846 through the interconnecting member 870. The sun gear member 822 is continuously connected with the ring gear member 834 through the interconnecting member 872. The sun gear member 832 is continuously connected with the sun gear member 842 through the interconnecting member 874.

[00138] The ring gear member 834 is selectively connectable with the input shaft 17 through the clutch 850. The planet carrier assembly member 836 is selectively connectable with the input shaft 17 through the clutch 852. The sun gear member 842 is selectively connectable with the input shaft 17 through the clutch 854. The sun gear member 822 is selectively connectable with the transmission housing 860 through the brake 856. The ring gear member 824 is selectively connectable with the transmission housing 860 through the brake 857. The sun gear member 842 is selectively connectable with the transmission housing 860 through the brake 858. The ring gear member 844 is selectively connectable with the transmission housing 860 through the brake 859.

[00139] The truth table shown in Figure 9b defines the torque-transmitting mechanism engagement sequence that provides two reverse speed ratios and eight forward speed ratios shown in the truth table and available with the planetary gear arrangement 818. A sample of numerical values for the individual ratios is also given in the truth table of Figure 9b. These numerical values have been calculated using the ring gear/sun gear tooth ratios also given by way of example in Figure 9b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 820; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 830; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 840. Figure 9b also describes the ratio steps between adjacent forward ratios and between the reverse and first forward ratio.

[00140] The powertrain 910, shown in Figure 10a, includes the conventional engine 12, a planetary transmission 914, and the conventional final drive mechanism 16. The engine 12 is drivingly connected with the planetary transmission 914 through the input shaft 17. The planetary transmission 914 is drivingly connected with the final drive mechanism 16 through the output shaft 19. The planetary transmission 914 includes a planetary gear arrangement 918 that has a first planetary gear set 920, a second planetary gear set 930, and a third planetary gear set 940.

[00141] The planetary gear set 920 includes a sun gear member 922, a ring gear member 924, and a planet carrier assembly 926. The planet carrier assembly 926 includes a plurality of pinion gears 927 that are rotatably mounted on a carrier member 929 and disposed in meshing relationship with both the sun gear member 922 and the ring gear member 924.

[00142] The planetary gear set 930 includes a sun gear member 932, a ring gear member 934, and a planet carrier assembly member 936. The planet carrier assembly member 936 includes a plurality of pinion gears 937, 938 rotatably mounted on a carrier member 939 and disposed in meshing relationship with each other. The pinion gears 937 are engaged with the ring gear member 934, and the pinion gears 938 are engaged with the sun gear member 932.

[00143] The planetary gear set 940 includes a sun gear member 942, a ring gear member 944, and a planet carrier assembly member 946. The planet carrier assembly

member 946 includes a plurality of pinion gears 947 rotatably mounted on a carrier member 949 and disposed in meshing relationship with both the sun gear member 942 and the ring gear member 944.

[00144] The planetary gear arrangement 918 also includes seven torque-transmitting mechanisms 950, 952, 954, 956, 957, 958 and 959. The torque-transmitting mechanisms 950, 952 and 954 are rotating-type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 956, 957, 958 and 959 are stationary-type torque-transmitting mechanisms, commonly termed brakes or reaction clutches.

[00145] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the planet carrier assembly member 926. The planet carrier assembly member 926 is continuously connected with the planet carrier assembly member 936 and with the sun gear member 942 through the interconnecting member 970. The ring gear member 924 is continuously connected with the ring gear member 934 through the interconnecting member 972. The sun gear member 932 is continuously connected with the ring gear member 944 through the interconnecting member 974.

[00146] The sun gear member 942 is selectively connectable with the input shaft 17 through the clutch 950. The sun gear member 922 is selectively connectable with the input shaft 17 through the clutch 952. The planet carrier assembly member 942 is selectively connectable with the input shaft 17 through the clutch 954. The sun gear member 922 is selectively connectable with the transmission housing 960 through the brake 956. The planet carrier assembly member 936 is selectively connectable with the transmission housing 960 through the brake 957. The planet carrier assembly member 946 is selectively connectable with the transmission housing 960 through the brake 958. The ring gear member 944 is selectively connectable with the transmission housing 960 through the brake 959.

[00147] The truth table of Figure 10b describes the torque-transmitting mechanism engagement sequence utilized to provide the reverse speed ratio and eight forward speed ratios, as well as an extra third forward speed ratio. The truth table

also provides a set of examples for the ratios for each of the reverse and forward speed ratios. These numerical values have been determined utilizing the ring gear/sun gear tooth ratios given in Figure 10b. The N_{R1}/N_{S1} value is the tooth ratio of the planetary gear set 920; the N_{R2}/N_{S2} value is the tooth ratio of the planetary gear set 930; and the N_{R3}/N_{S3} value is the tooth ratio of the planetary gear set 940.

[00148] A powertrain 1010, shown in Figure 11a, includes the conventional engine 12, a planetary transmission 1014, and the conventional final drive mechanism 16. The engine is drivingly connected with the planetary transmission 1014 through the input shaft 17. The planetary transmission 1014 is drivingly connected with the final drive mechanism 16 through the output shaft 19. The planetary transmission 1014 includes a planetary gear arrangement 1018 that has a first planetary gear set 1020, a second planetary gear set 1030, and a third planetary gear set 1040.

[00149] The planetary gear set 1020 includes a sun gear member 1022, a planet carrier assembly 1026, and a plurality of long pinion gears 1027. The plurality of pinion gears 1027 are rotatably mounted on a carrier member 1029 and disposed in meshing relationship with the sun gear member 1022.

[00150] The planetary gear set 1030 includes a sun gear member 1032, a ring gear member 1034, and a planet carrier assembly member 1036. The planet carrier assembly member 1036 is integral with the planet carrier assembly member 1026. The planet carrier assembly member 1036 includes a plurality of pinion gears 1037, 1038 rotatably mounted on a carrier member 1039. The pinion gears 1038 are integral with the pinion gears 1027 (i.e. they are formed by long pinion gears) and are disposed in meshing relationship with the ring gear member 1034 and with the pinion gears 1037. The pinion gears 1037 are also engaged with the sun gear member 1032.

[00151] The planetary gear set 1040 includes a sun gear member 1042, a ring gear member 1044, and a planet carrier assembly member 1046. The planet carrier assembly member 1046 includes a plurality of pinion gears 1047 rotatably mounted on a carrier member 1049 and disposed in meshing relationship with both the ring gear member 1044 and the sun gear member 1042.

[00152] The planetary gear arrangement 1018 also includes seven torque-transmitting mechanisms 1050, 1052, 1054, 1056, 1057, 1058 and 1059. The torque-transmitting mechanisms 1050, 1052, and 1054 are rotating-type torque-transmitting mechanisms, commonly termed clutches. The torque-transmitting mechanisms 1056, 1057, 1058 and 1059 are stationary-type torque-transmitting mechanisms, commonly termed brakes or reaction clutches.

[00153] The input shaft 17 is not continuously connected with any planetary gear member. The output shaft 19 is continuously connected with the ring gear member 1044. The planet carrier assembly member 1026 is continuously connected with (i.e. integral with) the planet carrier assembly member 1036. This integral connection, and its connection with the sun gear member 1042 is referred to herein as the interconnecting member 1070. The integral connection of the long pinion gears 1027 and 1038 is referred to herein as the interconnecting member 1072. The ring gear member 1034 is continuously connected with the planet carrier assembly member 1046 through the interconnecting member 1074.

[00154] The planet carrier assembly member 1036 is selectively connectable with the input shaft 17 through the clutch 1050. The planet carrier assembly member 1046 is selectively connectable with the input shaft 17 through the clutch 1052. The sun gear member 1032 is selectively connectable with the input shaft 17 through the clutch 1054. The planet carrier assembly member 1026 is selectively connectable with the transmission housing 1066 through the brake 1056. The ring gear member 1034 is selectively connectable with the transmission housing 1060 through the brake 1057. The sun gear member 1032 is selectively connectable with the transmission housing 1060 through the brake 1058. The sun gear member 1022 is selectively connectable with the transmission housing 1060 through the brake 1059.

[00155] The truth table shown in Figure 11b describes the engagement combinations and the engagement sequence necessary to provide the reverse drive ratio and eight forward speed ratios, as well as an extra second forward speed ratio. A sample of the numerical values for the ratios is also provided in the truth table of Figure 11b. These values are determined utilizing the ring gear/sun gear tooth ratios

also given in Figure 11b. The N_{R1}/N_{S1} value is the tooth ratio for the planetary gear set 1020; the N_2/N_{S2} value is the tooth ratio for the planetary gear set 1030; and the N_{R3}/N_{S3} value is the tooth ratio for the planetary gear set 1040. Also given in Figure 11b is a chart describing the step ratios between the adjacent forward speed ratios and the reverse to first forward speed ratio.

[00156] While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims.

CLAIMS

1. A multi-speed transmission comprising:
an input shaft;
an output shaft;
first, second and third planetary gear sets each having first, second and
5 third members;
said output shaft being continuously interconnected with a member of
said planetary gear sets, and said input shaft not being continuously interconnected
with any member of said planetary gear sets;
a first interconnecting member continuously interconnecting said first
10 member of said first planetary gear set with said first member of said second planetary
gear set and said first member of said third planetary gear set;
a second interconnecting member continuously interconnecting said
second member of said first planetary gear set with said second member of said
second planetary gear set;
15 a third interconnecting member continuously interconnecting said third
member of said second planetary gear set with said second member of said third
planetary gear set;
a first torque-transmitting mechanism selectively interconnecting a
member of said first planetary gear set with said input shaft;
20 a second torque-transmitting mechanism selectively interconnecting a
member of said second planetary gear set with said input shaft;
a third torque-transmitting mechanism selectively interconnecting a
member of said first or third planetary gear set with said input shaft;
a fourth torque-transmitting mechanism selectively interconnecting a
25 member of said first planetary gear set with a stationary member;
a fifth torque-transmitting mechanism selectively interconnecting a
member of said second planetary gear set with said stationary member;
a sixth torque-transmitting mechanism selectively interconnecting a
member of said first or third planetary gear set with said stationary member; and

30 a seventh torque-transmitting mechanism selectively interconnecting a member of said first, second or third planetary gear set with another member of said first, second or third planetary gear set, or with said stationary member;

 said torque-transmitting mechanisms being engaged in combinations of two to establish at least eight forward speed ratios and at least one reverse speed ratio
35 between said input shaft and said output shaft.

2. The transmission defined in claim 1, wherein said first, second and third torque-transmitting mechanisms comprise clutches, and said fourth, fifth, sixth and seventh torque-transmitting mechanisms comprise brakes.

3. The transmission defined in claim 1, wherein said first, second, third and seventh torque-transmitting mechanisms comprise clutches, and said fourth, fifth, and sixth torque-transmitting mechanisms comprise brakes.

4. The transmission defined in claim 1, wherein planet carrier assembly members of each of said planetary gear sets are single-pinion carriers.

5. The transmission defined in claim 1, wherein at least one planet carrier assembly member of said planetary gear sets is a double-pinion carrier.

6. The transmission defined in claim 1, wherein two planet carrier assembly members of said planetary gear sets are double-pinion carriers.

7. The transmission defined in claim 1, wherein said first, second and third members comprise a ring gear member, sun gear member, and planet carrier assembly member, in any order.

8. The transmission defined in claim 1, wherein said first, second and third members are selected from a ring gear member, a sun gear member, a planet carrier assembly member, and a long pinion gear, in any order.

9. A multi-speed transmission comprising:
an input shaft;
an output shaft;
a planetary gear arrangement having first, second and third planetary
5 gear sets, each planetary gear set having first, second and third members;
said output shaft being continuously interconnected with a member of
said planetary gear sets, and said input shaft not being continuously interconnected
with any member of said planetary gear sets;
a first interconnecting member continuously interconnecting said first
10 member of said first planetary gear set with said first member of said second planetary
gear set and said first member of said third planetary gear set;
a second interconnecting member continuously interconnecting said
second member of said first planetary gear set with said second member of said
second planetary gear set;
15 a third interconnecting member continuously interconnecting said third
member of said second planetary gear set with said second member of said third
planetary gear set; and
seven torque-transmitting mechanisms for selectively interconnecting
said members of said planetary gear sets with said input shaft, with a stationary
20 member or with other members of said planetary gear sets, said seven torque-
transmitting mechanisms being engaged in combinations of two to establish at least
eight forward speed ratios and at least one reverse speed ratio between said input shaft
and said output shaft.

10. The transmission defined in claim 9, wherein a first of said seven torque-transmitting mechanisms is operable for selectively interconnecting a member of said first planetary gear set with said input shaft.

11. The transmission defined in claim 9, wherein a second of said seven torque-transmitting mechanisms is operable for selectively interconnecting a member of said second planetary gear set with said input shaft.

12. The transmission defined in claim 9, wherein a third of said seven torque-transmitting mechanisms is selectively operable for interconnecting a member of said first or third planetary gear set with said input shaft.

13. The transmission defined in claim 9, wherein a fourth of said seven torque-transmitting mechanisms is selectively operable for interconnecting a member of said first planetary gear set with said stationary member.

14. The transmission defined in claim 9, wherein a fifth of said seven torque-transmitting mechanisms is selectively operable for interconnecting a member of said second planetary gear set with said stationary member.

15. The transmission defined in claim 9, wherein a sixth of said seven torque-transmitting mechanisms selectively interconnects a member of said first or third planetary gear set with said stationary member.

16. The transmission defined in claim 9, wherein a seventh of said seven torque-transmitting mechanisms selectively interconnects a member of said first, second or third planetary gear set with another member of said first, second or third planetary gear set, or with said stationary member.

17. The transmission defined in claim 9, wherein planet carrier assembly members of each of said planetary gear sets are single-pinion carriers.

18. The transmission defined in claim 9, wherein at least one planet carrier assembly member of said planetary gear sets is a double-pinion carrier.

19. The transmission defined in claim 9, wherein said first, second and third members comprise a ring gear member, sun gear member, and planet carrier assembly member, in any order.

20. The transmission defined in claim 9, wherein said first, second and third members are selected from a ring gear member, a sun gear member, a planet carrier assembly member, and a long pinion gear, in any order.

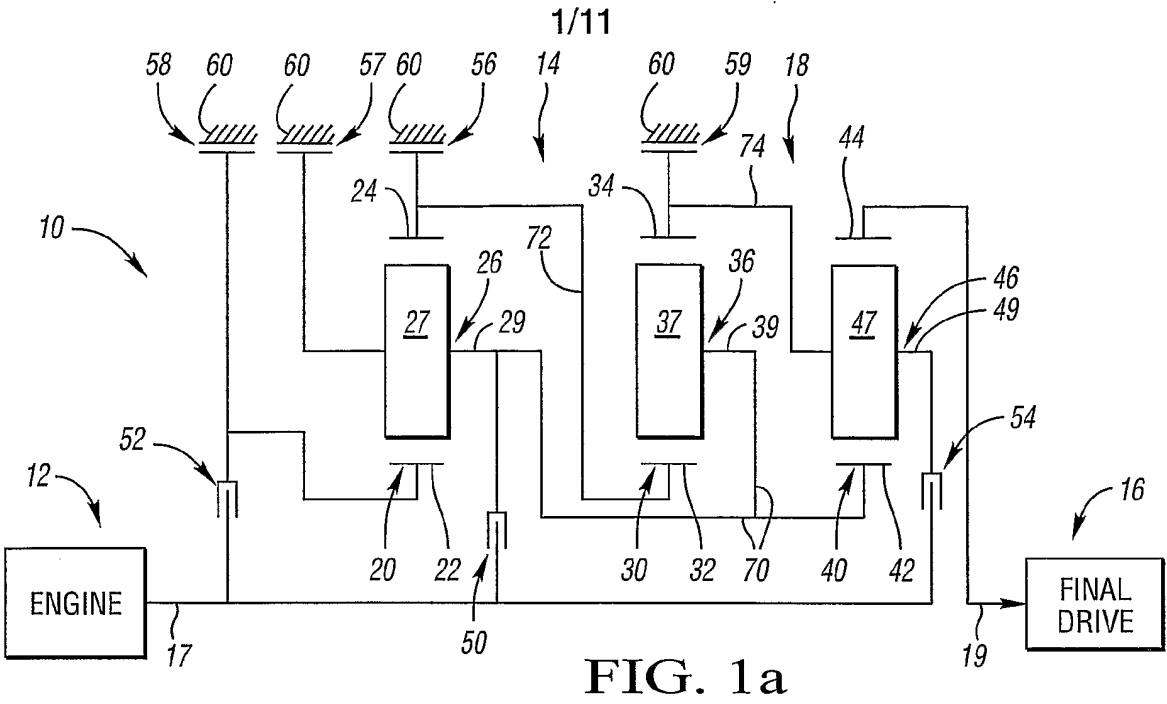


FIG. 1b

	RATIOS	50	52	54	56	57	58	59
REVERSE	-2.25	X						X
NEUTRAL	0.00							X
1	5.38		X					X
2	2.35		X			X		
3	1.74	X					X	
3'	1.66		X		X			
4	1.23			X			X	
5	1.00	X		X				
6	0.85			X	X			
7	0.69			X		X		
8	0.51	X			X			

(X = ENGAGED CLUTCH)

RING GEAR TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.25$, $\frac{N_{R2}}{N_{S2}} = 1.51$, $\frac{N_{R3}}{N_{S3}} = 2.25$

RATIO SPREAD	10.55
RATIO STEPS	
REV/1	-0.42
1/2	2.29
2/3	1.35
3/4	1.41
4/5	1.23
5/6	1.18
6/7	1.23
7/8	1.35

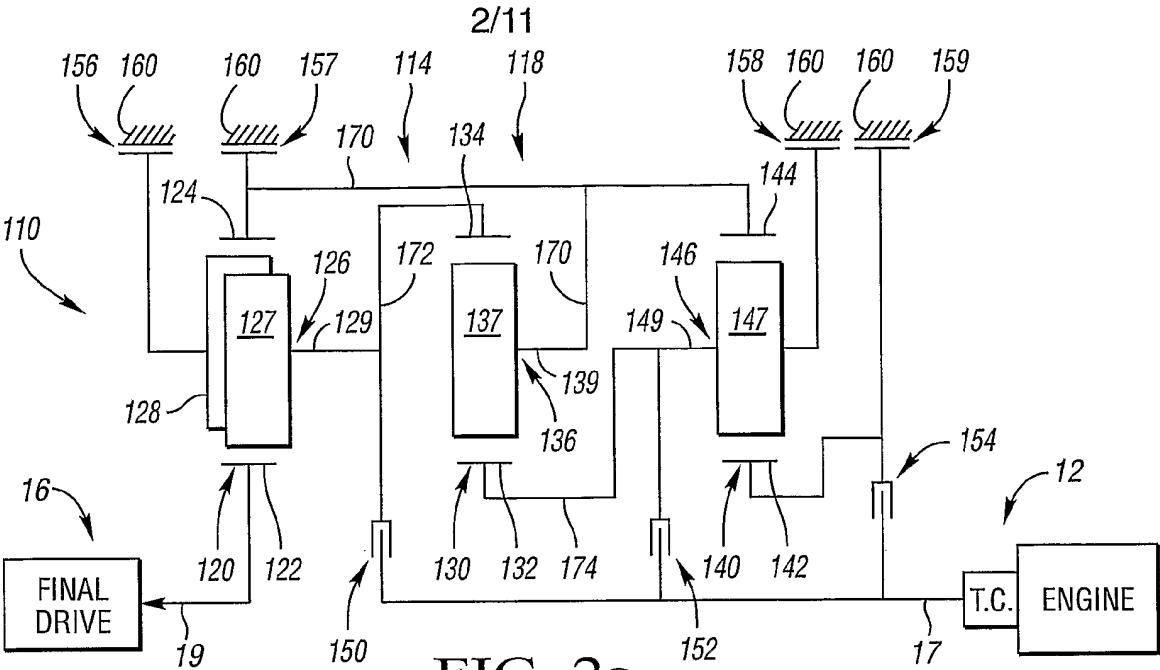


FIG. 2a

FIG. 2b

	RATIOS	150	152	154	156	157	158	159
REVERSE	-6.01			X			X	
REVERSE'	-0.67	X				X		
NEUTRAL	0.00			X				
1	7.99			X		X		
2	5.19			X	X			
3	2.67	X					X	
4	2.00		X			X		
5	1.60		X		X			
6	1.24	X						X
7	1.00	X	X					
8	0.86		X					X

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.50$, $\frac{N_{R2}}{N_{S2}} = 2.99$, $\frac{N_{R3}}{N_{S3}} = 3.00$

RATIO SPREAD	9.29
RATIO STEPS	
REV/1	-0.75
1/2	1.54
2/3	1.94
3/4	1.34
4/5	1.25
5/6	1.29
6/7	1.24
7/8	1.16

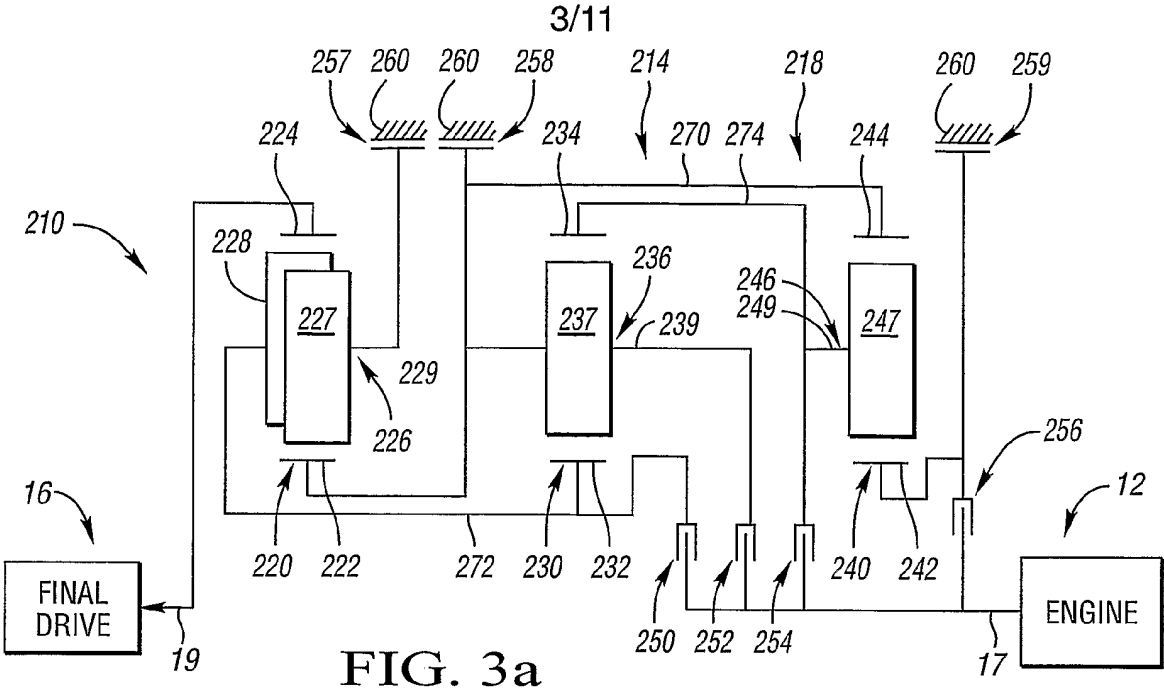


FIG. 3a

FIG. 3b

	RATIOS	250	252	254	256	257	258	259
REVERSE	-4.41				X		X	
REVERSE'	-1.10			X			X	
NEUTRAL	0.00				X			
1	9.17				X	X		
2	4.18			X		X		
3	2.51		X			X		
4	1.66	X					X	
5	1.12	X						X
6	1.00	X	X					
7	0.82		X					X
8	0.61			X				X

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.51$, $\frac{N_{R2}}{N_{S2}} = 1.51$, $\frac{N_{R3}}{N_{S3}} = 3.00$

RATIO SPREAD	15.03
RATIO STEPS	
REV/1	-0.48
1/2	2.19
2/3	1.67
3/4	1.51
4/5	1.48
5/6	1.12
6/7	1.22
7/8	1.34

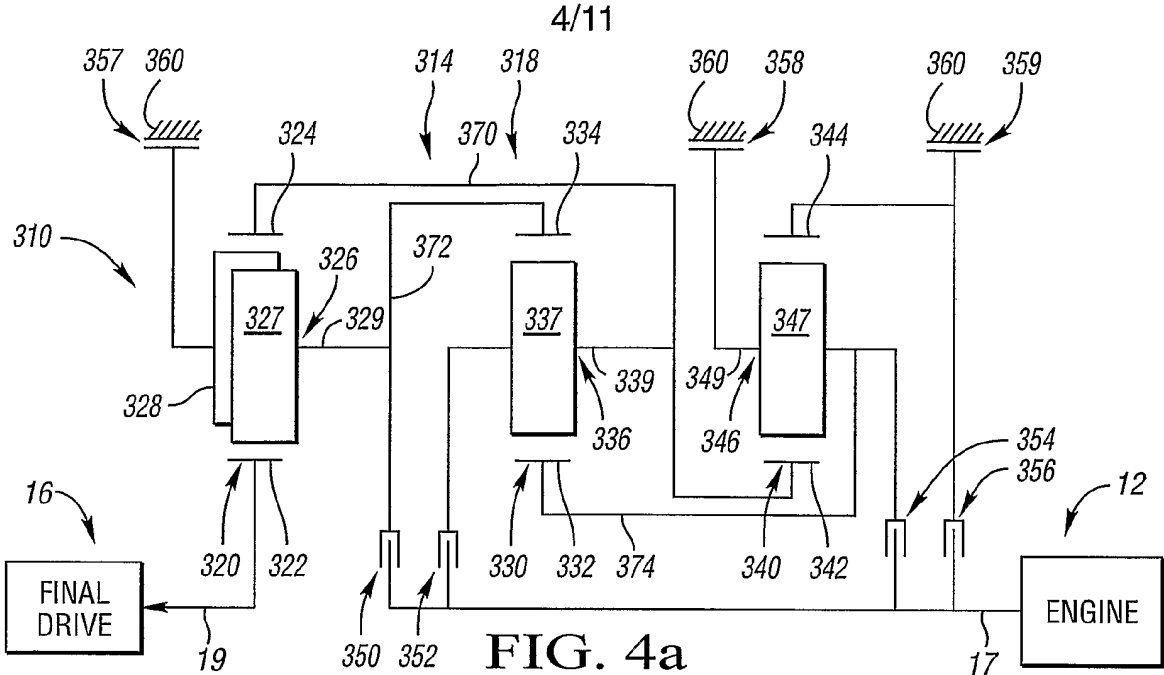


FIG. 4b

	RATIOS	350	352	354	356	357	358	359
REVERSE	-4.07				X		X	
NEUTRAL	0.00						X	
1	9.48	X					X	
2	6.08		X				X	
3	2.67	X						X
4	2.00		X					X
5	1.60				X	X		
6	1.12			X		X		
7	1.00	X		X				
8	0.80			X				X
8'	0.40		X			X		

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.50$, $\frac{N_{R2}}{N_{S2}} = 1.79$, $\frac{N_{R3}}{N_{S3}} = 1.50$

RATIO SPREAD	11.85
RATIO STEPS	
REV/1	-0.43
1/2	1.56
2/3	2.28
3/4	1.34
4/5	1.25
5/6	1.43
6/7	1.12
7/8	1.25

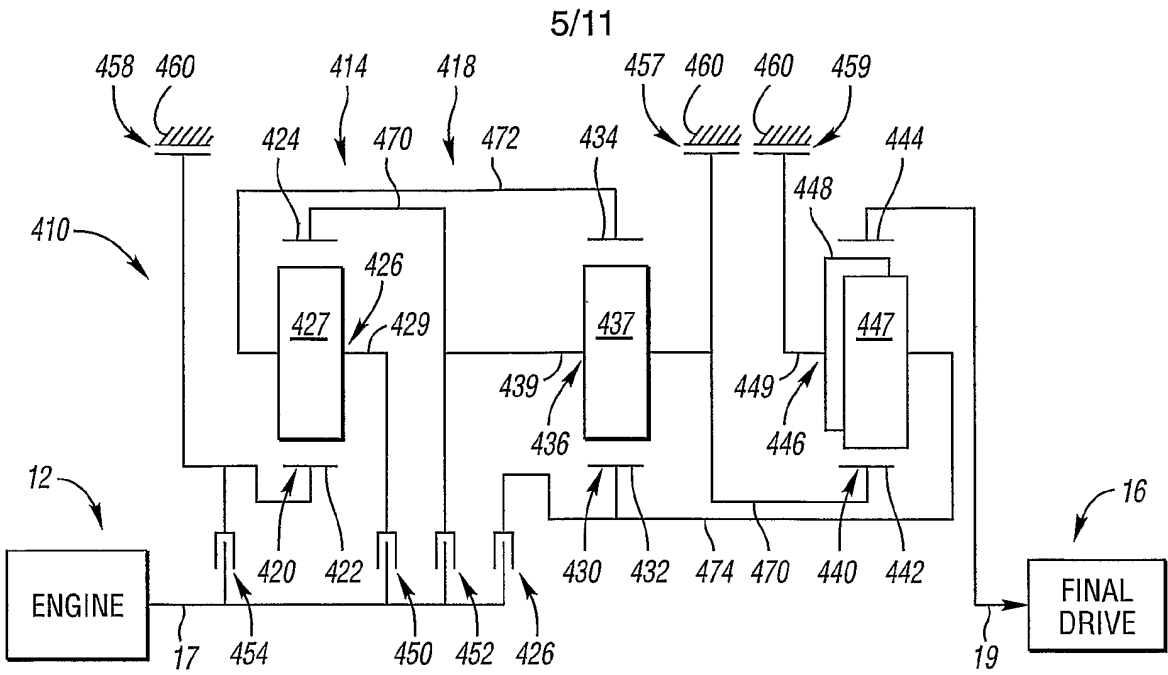


FIG. 5a

FIG. 5b

	RATIOS	450	452	454	456	457	458	459
REVERSE	-3.62			X		X		
REVERSE'	-0.99	X				X		
NEUTRAL	0.00			X				
1	8.53			X				X
2	4.24	X						X
3	2.63		X					X
4	1.61				X	X		
5	1.13				X		X	
6	1.00		X		X			
7	0.78		X				X	
8	0.57	X					X	

(X = ENGAGED CLUTCH)

RING GEAR
SUN GEAR TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.65$, $\frac{N_{R2}}{N_{S2}} = 1.63$, $\frac{N_{R3}}{N_{S3}} = 2.63$

RATIO SPREAD	14.96
RATIO STEPS	
REV/1	-0.42
1/2	2.01
2/3	1.61
3/4	1.63
4/5	1.42
5/6	1.13
6/7	1.28
7/8	1.37

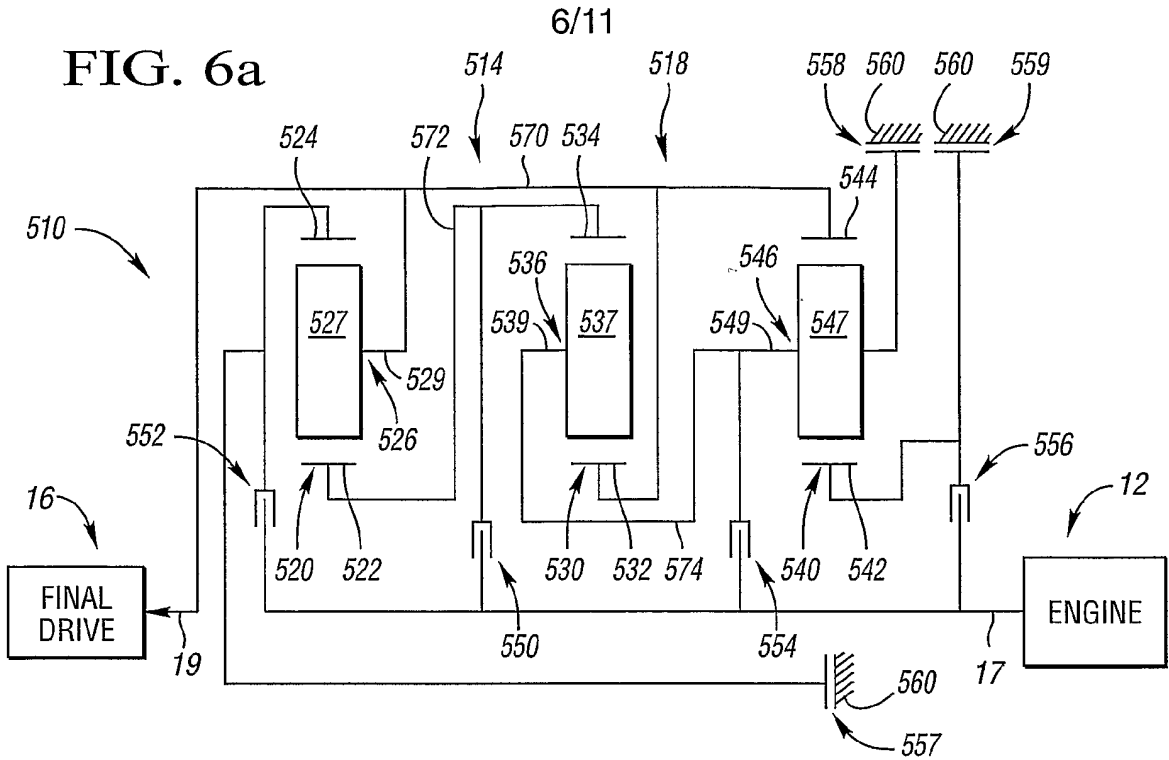


FIG. 6b

	RATIOS	550	552	554	556	557	558	559
REVERSE	-3.00				X		X	
REVERSE'	-0.67		X				X	
NEUTRAL	0.00				X			
1	7.00				X	X		
2	3.50	X				X		
3	2.50			X		X		
4	1.67		X				X	
5	1.17		X					X
6	1.00		X	X				
7	0.75			X				X
8	0.58	X						X

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.50$, $\frac{N_{R2}}{N_{S2}} = 1.50$, $\frac{N_{R3}}{N_{S3}} = 3.00$

RATIO SPREAD	12.07
RATIO STEPS	
REV/1	-0.43
1/2	2.00
2/3	1.40
3/4	1.50
4/5	1.43
5/6	1.17
6/7	1.33
7/8	1.29

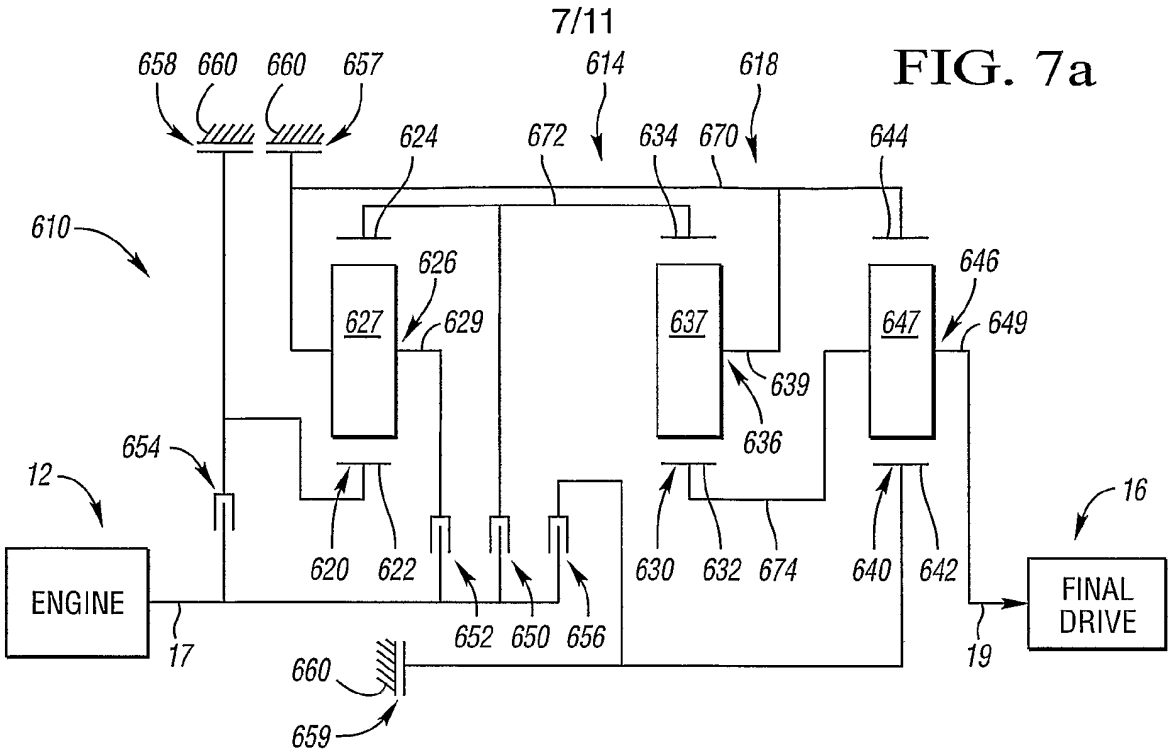


FIG. 7b

	RATIOS	650	652	654	656	657	658	659
REVERSE	-6.67				X		X	
REVERSE'	-0.61	X				X		
NEUTRAL	0.00						X	
1	8.08	X					X	
2	5.39		X				X	
3	2.75				X	X		
4	1.92	X						X
5	1.57		X					X
6	1.23			X		X		
7	1.00	X		X				
8	0.87			X				X

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 2.00$, $\frac{N_{R2}}{N_{S2}} = 1.63$, $\frac{N_{R3}}{N_{S3}} = 1.75$

RATIO SPREAD	9.29
RATIO STEPS	
REV/1	-0.83
1/2	1.50
2/3	1.96
3/4	1.43
4/5	1.22
5/6	1.28
6/7	1.23
7/8	1.15

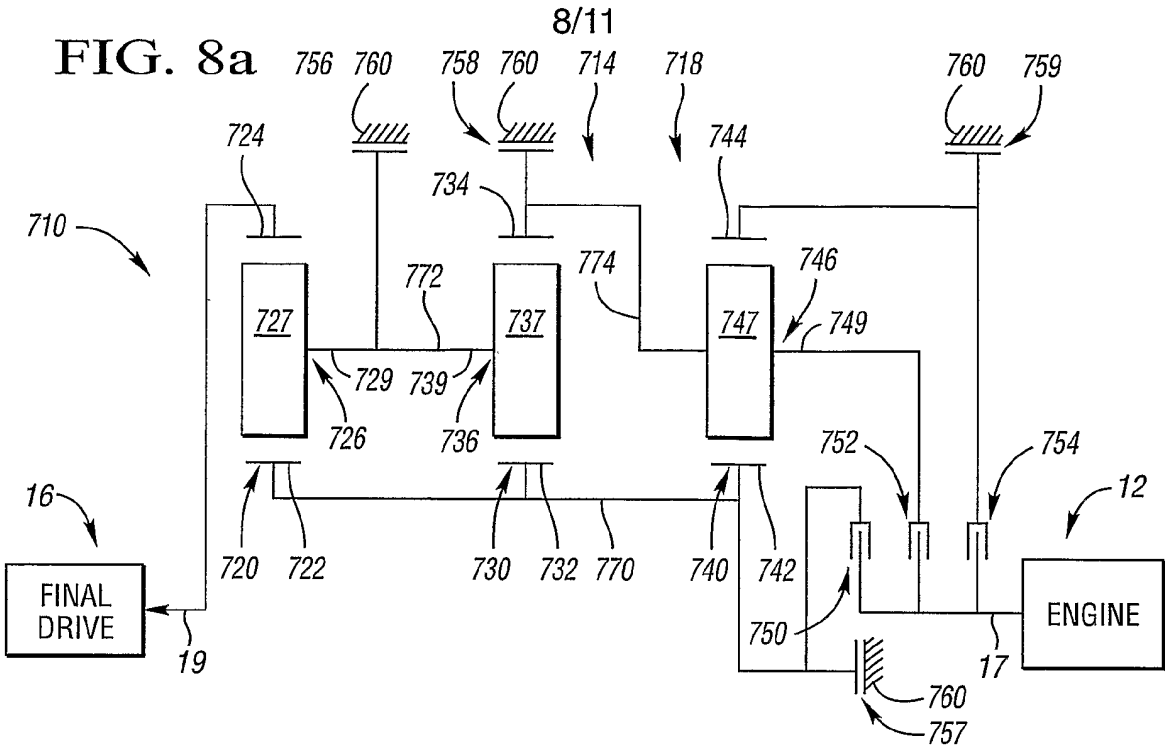


FIG. 8b

	RATIOS	750	752	754	756	757	758	759
REVERSE	-12.39	X					X	
REVERSE'	-1.82	X			X			
NEUTRAL	0.00						X	
1	6.90			X			X	
2	3.27	X						X
3	2.24			X	X			
4	1.44			X		X		
5	1.17		X					X
6	1.00	X	X					
7	0.93		X			X		
8	0.79		X		X			

(X = ENGAGED CLUTCH)

$\frac{\text{RING GEAR}}{\text{SUN GEAR}}$ TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 1.82$, $\frac{N_{R2}}{N_{S2}} = 2.31$, $\frac{N_{R3}}{N_{S3}} = 1.80$

RATIO SPREAD	8.73
RATIO STEPS	
REV/1	-1.80
1/2	2.11
2/3	1.46
3/4	1.56
4/5	1.23
5/6	1.17
6/7	1.08
7/8	1.18

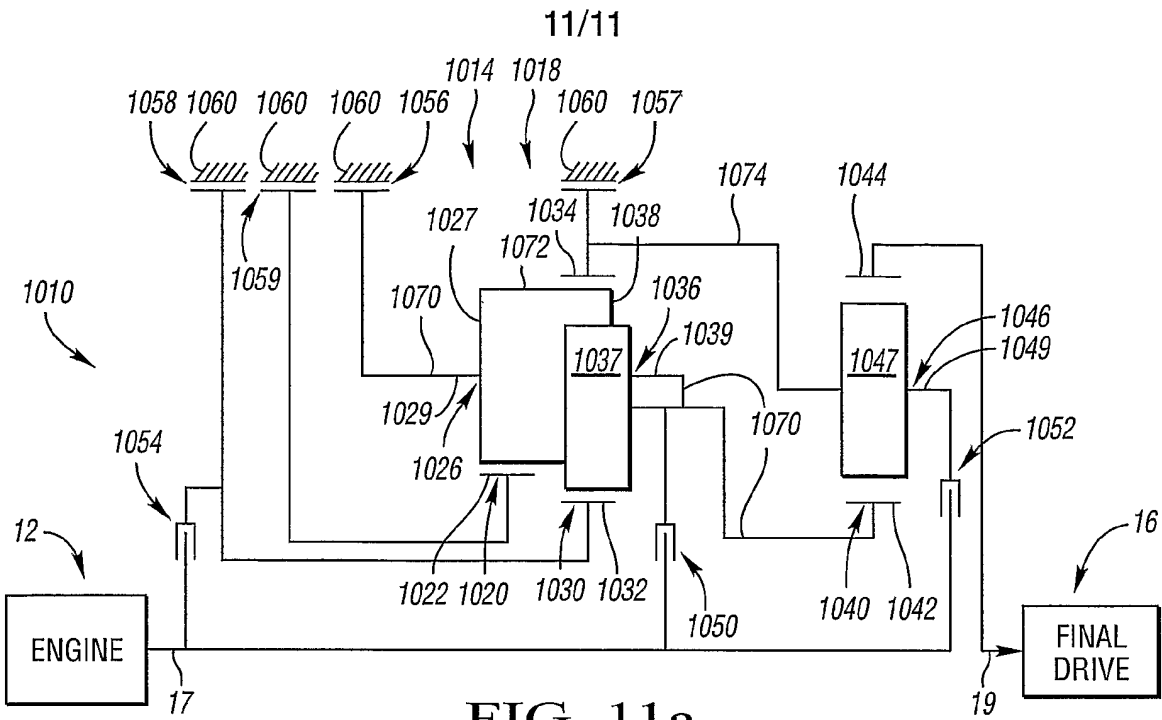


FIG. 11b

	RATIOS	1050	1052	1054	1056	1057	1058	1059
REVERSE	-2.50	X				X		
NEUTRAL	0.00					X		
1	5.63			X		X		
2	2.32			X	X			
2'	1.76	X					X	
3	1.64			X				X
4	1.22		X				X	
5	1.00	X	X					
6	0.86		X					X
7	0.71		X		X			
8	0.52	X						X

(X = ENGAGED CLUTCH)

RING GEAR
SUN GEAR

TOOTH RATIO: $\frac{N_{R1}}{N_{S1}} = 1.83, \frac{N_{R2}}{N_{S2}} = 3.25, \frac{N_{R3}}{N_{S3}} = 2.50$

RATIO SPREAD	10.83
RATIO STEPS	
REV/1	-0.44
1/2	2.43
2/3	1.41
3/4	1.34
4/5	1.22
5/6	1.16
6/7	1.21
7/8	1.37