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(54) CHANGE-SPEED TRANSMISSION WITH SELECTIVE BYPASS OF HYDROKINETIC UNIT

(71) We, NISSAN MOTOR COMPANY, LIMITED, a corporation organized under the laws of Japan, of No. 2, Takaracho, Kanaqawa-ku, Yokohama City, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a change-speed transmission and more particularly to an automatic transmission comprising a hydrokinetic unit, such as a torque converter or a hydraulic coupling, a divider in the form of a planetary gear set, and a planetary gear train.

The conventional automatic transmissions using a hydrokinetic unit will provide smooth and effortless start-up of the automobile and shockless shifting as compared to the conventional manual transmissions. However, as there is a slip in a hydrokinetic unit, the automobile equipped with an automatic transmission using a hydrokinetic unit is worse in fuel economy than the automobile equipped with a manual transmission.

In order to improve fuel economy of an automobile equipped with an automatic transmission having a hydrokinetic unit, it has been proposed to provide a torque flow path bypassing the hydrokinetic unit which is selectively established by means of a clutch so that when the first forward speed is to be selected, the clutch is disengaged or uncoupled to make full use of the slip characteristics of the hydrokinetic unit for ease of start-up of the automobile. When another forward speed is to be selected, the clutch is engaged or coupled to establish the torque flow path so as to allow a portion of the input torque to flow through this direct path, although the balance portion of the engine torque is transmitted by the hydrokinetic unit. This torque split arrangement results in substantial reduction in the fuel consumption of the automobile.

There is known a two-speed automatic transmission embodying the proposal described above, in which all of the input torque on an input member is transmitted through a hydrokinetic unit to provide the first forward speed and in which, to provide the second forward speed, the transmission of a portion of the input torque is effected through a first or torque split clutch bypassing the hydrokinetic unit with the balance portion of the input torque being transmitted by the hydrokinetic unit. This known transmission comprises: an input member; an output member; a hydrokinetic unit having a pump connected to the input member and a turbine; a divider in the form of a planetary gear set which has a ring gear connected to the turbine, a sun gear, and a carrier, which is in turn connected to the output member. The sun gear is connectable through a first or forward clutch to the input member. The first clutch is engaged upon selection of the second forward speed to permit a portion of the input torque to be transmitted directly to the output member bypassing the hydrokinetic unit. This automatic transmission has limited application and particularly is not well suited for an automobile, such as a passenger car of the type in use today, because it has only two forward speeds so that it can not meet the varied demands for every day operating conditions.

Thus, an object of the invention is to provide a change-speed automatic

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transmission for an automobile, particularly a passenger car, which substantially increases the fuel economy of the automobile.

Another object of the invention is to provide a change-speed automatic transmission, including a divider in the form of a planetary gear set and a torque split clutch, providing more than two forward speeds and at least a portion of the upper or higher speeds of the transmission bypassing the hydrokinetic unit.

Still another object of the invention is to provide a change-speed automatic transmission having a wide range of gear ratios constructed of a minimum number of key subcombination component parts, namely, (1) a torque split clutch to bypass the hydrokinetic unit, (2) a divider, and (3) planetary gear train of one or more planetary gear sets.

A change-speed transmission of the invention comprises: an input member; a hydrokinetic unit having a pump connected to the input member and a turbine; a divider in the form of a planetary gear set which has a first, a second and a third rotary element; a planetary gear train having a first, a second and a third rotary element; and an output member. The divider and planetary gear train is so interconnected as to reduce the component parts needed for an effective full-range automatic transmission, thus reducing the initial cost as well as the operating expenses. More particularly, the first rotary element of the divider is connected to the first rotary element of the planetary gear train, while, the second rotary element of the divider is connectable through a clutch (a second clutch) to the second rotary element of the gear train.

The output member is in two series of embodiments of the present invention is connected to the third rotary element of the planetary gear train. In this case, the turbine is connected to one of the second or third rotary elements of the divider, while, the input member is connectable through another clutch (a first clutch) to the other one of these rotary elements of the divider. In at least one embodiment, a fourth rotary element of said gear train is connected to the second rotary element of the divider.

Another series of alternative embodiments are provided. For example, if desired, the output member may be connected to the third rotary element of the divider. In this case, the turbine is connected to the third rotary element of the gear train, while, the input member is connectable through a clutch to the second rotary element of the divider.

Accordingly, various embodiments of a change-speed transmission of the invention are illustrated in the accompanying drawings, as follows.

In the accompanying drawings:

Figs. 1 to 8 are schematic diagrams of a first series of eight embodiments of a change-speed transmission of the invention which has the common features: (1) an output member is connected to a third rotary element of a planetary gear train; (2) a turbine of a hydrokinetic unit is connected to a third rotary element of a divider in the form of a planetary gear set; and (3) an input member connected to a pump of the hydrokinetic unit being also connectable through a first clutch (C_1) to a second rotary element of the divider.

Figs. 9 to 17 are schematic diagrams of a second series of nine additional embodiments of a change-speed transmission of the invention which has the common feature: (1) an output member is connected to a third rotary element of a planetary gear train; (2) a turbine of a hydrokinetic unit is connected to a second rotary element of a divider in the form of a planetary gear set; and (3) an input member connected to a pump of the hydrokinetic unit is connectable through a first clutch (C_1) to a third rotary element of the divider.

Figs. 18 and 19 are schematic diagrams of still another or third series of two additional embodiments of a change-speed transmission of the invention which has the common feature: (1) an output member is connected to a third rotary element of a divider in the form of a planetary gear set; (2) a turbine of a hydrokinetic unit is connected to a third rotary element of a planetary gear train, and (3) an input member connected to a pump of the hydrokinetic unit is connectable through a first clutch (C_1) to a second rotary element of the divider.

To facilitate understanding of an comparison between the embodiments illustrated in Figs. 1 to 19, a divider in the form of a planetary gear set is enclosed by a broken (dash) line box, while, a planetary gear train enclosed by an imaginary (dash-dot) line box; a first or a torque split clutch is denoted by C_1 and a second clutch by C_2 .

Fig. 1 shows a first embodiment of a change-speed transmission according to the invention in which the reference numeral 1 indicates an input shaft, the

reference numeral 2 an output shaft and three planetary gear sets X, Y and Z are arranged with their axes aligned with the input and output shafts 1 and 2.

5 First planetary gear set X is a basic or simple planetary gear set and is used in this combination as a divider. The gear set comprises a first sun gear S_1 , a first ring gear R_1 and a carrier A_1 rotatably supporting a plurality of first pinions P_1 , each meshing both with the sun gear S_1 and ring gear R_1 .

10 Second planetary gear set Y is a simple planetary gear set, similar to the first planetary gear set, which comprises a second sun gear S_2 , a second ring gear R_2 and a second carrier A_2 rotatably carrying a plurality of second pinions P_2 , each meshing both with the sun gear S_2 and ring gear R_2 .

15 Third planetary gear set Z is a dual-intermeshed planet pinion planetary gear set which comprises two third sun gears S_3 and S_3' , a third ring gear R_3 and a third carrier A_3 rotatably supporting a plurality of pairs of intermeshing pinions P_3 and P_3' . Each pinion P_3 meshes with both of the third sun gears S_3 and S_3' , while, each pinion P_3' meshes with the ring gear R_3 . The third gear set Z in combination with the second gear set Y forms the planetary gear train of this first series of embodiments.

In the first planetary gear set X, the following equation holds.

$$N_{R1} + \alpha_1 N_{S1} = (1 + \alpha_1)N_{A1} \quad (1)$$

20 In second planetary gear set Y, the following equation holds.

$$N_{R2} + \alpha_2 N_{S2} = (1 + \alpha_2)N_{A2} \quad (2)$$

In third planetary gear set Z, the following equation holds.

$$N_{R3} - \alpha_3 N_{S3} = (1 - \alpha_3)N_{A3} \quad (3)$$

25 where, N_{R1} , N_{R2} and N_{R3} denote number of rotations of the ring gears of three planetary gear sets X, Y and Z respectively.

N_{S1} , N_{S2} and N_{S3} denote number of rotation of the sun gears of three planetary gear sets X, Y and Z, respectively.

30 N_{A1} , N_{A2} and N_{A3} denote number of rotations of the carriers of the three planetary gear sets X, Y and Z,

α_1 , α_2 and α_3 denote the ratio of number of teeth of a sun gear to that of a ring gear in the three planetary gear sets X, Y and Z, respectively.

35 The transmission comprises an input shaft 1 for supplying the input torque and a hydrokinetic unit or hydraulic torque converter 3 having a pump 3a connected to said input shaft 1 for simultaneous rotation therewith. A turbine 3b is connected to ring gear R_1 for simultaneous rotation therewith. Sun gear S_1 is connectable to input shaft 1 through a first clutch C_1 and connectable also to sun gear S_2 through a second clutch C_2 . Carrier A_1 is connected to ring gear R_2 for simultaneous rotation therewith and both can be braked by means of a first brake B_1 . Sun gear S_2 is connected to ring gear R_3 for simultaneous rotation therewith and can be braked by means of a second brake B_2 . Carrier A_2 is connected to carrier A_3 for simultaneous rotation therewith and the carrier A_3 is connected to output shaft 2 to provide the output torque of the transmission. Sun gear S_3' can be braked by means of a third brake B_3 .

40 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of the transmission is tabulated in *Table 1*, in which legend O denotes engagement condition of a clutch or application condition of a brake. Gear ratio and direct transmission rate, i.e., the rate of a portion of a torque transmitted through clutch C_1 bypassing torque converter 3 to all of the input torque, are calculated on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$.

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TABLE 1

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$(1+\alpha_1)(1+\alpha_2)+\frac{\alpha_1}{\alpha_3}(1-\alpha_3)$	2.652	0
2nd speed	0			0		$1+\alpha_2$	1.450	31
3rd speed	0				0	$1+\alpha_2\alpha_3$	1.202	31
4th speed	0	0				1.0	1.000	42.6
Rev.		0	0			$-\frac{\alpha_1(1+\alpha_2\alpha_3)}{\alpha_2\alpha_3}$	-2.672	0

Referring to Figs. 2 through 19, the other embodiments will be described hereinafter. In these embodiments, like reference numerals and characters to those used in Fig. 1 are used to denote like component parts. Since the same or similar function is being carried out in each instance by the parts with like references, no additional or distinguishing identification is necessary or desirable.

In the second embodiment shown in Fig. 2, a first planetary gear set X is a dual-intermeshed planet pinion planetary gear set which comprises a first sun gear S_1 , a first ring gear R_1 and a first carrier A_1 , rotatably carrying a plurality of pairs of intermeshing pinions P_1 and P_1' . Each pinion P_1 meshes with the sun gear S_1 , while each pinion P_1' meshes with the ring gear R_1 .

Second planetary gear set Y of this embodiment is a basic planetary gear set which comprises two second sun gears S_2 and S_2' , a second ring gear R_2 and a carrier A_2 rotatably carrying a plurality of second pinions P_2 each meshing with both of the sun gears S_2 and S_2' and ring gear R_2 .

Third planetary gear set Z of this embodiment is a dual-intermeshed planet pinion planetary gear set which comprises a third sun gear S_3 , a third ring gear R_3 and a third carrier A_3 rotatably supporting a plurality of pairs of intermeshed pinions P_3 and P_3' . Each pinion P_3 meshes with the sun gear S_3 , while each pinion P_3' meshes with ring gear R_3 .

In the first planetary gear set X of this embodiment, the following equation holds.

$$N_{R1} - \alpha_1 N_{S1} = (1 - \alpha_1) N_{A1} \quad (4)$$

In the second and third planetary gear sets Y and Z of this embodiment, the above equations (2) and (3) hold, respectively.

The transmission comprises an input shaft 1 supplying driving torque and a hydrokinetic unit in the form of a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith. A turbine 3b is connected to carrier A_1 for simultaneous rotation therewith. Sun gear S_1 is connectable to input shaft 1 through a first clutch C_1 and connectable also to sun gear S_2 through a second clutch C_2 . Ring gear R_1 and ring gear R_2 are connected to each other for simultaneous rotation and are brakeable by means of a first brake B_1 . Sun gear S_2' is connected to ring gear R_3 for simultaneous rotation therewith and the combination may be braked by means of a second brake B_2 . Carriers A_2 and A_3 are connected to output shaft 2 for simultaneous rotation therewith and sun gear S_3 is brakeable by means of a third brake B_3 .

The operating sequence of the two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 is tabulated in Table 2 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$.

TABLE 2

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1 + \alpha_2}{1 - \alpha_1}$	2.636	0
2nd speed	0			0		1 + α_2	1.430	45
3rd speed	0				0	1 + $\alpha_2\alpha_3$	1.202	45
4th speed	0	0				1.0	1.000	62
Rev.		0	0			$-\frac{\alpha_1(1+\alpha_2)}{\alpha_2(1-\alpha_1)}$	-2.636	0

5 In the third embodiment shown in Fig. 3, a first planetary gear set X and a third planetary gear set Z are a basic planetary gear set and a dual-intermeshed planet pinion planetary gear set similar to those of the first embodiment, respectively. A second planetary gear set Y is a dual-intermeshed planet pinion planetary gear set which comprises a second sun gear S₂, a second ring gear R₂ and a second carrier A₂ rotatably supporting a plurality pairs of intermeshing pinions P₂ and P_{2'}. Each pinion P₂ meshes with the sun gear S₂, each pinion P_{2'} meshes with the ring gear R₂.

10 Equations (1) and (3) hold for the first and third planetary gear sets X and Z of this embodiment. In the second planetary gear set Y of this embodiment, the following equation holds.

$$N_{R2} - \alpha_2 N_{S2} = (1 - \alpha_2) N_{A2} \quad (5)$$

15 Explaining different structural portions of this embodiment from the Fig. 1 embodiment, the carrier A₁ and carrier A₂ are connected to each other for simultaneous rotation and they are brakeable by means of a first brake B₁, and ring gear R₂ and carrier A₃ are connected to each other for simultaneous rotation.

20 The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of this embodiment is tabulated in Table 3 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$.

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TABLE 3

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1+\alpha_1}{1-\alpha_2} + \frac{\alpha_1}{\alpha_3} (1-\alpha_3)$	3.186	0
2nd speed	0			0		$\frac{1}{1-\alpha_2}$	1.818	31
3rd speed	0				0	$\frac{1-\alpha_2(1-\alpha_3)}{1-\alpha_2}$	1.368	31
4th speed	0	0				1.0	1.000	49.6
Rev.		0	0			$-\frac{\alpha_1(1-\alpha_2+\alpha_2\alpha_3)}{\alpha_2\alpha_3}$	-1.672	0

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In the fourth embodiment shown in Fig. 4, a first planetary gear set X is a dual-intermeshed planet pinion planetary gear set which has two first sun gears S₁ and S_{1'}. A second planetary gear set Y is a basic planetary gear set having two second ring gears R₂ and R_{2'}; and a third planetary gear set Z is a basic planetary gear set which has a ring gear R₃, a sun gear S₃ and a carrier A₃ rotatably supporting a plurality of pinions P₃ each meshing with both the ring gear R₃ and sun gear S₃.

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Equations (4) and (2) hold for the first and second planetary gearings X and Y, while the following equation holds for the third planetary gearing Z.

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$$N_{R3} + \alpha_3 N_{S3} = (1 + \alpha_3) N_{A3} \quad (6)$$

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This transmission also comprises an input shaft 1, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to the carrier A₁ for simultaneous rotation therewith. Sun gear S_{1'} is connectable to input shaft 1 through a first clutch C₁, while another sun gear S₁ is connectable to ring gear R₃ through a second clutch C₂. Ring gear R₃ is brakeable by means of a first brake B₁. Ring gear R₁, sun gear S₃ and ring gear R_{2'} are connected to each other for simultaneous rotation. Carrier A₃ and sun gear S₂ are connected to each other for simultaneous rotation and are brakeable by means of a second brake B₂. Ring gear R₂ is brakeable by means of a third brake B₃. Carrier A₂ is connected to output shaft 2 for providing the output torque.

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The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of this transmission is tabulated in Table 4 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$.

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TABLE 4

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{(1+\alpha_1\alpha_3)(1+\alpha_2)}{1-\alpha_1}$	3.170	0
2nd speed	0			0		$1+\alpha_2$	1.450	55
3rd speed	0		0			$\frac{(1+\alpha_3)(1+\alpha_2)}{1+\alpha_2\alpha_3+\alpha_3}$	1.272	55
4th speed	0	0				1.0	1.000	57
Rev.		0			0	$-\frac{\alpha_1(1+\alpha_2)(1+\alpha_3)}{\alpha_2(1-\alpha_1)}$	-3.823	0

In the fifth embodiment shown in Fig. 5, a first planetary gear set X is a basic planetary gear set, while, second and third planetary gear sets Y and Z are dual-intermeshed planet pinion planetary gear sets.

Equations (1), (5) and (3) hold for the first, second and third planetary gear sets X, Y and Z, respectively.

This embodiment of the transmission has an input shaft 1, a torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to carrier A₂ for simultaneous rotation therewith. The pump 3a is connectable to sun gear S₂ through a first clutch C₁. The sun gear S₁ is connectable to sun gear S₂ through a second clutch C₂. Sun gear S₁ is brakeable by means of a first brake B₁. Carrier A₁ and ring gears R₂ and R₃ are connected to one another for simultaneous rotation and they are brakeable by means of a second brake B₂. Ring gear R₁ and sun gear S₃ are connected to each other for simultaneous rotation and they are brakeable by brake B₃. Carrier A₃ is coupled to out shaft 2 for providing the output torque. In this embodiment, the planetary gear train (dash-dot lines) is made up of gear sets X and Z and the divider (dashed lines) is formed by gear sets Y (see also embodiments of Figs. 8 and 14).

The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ is tabulated in Table 5 on the assumption that $\alpha_1 = 0.55$, $\alpha_2 = 0.45$ and $\alpha_3 = 0.35$.

TABLE 5

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0	0			$\frac{1-\alpha_3}{(1-\alpha_2)\{1-\alpha_3(1+\alpha_1)\}}$	2.583	0
2nd speed	0		0			$\frac{1-\alpha_3}{1-\alpha_3(1+\alpha_1)}$	1.421	45
3rd speed	0	0				1.0	1.000	55
4th speed	0				0	$1-\alpha_3$	0.650	45
Rev.		0		0		$-\frac{\alpha_2(1-\alpha_3)}{\alpha_1\alpha_3(1-\alpha_2)}$	-2.763	0

In the sixth embodiment shown in Fig. 6, first and a second planetary gear sets X and Y are dual-intermeshed planet pinions planetary gear sets, while, a third planetary gear set Z is a dual-intermeshed planet pinion planetary gear set with two ring gears R_3 and R_3' .

5 Equations (4), (5) and (3) hold for first, second, and third planetary gear sets X, Y and Z of this transmission embodiment. 5

This transmission comprises an input shaft providing the input torque, a torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith, and turbine 3b connected to carrier A_1 for simultaneous rotation therewith. The pump 3a is connectable to sun gear S_1 through a first clutch C_1 . The sun gear S_1 is connectable to carrier A_2 through a second clutch C_2 . The carrier A_2 is brakeable by means of a first brake B_1 . Sun gears S_2 and S_3 are connected to each other for simultaneous rotation and are brakeable by means of a second brake B_2 . Ring gear R_2 and carrier A_3 are connected to each other for simultaneous rotation. Ring gear R_1 and ring gear R_3' are connected to each other for simultaneous rotation. Ring gear R_3 is brakeable by means of a third brake B_3 . Carrier A_3 is connected to an output shaft 2 to provide the output torque. 10

15 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of the transmission is tabulated in Table 6 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$. 15

TABLE 6

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0	0			$\frac{\alpha_3 + \alpha_2 (1 - \alpha_3)}{\alpha_2 (1 - \alpha_1)}$	2.818	0
2nd speed	0		0			$\frac{\alpha_3 + \alpha_2 (1 - \alpha_3)}{\alpha_2}$	1.550	45
3rd speed	0	.0				1.0	1.000	65
4th speed	0			0		$1 - \alpha_3$	0.55	45
Rev.		0			0	$-\frac{\alpha_1 \{\alpha_3 + \alpha_2 (1 - \alpha_3)\}}{\alpha_3 (1 - \alpha_1) (1 - \alpha_2)}$	-2.306	0

In the seventh embodiment shown in Fig. 7, a first planetary gear set X and a third planetary gear set Z are dual-intermeshed planet pinion planetary gear sets respectively, while a second planetary gear set Y is a basic planetary gear set.

25 Equations (4), (2) and (3) hold for the first, second and third planetary gear sets X, Y and Z, respectively. 25

This transmission has an input shaft 1 and a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to carrier A_1 for simultaneous rotation therewith. 30

Pump 3a, which is connected to input shaft 1 for simultaneous rotation therewith, is connectable to sun gear S_1 through a first clutch C_1 . The sun gear S_1 is connectable to sun gear S_2 through a second clutch C_2 . Ring gear R_1 and carrier A_2 are connected to each other for simultaneous rotation and are brakeable by means of a first brake B_1 . Ring gear R_2 and sun gear S_3 are connected to each other for simultaneous rotation and are brakeable by means of a second brake B_2 . Sun gear S_2 and carrier A_3 are connected to each other for simultaneous rotation and are brakeable by means of a third brake B_3 . Ring gear R_3 is connected to an output shaft 2 for simultaneous rotation to provide the output torque. 35

40 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of the transmission is tabulated in Table 7 on the assumption that $\alpha_1 = 0.40$, $\alpha_2 = 0.55$ and $\alpha_3 = 0.45$. 40

TABLE 7

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{\alpha_1}{\alpha_3(1-\alpha_1)(1+\alpha_2)}$	2.841	0
2nd speed	0				0	$\frac{1}{\alpha_3(1+\alpha_2)}$	1.563	45
3rd speed	0	0				1.0	1.000	35
4th speed	0			0		$\frac{\alpha_2}{(1+\alpha_2)(1-\alpha_3)}$	0.625	45
Rev.		0	0			$-\frac{\alpha_1}{(1-\alpha_1)(1-\alpha_3-\alpha_2\alpha_3)}$	-2.273	0

In the eighth embodiment shown in Fig. 8, first planetary gear set X and third planetary gear set Z are dual-intermeshed planet pinion planetary gear sets. Also, second planetary gear set Y is a dual-intermeshed planet pinion planetary gear set.

5 Equations (4), (5) and (3) hold for first, second and third planetary gear sets, respectively.

10 This embodiment of the transmission has an input shaft 1, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to carrier A₂ for simultaneous rotation therewith. The pump 3a is connectable to sun gear S₁ through a first clutch C₁. Sun gears S₁ and S₂ are connected to each other for simultaneous rotation and are connectable to carrier A₁ through a second clutch C₂. Carrier A₁ is brakeable by means of a first brake R₁. Ring gear R₁ and sun gear S₃ are connected to each other for simultaneous rotation and are brakeable by means of a second brake B₂. Ring gear R₂ and carrier A₃ are connected to each other for simultaneous rotation and are brakeable by means of a third brake B₃. Ring gear R₃ is connected to output shaft 2 providing the output torque.

15 The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of the transmission is tabulated in Table 8 on the assumption that $\alpha_1=0.60$, $\alpha_2=0.60$ and $\alpha_3=0.45$.

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TABLE 8

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed			0	0		$\frac{1}{(1 - \alpha_2)(1 - \alpha_3)}$	4.545	0
2nd speed	0			0		$\frac{1}{1 - \alpha_3}$	1.818	60
3rd speed	0		0			$\frac{1}{1 - \alpha_3 + \alpha_1 \alpha_3}$	1.220	73
4th speed	0	0				1.0	1.000	78
Rev.		0			0	$-\frac{\alpha_2}{\alpha_3(1 - \alpha_2)}$	-3.333	0

In the ninth embodiment shown in Fig. 9, first planetary gear set X and second planetary gear set Y are basic planetary gear sets, respectively, while, a third planetary gear set Z is a dual-intermeshed planet pinion planetary gear set which has two ring gears R₃ and R_{3'} meshing with each pinion P₃.

Equations (1), (2) and (3) hold for first, second and third planetary gear sets X, Y and Z, respectively.

This transmission comprises an input shaft 1, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S₁ for simultaneous rotation therewith. The pump 3a is connectable to ring gear R₁ through a first clutch C₁. Sun gear S₁ is connectable to carrier A₃ through a second clutch C₂. Carrier A₃ is brakeable by means of a first brake B₁. Carrier A₁, ring gear R₂ and ring gear R₃ are connected to one another for simultaneous rotation. Ring gear R_{3'} can be braked by means of a second brake B₂. Sun gears S₂ and S₃ are connected to each other for simultaneous rotation and are brakeable by means of a third brake B₃. Carrier A₂ is connected to the output shaft 2 for simultaneous rotation therewith and providing the output torque of the transmission.

The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of this transmission is tabulated in Table 9 on the assumption that $\alpha_1 = \alpha_2 = 0.45$ and $\alpha_3 = 0.50$.

TABLE 9

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{1 + \alpha_2}{1 - \alpha_3}$	2.900	0
2nd speed	0				0	1 + α_2	1.450	69
3rd speed	0	0				1.0	1.000	90
4th speed	0		0			$\frac{\alpha_3(1 + \alpha_2)}{\alpha_2 + \alpha_3}$	0.763	69
Rev.		0		0		$-\frac{\alpha_3(1 + \alpha_2)}{\alpha_2(1 - \alpha_3)}$	-2.929	0

In the tenth embodiment shown in Fig. 10, first planetary gear set X and second planetary gear set Y are dual-intermeshed planet pinion planetary gear sets, respectively, while a third planetary gear set Z is a basic planetary gear set.

Equations (4), (5) and (6) hold for the first, second and third planetary gear sets X, Y and Z, respectively.

This transmission comprises an input shaft 1, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to a carrier A_1 for simultaneous rotation therewith. The pump 3a is connectable to sun gear S_1 of gear set X through a first clutch C_1 . Carrier A_1 is selectively connectable to carrier A_2 through a second clutch C_2 . The carrier A_2 and sun gear S_3 are connected to each other for simultaneous rotation and are brakeable by means of a second brake B_2 . Ring gears R_1 and R_2 are connected to each other for simultaneous rotation and are brakeable by means of a first brake B_1 . Sun gear S_2 and ring gear R_3 are connected to each other for simultaneous rotation and they are brakeable by means of a third brake B_3 . Carrier A_3 is connected to an output shaft 2 for simultaneous rotation therewith and thus to provide the output torque.

The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 10 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.50$.

TABLE 10

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{1 + \alpha_3}{\alpha_3}$	3.000	0
2nd speed	0				0	$\frac{(1 - \alpha_2)(1 + \alpha_3)}{\alpha_3}$	1.500	50
3rd speed	0	0				1.0	1.000	67
4th speed	0			0		$\alpha_2(1 + \alpha_3)$	0.750	50
Rev.		0	0			$-\frac{\alpha_2(1 + \alpha_3)}{1 - \alpha_2 - \alpha_2\alpha_3}$	-3.000	0

In the eleventh embodiment shown in Fig. 11, a first planetary gear set X is a basic planetary gear set having two sun gears S_1 and S_1' meshing with each pinion P_1 , while, a second planetary gear set Y and a third planetary gear set Z are basic planetary gear sets, respectively.

Equations (1), (5) and (6) hold for the first, second and third planetary gear sets X, Y and Z of this transmission, respectively.

This transmission comprises an input shaft 1, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S_1' for rotation therewith. The pump 3a is connectable to ring gear R_1 through a first clutch C_1 . Sun gear S_1 is connectable to carrier A_2 through a second clutch C_2 . Carrier A_2 is connected to sun gear S_3 for simultaneous rotation therewith. Carrier A_1 and ring gear R_2 are connected to each other for simultaneous rotation and are brakeable by means of a first brake B_1 . Carrier A_2 is brakeable by means of a second brake B_2 . Sun gear S_2 and ring gear R_3 are connected to each other for simultaneous rotation and are brakeable by means of a third brake B_3 . Carrier A_3 is connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 11 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.50$.

TABLE 11

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{1 + \alpha_3}{\alpha_3}$	3.000	0
2nd speed	0				0	$\frac{(1 + \alpha_3)(1 - \alpha_2)}{\alpha_3}$	1.500	67
3rd speed	0	0				1.0	1.000	89
4th speed	0			0		$\alpha_2(1 + \alpha_3)$	0.750	67
Rev.		0	0			$-\frac{\alpha_2(1 + \alpha_3)}{(1 - \alpha_2) - \alpha_2\alpha_3}$	-3.000	0

In the twelfth embodiment shown in Fig. 12, first planetary gear set X and second planetary gear set Y are dual-intermeshed planet pinion planetary gear sets, respectively, while, a third planetary gear set Z is a basic planetary gear set having two sun gears S₃ and S₃' meshing with each pinion P₃.

Equations (4), (5) and (6) hold for the first, second and third planetary gear sets of this transmission respectively.

This transmission comprises an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to carrier A, for simultaneous rotation therewith. The pump 3a is connectable to sun gear S₁ through a first clutch C₁. Carrier A₁ is connectable to sun gear S₃ through a second clutch C₂. Ring gear R₁ and carrier A₂ are connected to each other for simultaneous rotation and are brakeable by means of a first brake B₁. Sun gear S₂ and ring gear R₃ are connected to each other for simultaneous rotation and they are brakeable by means of a second brake B₂. Ring gear R₂ and carrier A₃ are connected to each other for simultaneous rotation and are connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque. Sun gear S₃' is brakeable by means of a third brake B₃.

The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of this transmission is tabulated in Table 12 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.35$.

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TABLE 12

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1 + \alpha_3}{\alpha_3}$	3.857	0
2nd speed	0			0		$\frac{1}{1 - \alpha_2}$	1.539	35
3rd speed	0	0				1.0	1.000	57
4th speed	0				0	$\frac{1 - \alpha_2(1 + \alpha_3)}{1 - \alpha_2}$	0.812	35
Rev.		0	0			$-\frac{\alpha_3 + \alpha_2\alpha_3 - 1}{\alpha_2\alpha_3}$	-4.306	0

In the thirteenth embodiment shown in Fig. 13, first planetary gear set X, second planetary gear set Y and third planetary gear set Z are dual-intermeshed planet pinion planetary gear sets, respectively.

5 Equations (4), (5) and (3) hold for the first, second and third planetary gear sets X, Y and Z of this transmission, respectively.

10 This transmission comprises an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for rotation therewith and a turbine 3b is connected to sun gear S₁ for simultaneous rotation therewith. The pump 3a is connectable to carrier A₁ through a first clutch C₁. Sun gear S₁, connected to the turbine 3b for simultaneous rotation therewith, is connectable to carrier A₃. The carrier A₃ is brakeable by means of a first brake B₁. Sun gears S₂ and S₃ are connected to each other for simultaneous rotation and are brakeable by means of a second brake B₂. Ring gear R₁, carrier A₂ and carrier A₃ are connected to one another for simultaneous rotation and are brakeable by means of a third brake B₃. Ring gear R₂ is connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

15 The operating sequence of two clutches and three brakes is tabulated in Table 13 on the assumption that $\alpha_1 = \alpha_2 = 0.45$ and $\alpha_3 = 0.55$.

TABLE 13

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1}{(1 - \alpha_2)(1 - \alpha_3)}$	4.040	0
2nd speed	0			0		$\frac{1}{1 - \alpha_2}$	1.818	55
3rd speed	0	0				1.0	1.000	75
4th speed	0		0			$\frac{\alpha_3}{\alpha_2 + \alpha_3(1 - \alpha_3)}$	0.788	55
Rev.		0			0	$-\frac{\alpha_3}{\alpha_2(1 - \alpha_3)}$	-2.716	0

In the fourteenth embodiment shown in Fig. 14, first planetary gear set X and third planetary gear set Z are basic planetary gear sets, while, a second planetary gear set Y is a dual-intermeshed planet pinion planetary gear set. In this embodiment, the torque divider of the transmission is planetary gear set Y.

5 Equations (1), (5) and (6) hold for the first, second and third planetary gear sets X, Y and Z of this transmission, respectively.

This transmission comprises an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S_2 for simultaneous rotation therewith. The pump 3a is connectable to carrier A_2 , through a first clutch C_1 . Sun gear S_2 , connected to the turbine 3b for simultaneous rotation therewith, is connectable to sun gear S_1 through a second clutch C_2 . The sun gear S_1 is brakeable by means of a first brake B_1 . Carrier A_1 , and ring gears R_2 and R_3 are connected to one another for simultaneous rotation and are brakeable by means of a second brake B_2 . Sun gear S_3 is brakeable by means of a third brake B_3 . Ring gear R_1 and carrier A_3 are connected to each other for simultaneous rotation and are connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

10 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 14 on the assumption that $\alpha_1 = \alpha_2 = 0.35$ and $\alpha_3 = 0.50$.

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TABLE 14

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{(1 + \alpha_1)(1 + \alpha_3) - 1}{\alpha_1}$	2.929	0
2nd speed	0				0	$1 + \alpha_3$	1.500	65
3rd speed	0	0				1.0	1.000	88
4th speed	0		0			$\frac{1}{1 + \alpha_1}$	0.741	65
Rev.		0		0		$-\frac{1}{\alpha_1}$	-2.857	0

25 In the fifteenth embodiment shown in Fig. 15, a first planetary gear set X is a basic planetary gear set having two sun gears S_1 and S_1' meshing with each pinion P_1 , a second planetary gear set Y is a dual-intermeshed planet pinion planetary gear set, and a third planetary gear set Z is a basic planetary gear set having two sun gears S_3 and S_3' meshing with each pinion P_3 .

25 Equations (1), (5) and (6) hold for the first, second and third planetary gear sets X, Y and Z of this transmission, respectively.

30 This transmission comprises an output shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S_1' for simultaneous rotation therewith. The pump 3a is connectable to ring gear R_1 through a first clutch C_1 . Sun gear S_1 is connectable to sun gear S_3 through a second clutch C_2 . Carrier A_1 and carrier A_2 are connected to each other for simultaneous rotation and are brakeable by means of a first brake B_1 . Sun gear S_2 and ring gear R_3 are connected to each other for simultaneous rotation and are brakeable by means of a second brake B_2 . Sun gear S_3' is brakeable by means of a third brake B_3 .

35 Ring gear R_2 and carrier A_3 are connected to each other for simultaneous rotation and are connected to an output shaft 2 for simultaneous rotation therewith and providing the output torque.

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The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 15 on the assumption that $\alpha_1 = 0.45$, $\alpha_2 = 0.35$ and $\alpha_3 = 0.45$.

TABLE 15

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1 + \alpha_3}{\alpha_3}$	3.222	0
2nd speed	0			0		$\frac{1}{1 - \alpha_2}$	1.538	69
3rd speed	0	0				1.0	1.000	90
4th speed	0				0	$\frac{1 - \alpha_2(1 + \alpha_3)}{1 - \alpha_2}$	0.758	69
Rev.		0	0			$-\frac{\alpha_2(1 + \alpha_3) - 1}{\alpha_2\alpha_3}$	-3.126	0

5 In the sixteenth embodiment shown in Fig. 16, first planetary gear set X and third planetary gear set Z are dual-intermeshed planet pinion planetary gear sets, respectively, while a second planetary gear set Y is a basic planetary gear set.

5 Equations (4), (2) and (3) hold for the first, second and third planetary gear sets

X, Y and Z, respectively.

10 This transmission has an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S_1 for simultaneous rotation therewith. The pump 3a is connectable to carrier A_1 through a first clutch C_1 . The sun gear S_1 , connected to turbine 3b for simultaneous rotation therewith, is connectable to sun gear S_2 through a second clutch C_2 . The sun gear S_2 is brakeable by means of a first brake B_1 . Ring gear R_1 , carrier A_2 and carrier A_3 are connected on one another for simultaneous rotation and are breakable by means of a second brake B_2 . Ring gears R_2 and R_3 are connected to each other for simultaneous rotation and are connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque. Sun gear S_3 is brakeable by means of a third brake B_3 .

15 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 16 on the assumption that $\alpha_1 = \alpha_2 = 0.40$ and $\alpha_3 = 0.35$.

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TABLE 16

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{\alpha_2 + \alpha_3}{\alpha_2(1 - \alpha_3)}$	2.885	0
2nd speed	0				0	$\frac{1}{1 - \alpha_3}$	1.538	60
3rd speed	0	0				1.0	1.000	84
4th speed	0		0			$\frac{1}{1 + \alpha_2}$	0.714	60
Rev.		0		0		$-\frac{1}{\alpha_2}$	-2.500	0

In the seventeenth embodiment shown in Fig. 17, a first planetary gear set X is a basic planetary gear set, while, a second planetary gear set Y and a third planetary gear set Z are dual-intermeshed planet pinion planetary gear sets, respectively.

5 Equations (1), (5) and (3) hold for the first, second and third planetary gear sets X, Y and Z of this transmission.

10 This transmission comprises an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to sun gear S₁ for simultaneous rotation therewith. The input shaft 1 and the pump 3a are connectable to ring gear R₁ through a first clutch C₁. The sun gear S₁, connected to turbine 3b for simultaneous rotation therewith, is connectable to carrier A₂ through a second clutch C₂. The carrier A₂ is brakeable by means of a first brake B₁. Sun gears S₂ and S₃ are connected to each other for simultaneous rotation and are 15 brakeable by means of a second brake B₂. Carrier A₁, ring gear R₂ and carrier A₃ are connected to one another for simultaneous rotation and are brakeable by means of a third brake B₃. Ring gear R₃ is connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

15 The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of this transmission is tabulated in Table 17 on the assumption that $\alpha_1 = \alpha_2 = 0.50$ and $\alpha_3 = 0.45$.

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TABLE 17

	C_1	C_2	B_1	B_2	B_3		Gear Ratio	Direct Transmission Rate (%)
1st speed		0		0		$\frac{1}{(1 - \alpha_2)(1 - \alpha_3)}$	3.333	0
2nd speed	0			0		$\frac{1}{1 - \alpha_3}$	1.667	67
3rd speed	0	0				1.0	1.000	93
4th speed	0		0			$\frac{\alpha_2}{\alpha_3 + \alpha_2(1 - \alpha_3)}$	0.714	67
Rev.		0			0	$-\frac{\alpha_2}{\alpha_3(1 - \alpha_2)}$	-2.500	0

5 In the eighteenth embodiment shown in Fig. 18, a first planetary gear set X is a dual-intermeshed planet pinion planetary gear set, a second planetary gear set Y is a basic planetary gear set, and a third planetary gear set Z is a basic planetary gear set Z having two sun gears S_3 and S_3' meshing with each pinion P_3 . In this embodiment, as well as the embodiment of Fig. 19, the torque divider is the third planetary gear set Z. Equations (4), (2) and (6) hold for the first, second and third planetary gear sets X, Y and Z of this transmission, respectively.

10 This transmission comprises an input shaft 1 supplying the input torque, a hydraulic torque converter 3 having a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to ring gear R_2 for simultaneous rotation therewith. The pump 3a is connectable to sun gear S_3 through a first clutch C_1 . Sun gear S_3' is connectable to ring gear R_1 through a second clutch C_2 . Sun gear S_1 , carrier A_2 and ring gear R_3 are connected to one another for simultaneous rotation and are brakeable by means of a first brake B_1 . Carrier A_1 and sun gear S_2 are connected to each other for simultaneous rotation and are brakeable by means of a second brake B_2 . Ring gear R_1 is brakeable by means of a third brake B_3 . Carrier A_3 is connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

15 The operating sequence of two clutches C_1 and C_2 and three brakes B_1 , B_2 and B_3 of this transmission is tabulated in Table 18 on the assumption that $\alpha_1 = 0.35$ and $\alpha_2 = \alpha_3 = 0.45$.

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TABLE 18

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0			0	$\frac{(1+\alpha_3) \{ \alpha_1 \alpha_2 + (1+\alpha_2) (1-\alpha_1) \}}{1 - \alpha_1}$	2.453	0
2nd speed	0				0	$\frac{(1+\alpha_3) (1-\alpha_1+\alpha_2)}{1-\alpha_1+\alpha_2(1-\alpha_1+\alpha_2)}$	1.526	47
3rd speed	0			0		$\frac{(1+\alpha_2) (1+\alpha_3)}{1+\alpha_3(1+\alpha_2)}$	1.273	39
4th speed	0	0				1.0	1.000	63
Rev.		0	0			$- \frac{\alpha_2(1+\alpha_3)}{\alpha_3(1-\alpha_2)}$	-2.230	0

In the nineteenth embodiment shown in Fig. 19, first planetary gear set X and third planetary gear set Z are basic planetary gear sets, respectively, while, a second planetary gear set Y is a dual-intermeshed planet pinion planetary gear set.

5 Equations (1), (5) and (6) hold for first, second and third planetary gear sets X, Y and Z, respectively.

10 This transmission comprises an input shaft 1 supplying the input torque, a pump 3a connected to the input shaft 1 for simultaneous rotation therewith and a turbine 3b connected to both sun gears S₁ and S₂ for simultaneous rotation therewith. The pump 3a is connectable to sun gear S₃ through a first clutch C₁. The sun gear S₃ is connectable to carrier A₂ through a second clutch C₂. The carrier A₂ and carrier A₁ are connected to each other for simultaneous rotation and are brakeable by means of a first brake B₁. Ring gear R₁ is brakeable by means of a second brake B₂. Ring gears R₂ and R₃ are connected to each other for simultaneous rotation and are brakeable by means of a third brake B₃. Carrier A₃ is connected to an output shaft 2 for simultaneous rotation therewith and thus providing the output torque.

15 The operating sequence of two clutches C₁ and C₂ and three brakes B₁, B₂ and B₃ of the transmission is tabulated in Table 19 on the assumption that $\alpha_1 = \alpha_2 = \alpha_3 = 0.45$.

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TABLE 19

	C ₁	C ₂	B ₁	B ₂	B ₃		Gear Ratio	Direct Transmission Rate (%)
1st speed		0	0			$\frac{1 + \alpha_3}{\alpha_2}$	3.222	0
2nd speed	0		0			$\frac{\alpha_2(1 + \alpha_3)}{\alpha_3(\alpha_1 + \alpha_2)}$	1.611	50
3rd speed	0			0		$\frac{(1 + \alpha_3)(1 + \alpha_1)}{\alpha_1 + \alpha_2 + \alpha_3(1 + \alpha_1)}$	1.354	42
4th speed	0	0				1.0	1.000	31
Rev.		0			0	$-\frac{(1 - \alpha_2)(1 - \alpha_3)}{\alpha_2\alpha_3}$	-3.938	0

5 In operation of several embodiments of the change-speed transmission, the shift may be made from first through the fourth speeds in an obvious manner illustrated in each of the Tables 1-19. The torque path in each speed of each embodiment is simply traced through the transmission by properly considering the noted operative or inoperative condition of the clutches C₁, C₂ and brakes B₁, B₂ and B₃. As noted above in discussing each individual embodiment, when a clutch C₁, C₂ is noted as engaged, the two rotary elements are coupled for simultaneous rotation, and when a brake B₁, B₂, B₃ is noted as applied the gear and/or carrier involved is anchored against rotation.

10 Advantageously, the shift from one gear ratio to the other is capable of being performed smoothly. Most importantly, because of the partial direct interconnection between the input member 1 and the output member 2 in the upper gear ratios, a substantial increase in fuel economy is realized.

15 This transmission of the present invention also provides a wide range of gear ratios that is highly suitable for automotive use. With the use of the torque split clutch, the divider and the planetary gear train, a reduction in initial cost can be obtained in addition to holding the operating expenses to a minimum.

20 The overall change-speed transmission is more compact in design than previous arrangements wherein a full complement of forward gears (four speeds) and a reverse are provided. The transmission is also clearly adaptable to be manufactured in quantity since all of the rotary elements are planetary gear sets; which sets are used for both the divider and the planetary gear train.

25 WHAT WE CLAIM IS:—

1. A change-speed transmission comprising:
an input member (1) to receive the input torque;
an output member (2) to provide the output torque;
a hydrokinetic unit (3) having a pump (3a) connected to said input member for simultaneous rotation therewith and a turbine (3b);
a first and a second clutch (C₁, C₂);
a divider in the form of a planetary gear set having at least a first, a second and a third rotary element;
a planetary gear train having at least a first, a second and a third rotary element;
said first rotary element of said divider being connected to said first rotary element of said gear train for simultaneous rotation therewith;
said second rotary element of said divider being connectable through said second clutch (C₂) to said second rotary element of said gear train for simultaneous rotation therewith when said second clutch is engaged;

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5 said output member (2) being connected to one of said third rotary elements for simultaneous rotation therewith;

5 said turbine (3b) being connected to one of said second and third rotary elements of said divider, or to said third rotary element of said planetary gear train for simultaneous rotation therewith;

10 said input member being directly connectable through said first clutch (C₁) to the other one of said second and third rotary elements of said divider, or to said second rotary element of said divider when said turbine is connected to said third rotary element of the planetary gear train for simultaneous rotation therewith so as to bypass said hydrokinetic unit when said first clutch is engaged;

10 whereby upon engagement of said first clutch (C₁) the input torque of the input member may be split providing a portion of the input torque to the output member bypassing said hydrokinetic unit and providing the remaining portion to the input torque to the output member passing through said hydrokinetic unit, irrespective of the condition of said second clutch (C₂).

15 2. A change-speed transmission as claimed in claim 1, in which

15 said turbine is connected to said third rotary element of said divider for simultaneous rotation therewith; and

20 said input member is connectable through said first clutch (C₁) to said second rotary element of said divider for simultaneous rotation therewith so as to bypass said hydrokinetic unit when said first clutch is engaged.

20 3. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:

25 a first sun gear (S₁) as said second rotary element of said divider;

25 a first ring gear (R₁) as said third rotary element of said divider; and

25 a first carrier (A₁) as said first rotary element of said divider, said first carrier rotatably carrying a plurality of first pinions (P₁), each meshing both with said first sun gear and first ring gear; in which said planetary gear train comprises.

30 a second planetary gear set (Y) which comprises

30 a second sun gear (S₂);

30 a second ring gear (R₂) as said first rotary element of said gear train; and

30 a second carrier (A₂) rotatably carrying a plurality of second pinions (P₂), each meshing both with said second sun gear and second ring gear; and

35 a third planetary gear set (Z) which comprises two third sun gears (S₃, S₃') as said second rotary element of said gear train;

35 a third ring gear (R₃) connected to said second sun gear (S₂) for simultaneous rotation therewith; and

40 a third carrier (A₃) as said third rotary element of said gear train, said third carrier rotatably carrying a plurality of pairs of intermeshing third pinions (P₃, P₃'), one of said intermeshing third pinions of each pair (P₃) meshing with both of said two third sun gears (S₃, S₃'), the other one of said intermeshing third pinions of each pair (P₃) meshing with said third ring gear (R₃), said third carrier (A₃) being connected to said second carrier (A₂) for simultaneous rotation therewith; and, in which said planetary gear train further comprises:

45 a first brake (B₁) operable to anchor said first carrier (A₁) and second ring gear (R₂);

45 a second brake (B₂) operable to anchor said second sun gear (S₂) and third ring gear (R₃); and

50 a third brake (B₃) operable to anchor one of said two third sun gears (S₃').

50 4. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:

55 a first sun gear (S₁) as said second rotary element of said divider;

55 a first ring gear (R₁) as said first rotary element of said divider; and

55 a first carrier (A₁) as said third rotary element of said divider, said first carrier rotatably carrying a plurality of pairs of intermeshing first pinions (P₁, P₁'), one of said intermeshing first pinions of each pair (P₁) meshing with said first sun gear (S₁), the other one of said intermeshing first pinions of each pair (P₁') meshing with said first ring gear (R₁);

60 in which said planetary gear train comprises:

60 a second planetary gear set (Y) which comprises

60 two second sun gears (S₂, S₂') as said second rotary element of said gear train;

60 a second ring gear (R₂) as said first rotary element of said gear train; and

65 a second carrier (A₂) rotatably carrying a plurality of second pinions (P₂), each meshing with both of said two second sun gears (S₂, S₂') and with said second ring gear (R₂); and

a third planetary gear set (Z) which comprises
 a third ring gear (R_3) connected to one of said two second sun gears (S_2') for simultaneous rotation therewith;
 a third sun gear (S_3); and

5 a third carrier (A_3) as said third rotary element of said gear train, said third carrier rotatably carrying a plurality of pairs of intermeshed third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3), said third carrier (A_3) being connected to said second carrier (A_2) for simultaneous rotation therewith; 10 and, in which said planetary gear train further comprises:
 a first brake (B_1) operable to anchor said first ring gear (R_1) and second ring gear (R_2);
 a second brake (B_2) operable to anchor said third ring gear (R_3) and that one of 15 said two second sun gears (S_2') which is connected to said third ring gear for simultaneous rotation therewith; and
 a third brake (B_3) operable to anchor said third sun gear (S_3).

5. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:
 20 a first sun gear (S_1) as said second rotary element of said divider;
 a first ring gear (R_1) as said third rotary element of said divider; and
 a first carrier (A_1) as said first rotary element of said divider, said first carrier rotatably carrying a plurality of first pinions (P_1), each meshing with both of said first ring gear (R_1) and first sun gear (S_1); in which said planetary gear train 25 comprises:
 a second planetary gear set (Y) which comprises
 a second sun gear (S_2);
 a second ring gear (R_2); and
 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2') one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and 30 a third planetary gear set (Z) which comprises
 35 two third sun gears (S_3, S_3') as said second rotary element of said gear train;
 a third ring gear (R_3) connected to said second sun gear (S_2) for simultaneous rotation therewith; and
 a third carrier (A_3) as said third rotary element of said gear train, said third carrier rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with both of said two third sun gears (S_3, S_3'), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3), said third carrier (A_3) being 40 connected to said second ring gear (R_2) for simultaneous rotation therewith; and, in which said planetary gear train further comprises:
 45 a first brake (B_1) operable to anchor said first carrier (A_1) and second carrier (A_2);
 a second brake (B_2) operable to anchor said second sun gear (S_2) and third ring gear (R_3); and
 a third brake (B_3) operable to anchor one of said two third sun gears (S_3').

50 6. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:
 two first sun gears (S_1, S_1') as said second rotary element of said divider;
 a first ring gear (R_1) as said first rotary element of said divider; and
 55 a first carrier (A_1) as said third rotary element of said divider, said first carrier rotatably carrying a plurality of pairs of intermeshed first pinions (P_1, P_1'), one of said intermeshed first pinions of each pair (P_1) meshing with both of said two first sun gears (S_1, S_1'), the other one of said intermeshed first pinions of each pair (P_1') meshing with said first ring gear (R_1); in which said planetary gear train comprises:
 a second planetary gear set (Y) which comprises
 a second sun gear (S_2);
 60 two second ring gears (R_2, R_2') as said first rotary element of said gear train; and
 a second carrier (A_2) as said third rotary element of said gear train, said second carrier rotatably carrying a plurality of second pinions (P_2), each meshing with said second sun gear (S_2) and with both of said two ring gears (R_2, R_2'); and 65

a third planetary gear set (Z) which comprises
 a third sun gear (S_3) connected to one of said two second ring gears (R_2') for simultaneous rotation therewith;
 a third ring gear (R_3) as said second rotary element of said gear train; and
 5 a third carrier (A_3) rotatably carrying a plurality of third pinions (P_3), each meshing with both of said third sun gear (S_3) and third ring gear (R_3), said third carrier (A_3) being connected to said second sun gear (S_2) for simultaneous rotation therewith; 5
 and, in which said planetary gear train further comprises:
 10 a first brake (B_1) operable to anchor said third ring gear (R_3);
 a second brake (B_2) operable to anchor said second sun gear (S_2) and third carrier (A_3); and
 a third brake (B_3) operable to anchor the other one of said two second ring gears (R_2').
 15 7. A change-speed transmission as claimed in claim 2, in which said planetary gear set (Y) of said divider comprises:
 a first sun gear (S_2) as said second rotary element of said divider;
 a first ring gear (R_2) as said first rotary element of said divider; and
 20 a first carrier (A_2) as said third rotary element of said divider, said first carrier rotatably carrying a plurality of pairs of intermeshing first pinions (P_2, P_2'), one of said intermeshing first pinions of each pair (P_2) meshing with said first sun gear (S_2), the other one of said intermeshing first pinions of each pair (P_2') meshing with said first ring gear (R_2); in which said planetary gear train comprises: 20
 a second planetary gear set (X) which comprises
 25 a second sun gear (S_1) as said second rotary element of said gear train;
 a second ring gear (R_1);
 a second carrier (A_1) as said first rotary element of said gear train, said second carrier (A_1) rotatably carrying a plurality of second pinions (P_1), each meshing with both of said second sun gear (S_1) and second carrier (R_1); and
 30 a third planetary gear set (Z) which comprises:
 a third sun gear (S_3) connected to said second ring gear (R_1) for simultaneous rotation therewith:
 a third ring gear (R_3) connected to said second carrier (A_1) for simultaneous rotation therewith; and
 35 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3); 35
 40 and in which said planetary gear train further comprises;
 a first brake (B_1) operable to anchor said second sun gear (S_1);
 a second brake (B_2) operable to anchor said second carrier (A_1), first ring gear (R_2) and third ring gear (R_3); and
 45 a third brake (B_3) operable to anchor said second ring gear (R_1) and third sun gear (S_3). 45
 8. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:
 a first sun gear (S_1) as said second rotary element of said divider;
 a first ring gear (R_1 as said first rotary element of said divider; and
 50 a first carrier (A_1) as said third rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of first pinions (P_1), each meshing with both of said first sun gear (S_1) and first ring gear (R_1);
 in which said planetary gear train comprises:
 a second planetary gear set (Y) which comprises
 55 a second sun gear (S_2); and
 a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) with said second sun gear, the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and
 60 a third planetary gear set (Z) which comprises
 a third sun gear (S_3) connected to said second sun gear (S_2) for simultaneous rotation therewith;
 65 two third ring gears (R_3, R_3') as said first rotary element of said gear train; and
 a third carrier (A_3) as said third rotary element of said gear train, said third 65

carrier (A_3) rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions (P_3') meshing with both of said two third ring gears (R_3, R_3'); and, in which said planetary gear train further comprises:

a first brake (B_1) operable to anchor said second carrier (A_2);
 a second brake (B_2) operable to anchor said second sun gear (S_2) and third sun gear (S_3); and
 a third brake (B_3) operable to anchor one of said two third ring gears (R_3).

9. A change-speed transmission as claimed in claim 2, in which said planetary gear set (X) of said divider comprises:

a first sun gear (S_1) as said second rotary element of said divider;
 a first ring gear (R_1) as said first rotary element of said divider; and
 a first carrier (A_1) as said third rotary element of said divider, said first carrier rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair (P_1') meshing with said first ring gear (R_1); in which said planetary gear train comprises:

a second planetary gear set (Y) which comprises
 a second sun gear (S_2) as said second rotary element of said gear train;
 a second ring gear (R_2); and
 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of second pinions (P_2), each meshing with both of said second sun gear (S_2) and second ring gear (R_2); and
 a third planetary gear set which comprises
 a third sun gear (S_3) connected to said second ring gear (R_2) for simultaneous rotation therewith;
 a third ring gear (R_3) as said third rotary element of said gear train;
 a third carrier (A_3) rotatably carrying a plurality of apirs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3), said third carrier (A_3) being connected to said second sun gear (S_2) for simultaneous rotation therewith; and, in which said planetary gear train further comprises

a first brake (B_1) operable to anchor said first ring gear (R_1) and second carrier (A_2);
 a second brake (B_2) operable to anchor said second ring gear (R_2) and third sun gear (S_3); and
 a third brake (B_3) operable to anchor said third carrier (A_3) and second sun gear (S_2).

10. A change-speed transmission as claimed in claim 2, in which said second rotary element of said divider is further connected to a fourth rotary element of said gear train for simultaneous rotation therewith.

11. A change-speed transmission as claimed in claim 2 in which said planetary gear set (Y) of said divider comprises:

a first sun gear (S_1) as said second rotary element of said divider;
 a first ring gear (R_1) as said rotary element of said divider; and
 a first carrier (A_1) as said third rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair (P_1') meshing with said first ring gear (R_1); in which said planetary gear train comprises

a second planetary gear set (X) which comprises
 a second sun gear (S_2) as said fourth rotary element of said gear train;
 a second ring gear (R_2); and
 a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and
 a third planetary gear set (Z) which comprises
 a third sun gear (S_3) connected to said second ring gear (R_2) for simultaneous rotation therewith;
 a third ring gear (R_3) as said third rotary element of said gear train; and

5 a third carrier (A_3) as said first rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3); and in which said planetary gear train further comprises 5

10 a first brake (B_1) operable to anchor said second carrier (A_1);
a second brake (B_2) operable to anchor said second ring gear (R_1) and third sun gear (S_3); and 10

15 a third brake (B_3) operable to anchor said third carrier (A_3).
12. A change-speed transmission as claimed in claim 1, in which said output member is connected to said third rotary element of said gear train for simultaneous rotation therewith;
said turbine is connected to said second rotary element of said divider for simultaneous rotation therewith; and 15

20 said input member is connectable through said first clutch (C_1) to said third rotary element of said divider for simultaneous rotation therewith so as to bypass said hydrokinetic unit when said first clutch is engaged.
13. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises: 20

25 a first sun gear (S_1) as said second rotary element of said divider;
a first ring gear (R_1) as said third rotary element of said divider; and
a first carrier (A_1) as said first rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of first pinions (P_1), each meshing with said first sun gear (S_1) and first ring gear (R_1); in which said planetary gear train comprises: 25

30 a second planetary gear set (Y) which comprises
a second sun gear (S_2);
a second ring gear (R_2) as said first rotary element of said gear train; and
a second carrier (A_2) as said third rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of second pinions (P_2), each meshing with said second sun gear (S_2) and said second ring gear (R_2); and 30

35 a third planetary gear set (Z) which comprises
a third sun gear (S_3) connected to said second sun gear (S_2) for simultaneous rotation therewith;
two third ring gears (R_3, R_3') connected to said second ring gear (R_2) for simultaneous rotation therewith;
a third carrier (A_3) as said second rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3 '); and in which said planetary gear train further comprises 40

40 a first brake (B_1) operable to anchor said third carrier (A_3);
a second brake (B_2) operable to anchor one of said two third ring gears (R_3'); and
45 a third brake (B_3) operable to anchor said second sun gear (S_2) and third sun gear (S_3). 45

45 14. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:
a first sun gear (S_1) as said third rotary element of said divider.
50 a first ring gear (R_1) as said first rotary element of said divider; and
a first carrier (A_1) as said second rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions (P_1) of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair (P_1') meshing with said first ring gear (R_1); in which said planetary gear train comprises 55

55 a second planetary gear set (Y) which comprises
a second sun gear (S_2);
a second ring gear (R_2) as said first rotary element of said gear train; and
a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2 '); and 60

60 a third planetary gear set (Z) which comprises

a third sun gear (S_3) connected to said second carrier (A_2) for simultaneous rotation therewith;

5 a third ring gear (R_3) connected to said second sun gear (S_2) for simultaneous rotation therewith; and

5 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of third pinions (P_3), each meshing with said third sun gear (S_3) and third ring gear (R_3); and, in which said planetary gear train further comprises

10 a first brake (B_1) operable to anchor said first ring gear (R_1) and second ring gear (R_2);

10 a second brake (B_2) operable to anchor said second carrier (A_2); and

10 a third brake (B_3) operable to anchor said second sun gear (S_2) and third ring gear (R_3).

15 15. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:

15 two first sun gears (S_1, S_1') as said second rotary element of said divider;

15 a first ring gear (R_1) as said third rotary element of said divider; and

15 a first carrier (A_1) as said first rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of first pinions (P_1), each meshing with both of said two first sun gears (S_1, S_1') and with said first ring gear (R_1);

20 20 in which said planetary gear train comprises

20 a second planetary gear set (Y) which comprises

20 a second sun gear (S_2);

25 A second ring gear (R_2) as said first rotary element of said gear train; and

25 a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and

30 30 a third planetary gear set (Z) which comprises

30 a third sun gear (S_3) connected to said second carrier (A_2) for simultaneous rotation therewith;

30 a third ring gear (R_3) connected to said second sun gear (S_2) for simultaneous rotation therewith; and

35 35 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of third pinions (P_3), each meshing with said third sun gear (S_3) and third ring gear (R_3); and in which said planetary gear train further comprises

35 a first brake (B_1) operable to anchor said first carrier (A_1) and second ring gear (R_2);

40 40 a second brake (B_2) operable to anchor said second carrier (A_2) and third sun gear (S_3); and

40 a third brake (B_3) operable to anchor said second sun gear (S_2) and third ring gear (R_3).

45 45 16. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises

45 a first sun gear (S_1) as said third rotary element of said divider;

45 a first ring gear (R_1) as said first rotary element of said divider; and

45 a first carrier (A_1) as said second rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair meshing with said first ring gear (R_1);

50 50 in which said planetary gear train comprises

50 a second planetary gear set (Y) which comprises

50 a second sun gear (S_2);

50 a second ring gear (R_2); and

55 55 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and

55 a third planetary gear set (Z) which comprises

55 two third sun gears (S_3, S_3') as said second rotary element of said gear train;

a third ring gear (R_3) connected to said second sun gear (S_2) for simultaneous rotation therewith; and

5 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of third pinions (P_3), each meshing with both of said two third sun gears (S_3, S_3') and with said third ring gear (R_3); and, in which said planetary gear train further comprises

5 a first brake (B_1) operable to anchor said first ring gear (R_1) and second carrier (A_2);

10 a second brake (B_2) operable to anchor said second sun gear (S_2) and third ring gear (R_3); and

10 a third brake (B_3) operable to anchor one of said two third sun gears (S_3').

17. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:

15 a first sun gear (S_1) as said second rotary element of said divider;

15 a first ring gear (R_1) as said first rotary element of said divider; and

15 a first carrier (A_1) as said third rotary element of said divider, said first carrier rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair (P_1') meshing with said 20 first ring gear (R_1); in which said planetary gear train comprises

20 a second planetary gear set (Y) which comprises

20 a second sun gear (S_2);

20 a second ring gear (R_2) as said third rotary element of said gear train; and

25 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and

25 a third planetary gear set (Z) which comprises

30 a third sun gear (S_3) connected to said second sun gear (S_2) for simultaneous rotation therewith;

30 a third ring gear (R_3) connected to said second carrier (A_2) for simultaneous rotation therewith; and

35 a third carrier (A_3) as said second rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3); and, in which said planetary gear train further comprises

40 a first brake (B_1) operable to anchor said third carrier (A_3);

40 a second brake (B_2) operable to anchor said second sun gear (S_2) and third sun gear (S_3); and

40 a third brake (B_3) operable to anchor said first ring gear (R_1), second carrier (A_2) and third ring gear (R_3).

45 18. A change-speed transmission as claimed in claim 12, in which said planetary gear set (Y) of said divider comprises:

45 a first sun gear (S_2) as said second rotary element of said gear train;

45 a first ring gear (R_2) as said first rotary element of said gear train; and

45 a first carrier (A_2) as said third rotary element of said gear train, said first carrier (A_2) rotatably carrying a plurality of pairs of intermeshing first pinions (P_2, P_2') one of said intermeshing first pinions of each pair (P_2) meshing with said first sun gear (S_2), the other one of said intermeshing first pinions of each pair (P_2') meshing with said first ring gear (R_2); in which said planetary gear train comprises

50 a second planetary gear set (X) which comprises

50 a second sun gear (S_1) as said second rotary element of said gear train;

50 a second ring gear (R_1); and

50 a second carrier (A_1) as said first rotary element of said gear train, said second carrier (A_1) rotatably carrying a plurality of second pinions (P_1) each meshing with said second sun gear (S_1) and second ring gear (R_1); and

55 60 a third planetary gear set (Z) which comprises

55 a third sun gear (S_3);

55 a third ring gear (R_3) connected to said second carrier (A_1) for simultaneous rotation therewith; and

55 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of third pinions (P_3), each meshing with

5 said third sun gear (S_3) and third ring gear (R_3), said third carrier (A_3) being connected to said first ring gear (R_1) for simultaneous rotation therewith; and, in which said planetary gear train further comprises
 a first brake (B_1) operable to anchor said second sun gear (S_1);
 a second brake (B_2) operable to anchor said second carrier (A_1) and third ring gear (R_3); and
 a third brake (B_3) operable to anchor said third sun gear (S_3).
 19. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:
 10 two first sun gears (S_1, S_1') as said second rotary element of said divider;
 a first ring gear (R_1) as said third rotary element of said divider; and
 a first carrier (A_1) as said first rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of first pinions (P_1), each meshing with both of said two first sun gears (S_1, S_1') and with said first ring gear (R_1);
 15 in which said planetary gear train comprises
 a second planetary gear set (Y) which comprises
 a second sun gear (S_2);
 a second ring gear (R_2); and
 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and
 20 a third planetary gear set (Z) which comprises
 two third sun gears (S_3, S_3') as said second rotary element of said gear train;
 a third ring gear (R_3) connected to said second sun gear (S_2) for simultaneous rotation therewith; and
 25 a third carrier (A_3) as said third rotary element of said gear train, said third carrier (A_3) rotatably carrying a plurality of third pinions (P_3) meshing with both of said third sun gears (S_3, S_3') and with said third ring gear (R_3);
 30 and, in which said planetary gear train further comprises
 a first brake (B_1) operable to anchor said second carrier (A_2);
 a second brake (B_2) operable to anchor said second sun gear (S_2) and third ring gear (R_3); and
 35 a third brake (B_3) operable to anchor one of said two third sun gears (S_3').
 20. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:
 40 a first sun gear (S_1) as said second rotary element of said divider;
 a first ring gear (R_1) as said rotary element of said divider; and
 a first carrier (A_1) as said third rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of pairs of intermeshing first pinions (P_1, P_1'), one of said intermeshing first pinions of each pair (P_1) meshing with said first sun gear (S_1), the other one of said intermeshing first pinions of each pair (P_1') meshing with said first ring gear (R_1); in which said planetary gear train comprises
 45 a second planetary gear set (Y) which comprises
 a second sun gear (S_2) as said second rotary element of said gear train;
 a second ring gear (R_2); and
 a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of second pinions (P_2), each meshing with said second sun gear (S_2) and ring gear (R_2); and
 50 a third planetary gear set (Z) which comprises
 a third sun gear (S_3);
 a third ring gear (R_3) as said third rotary element of said gear train, said third ring gear (R_3) being connected to said second ring gear (R_2) for simultaneous rotation therewith; and
 55 a third carrier (A_3) connected to said second carrier (A_2) for simultaneous rotation therewith, said third carrier (A_3) rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3);
 60 and, in which said planetary gear train further comprises
 a first brake (B_1) operable to anchor said second sun gear (S_2);
 a second brake (B_2) operable to anchor said second carrier (A_2) and third carrier (A_3); and
 65 a third brake (B_3) operable to anchor said third sun gear (S_3).

21. A change-speed transmission as claimed in claim 12, in which said planetary gear set (X) of said divider comprises:

a first sun gear (S_1) as said second rotary element of said divider;

a first ring gear (R_1) as said third rotary element of said divider; and

a first carrier (A_1) as said first rotary element of said divider, said first carrier (A_1) rotatably carrying a plurality of first pinions (P_1), each meshing with said first sun gear (S_1) and ring gear (R_1); in which said planetary gear train comprises

a second planetary gear set (Y) which comprises

a second sun gear (S_2);

a second ring gear (R_2) as said first rotary element of said gear train; and

a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and

a third planetary gear set (Z) which comprises

a third ring gear (R_3) as said third rotary element of said gear train;

a third sun gear (S_3) connected to said second sun gear for simultaneous rotation therewith; and

a third carrier (A_3) connected to said second ring gear (R_2) for simultaneous rotation therewith, said third carrier (A_3) rotatably carrying a plurality of pairs of intermeshing third pinions (P_3, P_3'), one of said intermeshing third pinions of each pair (P_3) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_3') meshing with said third ring gear (R_3);

and, in which said planetary gear train further comprises

a first brake (B_1) operable to anchor said second carrier (A_2);

a second brake (B_2) operable to anchor said second sun gear (S_2) and third sun gear (S_3); and

a third brake (B_3) operable to anchor said second ring gear (R_2) and third carrier (A_3).

22. A change-speed transmission comprising:

an input member (1) to receive the input torque;

an output member (2) to provide the output torque;

a hydrokinetic unit (3) having a pump (3a) connected to said input member for simultaneous rotation therewith and a turbine (3b);

a first and a second clutch;

a divider in the form of a planetary gear set having at least a first, a second and a third rotary element;

a planetary gear train having at least a first, a second and a third rotary element;

said first rotary element of said divider being connected to said first rotary element of said gear train for simultaneous rotation therewith;

said second rotary element of said divider being connectable through a second clutch (C_2) to said second rotary element of said gear train for simultaneous rotation therewith with said clutch engaged;

said output member (2) being connected to said third rotary element of said divider for simultaneous rotation therewith;

said turbine being connected to said third rotary element of said gear train for simultaneous rotation therewith and

said input member being directly connectable through said first clutch (C_1) to said second rotary element of said divider for simultaneous rotation therewith so as to bypass said hydrokinetic unit when said clutch is engaged;

whereby upon engagement of said first clutch (C_1) the input torque of the input member may be split providing a portion of the input torque to the output member bypassing said hydrokinetic unit and providing the remaining portion of the input torque to the output member passing through said hydrokinetic unit, irrespective of the condition of said second clutch (C_2).

23. A change-speed transmission as claimed in claim 22, in which said planetary gear set (Z) of said divider comprises:

two first sun gears (S_3, S_3') as said second rotary element of said divider;

a first ring gear (R_3) as said first rotary element of said divider; and

a first carrier (A_3) as said third rotary element of said divider, said first carrier (A_3) rotatably carrying a plurality of first pinions (P_3), each meshing with both of said first sun gears (S_3, S_3') and with said first ring gear (R_3);

in which said planetary gear train comprises

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a second planetary gear set (Y) which comprises
a second sun gear (S_2);
a second ring gear (R_2) as said third rotary element of said gear train; and
a second carrier (A_2) as said first rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of second pinions (P_2), each meshing with said second sun gear (S_2) and second ring gear (R_2); and
a third planetary gear set (X) which comprises
a third sun gear (S_3) connected to said second carrier (A_2) for simultaneous rotation therewith;

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a third ring gear (R_1) as said second rotary element of said gear train; and
a third carrier (A_1) connected to said second sun gear (S_2) for simultaneous rotation therewith, said third carrier (A_1) rotatably carrying a plurality of pairs of intermeshing third pinions (P_1, P_1'), one of said intermeshing third pinions of each pair (P_1) meshing with said third sun gear (S_3), the other one of said intermeshing third pinions of each pair (P_1') meshing with said third ring gear (R_1);
and, in which said planetary gear train further comprises
a first brake (B_1) operable to anchor said second carrier (A_2) and third sun gear (S_3);
a second brake (B_2) operable to anchor said second sun gear (S_2) and third carrier (A_1); and
a third brake (B_3) operable to anchor said third ring gear (R_1).

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24. A change-speed transmission as claimed in claim 22, in which said planetary gear set (Z) of said divider comprises:

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a first sun gear (S_3) as said second rotary element of said divider;
a first ring gear (R_3) as said first rotary element of said divider; and
a first carrier (A_3) as said third rotary element of said divider, said first carrier (A_3) rotatably carrying a plurality of first pinions (P_3), each meshing with said first sun gear (S_3) and first ring gear (R_3); in which said planetary gear train comprises
a second planetary gear set (Y) which comprises
a second sun gear (S_2);
a second ring gear (R_2) as said first rotary element of said gear train; and
a second carrier (A_2) as said second rotary element of said gear train, said second carrier (A_2) rotatably carrying a plurality of pairs of intermeshing second pinions (P_2, P_2'), one of said intermeshing second pinions of each pair (P_2) meshing with said second sun gear (S_2), the other one of said intermeshing second pinions of each pair (P_2') meshing with said second ring gear (R_2); and
a third planetary gear set (X) which comprises
a third sun gear (S_1) connected to said second sun gear (S_2) for simultaneous rotation therewith;

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a third ring gear (R_1); and
a third carrier (A_1) connected to said second carrier (A_2) for simultaneous rotation therewith, said third carrier (A_1) rotatably carrying a plurality of third pinions (P_1), each meshing with said third sun gear (S_1) and third ring gear (R_1);
and, in which said planetary gear train further comprises
a first brake (B_1) operable to anchor said second carrier (A_2) and third carrier (A_1);
a second brake (B_2) operable to anchor said second ring gear (R_1); and
a third brake (B_3) operable to anchor said second ring gear (R_2).

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Fig. 1

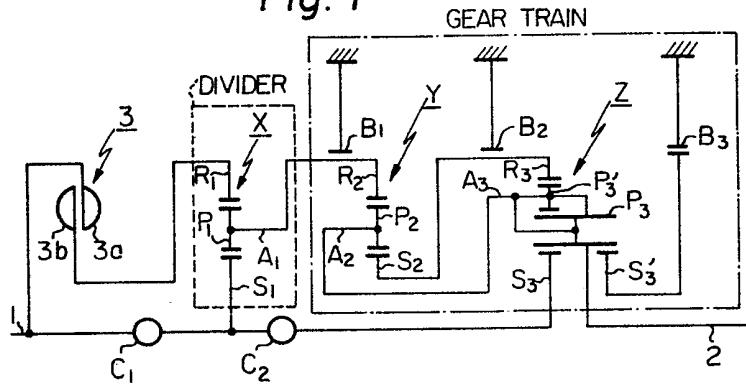


Fig. 2

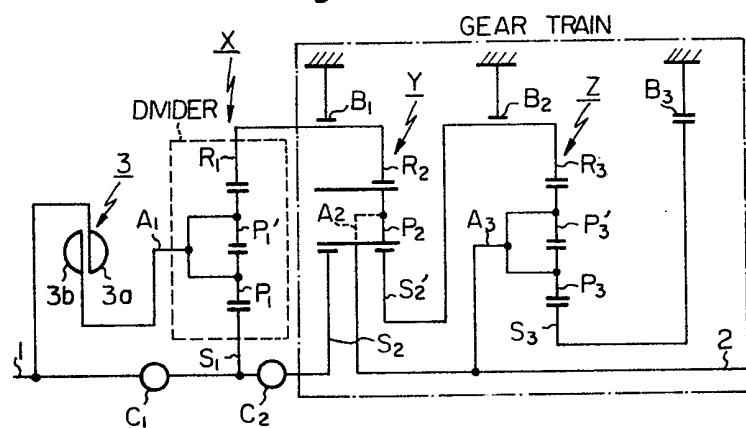


Fig. 3

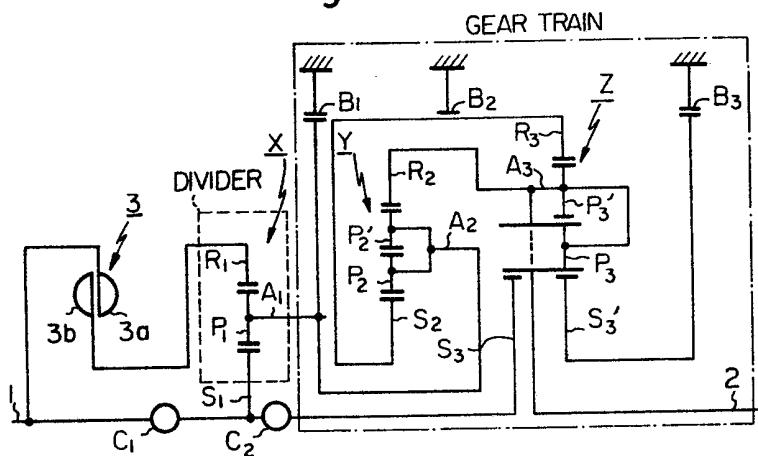


Fig. 4

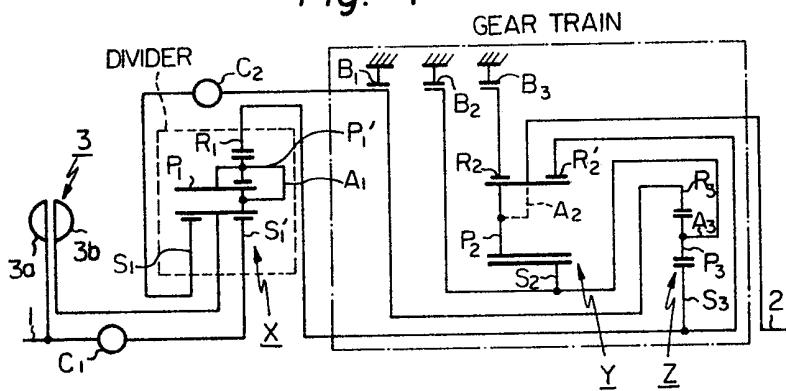


Fig. 5

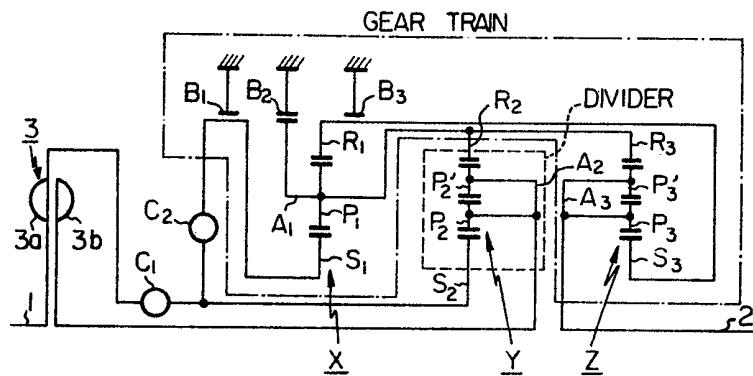


Fig. 6

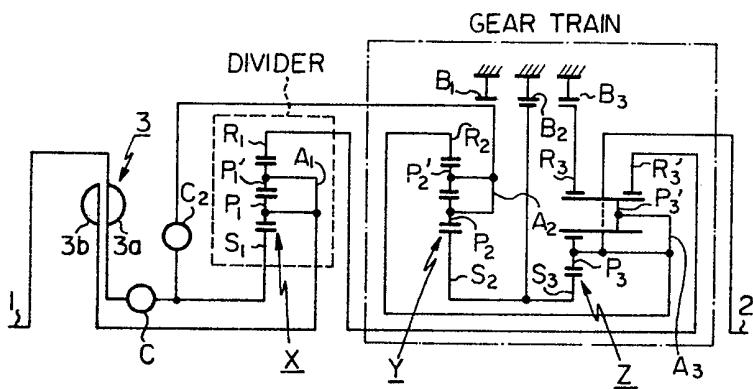


Fig. 7

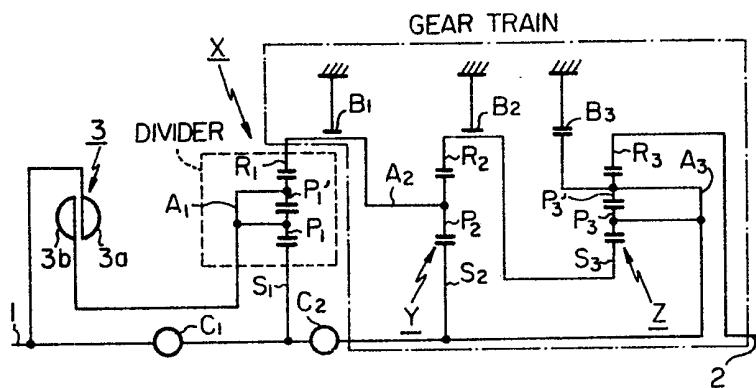


Fig. 8

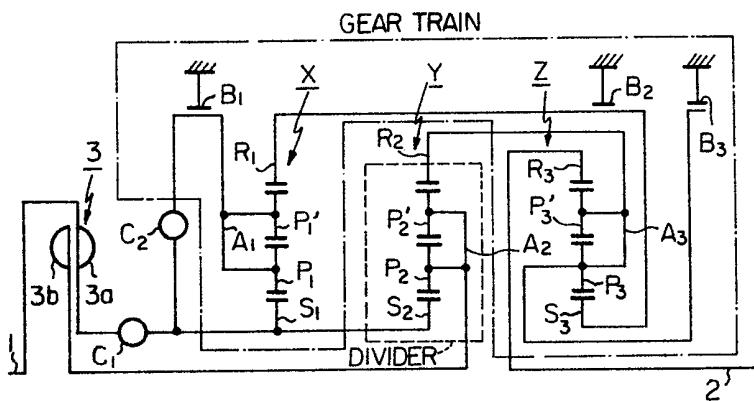


Fig. 9

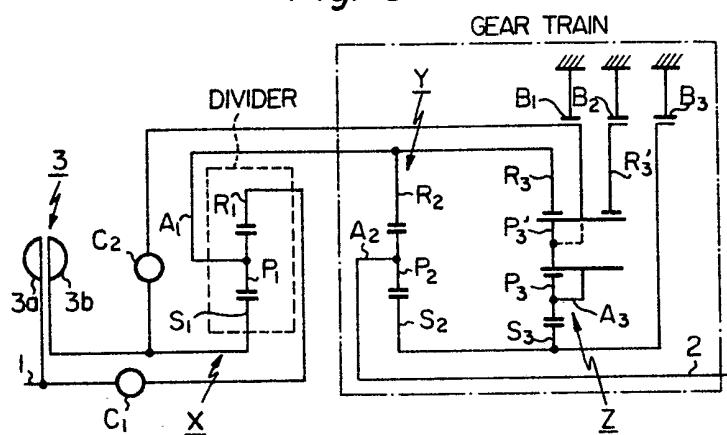


Fig. 10

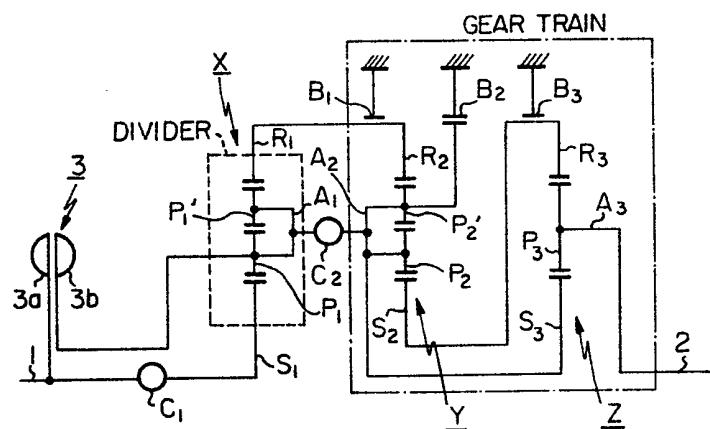


Fig. 11

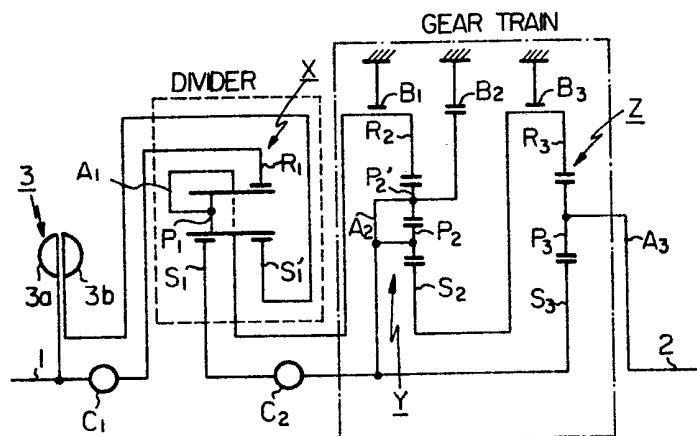


Fig. 12

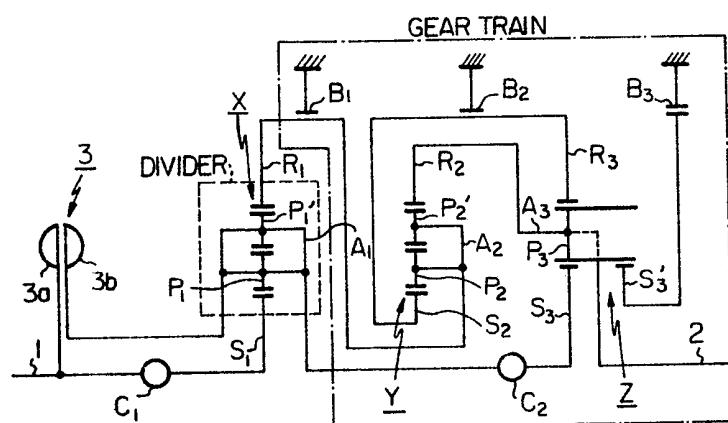


Fig. 13

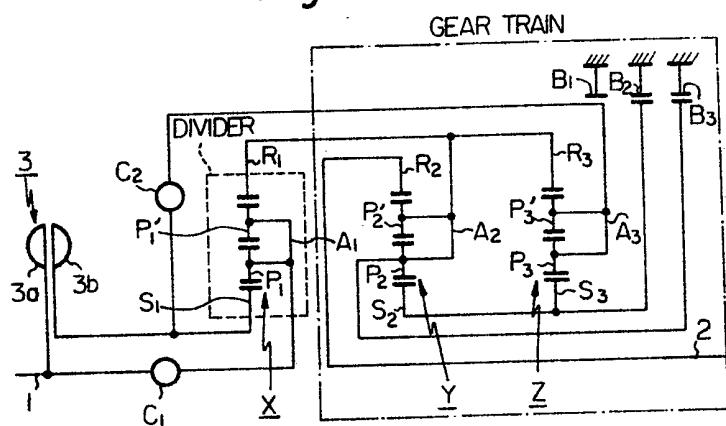


Fig. 14

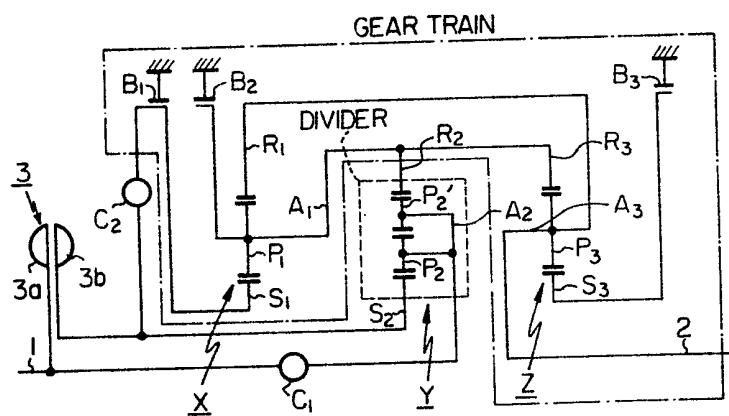


Fig. 15

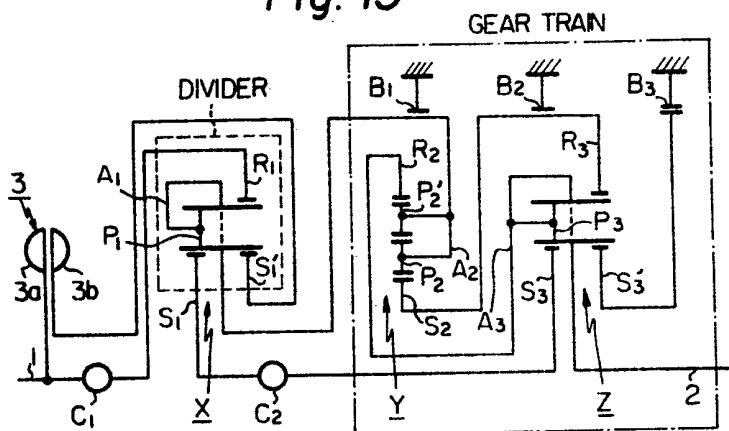


Fig. 16

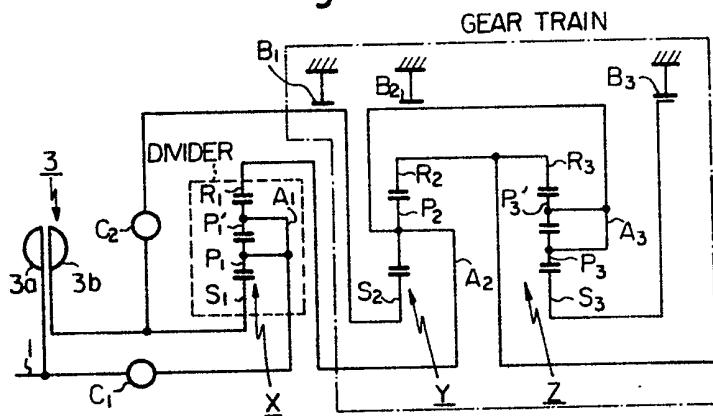


Fig. 17

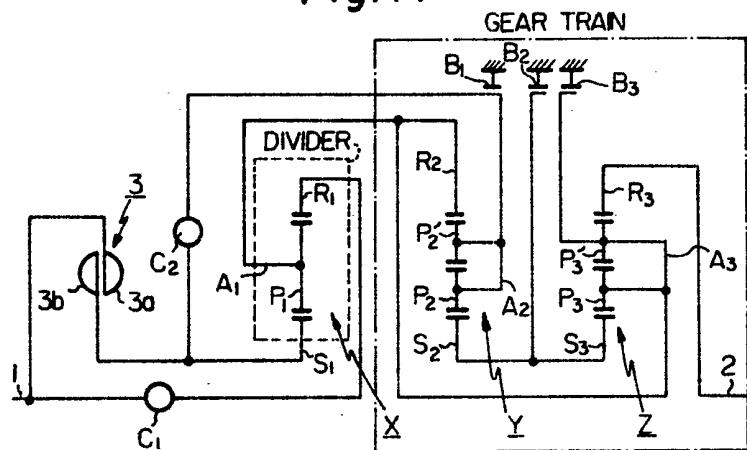


Fig. 18

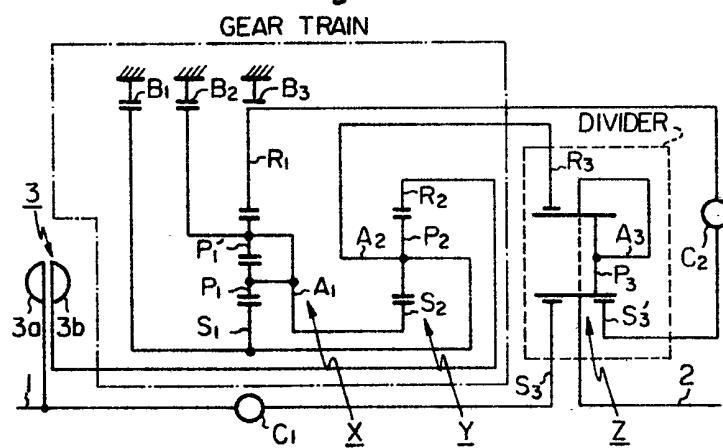


Fig. 19

