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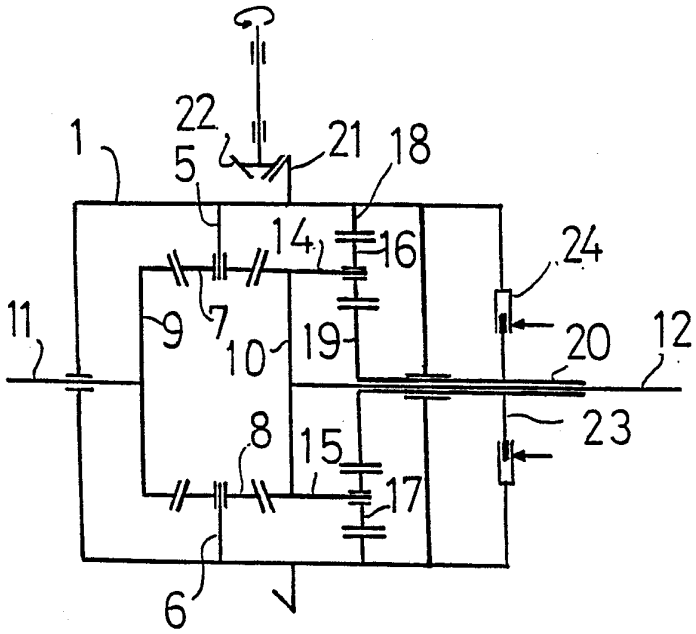

(57) Abstract

A controllable differential gear, e.g., of the kind having a differential gear housing (1) driveable for rotation, in said housing, rotating therewith, being arranged the shafts (5, 6) of differential planet wheels (6, 7) freely rotatable per se and side wheels (9, 10) meshing therewith, said side wheels being freely rotatably journalled relative to the differential gear housing (1) and being in non-rotational connection with a respective shaft (11, 12) rotatable relative to the differential gear housing. The differential gear housing (1) is rigidly connected to the ring wheel (18) of a planetary gear. At least one of the side wheels (10) carries the planet wheel holders (14, 15) and planet wheels (16, 17) of the planetary gear. The sun wheel (19) of the planetary gear is rotatable relative to the shaft (12) connected to the side wheel (10) in question. Control of the gear is accomplished in one embodiment by braking or rotationally driving the sun wheel (19) relative to the differential gear housing (1) or a shaft (12) connected to the side wheel (10).

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DIFFERENTIAL GEAR

The present invention concerns a differential gear having a differential gear housing driveable for rotation, in said housing, rotating therewith, being arranged the shafts of differential planet wheels freely rotatable per se and side wheels meshing therewith, said side wheels being freely rotatably journalled relative to the differential gear housing and being in rotational connection with a respective shaft rotatable relative to the differential gear housing.

Such a differential gear is commonly used in motor vehicles to distribute the drive power from the drive engine to two driving wheels. The differential gear housing carries a crown wheel meshing with a differential drive pinion which in turn is driven by the motor. The side wheels are directly connected to a respective output shaft carrying a driving wheel. Known differential gears have the serious drawback that they function as intended only when the driving wheels are in full frictional engagement with the ground. As soon as a driving wheel looses its full engagement, the driving capacity of the other driving wheel is correspondingly decreased so as to entirely cease when the first driving wheel has lost all frictional contact with the ground. This peculiarity of conventional differential gears involves great risks in skid situations, particularly in connection with the so called secondary skid. A secondary skid occurs after a primary skid when both driving wheels, according to the above, have lost their driving capacity. During the primary skid the driving wheel leading in the direction of skidding has at least some engagement in the direction of traction, while the other driving wheel is more or less raised from the ground. The differential gear then transfers substantially all drive power to the easiest driveable driving wheel, viz. the raised one, in which is built up a large mass energy.

When the primary skid ceases, this driving wheel regains its contact with the ground, whereupon the stored energy is momentaneously transferred to the ground resulting in a violent throw in the opposite direction. Unlike the primary skid, which is built up relatively slowly, the secondary skid occurs considerably faster and often has serious consequences.

It is realized from the above presentation that there is a need to be able to control the power distribution to the output shafts of a differential gear. A known extremity in this respect is the differential lock that blocks the distributing function of the differential gear such that the output shafts are rigidly interconnected. Advantages and disadvantages herewith are commonly known. Further, so called anti-spin systems are known which lower the drive power until wheel spin ceases. However, there is no possibility to direct the drive power to a selective driving wheel.

The object of the present invention, thus, is to provide a differential gear which makes it possible to completely freely distribute input power between the two output shafts of the gear, i.e., to choose everything from a pure differential lock function to a function where the shafts rotate oppositely.

This object has been achieved in that the invention has been given the characteristic features of the appended claims.

The differential gear of the present invention, thus, is basicly a conventional differential gear which is completed with at least one planetary gear. More precisely, it is a differential gear, at least one output wheel (side wheel) of which carries the planet wheel holders of a planetary gear, the sun wheel of which is freely rotatably journalled relative to the shaft of the side wheel and the ring wheel of which is rigidly connected to the differential gear housing.

In a first, preferred embodiment of the invention, the differential gear can be so arranged that the sun wheel is connected to a control shaft in the shape of a hollow shaft which is journalled on the shaft of the side wheel, which, in this case, is one output shaft of the gear. Control of the gear is accomplished in that the control shaft and therewith the sun wheel is imparted a rotational speed differing from that of the output shaft, or, the differential gear housing. This can be done in that the control shaft is separately driveable (active control), or, brakeable (passive control) relative to the differential gear housing, or, the output shaft.

In a second embodiment the differential gear according to the invention can be arranged such that the sun wheel is connected to an output shaft, while the shaft of the side wheel is control shaft in the shape of a hollow shaft journalled around the output shaft. Control is achieved in that the control shaft and with it the planet wheel holder and the side wheel is given a rotational speed differing from that of the output shaft (active or passive control as above).

Control of the gear by actuating the control shaft in both embodiments results in a rotational speed difference between the output shafts. Unactuated it operates like an entirely ordinary differential gear.

The invention will now be described reference being made to the accompanying drawings, wherein fig. 1 shows an axial section through a gear made according to the preferred embodiment, fig. 2 shows schematically the same gear, fig. 3 shows in the same manner the same gear adapted for passive control, fig. 4 shows in the same manner the same gear adapted for alternative passive control, fig. 5 shows in the same manner the same gear adapted for active control, fig. 6 shows schematically the gear according to the second embodiment, fig. 7 shows schematically a differential gear having two planetary gears, fig. 8 shows

schematically a passively controllable gear according to fig. 7, and, fig. 9 shows an actively controllable gear according to fig. 7.

In a differential gear housing 1, in the example according to fig. 1 including several assembled parts 2, 3 and 4, is arranged a plurality of radial shafts, of which are shown two shafts 5 and 6. These shafts freely rotatably carries the planetary wheels 7 and 8, respectively, of the differential gear, which are meshing with the side wheels 9 and 10, respectively, of the gear. The side wheels 9 and 10 are freely rotatable relative to the housing 1 and by means of splines non-rotationally connected to a respective output shaft 11 and 12 extending out of the housing 1 and being rotatable relative thereto. The part 4 of the housing 1 is provided with flanges 13 for mounting a non-shown crown wheel by which the housing 1 is driveable in rotation. The differential gear now described, in all essential is a conventional differential gear the gear-wheels of which are permanently meshing with each other.

Instead of the differential gear described above having differential planetary wheels with radial axes, the invention is as well applicable to any other kind of differential gear, e.g. such having differential planetary wheels with axial axes.

According to the invention, at least one of the side wheels of the gear is adapted as a holder for the planet wheels of a planetary gear. In the example shown in fig. 1, the side wheel 10 is planet wheel holder for a plurality of planet wheels, of which are shown two planet wheels 16 and 17 freely rotatable about shafts 14 and 15. Further, according to the invention, the differential gear housing is connected to the ring wheel of the planetary gear. In the example shown in fig. 1 a ring wheel 18 is pressed into the part 4 of the housing 1 and is rotatable with the housing. Finally, according to the invention, the sun wheel of the planetary gear is rotatable relative to the shaft

connected to the side wheel in question. In the example according to fig. 1 the sun wheel 19 of the planetary gear is arranged in the end of a hollow shaft 20 which is rotatable about the output shaft 12 connected to the side wheel 10. The planet wheels 16 and 17, which are freely rotatable relative to the side wheel 10, are meshing with the ring wheel 18 and the sun wheel 19.

When drivingly rotating the housing 1 and when the shafts 11 and 12 rotate at equal speeds (e.g. driving straight ahead in a motor vehicle application), the differential planet wheels 7 and 8 rotating with the housing 1 drive the two side wheels 9 and 10 at equal rotational speeds. The planetary gear, which, according to the invention, is associated to the differential gear, has no effect herein, since the ring wheel 18 rotates with the speed of the housing 1 at the same time as the shafts 14 and 15 of the planet wheels 16 and 17, respectively, rotate with the side wheel 10. Thus, there is no rotation of the planet wheels 16 and 17 per se, but the hollow shaft 20 rotates with the speed of the output shaft 12 and the gear functions like an ordinary differential gear. The relative rotation occuring at rotational speed difference between the shafts 11 and 12 (driving in curve) not only results in rotation of the planet wheels 7 and 8 about their shafts 5 and 6, but also rotation of the planet wheels 16 and 17, which brings about rotation of the hollow shaft 20 relative to the shaft 12. Since the hollow shaft 20 is allowed to rotate freely, the gear still functions like a conventional differential gear.

The principal structure of the differential gear of fig. 1 is schematically shown in fig. 2, the same reference numerals as in fig. 1 being used where applicable.

Now, according to the invention, there is a possibility to control the rotation of the hollow shaft 20 acting as control shaft and thereby to control the differential gear. This can take place actively in that the control shaft is being driven, or, passively in that it is being braked.

These possibilities shall hereinafter be gone through referring to the schematic figs. 3 - 5. In these figures are used the same reference numerals as in figs. 1 and 2 where applicable.

In addition to the reference numerals used before, 21 represents a crown wheel connected to the housing 1 and 22 a pinion driving same.

Passive control of the gear is shown in fig. 3. For this purpose a braking disk 23 is arranged on the control shaft 20, and a brake 24 co-operating therewith is connected to the gear housing 1. The brake 24 can be so arranged, that it can cause anything from slip braking of the brake disk 23 to complete retention thereof, i.e., it can act as differential brake and as differential lock.

Alternative passive control of the gear is shown in fig. 4. On the output shaft 12 is arranged a brake disk 25 and on the control shaft 20 a brake 26 co-operating with the brake disk, whereby the shafts 12 and 20 can be more or less firmly coupled to each other.

Active control of the gear is shown in fig. 5. Between the gear housing 1 and the control shaft 20 is arranged a motor, in this case a hydraulic motor 27, which can give the hollow shaft 20 a rotational speed differing from that of the gear housing 1. If the gear is used in a motor vehicle, the driving wheels of which are mounted on the shafts 11 and 12, and driving takes place straight ahead, the control shaft 20 rotates with the same rotational speed as the differential gear housing 1 and the output shaft 12. When driving in a curve the control shaft 20, by means of the motor 27, can be given a higher or lower rotational speed than the housing 1. Higher speed results in that the output shaft 12 rotates faster than the shaft 11 and vice versa. This condition can be used to positively give the drive wheels of a vehicle different rotational speeds depending

on curve radiuses. Control of such a process can take place depending on, e.g., steering wheel position. Differential brake and/or lock function can be accomplished by means of a restriction valve between the inlet and outlet of the hydraulic motor.

It is appreciated that driving of the control shaft 20 can take place in many other ways than the one described, e.g., by means of gear-wheel or chain transmissions.

In fig. 6 is schematically shown the second embodiment of the differential gear according to the invention, wherein the sun wheel 19 is connected to the output shaft 12 and the shaft of the side wheel 10 in the shape of a hollow shaft 20 is journalled around the shaft 12. Also in this embodiment passive or active control in the way described above with reference to figs. 3, 4 and 5 can be utilized, a brake or a drive motor, respectively, then being arranged between the hollow shaft 20, acting as a control shaft, and the differential gear housing 1.

As is appreciated by a person skilled in the art, passive and active control, i.e., braking and driving, can be combined in both embodiments.

According to the invention a differential gear can be provided with two planetary gears. An example of such a gear, in principle being constituted by doubling the gear of figs. 1 and 2, is shown in fig. 7.

As the gear is shown in fig. 7, its right part from the output shaft 12 to the differential gear planet wheels 7 and 8 corresponds to the gear of fig. 2. In the gear according to fig. 7, however, the side wheel 9 is adapted as a planet wheel holder for the planet wheels of a second planetary gear. These, as well as the further parts included in the second planetary gear, have the same reference numerals as corresponding parts in the first planetary gear completed with a prime.

Control of the gear according to fig. 7 can, as before, be passive or active. At passive control for obtaining differential brake or differential lock function one or both control shafts, i.e., the hollow shafts 20, 20′, are braked against the differential gear housing 1 in the manner shown in fig. 3.

Braking also can take place against ground, e.g., against brakes 29, 29′ connected to a vehicle chassis 28 according to fig. 8. Equal braking of the hollow shafts 20, 20′ involves a driving brake function, while unsymmetrical braking involves turning.

In practice, active control of the gear of fig. 7 takes place by driving only one of the control shafts 20, 20′. This form of control, which is mainly contemplated as a complement to passive control, particularly when small turning radiuses are concerned, e.g., in tracked vehicles, is shown in fig. 9 and comprises, as appears, in principle a combination of the gears of figs. 5 and 8. Between the gear housing 1 and the hollow shaft 20, thus, inside the brake 23,29 is arranged a hydraulic motor 27.

When actively controlling a gear according to the present invention, i.e., driving of a control shaft, rotation of a vehicle can be achieved around the centre of the driving wheels or driving tracks when the drive transmission is inactive, i.e., when the differential gear housing is standing still.

Specific for a differential gear according to the invention is that active or passive control of a control shaft does not affect the algebraic sum of the rotational speeds of the two output shafts.

A practical way of providing active control, i.e., driving of the control shaft, is to arrange outside the differential gear a further planetary gear, the housing of which is driven by the differential gear housing and the planet wheel holder of which

is driven by the control shaft, the gear ratios being chosen such that the sun wheel of the further planetary gear stands still when the output shafts of the differential gear have the same rotational speed. This means that a control lever or wheel can be mounted on the normally still-standing sun wheel shaft of the further planetary gear for direct manual influence on the control of the differential gear.

As is appreciated by a person skilled in the art a differential gear according to the invention can be realized in many ways. Further, several gears according to the invention can be combined for achieving special functions.

For instance, in a four wheel drive vehicle, a gear according to fig. 5 can be arranged for each pair of driving wheels and a third such gear therebetween. The drive motor of the vehicle then drives the gear housing of the intermediate gear, and the output shafts of the intermediate gear drive one each of the gear housings of the driving wheel gears, while the output shafts of the latter gears carry the driving wheels. With this arrangement separate control for each driving wheel can be obtained, and, further, power distribution between the front and rear axles. With two motors connected to one each of the output shafts of a gear according to fig. 5, said shafts then actually being input shafts, the gear housing can drive an output shaft common to the motors. With one motor driving the gear housing of a gear according to fig. 5, propellers connected to the output shafts through angular drive gears can be separately controlled.

CLAIMS

1. A differential gear having a differential gear housing (1) driveable for rotation, in said housing, rotating therewith, being arranged the shafts (5,6) of differential planet wheels (6,7) freely rotatable per se and side wheels (9,10) meshing therewith, said side wheels being freely rotatably journalled relative to the differential gear housing (1) and being in non-rotational connection with a respective shaft (11,12; 11,20) rotatable relative to the differential gear housing, c h a r a c t e r i z e d i n

- that the differential gear housing (1) is rigidly connected to the ring wheel (18) of a planetary gear,

- that at least one of the side wheels (10) carry the planet wheel holders (14,15) and planet wheels (16,17) of the planetary gear,

- and that the sun wheel (19) of the planetary gear is rotatable relative to the shaft (12;20) connected to the side wheel (10) in question.

2. A differential gear according to claim 1, c h a r a c t e r i z e d i n that the sun wheel (19) is rotatable about the shaft (12) connected to the side wheel (10), said shaft being an output shaft, and said sun wheel being actuatable for the purpose of being imparted a rotational movement relative to said shaft (12). (Fig. 2)

3. A differential gear according to claim 1, c h a r a c t e r i z e d i n that the sun wheel (19) is non-rotationally connected to an output shaft (12) and that the side wheel (19) is actuatable for the purpose of being imparted a rotational movement relative to said shaft (12). (Fig. 6)

4. A differential gear according to claim 1 or 2, c h a r a c t e r i z e d i n that the sun wheel (19) is brakeable relative to the differential gear housing (1) or relative to the shaft (12) connected to the side wheel (10).

5. A differential gear according to claim 1, 2 or 4, c h a r a c t e r i z e d i n that the sun wheel (19) is driveable in order to be imparted a rotational speed differing from that of the differential gear housing (1).

6. A differential gear according to claim 2, 4 or 5, c h a r a c t e r i z e d i n that the sun wheel (19) is connected to a hollow shaft (20) arranged around the output shaft (12), said hollow shaft constituting the control shaft of the gear.

7. A differential gear according to claim 1 or 3, c h a r a c t e r i z e d i n that the side wheel (10) is brakeable relative to the differential gear housing (1) or relative to the shaft (12) connected to the side wheel (10).

8. A differential gear according to claim 1, 3 or 7, c h a r a c t e r i z e d i n that the side wheel (10) is driveable in order to be imparted a rotational speed differing from that of the differential gear housing (1).

9. A differential gear according to claim 3, 7 or 8, c h a r a c t e r i z e d i n that the side wheel (10) is connected to a hollow shaft (20), which is the control shaft of the gear and through which extends the output shaft (12).

FIG. 1

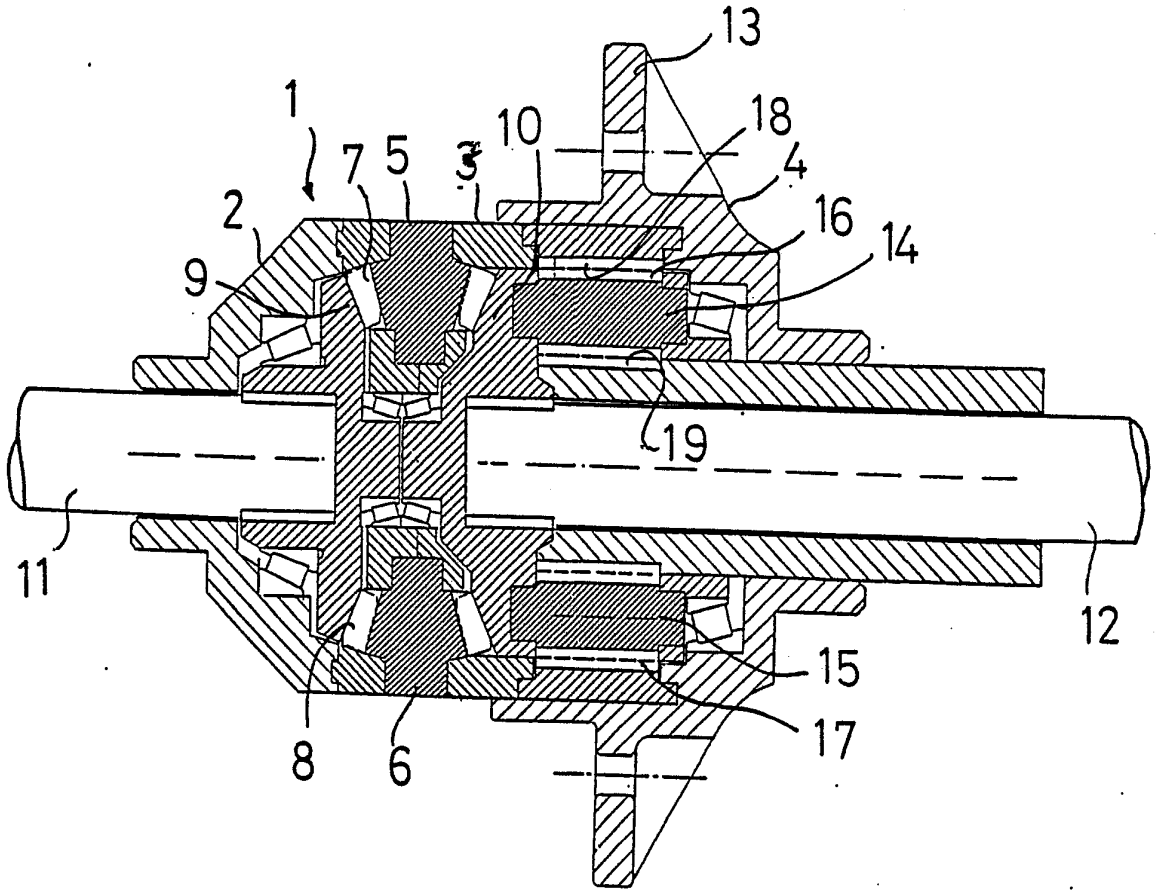
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FIG. 2

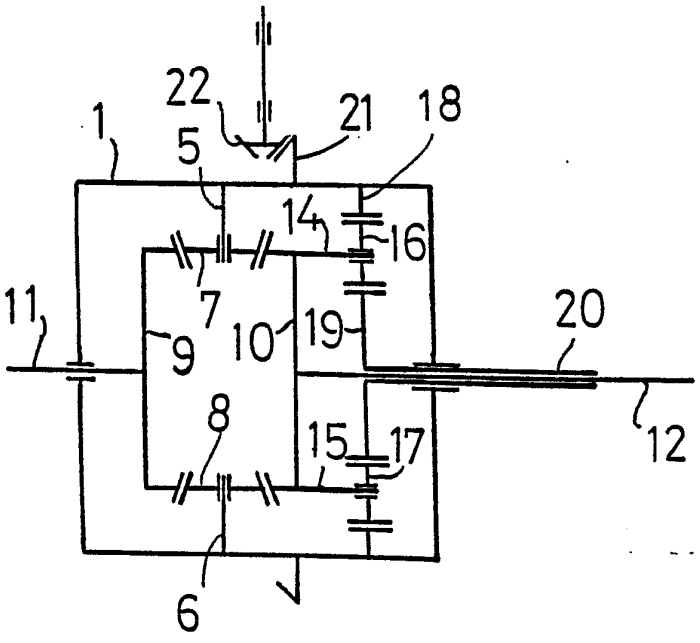
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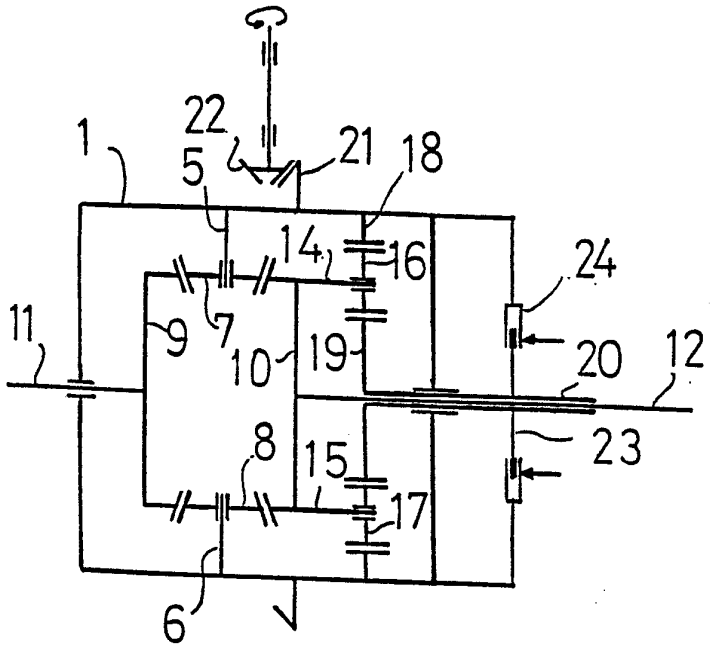
FIG. 3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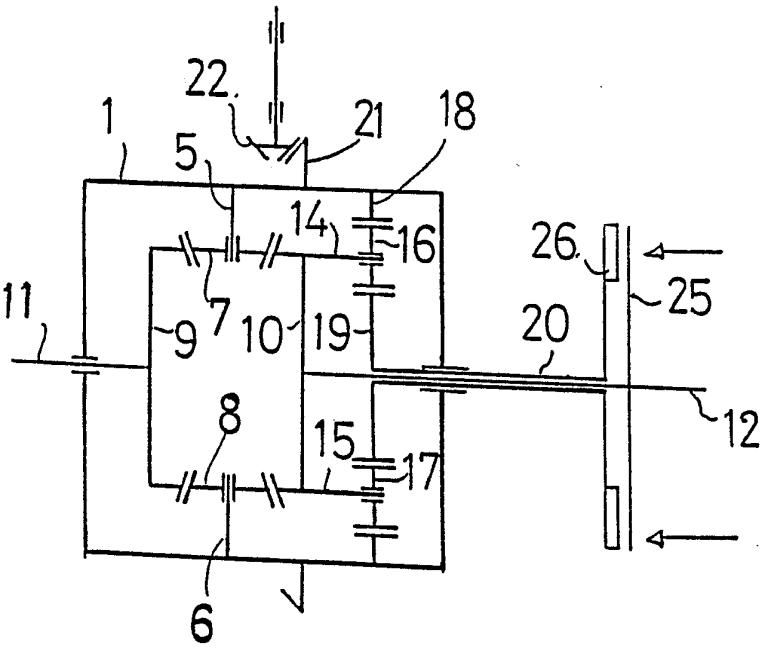
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FIG. 5

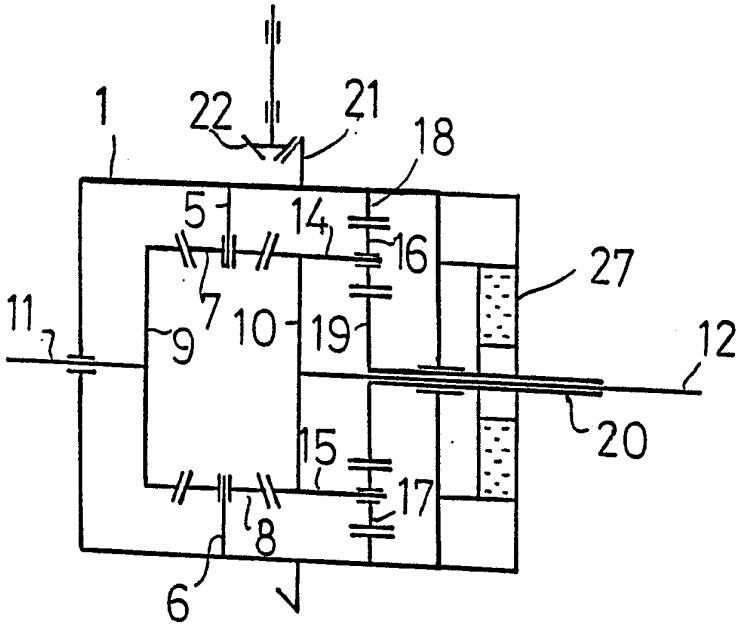
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FIG. 6

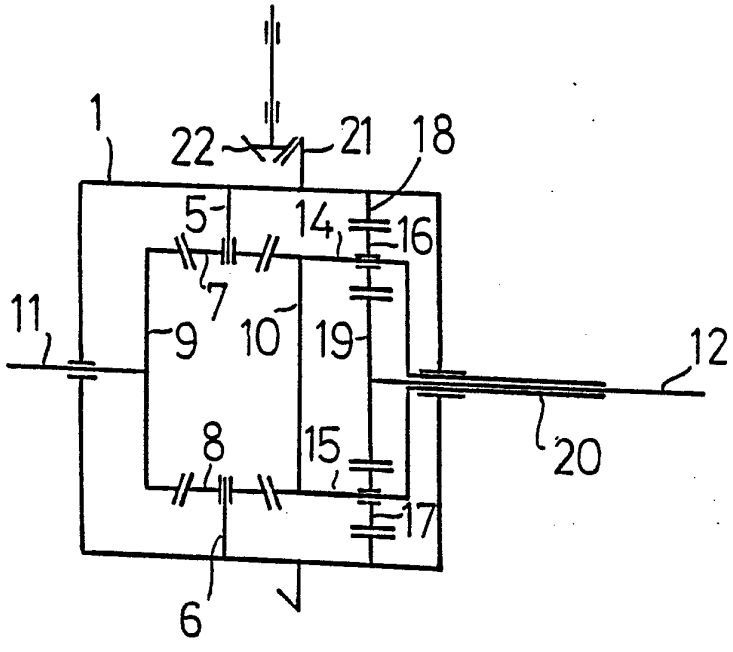
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FIG. 7

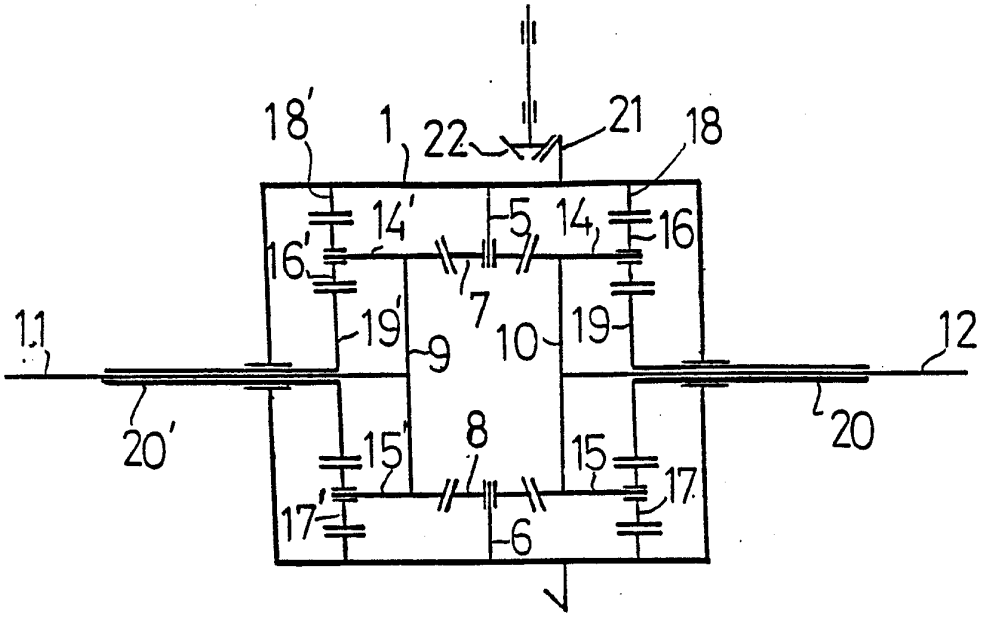
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FIG. 8

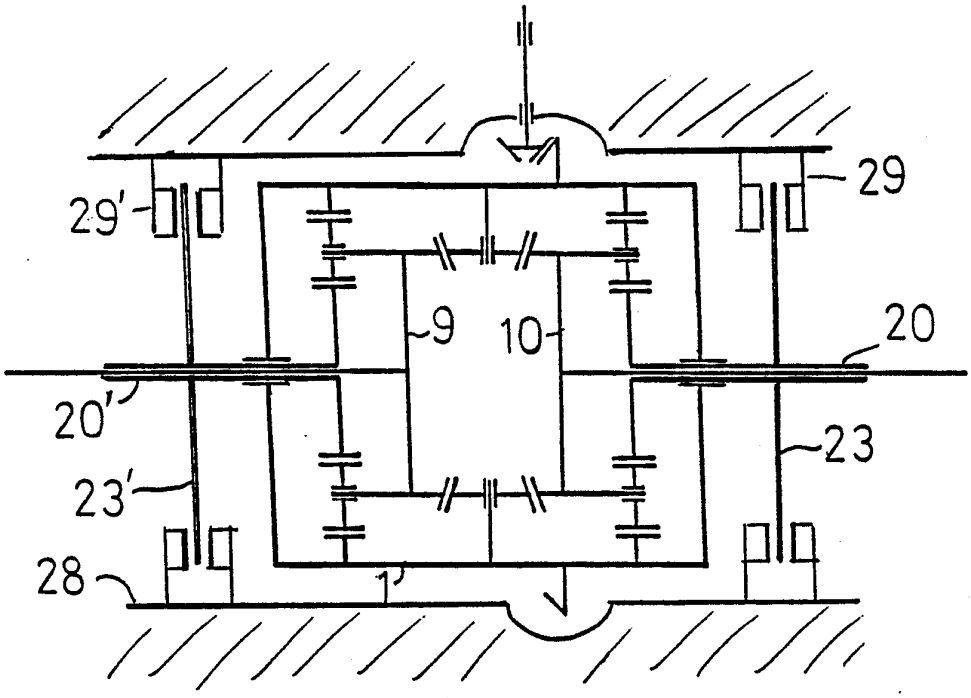
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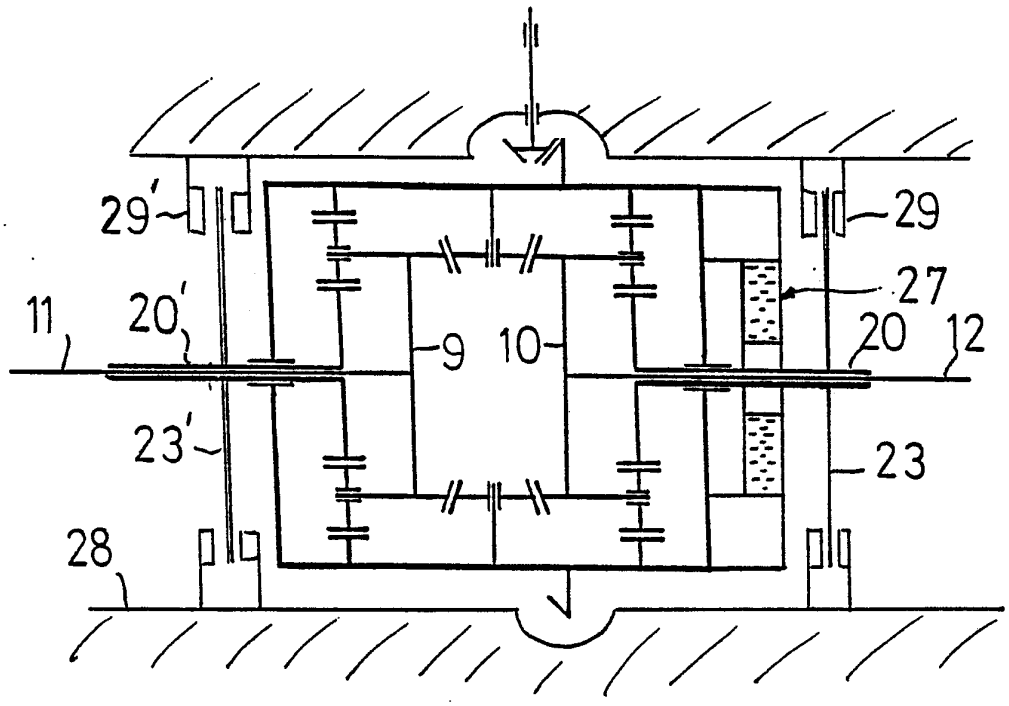
FIG. 9



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE87/00266

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

F 16 H 1/44 [4]

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	F 16 H 1/44-/45; B 60 K 17/16-/20
US Cl	74:710-715

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	DE, A, 2 609 377 (GERHARD STAUDENMAIER) 8 September 1977	
A	DE, C, 956 649 (ALLGAIER-WERKE GmbH) 3 January 1957	
A	GB, A, 507 534 (RICHARD JOSEPH IFIELD) 16 June 1939	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
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