(54) Title: GEAR SYSTEM HAVING NESTED MODULES

(57) Abstract

A gear system includes a plurality of gear modules (10) each having spring clips (14, 15, 16, 17) for performing a snap-fit attachment to another similarly configured gear module (110) and for providing gear coupling between the modules. Each module includes a housing (11) within which a plurality of planetary gears (41, 42, 43, 44) are rotatably supported about a common opening (45) and a gear rotor (30) received upon the planetary gears and having an internal ring gear (32) in engagement with the planetary gears. Each rotor of each module includes a forwardly extending center gear (31). Each housing of each gear module includes a plurality of spring clips (14, 15, 16, 17) having gripping edges (24, 25, 26, 27) for being received upon and snap-fit engaging the housing of the next succeeding gear module. The modules may be combined in virtually any practical number to obtain a desired gear ratio which is a multiple of the individual gear ratios of the modules.
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GEAR SYSTEM HAVING NESTED MODULES

SPECIFICATION

Field of the Invention

This invention relates generally to gear systems and particularly to gear systems known as planetary gear systems.

Background of the Invention

In many power drive systems ranging from very large industrial and power industry systems to small battery powered toys, the basic conversion of energy to useful power occurs within a device that is in essence rotary. Thus while reciprocating engines are prevalent in the form, for example, of internal combustion engines or the like, their useful output is generally converted to a rotary power. Similarly, engines such as turbines or motors such as electric motors operate to produce rotary power. In many power utilization systems, or power producing systems, the optimum speed of the power producing or energy converting device is different from the optimum speed of the utilization device. For example, in systems powered by electric motors, a relatively small motor may be used running at high speed to power a load or utilization device requiring substantially more torque than the small high speed motor can produce. In such systems, a speed reduction gear set is commonly used to divide the speed down for eventual use due to the corresponding torque multiplication which occurs. The use of gear systems to trade speed versus torque has
been basic in the design of such systems and is well known. In essence, as rotational power is coupled between a power producing device such as a motor and a utilization device such as a drive wheel or a vehicle, two basic types of systems emerge. The first is often referred to as "speed reduction" gear system in which the rotational speed output of a high speed motor is reduced by a series of gears to a lower speed while the torque is correspondingly multiplied up. The second system is the converse of the speed reduction gear in which the rotational output of a slower motor is increased in speed by a plurality of gears with a corresponding multiple for loss of torque.

Despite the great variance of gear systems to suit various industry needs, one of the most flexible and pervasive gear systems is known as a "planetary" gear system. The name for such planetary gear systems arises out of the arrangement of gears which in some sense is similar to the rotation of planets about the sun. Thus such gear systems are often also referred to as "sun" gears. In such systems, a plurality of gears are rotatably supported on fixed posts at radial positions from a center. The gears are spaced and of such size that a center gear may be inserted into the center of the gear array and engage all of the planetary gears. The planetary gear system further includes a ring gear encircling the outer portions of the planetary gears. The coupled portions of the gear system are the ring gear and the center gear, both of which engage the planetary gears. Thus speed reduction occurs when the center gear is the driven power input gear and the ring gear is the output gear. Conversely, speed increase is accomplished when the outer ring gear is the power driven gear and the center gear is coupled to the load.
The ruggedness and flexibility of such gear systems has allowed designers to utilize planetary gear systems in a wide range of applications extending from heavy industrial and commercial equipment to miniaturized toys powered by small battery driven motors. Despite this wide range of use and adaptability in each instance, the foregoing advantages are equally realized making the planetary gear system a popular choice by designers.

Not surprisingly in view of the advantages described above, planetary gear systems are found throughout the various arts as practitioners endeavor to utilize them. For example, U.S. Patent 5,240,462 issued to Mochizuki et al sets forth a PLANETARY REDUCTION GEAR having pairs of partial planetary gears, two partial internal gears, and a sun gear in which one of the partial gears is fixed to the input shaft or to the casing while the other gear is loosely connected to the input shaft or the casing by a spiral coupling. The spiral coupling allows the partial gear to move in a spiral direction. Means are provided for pushing the partial gear in the axial direction moving the partial gear.

U.S. Patent 848,244 issued to Horstmann sets forth a VARIABLE SPEED GEAR AND REVERSING MECHANISM utilizing a planetary gear apparatus in which the gear ratio is changeable.

U.S. Patent 4,186,626 issued to Chamberlain sets forth a WHEEL FINAL DRIVE ASSEMBLY in which a two stage or double reduction planetary gearing mechanism is positioned within wheel hubs of a vehicle and connected to the vehicle drive wheels. A drive axle
shaft for interconnecting a vehicle power train differential and gearing mechanism together with a separate part hollow hub having positioning faces containing an axially positioning gears of the mechanism is used.

U.S. Patent 3,815,445 issued to Gorrell sets forth a VARIABLE SPEED PLANETARY TRANSMISSION including a succession of planetary gear trains adapted to provide a relatively uniform step or percentage change between speed ratios.

U.S. Patent 4,334,440 issued to Fonck sets forth an AUTOMATIC TRANSMISSION providing a continuously varying speed characteristic using a plurality of planetary gear sets commonly coupled in pairs and having different gear ratios to vary the speed reduction or multiplication.

U.S. Patent 2,529,423 issued to Schou sets forth a TRANSMISSION MECHANISM in which a planetary gear system utilizes a beveled gear driving a plurality of smaller beveled gears in a four-sided arrangement to couple operative power.

U.S. Patent 5,012,693 issued to Enomoto et al sets forth a DRIVE MECHANISM FOR REAR-VIEW MIRROR ASSEMBLY OF MOTOR-DRIVEN FOLDING TYPE which includes an electric motor fixed on a mirror housing which in turn is supported rotatably on a shaft fixed to the mirror base. The mirror base is secured to a vehicle body such that it may be turned between normal and retracted positions by the drive mechanism.

U.S. Patent 5,136,197 issued to Hallett sets forth a REACTION CONTAINMENT DRIVE FOR POWER TOOL
having a motor supporting a rotatable case within the
tool casing and an internal drive shaft. A planetary
gear set is an integral portion of the drive.

U.S. Patent 5,171,194 issued to Shen sets forth a
BIFURCATED VARIABLE RATIO TRANSMISSION having a
plurality of planetary gear sets arranged in stages
for altering the torque flow from the motor to the
load.

U.S. Patent Re. 32,386 issued to Hunter sets
forth a SPRINKLER SYSTEMS having a fluid pressure
controlling device within a sprinkler head supporting
a pop-up nozzle which is actuated by fluid pressure.
An impeller is actuated by the fluid flow to rotate
the nozzle and thus rotate the spray of fluid
therefrom.

U.S. Patent 5,503,586 issued to Suto sets forth a
STEERING APPARATUS utilizing an extremely simple gear
system in which a pair of output gears may be
controlled so as to rotate in the same or opposite
directions. The gear system is particularly useful as
the steering system for a toy vehicle.

While the foregoing described prior art devices
have provided improvements in their various arts, and
in some instances enjoyed commercial success, there
remains nonetheless a continuing need in the art for
evermore improved, and efficient gear coupling
systems.

Summary of the Invention

Accordingly, it is a general object of the
present invention to provide an improved gear system.
It is a more particular object of the present invention to provide an improved gear system which is particularly well suited to toys, dolls, and entertainment products. It is a still more particular object of the present invention to provide an improved gear system which may be readily adapted to a variety of gear ratio needs.

In accordance with the present invention, there is provided a gear system comprising: a plurality of gear modules each having, a housing having a plurality of planetary gears supported by the housing, a rotor having an internal ring gear engaging the planetary gears and an output gear, and attachment means for securing each of the gear modules to another of the gear modules in the plurality of gear modules such that its output gear engages the plurality of planetary gears of another of the gear modules.

**Brief Description of the Drawings**

The features of the present invention, which are believed to be novel, are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, and in which:

Figure 1 sets forth a perspective view of an exemplary gear system module;

Figure 2 sets forth a perspective assembly view of the module of Figure 1; and
Figure 3 sets forth a section view of a plurality of nested gear modules constructed in accordance with the present invention.

Description of the Preferred Embodiment

Figure 1 sets forth a gear module constructed in accordance with the present invention and generally referenced by numeral 10. Gear module 10 includes a generally cylindrical housing 11 supporting a plurality of forwardly extending spring clips 14, 15, 16, and 17 which in turn define end portions having a gripping edge 24, 25, 26, and 27, respectively. Spring clips 14 through 17 are preferably fabricated of a resilient spring material such as resilient plastic or spring steel or the like. Housing 11 further defines an interior cavity 13 within which a generally cylindrical ring gear rotor 30 is received. Ring gear rotor 30 further supports a forwardly extending center gear 31. In accordance with the fabrication of module 10 set forth below in greater detail, and as is seen in Figure 3, rotor 30 defines an interior ring gear 32 which is received upon a plurality of planetary gears (gears 41 through 44 seen in Figure 2). In accordance with this fabrication, rotor 30 is rotatably supported within interior cavity 13 and is rotatable in either direction as indicated by arrows 36. The important aspect to note within Figure 1 is the manner in which gear module 10 forms a single stage which, as is described below, may be combined with other similar modules in a stacked arrangement using the attachment of spring clips 14 through 17 to provide a succession of gear modules to form a gear system. In its preferred fabrication, gear module 10 is fabricated of substantially rigid components and with the exception of spring clips 14
through 17 which are resilient, the remainder of gear
module 10 is preferably fabricated of relatively rigid
material such as molded plastic or composite material
or steel as required for a particular application.

Figure 2 sets forth a perspective assembly view
of module 10 showing ring gear rotor 30 in partial
section. As described above, module 10 includes a
housing 11 having a generally cylindrical shape and
defining a cylindrical wall 12. Housing 11 further
defines a generally planar back wall 40 supporting a
plurality of posts 61, 62, 63, and 64 which receive
and rotatably support a plurality of planetary gears
41, 42, 43, and 44. Gears 41 through 44 are secured
to posts 61 through 64 in a rotatable attachment in
which posts 61 through 64 are received within
apertures 51 through 54 formed respectively in gears
41 through 44.

Back wall 40 further defines a center aperture 45
which is aligned with the center line of the
arrangement of planetary gears 41 through 44.

Gear module 10 is completed by ring gear rotor 30
which, as described above, is generally cylindrical
and defines an outer face 35 and an outer wall 34. As
is also described above, rotor 30 supports a center
gear 31 extending forwardly from outer face 35. As
can be seen by the broken section of Figure 2, ring
gear rotor 30 defines an interior cavity 33 and an
internal ring gear 32. In accordance with
conventional ring gear fabrication, internal ring gear
32 will be understood to extend the entire
circumference of ring gear rotor 30. With planetary
gears 41. through 44 received upon posts 61 through
64, rotor 30 is assembled to housing 11 such that
planetary gears 41 through 44 each engage internal ring gear 32. In this fabrication, and as is better set forth below in Figure 3, the resulting assembly allows the insertion of a center gear identical to center gear 31 through aperture 45 of back wall 40 to mutually engage each of planetary gears 41 through 44. In planetary gear systems, the center gear commonly coupled to the plurality of planetary gears is referred to as the "sun" gear.

In operation, the completed and assembled gear module formed by housing 11, gears 41 through 44, and ring gear rotor 30 produces the module shown in Figure 1 in which rotation of rotor 30 produces corresponding rotations of gears 41 through 44. Conversely, and in accordance with the anticipated use of the present invention, a gear substantially identical to gear 31 is inserted through aperture 45 engaging gears 41 through 44. The resulting gear system of module 10 provides rotation of ring gear rotor 30 in response to such rotation of an inserted center gear. Conversely, rotation of ring gear rotor 30 produces a rotation of the inserted center gear.

It will be apparent to those skilled in the art that ring gear rotor 30 is securely joined to center gear 31. Thus in essence, center gear 31 provides the output gear of gear module 10. It will also be appreciated, and as is better seen in Figure 3, that module 10 once completed is configured to receive an identical gear module in a nesting arrangement in which center gear 31 becomes the input gear passing through the aperture formed in the next gear module in the manner shown in Figure 3 as center gear 31 passes through aperture 86 of housing 81 of module 80.
The speed and torque relationship between the input gear inserted through center aperture 45 and the output gear provided by center gear 31 is determined by the relative sizes of the center gear, the planetary gears, and the internal ring gear of the module. Thus for any given fabrication of module 10, there exists a drive characteristic such as speed reduction and torque multiplication which, in essence, defines the gear module. It will also be noted that successive gear modules having defined characteristics of gear ratio and torque ratio are multiplied when two or more gear modules are nested and engaged as set forth below in Figure 3.

Figure 3 sets forth a section view of a planetary gear system utilizing a plurality of gear modules coupled in a serial or stacked configuration. In the example shown in Figure 3, a motor 70 fabricated in accordance with conventional fabrication techniques, includes an output shaft 71 supporting an output gear 72. Figure 3 is intended to illustrate the nested or stacked configuration of a number of substantially identical gear modules to produce an overall gear ratio between output gear 72 of motor 70 and the final output gear of the end module (gear 134 of module 110). As mentioned above, the final ratio of speed and torque provided by the combined gear modules shown in Figure 3 is the multiplication of each gear module ratio. It will be apparent, therefore, that the number of modules which are assembled to form the complete gear system operated by motor 70 is not limited to the three modules shown in Figure 3. On the contrary, Figure 3 is intended to illustrate an indefinite number of modules continuing in succession in the same manner as modules 10 and 80 are coupled and engaged which indefinite number extends from motor
70 to an end cap 140 at the opposite end of the gear system.

More specifically, and as described above, module 10 includes a generally cylindrical housing 11 having a back wall 40 and an interior cavity 23. Back wall 40 further defines a center aperture 45 and a plurality of forwardly extending posts 61 through 64 (posts 62 and 64 seen in Figure 2). Housing 11 further defines an edge 28 and a plurality of forwardly extending spring clips such as spring clips 14 and 16. Spring clip 14 defines a gripping edge 24 while spring clip 16 defines a gripping edge 26.

Within housing 11, a ring gear rotor 30 defines an interior cavity 33 and a center gear 31. Ring gear rotor 30 further defines an internal ring gear 32 extending about the outer wall of ring gear rotor 30. Module 10 is assembled in the manner described above in Figures 1 and 2 and is completed by the insertion of ring gear rotor 30 into interior cavity 23 of housing 11 such that ring gear 32 engages planetary gears 41 through 44 (gears 42 and 44 seen in Figure 2). Motor 70 and shaft 71 are positioned with respect to module 10 such that output gear 72 is inserted through aperture 45 and commonly engages each of planetary gears 41 through 44 (gears 42 and 44 seen in Figure 2). Thus the combination of motor 70, shaft 71, and output gear 72 operatively coupled to gears 41 through 44 of module 10 together with the assembly of ring gear rotor 30 into interior cavity 23 completes a gear module in which a gear ratio of speed and torque is defined between output gear 72 of motor 70 and center gear 31 of rotor 30.
If desired, a single module may be used in the manner in which gear module 10 is assembled to output gear 72 if desired. In such case, end cap 140 is substituted for module 80 to complete the gear system. For purposes of illustration, however, and in accordance with an important aspect of the present invention, the inventive gear system is not limited to a single gear module but rather may be enhanced by the attachment of one or more additional modules. For purposes of illustration, a gear module 80 which is substantially identical to gear module 10, is secured to gear module 10 by the cooperation of edge 28 of housing 11 and spring clips 14 through 17 (clips 13 and 17 shown in Figure 2).

More specifically, module 80 includes a generally cylindrical housing 81 having a cylindrical wall 94 and a center aperture 45. Housing 81 supports a plurality of forwardly extending posts such as posts 96 and 98 which support planetary gears 97 and 99 in a rotatable attachment. Housing 81 further defines an edge 82 and a plurality of forwardly extending spring clips such as spring clips 90 and 91. It will be apparent to those skilled in the art that in the preferred embodiment of the present invention, housing 81 supports a greater plurality of forwardly extending spring clips similar to those shown in Figure 2 for module 10. However, the number of spring clips for any given module is subject to variation should the user desire in meeting certain design requirements. It is equally feasible to select nested or stacked gear modules which are constructed in accordance with gear module 10 but which have different gear sizes to produce different gear ratios. However, in the preferred fabrication of the present invention, gear
module 80 is substantially identical to gear module 10.

Module 80 further includes a ring gear rotor 83 having an internal ring gear 95 and a center gear 85. As was the case in the assembly of module 10, ring gear rotor 83 is received upon the plurality of planetary gears such as gears 97 and 99 in engagement with internal ring gear 95.

The multiple module gear system shown in Figure 3 provides a plurality of stacked or nested gears coupled between module 10 and the final gear module 110. Thus each successive module is secured to the preceding module by the engagement of spring clips having gripping edges and the outer edge of the succeeding housing. Thus module 80 having spring clips 90 and 91 which define gripping edges 92 and 93 will be understood to couple to and engage the next succeeding gear module in the manner in which spring clips 14 and 16 engage housing 81 of module 80.

Module 110 together with end cap 140 show the cooperation of the last or end most module and end cap 140. Assuming a module preceding module 110 supports a center gear 100, module 110 includes a housing 111 defining an aperture 113 through which center gear 100 extends in the manner described above for modules 10 and 80. Module 110 is preferably formed substantially identical to module 10 and thus includes a housing 111 supporting a plurality of posts such as posts 125 and 131, each of which supports a rotatable planetary gear such as gears 124 and 130. Module 110 further includes a ring gear rotor 132 having an internal ring gear 133. Once again, as described for previous modules, ring gear rotor 132 is received within
housing 111 such that internal ring gear 133 engages the planetary gears of the module such as gears 124 and 130. Housing 111 includes a plurality of forwardly extending spring clips such as spring clips 120 and 122 having respective gripping edges such as edges 121 and 123. Ring gear rotor 132 further includes a forwardly extending center gear 134.

To complete the assembly of the gear system provided by modules 10 through 110, an end cap 140 is secured to housing 111 of module 110 to maintain the captivity of ring gear rotor 132 within housing 111. Thus end cap 140 is generally cylindrical in shape and defines a center aperture 142, a forward edge 141, and a back 143. As is shown in Figure 3, the assembly of end cap 140 to module 110 is carried forward in substantially the same manner as assembly between successive gear modules in that the spring clips of module 110 such as clips 120 and 122 are received upon the outer surface of end cap 140 and snap-fit thereto through the engagement of the respective gripping edges of the spring clips such as edges 121 and 123 of spring clips 120 and 122.

With the entire gear system assembled in the manner shown in Figure 3, the gear ratio or ratio of speed and torque between output gear 72 of motor 70 and the final module gear shown as center gear 134 of module 110 is determined by the multiplication of the individual ratios of each module. Thus for example, if modules 10, 80, and 110 form the entire combination gear system, and if each is a 4 to 1 speed reduction gear set, the overall gear ratio of the system is 64 to 1. That is to say four times four times four. If two gear modules are used in the system and each has a
4 to 1 gear ratio, then the system exhibits a 16 to 1 overall gear ratio.

Once again, it will be understood that different gear ratios may be provided by the various modules which are nested or stacked together in accordance with the present invention. However, once again it must be mentioned that the preferable fabrication of the present invention is that in which the individual gear models are substantially identical both in structure and in gear ratio. This facilitates the high volume production of a great number of identical gear modules which may then be combined in the appropriate number in a given fabrication or design to produce the overall gear ratio desired. While the module of the present invention may be fabricated using virtually any sufficiently rigid material, it has been found extremely advantageous to utilize the present invention module gear system using low cost injection molded plastic components which are relatively strong and rigid, relatively quiet in their operation, and which are well suited to low cost, high volume production.

It will be apparent to those skilled in the art that the use of the present invention modulized gear system is not limited to the illustrated use in which a motor drives the gear module input and a gear shaft forms its output. As with many gear systems, the system of the present invention is bidirectional in that the roles may be reversed between input and output. Thus, for example, power may be applied to center gear 134 in the system of Figure 3 and the driven output gear may take the place of output gear 72 of motor 70. In such case, motor 70 may be any load such as a generator or lifting device without
departing from the spirit and scope of the present invention.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects. Therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.
THAT WHICH IS CLAIMED IS:

1. A gear system comprising:

   a plurality of gear modules each having,

   a housing having a plurality of planetary
gears supported by said housing,

   a rotor having an internal ring gear engaging
said planetary gears and an output gear; and

   attachment means for securing each of said
gear modules to another of said gear modules in said
plurality of gear modules such that its output gear
engages said plurality of planetary gears of said
another of said gear modules.

2. The gear system set forth in claim 1 wherein
said attachment means include a plurality of spring
clips extending from said housing of one module and an
edge formed on said another module.

3. The gear system set forth in claim 2 wherein
each of said housings are generally cylindrical.

4. The gear system set forth in claim 3 wherein
each of said housings define a back wall defining a
center aperture and a front edge and wherein said
plurality of spring clips each define a gripping edge
clasping said front edge of said another gear module.

5. The gear system set forth in claim 4 wherein
each of said center gears passes through one of said
center apertures of said another gear module to engage
said planetary gears therein.
6. The gear system set forth in claim 5 further including an end cap substantially sized and shaped in accordance with said housings, said end cap being snap-fit attachable to a selected one of said gear modules using said spring clips thereof.

7. The gear system set forth in claim 1 wherein each of said housings are generally cylindrical.

8. The gear system set forth in claim 7 wherein each of said housings define a back wall defining a center aperture and a front edge and wherein said plurality of spring clips each define a gripping edge clasping said front edge of said another gear module.

9. The gear system set forth in claim 8 wherein each of said center gears passes through one of said center apertures of said another gear module to engage said planetary gears therein.

10. The gear system set forth in claim 1 further including an end cap substantially sized and shaped in accordance with said housings, said end cap being snap-fit attachable to a selected one of said gear modules using said spring clips thereof.

11. A gear system comprising:

   a first gear module having a first housing having a first plurality of planetary gears rotatably supported therein, a first rotor received within said housing having a first internal ring gear engaging said first plurality of planetary gears and a first center gear extending from said first rotor and a
first plurality of attachment clips supported by said first housing; and

a second gear module having a second housing having a second plurality of planetary gears rotatably supported therein, a second rotor received within said housing having a second internal ring gear engaging said second plurality of planetary gears and a second center gear extending from said second rotor and a second plurality of attachment clips supported by said second housing,

said second gear module being attachable to said first gear module such that said first and second housings are attached and said first center gear engages said second plurality of planetary gears.

12. The gear system set forth in claim 11 further including:

a third gear module having a third housing having a third plurality of planetary gears rotatably supported therein, a third rotor received within said housing having a third internal ring gear engaging said third plurality of planetary gears and a third center gear extending from said third rotor and a third plurality of attachment clips supported by said third housing,

said third gear module being attachable to said second gear module such that said second and third housings are attached and said second center gear engages said third plurality of planetary gears.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(6) : F16H 37/02
   US CL : 475/219, 330, 275; 403/329; 206/509; 220/4.27
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
   Minimum documentation searched (classification system followed by classification symbols)
   U.S. : 475/219, 330, 275; 403/329; 206/509; 220/4.27
   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
   Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 28 SEPTEMBER 1999
Date of mailing of the international search report: 08 NOV 1999

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