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(54) **CONTINUOUSLY VARIABLE TRANSMISSION WITH TWO PIECE CAM**

(75) Inventor: **Barry A. Johnson**, Roseau, MN (US)

(73) Assignee: **Polaris Industries Inc.**, Medina, MN (US)

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(52) **U.S. Cl.** **474/19**; 474/8; 474/14; 180/376

(58) **Field of Search** 474/19–21, 12, 474/14, 37; 464/74–76, 83

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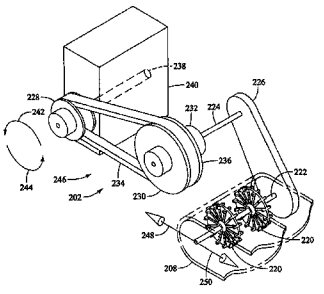
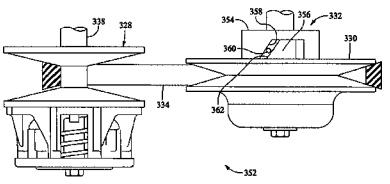
Primary Examiner—Marcus Charles
(74) *Attorney, Agent, or Firm*—Allen W. Groenke; Fredrikson & Byron, P.A.

(57) **ABSTRACT**

A vehicle with a continuously variable transmission (continuously variable transmission) includes a torque responsive clutch having a cam and at least one coupling. The cam has a plurality of projecting surfaces, and a plurality of slots being defined between the projecting surfaces. The slots of the cam are used to direct cam followers that move across the slot surfaces as the vehicle is driven forward or in reverse. As the vehicle adjusts from forward to reverse or vice versa, the cam followers may jump from one side of the slot to the other.

32 Claims, 7 Drawing Sheets





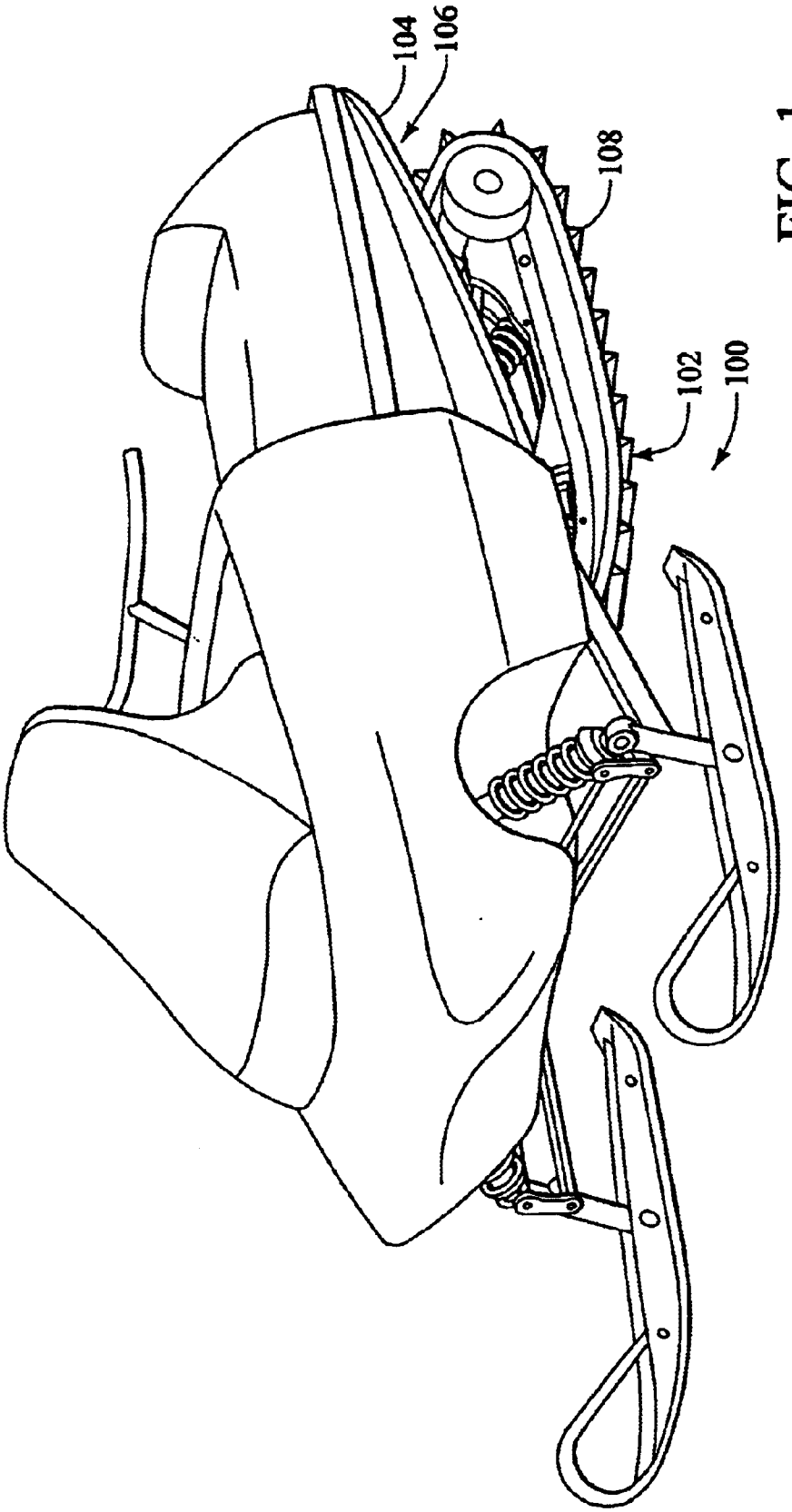


FIG. 1

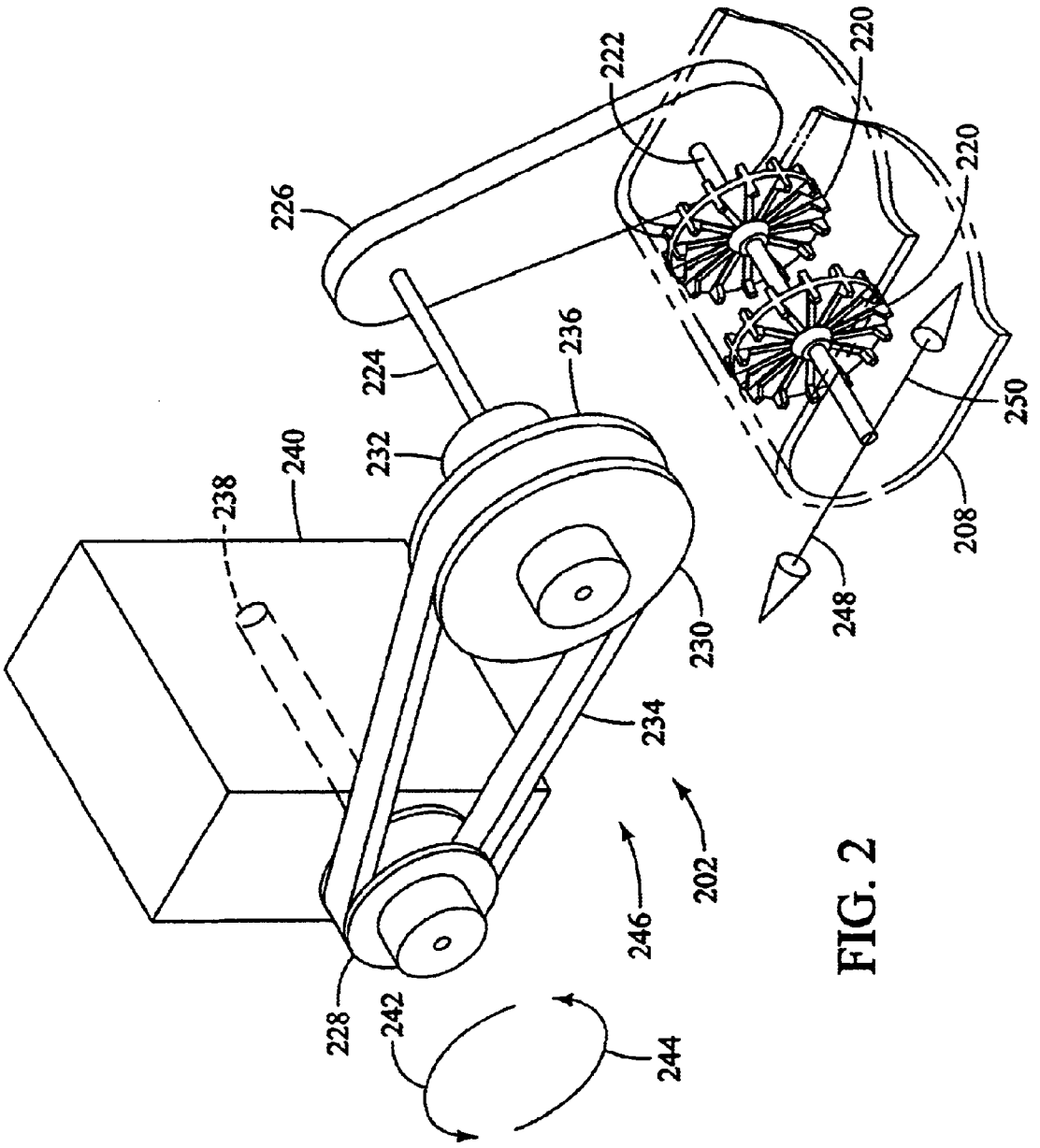

222
220
220
226
224
236
250
232
240
238
208
248
230
234
202
246
228
242
244

FIG. 2

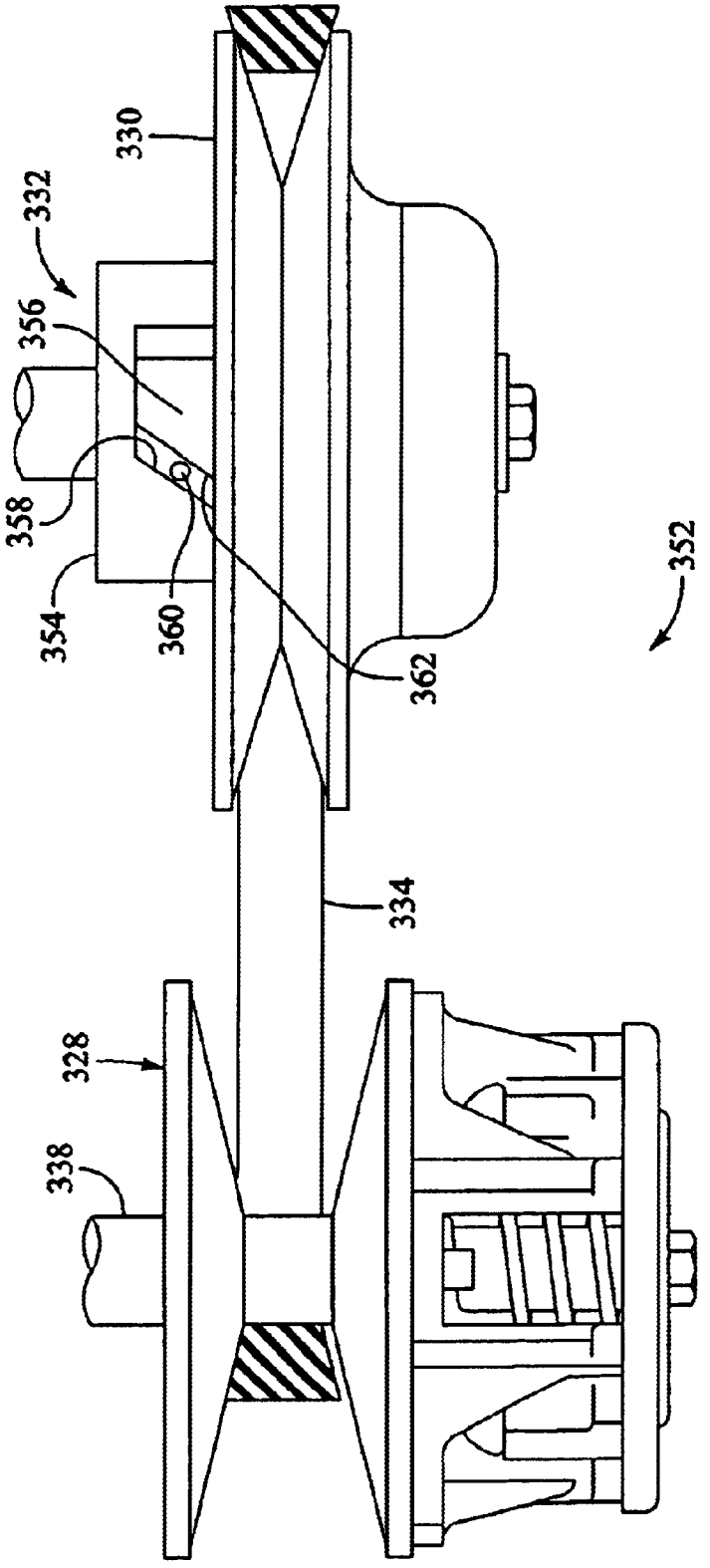


FIG. 3

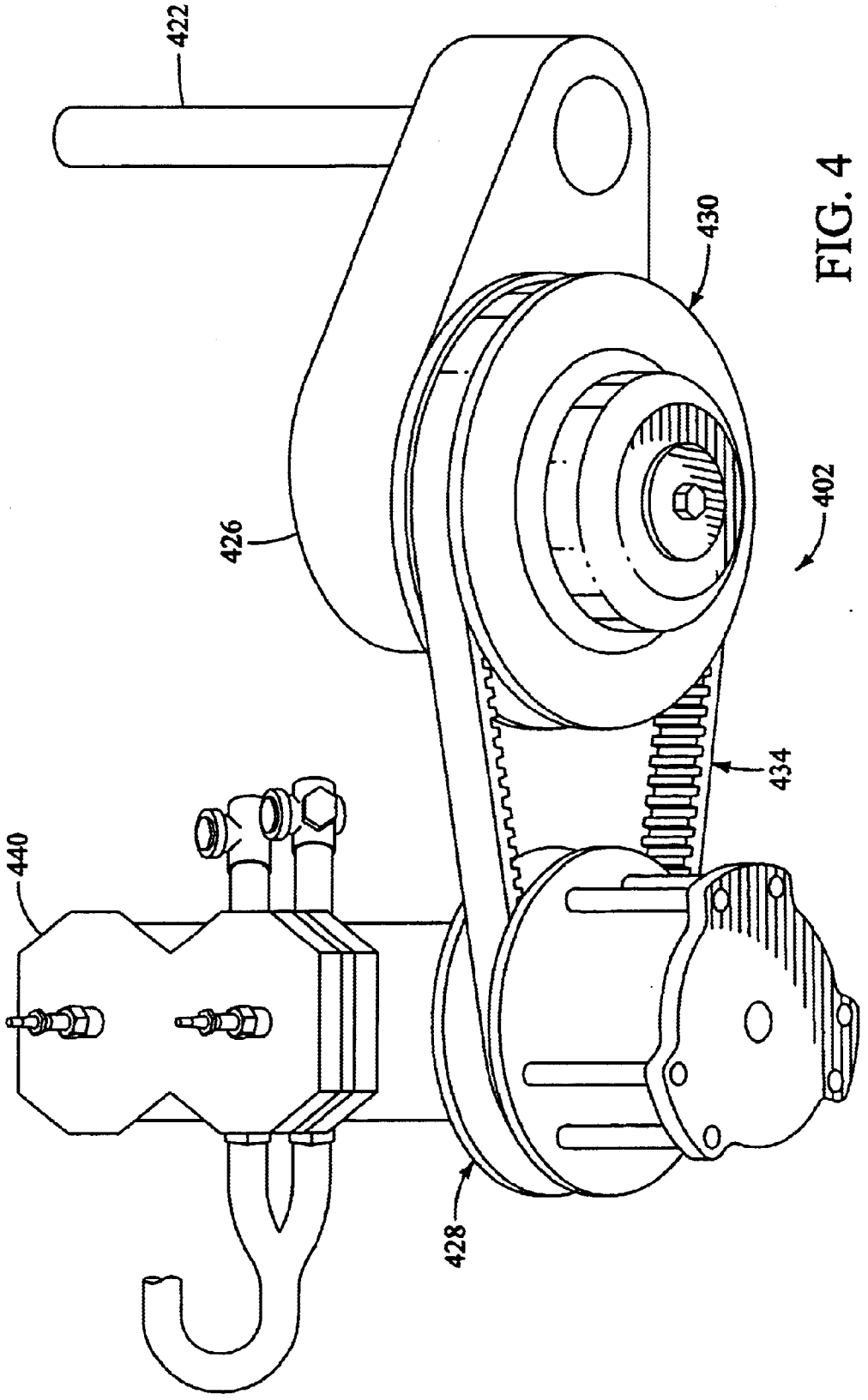


FIG. 4

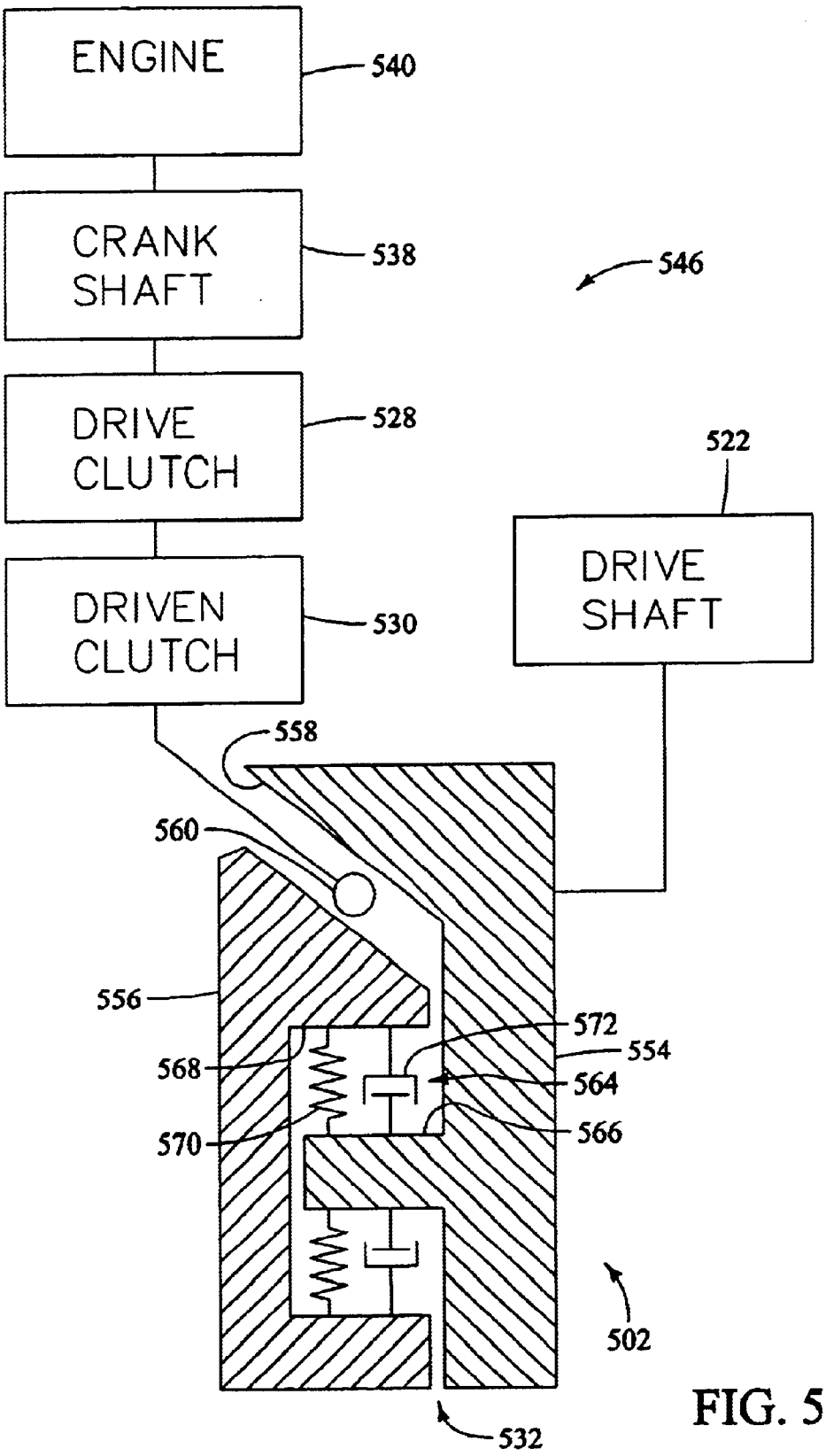

ENGINE
540
CRANK SHAFT
538
546
DRIVE CLUTCH
528
522
DRIVE SHAFT
DRIVEN CLUTCH
530
558
560
556
572
554
568
564
570
566
502
532

FIG. 5

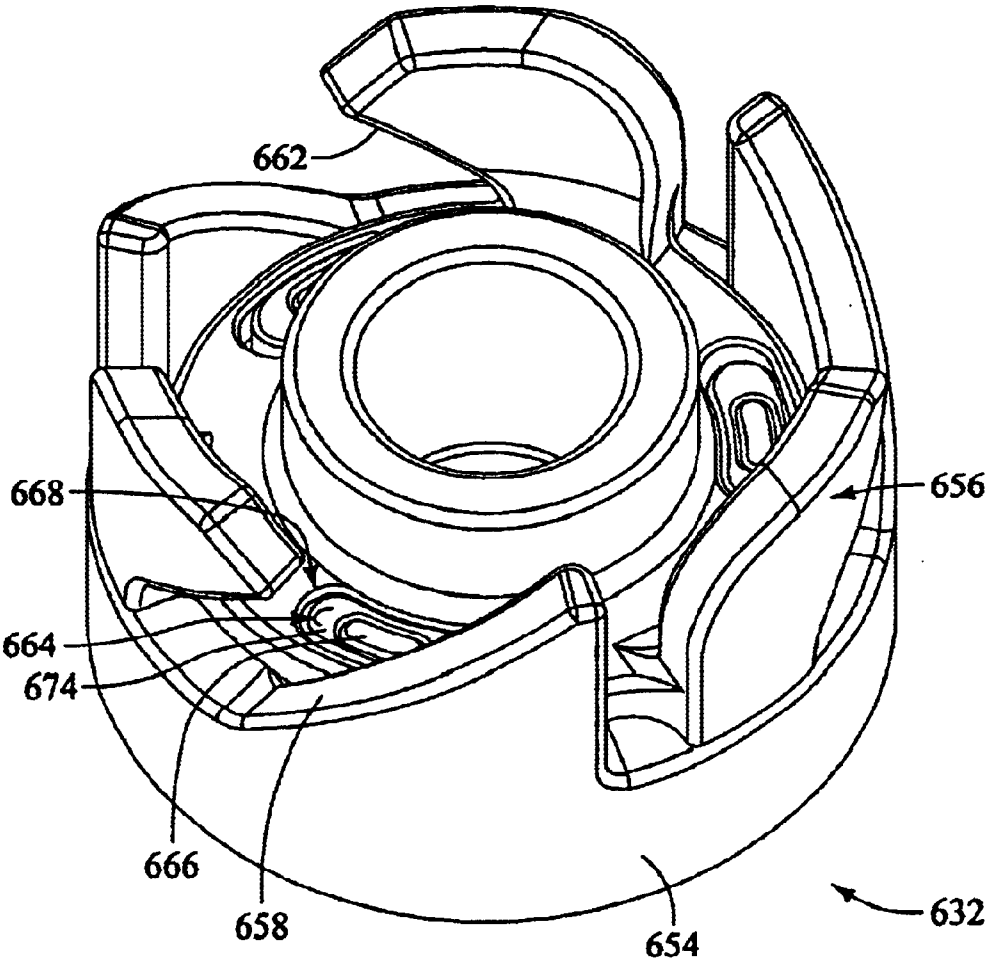


FIG. 6

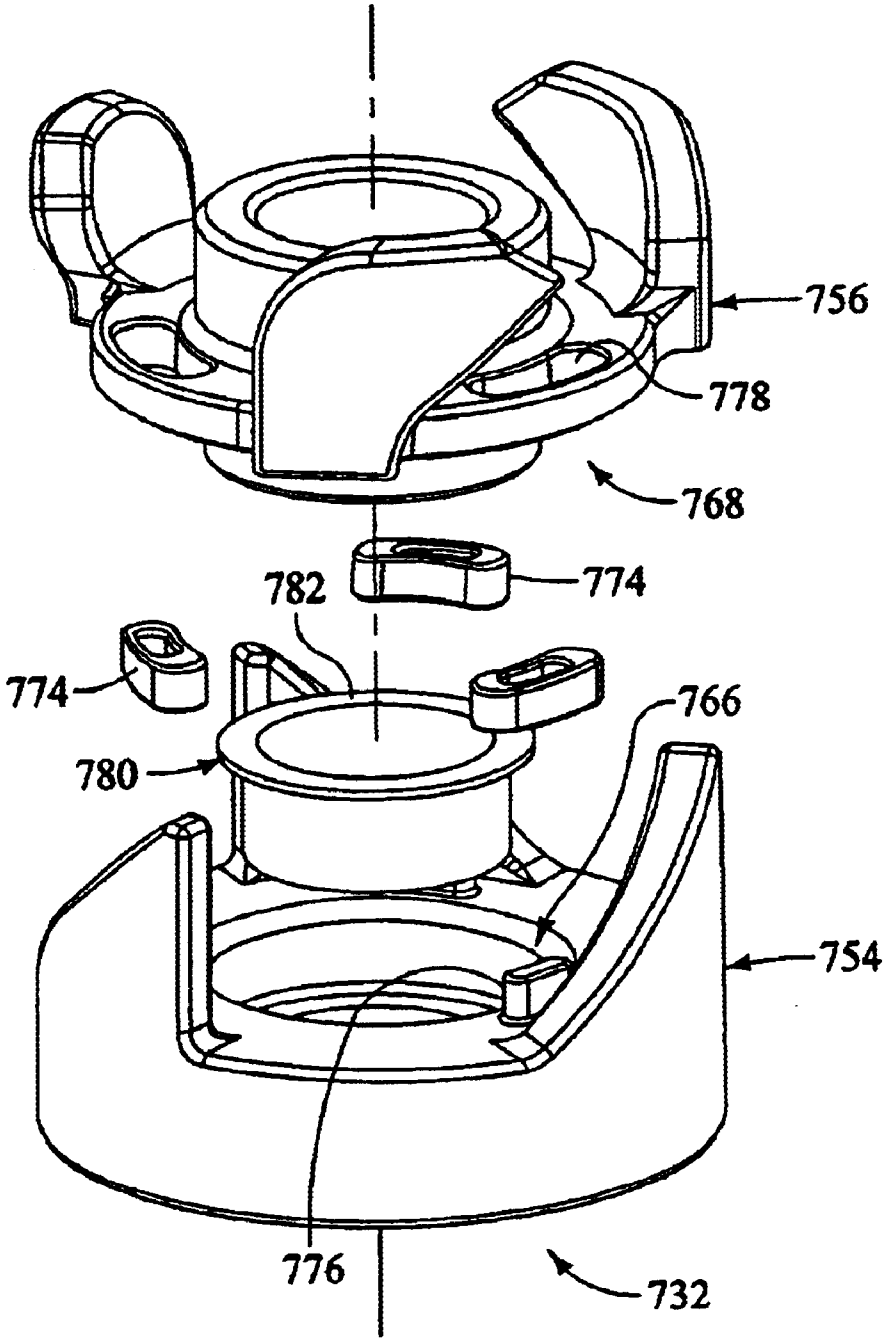


FIG. 7

CONTINUOUSLY VARIABLE TRANSMISSION WITH TWO PIECE CAM

RELATED APPLICATIONS

The present application is related to U.S. patent application Ser. No. 10/327,725 entitled "Methods and Apparatus for Providing Reverse Drive in a Recreational Vehicle" by the same inventor and filed on an even date herewith. The entire disclosure of the above mentioned patent application is hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates generally to recreational vehicles. More particularly, the present invention relates to drive systems for use with recreational vehicles.

BACKGROUND OF THE INVENTION

Split sheave continuously variable transmissions (continuously variable transmissions) are used in a variety of recreational type off-road vehicles such as snowmobiles, golf carts, all-terrain vehicles (ATVs), and the like. Continuously variable transmissions, as their name implies, do not require shifting through a series of forward gears, but rather provide a continuously variable gear ratio that automatically adjusts as the vehicle speeds up or slows down, thus providing relatively easy operation for the rider. Typically, continuously variable transmissions are comprised of a drive clutch, a driven clutch, and an endless drive belt disposed about the clutches. The driven clutch includes a pair of opposed sheaves, which together define a generally V-shaped "pulley" within which the drive belt rides. The drive clutch is similarly configured from a pair of opposed sheaves.

SUMMARY OF THE INVENTION

The invention provides a system and method for dampening a continuously variable transmission by utilizing a cam and at least one coupling with a bore extending therethrough. The continuously variable transmission is comprised of a drive clutch, a driven clutch, and an endless drive belt disposed about the drive and driven clutches. Each driven clutch includes a cam, which further includes a plurality of surfaces projecting upward, defining a plurality of slots. Cam followers contact first surfaces of the slots when the continuously variable transmission operates as the off-road vehicle is driven forward. Conversely, the cam followers contact second surfaces of the slots oppositely disposed from the first surfaces when the continuously variable transmission operates in reverse as the off-road vehicle is driven in reverse. The invention helps dampen the sound and impact from a contact between the cam followers and the first or second surfaces of the cam slots, which is a natural occurrence when the vehicle goes from forward to reverse, or vice versa.

This dampening can be accomplished by utilizing a two-part cam, whereby the cam includes a first and second member, each having a plurality of surfaces projecting upward, defining a plurality of slots. The first cam member is inserted and held in place by the inner shell of the second cam member, whereby a plurality of couplings are interposed between the bases of both cam members. The combination of the cam members forms a plurality of narrowed slots having first and second slot surfaces. As the two-part cam is utilized in a driven clutch of a continuously variable transmission, a plurality of cam followers are utilized in the two-part cam, whereby a single cam follower is disposed in every other narrowed slot. When the engine is driving the vehicle in the forward direction, the cam followers engage the first slot surfaces of the narrowed cam slots. As the torque applied to the driven pulley increases, the cam followers roll up these first slot surfaces. However, when these off-road vehicles are operated in reverse, the cam followers stop engaging the first slot surfaces, and instead, jump so as to make contact with the second slot surfaces located opposite the first slot surfaces of the narrowed cam slots. When this slamming occurs, the vehicle operator may hear and feel an impact from the cam followers coming into contact with the second slot surfaces of the narrowed cam slots. However, with the couplings located between the first and second cam members, there is a reduced force transfer from the first cam member to the second cam member upon switching between forward and reverse.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a snowmobile including a drive system in accordance with an exemplary embodiment of the present invention.

FIG. **2** is a perspective view of a drive system in accordance with an exemplary embodiment of the present invention.

FIG. **3** is a plan view of a continuously variable transmission in accordance with an exemplary embodiment of the present invention.

FIG. **4** is a perspective view of a drive system in accordance with an additional exemplary embodiment of the present invention.

FIG. **5** is a diagrammatic illustration of a drive system in accordance with an additional exemplary embodiment of the present invention.

FIG. **6** is a perspective view of a cam in accordance with an additional exemplary embodiment of the present invention.

FIG. **7** is an exploded perspective view of a cam in accordance with an exemplary embodiment of the present invention.

FIG. **6** is a perspective view of a cam **632** in accordance with an additional exemplary embodiment of the present invention.

FIG. **7** is an exploded perspective view of a cam **732** in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description should be read with reference to the drawings, in which like elements in different drawings are numbered identically. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. Accordingly, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of components set forth in the following description or illustrated in the drawings.

FIG. **1** is a perspective view of a snowmobile **100** including a drive system **102** in accordance with an exemplary embodiment of the present invention. Snowmobile **100** has a chassis **104** defining a tunnel **106**. In the embodiment of FIG. **1**, a drive track **108** can be seen extending from tunnel **106**. In the embodiment of FIG. **1**, drive track **108** comprises an endless loop that is supported by a rear

suspension. In a preferred embodiment, drive track **108** is operatively connected to an engine by a drivetrain so that drive track **108** may be used to propel snowmobile **100**. In some embodiments of the present invention drive track **108** maybe used to propel snowmobile **100** in both a forward direction and a reverse direction. In FIG. **1**, it may also be appreciated that snowmobile **100** includes a plurality of skis. Although a snowmobile is illustrated in FIG. **1**, it is to be appreciated that a drive system in accordance with the present invention may be used in conjunction with various types of vehicles. Examples of such vehicles include ATVs, golf carts and the like.

FIG. **2** is a perspective view of a drive system **202** in accordance with an exemplary embodiment of the present invention. Drive system **202** of FIG. **2** may be used, for example, to propel a snowmobile such as the one illustrated in the previous figure. Drive system **202** includes a drive track **208** that is illustrated using phantom lines in FIG. **2**. Drive track **208** may be driven by two drive sprockets **220** that are fixed to a drive shaft **222**. Drive shaft **222** is preferably adapted to be used to urge motion of drive track **208**, such that drive shaft **222** and drive track **208** propel a vehicle.

Drive system **202** of FIG. **2** also includes a jack shaft **224**. In the embodiment of FIG. **2**, jack shaft **224** and drive shaft **222** are connected to one another by a speed reduction mechanism **226**. In a preferred embodiment, speed reduction mechanism **226** is configured to provide a desired reduction in rotational velocity. Speed reduction mechanism **226** may comprise various elements without deviating from the spirit and scope of the present invention. Examples of elements which may be suitable in some applications include gears, sprockets, belts and chains.

A driven clutch **230** is connected to jack shaft **224** in the embodiment of FIG. **2**. Driven clutch **230** includes a cam **232** that can be seen extending beyond a sheave **236** of driven clutch **230**. Driven clutch **230** is connected to a drive clutch **228** by a drive belt **234**. In the embodiment of FIG. **2**, drive clutch **228** is fixed to a crankshaft **238** of an engine **240**. Crankshaft **238** is illustrated using dashed lines in FIG. **2**. In a preferred embodiment, engine **240** is capable of rotating crankshaft **238** in both a first rotational direction **242** and a second rotational direction **244**.

With reference to FIG. **2**, it may be appreciated that rotation of crankshaft **238** is transferred via a drivetrain **246** to drive-shaft **222** so as to cause rotation of drive shaft **222**. In the embodiment of FIG. **2**, drivetrain **246** comprises drive clutch **228**, drive belt **234**, driven clutch **230**, jack shaft **224**, and speed reduction mechanism **226**. Drive shaft **222** causes movement of drive track **208** such that drive track **208** propels a vehicle. When crankshaft **238** is rotated in a first rotational direction **242** vehicle is propelled in a forward direction **248**. When drive shaft **222** is rotated in a second rotational direction **244**, vehicle is propelled in a reverse direction **250**.

FIG. **3** is a plan view of a continuously variable transmission **352** in accordance with an exemplary embodiment of the present invention. Continuously variable transmission **352** includes a drive clutch **328**, a driven clutch **330**, and an endless drive belt **334** disposed about the drive clutch **328** and driven clutch **330**. Driven clutch **330** includes a pair of opposed sheaves which together define a generally V-shaped "pulley" within which drive belt **334** rides. One of the sheaves is axially movable (i.e., movable in the direction parallel to the axis of driven clutch **330**), and the other sheave is axially stationary.

Continuously variable transmission **352** includes a cam **332** that is preferably adapted to urge the sheaves of driven clutch **330** toward one another. In the embodiment of FIG. **3**, cam **332** comprises a first cam member **354** and a second cam member **356**. In the embodiment of FIG. **3**, cam **332** comprises a first cam member **354** and a second cam member **356**. As shown in FIG. **3**, first cam member **354** of cam **332** includes a first cam surface **358** that contacts a cam follower **360** when a crankshaft **338** of continuously variable transmission **352** is turning in a first direction. Also as shown in FIG. **3**, second cam member **356** of cam **332** includes a second cam surface **362** that contacts cam follower **360** when crankshaft **338** is turning in a second direction. Drive clutch **328** comprises a pair of opposed sheaves, one being axially movable and the other being axially stationary.

FIG. **4** is a perspective view of a drive system **402** in accordance with an additional exemplary embodiment of the present invention. Drive system **402** of FIG. **4** includes an engine **440** and a drive clutch **428** that is fixed to a crankshaft of engine **440**. In a preferred embodiment, engine **440** is capable of rotating the crankshaft in both a first direction and a second direction that is different from the first direction. Various methods and apparatus may be used to rotate the crankshaft in a first direction and a second direction without deviating from the spirit and scope of the present invention. Examples of methods and apparatus that may be suitable in some applications can be found in U.S. Pat. Nos. 5,161,489; 5,782,210; 5,794,574; 5,964,191; 6,039,010; 6,044,807; 6,098,574; 6,234,119; and 6,237,546. The entire disclosure of each of these U.S. Patents is herby incorporated by reference.

Drive clutch **428** is connected to a driven clutch **430** by a drive belt **434**. Driven clutch **430** is connected to a drive shaft **422** by a speed reduction mechanism **426**. In a preferred embodiment, speed reduction mechanism **426** is configured to provide a desired reduction in rotational velocity. Speed reduction mechanism **426** may comprise various elements without deviating from the spirit and scope of the present invention. Examples of elements which may be suitable in some applications include gears, sprockets, belts and chains.

FIG. **5** is a diagrammatic illustration of a drive system **502** in accordance with an additional exemplary embodiment of the present invention. Drive system **502** includes an engine **540**. In the exemplary embodiment of FIG. **5**, engine **540** is capable of rotating a crankshaft **538** in a first direction and a second direction. Crankshaft **538** of engine **540** is connected to a drive shaft **522** via a drivetrain **546**. In the embodiment of FIG. **5**, drivetrain **546** includes a drive clutch **528**, a driven clutch **530**, a cam **532**, and a cam follower **560**. In the embodiment of FIG. **5**, cam **532** comprises a first cam member **554** and a second cam member **556**. As shown in FIG. **5**, first cam member of cam **532** includes a first cam surface **558** that contacts a cam follower **560** when cam **532** is turning in a first direction. Also as shown in FIG. **5**, second cam member **556** of cam **532** includes a second cam surface **562** that contacts cam follower **560** when cam **532** is turning in a second direction.

In FIG. **5**, it may be appreciated that a coupling **564** extends between a coupling portion **566** of first cam member **554** and a coupling portion **568** of second cam member **556**. In some advantageous embodiments of the present invention, coupling **564** is capable of absorbing shock when the rotation of the crankshaft **538** is changed from the first direction to the second direction or from the second direction to the first direction. In the embodiment of FIG. **5**, coupling **564** comprises a spring **570** and a damper **572**.

FIG. **6** is a perspective view of a cam **632** in accordance with an additional exemplary embodiment of the present invention. Cam **632** of FIG. **6** comprises a first cam member **654** and a second cam member **656**. As shown in FIG. **6**, first cam member **654** of cam **632** includes a first cam surface **658** that is preferable dimensioned to contact a cam follower when cam **632** is turning in a first direction. Also as shown in FIG. **6**, second cam member **656** of cam **632** includes a second cam surface **662** that is preferably dimensioned to contact a cam follower when cam **632** is turning in a second direction.

In FIG. **6**, it may be appreciated that cam **632** comprises a plurality of couplings **664**. In the embodiment of FIG. **6**, each coupling **664** includes a coupling portion **666** of first cam member **654**, a coupling portion **668** of second cam member **656**, and an intermediate member **674**. In the embodiment of FIG. **6**, intermediate member **674** extends between coupling portion **666** of first cam member **654** and coupling portion **668** of second cam member **656**. In some advantageous embodiments of the present invention, coupling **664** is capable of absorbing shock when the rotation of cam **632** is changed from a first direction to a second direction or from the second direction to the first direction.

In some useful embodiments of the present invention, intermediate member **674** comprises a reversibly deformable material. For example, intermediate member **674** may comprise an elastomeric material. The term elastomeric generally refers to a rubberlike material (e.g., a material which can experience about a 7% deformation and return to the undeformed configuration). Examples of elastomeric materials include rubber (e.g., natural rubber, silicone rubber, nitrile rubber, polysulfide rubber, etc.), thermoplastic elastomer (TPE), butyl, polyurethane, and neoprene.

FIG. **7** is an exploded perspective view of a cam **732** in accordance with an exemplary embodiment of the present invention. In FIG. **7**, it may be appreciated that a first coupling portion **766** of first cam member **754** comprises a tang **776**. In FIG. **7**, it may also be appreciated that a second coupling portion **768** of second cam member **756** comprises a slot **778**. A plurality of intermediate members **774** are visible in FIG. **7**. In the embodiment of FIG. **7**, first cam member **754** and second cam member **756** are dimensioned so that they can be joined together with intermediate member **774** interposed between first coupling portion **766** of first cam member **754** and second coupling portion **768** of second cam member **756**.

A bushing **780** is also visible in FIG. **7**. In the embodiment of FIG. **7**, bushing **780** comprises of a flange **782** on its upper end and a bore extending there-through. A lower end of the bushing **780** may be inserted mounted into a central bore extending through first cam member **754**. In some embodiments of the present invention, a portion of second cam member **756** may be inserted into the bore defined by bushing **780**. The intermediate member **774** slides around and over tang **776** of coupling portion **766** of the second cam member **756**, such that when the first cam member **754** and the second cam-member **756** are adjoined, the coupling portion **766** of the first cam member **754** slides over and around the outer extent of intermediate member **774**.

The complete disclosures of all patents, patent applications, and publications are hereby incorporated by reference as if individually incorporated. Having thus described the various exemplary embodiments of the present invention, those of skill in the an will readily appreciate that yet other embodiments may be made and used within the scope of the claims hereto attached. Thus, it is to be understood that this disclosure is, in many respects, only illustrative. Changes may be made in details, particularly in matters of shape, size, and arrangement of parts without exceeding the invention's scope which is, of course, defined in the language in which the appended claims are expressed.

What is claimed is:

1. A vehicle comprising:

an engine capable of rotating a crankshaft in a first direction and a second direction;

a drivetrain coupling the crankshaft of the engine to a drive shaft of the vehicle;

the drivetrain comprising a cam having a first cam member and a second cam member;

the first cam member including a first cam surface which contacts a cam follower when the crankshaft is turning in the first direction;

the second cam member including a second cam surface which contacts the cam follower when the crankshaft is turning in the second direction;

a coupling linking a first cam member of the drivetrain to a second cam member;

the coupling absorbing shock when a rotational direction of the crankshaft is changed from the first direction to the second direction or from the second direction to the first direction; and

wherein the coupling comprises a sleeve having an inner surface dimensioned to engage a coupling portion of the first cam member and an outer surface dimensioned to engage a coupling portion of the second cam member.

2. The cam according to claim **1**, wherein the coupling provides for relative rotation between the first cam member and the second cam member.

3. The cam according to claim **2**, wherein the relative rotation between the first cam member and the second cam member is limited to a predetermined magnitude.

4. The vehicle according to claim **1**, wherein the coupling portion of the first cam member comprises a slot.

5. The vehicle according to claim **1**, wherein the coupling portion of the second cam member comprises a tab.

6. The vehicle according to claim **1**, wherein the sleeve comprises an elastomeric material.

7. The vehicle according to claim **6**, wherein the elastomeric material comprises a polyurethane.

8. The vehicle according to claim **1**, wherein the coupling is capable of damping shock.

9. The vehicle according to claim **1**, wherein the coupling is capable of assuming a compressed shape while absorbing shock.

10. The vehicle according to claim **1**, further including a bushing interposed between the first cam member and the second cam member.

11. A cam for use in a torque-responsive clutch comprising:

a first cam member;

a second cam member; and

a coupling extending between a coupling portion of the first cam member and a coupling portion of the second cam member;

the coupling absorbing shock when a rotational direction of the cam is changed from a first direction to a second direction or from the second direction to the first direction; and

wherein the coupling comprises a sleeve having an inner surface dimensioned to engage a coupling portion of

the first cam member and an outer surface dimensioned to engage a coupling portion of the second cam member.

12. The cam according to claim **11**, wherein the coupling provides for relative rotation between the first cam member and the second cam member.

13. The cam according to claim **12**, wherein the relative rotation between the first cam member and the second cam member is limited to a predetermined magnitude.

14. The cam according to claim **11**, wherein the coupling portion of the first cam member comprises a slot.

15. The cam according to claim **11**, wherein the coupling portion of the second cam member comprises a tab.

16. The cam according to claim **11**, wherein the sleeve comprises an elastomeric material.

17. The cam according to claim **16**, wherein the elastomeric material comprises a polyurethane.

18. The cam according to claim **11**, wherein the coupling is capable of damping shock.

19. The cam according to claim **11**, wherein the coupling comprises a reversibly deformable material and the coupling is capable of assuming a deformed shape while absorbing shock.

20. The cam according to claim **11**, further including a bushing interposed between the first cam member and the second cam member.

21. The cam according to claim **11**, further including a bushing that is received within a central aperture of the first cam member;

the bushing having a lumen dimensioned to receive a portion of the second cam member.

22. The cam according to claim **11**, wherein:

the first cam member includes a first cam surface which contacts a cam follower when the cam is turning in the first direction;

the second cam member including a second cam surface which contacts the cam follower when the cam is turning in the second direction.

23. A torque-responsive clutch comprising:

a cam including a first cam member and a second cam member;

at least one cam follower coupled to a sheave;

the at least one cam follower selectively engaging the first cam member and the second cam member;

a coupling extending between a coupling portion of the first cam member and a coupling portion of the second cam member;

the coupling absorbing shock when a rotational direction of the sheave is changed from a first direction to a second direction or from the second direction to the first direction; and

wherein the coupling comprises a sleeve having an inner surface dimensioned to engage a coupling portion of the first cam member and an outer surface dimensioned to engage a coupling portion of the second cam member.

24. The clutch according to claim **23**, wherein the coupling provides for relative rotation between the first cam member and the second cam member.

25. The clutch according to claim **24**, wherein the relative rotation between the first cam member and the second cam member is limited to a predetermined magnitude.

26. The clutch according to claim **23**, wherein the coupling portion of the first cam member comprises a slot.

27. The clutch according to claim **23**, wherein the coupling portion of the second cam member comprises a tab.

28. The clutch according to claim **23**, wherein the sleeve comprises an elastomeric material.

29. The clutch according to claim **28**, wherein the elastomeric material comprises a polyurethane.

30. The clutch according to claim **23**, wherein the coupling is capable of damping shock.

31. The clutch according to claim **23**, wherein the coupling comprises a reversibly deformable material and the coupling is capable of assuming a deformed shape while absorbing shock.

32. The cam according to claim **23**, further including a bushing interposed between the first cam member and the second cam member.

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