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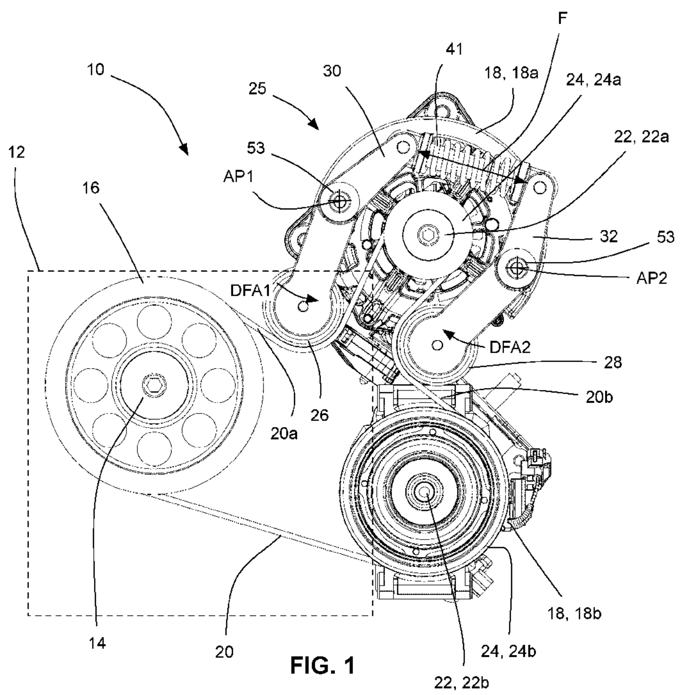

FIG. 1

(57) Abstract: In an aspect, a tensioner is provided for tensioning a belt and includes first and second tensioner arms having first and second pulleys respectively. The first and second pulleys are configured for engagement with first and second belt spans, and are biased in first and second free arm directions respectively. A second tensioner arm stop is positioned to limit the movement of the second tensioner arm in a direction opposite the second free arm direction. The second tensioner arm stop is positioned such that, in use, the second pulley is engaged with the endless drive member while the second tensioner arm is engaged with the second tensioner arm stop throughout a first selected range of operating conditions.

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ENDLESS DRIVE ARRANGEMENT AND IMPROVED TWO-ARMED TENSIONING SYSTEM FOR SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/066,719 filed October 21, 2014, U.S. Provisional Patent Application No. 62/113,302 filed February 6, 2015, U.S. Provisional Patent Application No. 62/141,514 filed April 1, 2015, and U.S. Provisional Patent Application No. 62/145,993 filed April 10, 2015, the contents of all of which are incorporated herein in their entirety.

FIELD

[0002] This disclosure relates generally to the art of endless drive arrangements and more particularly to systems for vehicular front engine accessory drive arrangements that employ a motor/generator unit or other secondary motive unit in addition to an engine and a two-armed tensioner.

BACKGROUND

[0003] Vehicular engines typically employ a front engine accessory drive to transfer power to one or more accessories, such as an alternator, an air conditioner compressor, a water pump and various other accessories. Some vehicles are hybrids and employ both an internal combustion engine, along with an electric drive. There are many possible configurations of such vehicles. For example, in some configurations, the electric motor is used to assist the engine in driving the vehicle (i.e. the electric motor is used to temporarily boost the amount of power being sent to the driven wheels of the vehicle). In some configurations, the electric motor is used to drive the driven wheels of the vehicle by itself and only after the battery is exhausted to a sufficient level does the engine turn on to take over the function of driving the vehicle.

[0004] While hybrid vehicles are advantageous in terms of improved fuel economy, their operation can result in higher stresses and different stresses on certain components such as the belt from the front engine accessory drive, which can lead to a reduction in the operating life of these components. It would be advantageous to provide improved operating life for components of the front engine accessory drive in a hybrid vehicle.

SUMMARY

[0005] In an aspect, a tensioner is provided for tensioning a belt and includes first and second tensioner arms having first and second pulleys respectively. The first and second pulleys are configured for engagement with first and second belt spans, and are biased in first and second free arm directions respectively. A second tensioner arm stop is positioned to limit the movement of the second tensioner arm in a direction opposite the second free arm direction. The second tensioner arm stop is positioned such that, in use, the second pulley is engaged with the endless drive member while the second tensioner arm is engaged with the second tensioner arm stop throughout a first selected range of operating conditions.

[0006] In another aspect, an endless drive arrangement is provided, and includes a crankshaft, a secondary drive device, an endless drive member connecting the crankshaft and the secondary drive device, and a tensioner. The tensioner includes a first tensioner arm that has a first tensioner pulley rotatably mounted thereto. The first tensioner pulley is engaged with a first span of the endless drive member on a first side of the secondary drive device. The first tensioner arm is pivotable about a first tensioner arm pivot axis. The tensioner further includes a second tensioner arm that has a second tensioner pulley rotatably mounted thereto. The second tensioner pulley is engaged with a second span of the endless drive member on a second side of the secondary drive device. The second tensioner arm is pivotable about a second tensioner arm pivot axis. The tensioner further includes a tensioner biasing member that is positioned to apply a tensioner biasing force to bias the first and second tensioner arms in respective first and second free arm directions, and a second tensioner arm stop that is positioned to limit the movement of the second tensioner arm in a direction opposite the second free arm direction. The second tensioner arm stop is positioned such that, in use, the second tensioner pulley is engaged with the endless drive member while the second tensioner arm is engaged with the second stop throughout a selected range of operating conditions. For this tensioner:

$$\frac{TR}{TL} > \frac{hF3}{hF1}$$

where

TR = TR2 – TR3,

TL = TR4 – TR5,

TR2 = the moment arm relative to the second tensioner arm pivot axis of a force T2 exerted on the second tensioner pulley by a first portion of the second span of the endless drive member,

TR3 = the moment arm relative to the second tensioner arm pivot axis of a force T3 exerted on the second tensioner pulley by a second portion of the second span of the endless drive member,

TR4 = the moment arm relative to the first tensioner arm pivot axis of a force T4 exerted on the first tensioner pulley by a first portion of the first span of the endless drive member,

TR5 = the moment arm relative to the second tensioner arm pivot axis of a force T5 exerted on the first tensioner pulley by a second portion of the first span of the endless drive member,

hF1 = the moment arm relative to the first tensioner arm pivot axis of a force FL exerted on the first tensioner arm by the tensioner biasing member, and

hF2 = the moment arm relative to the second tensioner arm pivot axis of the force FL exerted on the second tensioner arm by the tensioner biasing member.

[0007] In another aspect, an endless drive arrangement is provided and includes a crankshaft, a secondary drive device, an endless drive member connecting the crankshaft and the secondary drive device and a tensioner. The tensioner includes a base and a first tensioner arm that has a first tensioner pulley rotatably mounted thereto. The first tensioner pulley is configured for engagement with a first span of the endless drive member. The first tensioner arm is pivotally mounted to the base and is biased in a first free arm direction. The tensioner further includes a second tensioner arm that has a second tensioner pulley rotatably mounted thereto. The second tensioner pulley is configured for engagement with a second span of the endless drive member. The second tensioner arm is pivotally mounted to the base and a second load stop position and is biased in a second free arm direction. When tension in the endless drive member is between zero and a yield tension for the endless drive member, the first and second tensioner pulleys are movable along a first path and a second path respectively. The first path and the second path are entirely spaced from one another.

[0008] In another aspect, a tensioner is provided for tensioning an endless drive member. The tensioner includes a base, and a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is configured for engagement with a first span of the endless drive member. The first tensioner arm is pivotally mounted to the base for movement about a first tensioner arm pivot axis. The tensioner further includes a second tensioner arm that has a second tensioner pulley rotatably mounted thereto. The second tensioner pulley is configured for engagement with a second span of the endless drive member. The second tensioner arm is pivotally mounted to the base for movement about a second tensioner arm pivot axis. The tensioner further includes a biasing member that applies first and second biasing forces on the first and second tensioner arms in first and second free arm directions respectively. The tensioner further includes a first damping structure configured to dampen movement of the first tensioner arm, a second damping structure configured to dampen movement of the second tensioner arm and a third damping structure configured to dampen relative movement between the first and second tensioner arms. In another aspect, an endless drive arrangement is provided that includes the tensioner described above.

[0009] In another aspect, a tensioner is provided for tensioning an endless drive member. The tensioner includes a base, a first tensioner arm, and a second tensioner arm. The base is generally C-shaped and is configured to mount to a housing of an accessory that is drivable by the endless drive member. The first tensioner arm has a first tensioner pulley rotatably mounted thereto. The first tensioner pulley is configured for engagement with a first span of the endless drive member. The first tensioner arm is pivotally mounted to the base and is biased for movement in a first free arm direction. The second tensioner arm has a second tensioner pulley rotatably mounted thereto. The second tensioner pulley is configured for engagement with a second span of the endless drive member. The second tensioner arm is pivotally mounted to the base for movement along a second path and is biased for movement in a second free arm direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing and other aspects of the invention will be better appreciated with reference to the attached drawings, wherein:

[0011] Figures 1-10 depict inventive aspects of the disclosure.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0012] Figure 1 shows an endless drive arrangement 10 for an engine, schematically represented by a dashed-line rectangle and shown at 12. In embodiments wherein the engine 12 is mounted in a vehicle, the endless drive arrangement 10 may be a front engine accessory drive. The engine 12 includes a crankshaft 14 that has a crankshaft pulley 16 mounted thereon. The crankshaft pulley 16 is drivable by the crankshaft 14 of the engine 12 and itself drives one or more vehicle accessories 18 via an endless drive member 20, such as a belt. For convenience the endless drive member 20 will be referred to as a belt 20, however it will be understood that it could be any other type of endless drive member. The accessories 18 may include a motor-generator unit (MGU) 18a, an air conditioning compressor 18b, a water pump (not shown), a power steering pump (not shown) and/or any other suitable accessory.

[0013] In Figure 1, two accessories 18 are shown, however there could be more or fewer accessories. Each of the driven accessories has a drive shaft 22 and a pulley 24. The MGU 18a has an MGU drive shaft 22a and an MGU pulley 24a.

[0014] As can be seen in Figure 1, the belt 20 is engaged with the crankshaft pulley 16 and the MGU pulley shown at 24a (and the other accessory pulleys 24). Under normal operating conditions the endless drive arrangement is operable in a first mode in which the endless drive arrangement 10 may be driven by the engine 12, and in turn drives the pulleys 24 of the accessories 18. In the first mode, the tension in the first belt span 20a is lower than the tension in the second belt span 20b. The MGU 18a may be operable to as an alternator in the first mode, in order to charge the vehicle's battery (not shown).

[0015] The MGU 18a is also operable as a motor, wherein it drives the MGU pulley 24a, which in turn drives the belt 20. During such events where the

MGU 18a is operated as a motor, the endless drive arrangement may be considered to be operable in a second mode, in which the tension in the second belt span 20b is lower than the tension in the first belt span 20a. This may be during a 'boost' event when the engine is driving the wheels of the vehicle, but additional power is desired to supply further power to the wheels indirectly by transferring power to the engine's crankshaft 14 via the belt 20. Another situation in which the MGU 18a is operated as a motor include a BAS (Belt-Alternator Start) event, in which the MGU 18a drives the belt 20 in order to cause rotation of the crankshaft 14, and thereby start the engine 12. Yet another situation in which the MGU 18a is operated as a motor is an ISAF (Idle/Stop Accessory Function) event, when the MGU 18a is used to drive the belt 20 in order to drive one or more accessories when the engine is off (e.g. in some hybrid vehicles where the engine is turned off automatically when the vehicle is at a stoplight or is otherwise stopped briefly).

[0016] In the present disclosure, the span 20a of the belt 20 may be referred to at the belt span 20a, and the span 20b of the belt 20 may be referred to as the belt span 20b.

[0017] It will be noted that the MGU 18a is but one example of a secondary drive device that can be used as a motor to drive the belt 20 for any of the purposes ascribed above to the MGU 18a. In an alternative example, the accessory 18a may be a typical alternator and a separate electric motor may be provided adjacent to the alternator (either upstream or downstream on the belt 20 from the alternator) to driving the belt 20 when it is desired to boost acceleration of the vehicle, in BAS operation, and/or in ISAF operation.

[0018] A tensioner 25 for the endless drive arrangement 10 is shown in Figure 1. The tensioner 25 includes a first tensioner pulley 26 that is configured for engagement with the first span 20a and a second tensioner pulley 28 that is configured for engagement with the second belt span 20b. The first tensioner pulley 26 is rotatably mounted on a first tensioner arm 30. The second tensioner pulley 28 is rotatably mounted on a second tensioner arm 32 (Figure 1). The first and second tensioner arms 30 and 32 are each pivotable about respective first and second tensioner arm pivot axes AP1 and AP2. More specifically, the first and second tensioner arms 30 and 32 are mounted to a base 48 that mounts fixedly to the housing of the MGU 18a or any other suitable stationary member.

[0019] The first and second tensioner pulleys 26 and 28 are biased in first and second free arm directions (shown in Figure 1 at DFA1 and DFA2 respectively). More specifically, a tensioner biasing member 41 may be positioned to apply a tensioner biasing force F on the first and second tensioner arms 30 and 32 in the respective first and second free arm directions DFA1 and DFA2.

[0020] The tensioner biasing member 41 may have any suitable structure, such as, for example, a linear helical compression spring that extends between the first and second tensioner arms 30 and 32. In an alternative embodiment, shown in Figure 2, the tensioner biasing member 41 may, for example, be a torsion spring that abuts first and second drive surfaces 43 and 45 on the first and second arms 30 and 32 and urges the arms 30 and 32 in directions to drive the first and second tensioner pulleys 26 (shown partially in Figure 2) and 28 (not shown in Figure 2) into the belt 20.

[0021] In the embodiments shown in Figures 1 and 2, the first tensioner pulley 26 is on a first side of the first tensioner arm pivot axis AP1, and the tensioner biasing member 41 is positioned to apply the tensioner biasing force F on a second side of the first tensioner arm pivot axis AP1, and the second tensioner pulley 28 is on a first side of the second tensioner arm pivot axis AP2, and the tensioner biasing member 41 is positioned to apply the tensioner biasing force F on a second side of the second tensioner arm pivot axis AP2, wherein the second sides of the first and second tensioner arms 30 and 32 are opposite the first sides of the first and second tensioner arms 30 and 32.

[0022] Several features of the tensioner 25 may be advantageous and are described further below.

C-shaped base

[0023] In an embodiment, the base 48 for the tensioner 25 may be generally C-shaped as shown in Figure 3. In the embodiment shown in Figure 3, the base 48 has a base body 47, and first and second mounting apertures 49 and 51 proximate the circumferential ends of the base body 47, wherein the first and second apertures 49 and 51 are configured for mounting the base 28 to the housing of the MGU 18a or another suitable member. The mounting apertures 49 and 51 may also be used to receive pins (shown at 53 in Figures 1 and 2) for supporting the pivoting movement of the first and second tensioner arms 30 and 32 and may thus define the first and second pivot axes AP1 and AP2. Furthermore, the opening (shown at 53 that is defined by the C-shape of the base 48, is free of any obstructions in an axial direction. As a result, the tensioner 25 is configured to facilitate dissipation of heat from the MGU 18a.

Presence of first and second tensioner arm stops

[0024] In the embodiment shown in Figure 4, the tensioner 25 includes a first tensioner arm stop 60 that is positioned to limit the movement of the first tensioner arm 30 in a direction opposite the first free arm direction. The direction opposite the first free arm direction may be referred to as a first load stop direction. The tensioner 25 includes a second tensioner arm stop 62 that is positioned to limit the movement of the second tensioner arm 32 in a direction opposite the second free arm direction (i.e. a second load stop direction). The tensioner 25 may be configured such that the second tensioner arm stop 62 is positioned such that, in use, the second tensioner pulley 28 is engaged with the endless drive member 20 while the second tensioner arm 32 is engaged with the second tensioner arm stop 62 throughout a first selected range of operating conditions. The first selected range of operating conditions may be the conditions in which when the endless drive arrangement 10 is operated in the first mode (i.e. wherein the crankshaft 14 is used to drive the belt 20). The tensioner arm stops 60 and 62 have first and second base-mounted stop surfaces 64 and 66 respectively that are engageable with first and second arm-mounted stop surfaces 68 and 70 on the first and second tensioner arms 30 and 32 respectively.

[0025] Optionally, during use, the first tensioner pulley 26 is engaged with the endless drive member 20 while the first tensioner arm 30 is engaged with the first tensioner arm stop 60 throughout a second selected range of operating conditions that is different from the first range of operating conditions. For example, the second selected range of operating conditions may include conditions wherein the endless drive arrangement 10 is operated in the second mode (i.e. wherein the MGU 18a is used to drive the belt 20).

[0026] As a further option, during use, the first and second tensioner arm stops 60 and 62 are positioned such that, in use, the first and second tensioner pulleys 26 and 28 are engaged with the endless drive member 20 while the first and second tensioner arms 30 and 32 are disengaged from the first and second tensioner arm stops 60 and 62 throughout a third selected range of operating conditions that is different from the first and second ranges of operating conditions. This third range of operating conditions may include conditions in which the endless drive arrangement is transitioning between the first and second modes.

[0027] The relationships that exist in at least some embodiments in order for the second tensioner pulley 28 to be engaged with the endless drive member 20 while the second tensioner arm 32 is engaged with the second tensioner arm stop 62 throughout a first selected range of operating conditions are described below in relation to Figure 5, which is a schematic representation of the tensioner 25 to show the forces and moments acting thereon.

[0028] It has been found that it is advantageous for the following condition to be met:

$$\frac{TR}{TL} > \frac{hF3}{hF1}$$

where

TR = TR2 – TR3,

TL = TR4 – TR5,

TR2 = the moment arm relative to the second tensioner arm pivot axis of a force T2 exerted on the second tensioner pulley by a first portion of the second span of the endless drive member,

TR3 = the moment arm relative to the second tensioner arm pivot axis of a force T3 exerted on the second tensioner pulley by a second portion of the second span of the endless drive member,

TR4 = the moment arm relative to the first tensioner arm pivot axis of a force T4 exerted on the first tensioner pulley by a first portion of the first span of the endless drive member,

TR5 = the moment arm relative to the second tensioner arm pivot axis of a force T5 exerted on the first tensioner pulley by a second portion of the first span of the endless drive member,

hF1 = the moment arm relative to the first tensioner arm pivot axis of a force FL exerted on the first tensioner arm by the tensioner biasing member, and

hF2 = the moment arm relative to the second tensioner arm pivot axis of the force FL exerted on the second tensioner arm by the tensioner biasing member.

[0029] By meeting the above noted relationship, the tensioner 25 remains stable against the second base-mounted stop surface 66 when the endless drive arrangement is operating in the first mode. Meeting this relationship entails some preload against the second base-mounted stop surface 66 that exists due to the geometry of the tensioner 25. This preload permits the second arm 32 to remain against the stop surface 66 even during torsional vibrations that are inherent with the operation of internal combustion engines such as engine 12. It has been found that the spikes in the belt tension that occur during operation in the second mode (when the MGU 18a is being driven as a motor) were lower than they are for a tensioner of the prior art that does rest against one stop surface or another during the first and second modes of operation.

[0030] Another advantage maintaining the second arm 32 against the stop surface 66 when the endless drive arrangement 10 is in the first mode is that any damping structures that may be provided on the tensioner 25 in association with the second arm 32 incur a reduced amount of wear. Additionally, the stop surface 66 on the base (and the corresponding surface 70 on the second arm 32) incur a reduced amount of wear as compared to a situation where there is repeated impact with a stop surface.

[0031] Overall, because the tensioner 25 moves less than a tensioner that is not abutted against a stop during operation of the engine, the operating life of the tensioner may be increased as compared to such a prior art tensioner.

Three damping structures

[0032] Reference is made to Figure 6, which shows three damping structures that are optionally included for the tensioner 25, including a first damping structure 80 configured to dampen movement of the first tensioner arm 30, a second damping structure 82 configured to dampen movement of the second tensioner arm 32, and a third damping structure 84 configured to dampen relative movement between the first and second tensioner arms 30 and 32.

[0033] Referring to Figures 7 and 8a each damping structure 80 and 82 may be a rotary damping structure and may include one or more Belleville washers 86, that apply an axial force against a thrust bushing 88, which engages a frictional damping element 90, thereby resulting in a first or second damping force that resists movement of the first or second tensioner arm 30, as the case may be. It will be noted that such a first and second damping forces provided by the damping structures shown may be substantially independent of the first and second biasing forces.

[0034] Referring to Figure 8b, it is alternatively possible to provide a damping structure 92 that could be used instead of one or both of the damping structures 80 or 82. The damping structure 92 includes a circumferentially ramped thrust bushing that engages a corresponding circumferentially ramped frictional damping element 90. As a result, during pivoting in the load stop direction this damping structure 92 provides a first amount of damping force, but during pivoting in the free arm direction this damping structure 92 provides a second amount of damping force that is lower than the first damping force. Thus, for whichever of the arms 30 and 32 the damping structure 92 is provided on it provides a damping force that is dependent on a direction of rotation of the first and second tensioner arms respectively.

[0035] Examples of the third damping structure are shown in the sectional views in Figures 9 and 10. As shown in Figure 9, the biasing member 41 includes a helical compression spring that extends between the arms 30 and 32 and surrounds a strut 100 that includes a piston 102 that is movable in a cylinder 104. Hydraulic oil (or any other suitable incompressible fluid) is provided in the cylinder and passes through an orifice having a selected size in the piston 102. The third damping structure, which includes the piston with the orifice and the cylinder 104, inhibits movement of the piston 102 in the cylinder 104. A spring biased volume compensation member 106 (which itself is a piston) is provided to compensate for the change in effective volume that accompanies movement of the piston 102 in the cylinder 104.

[0036] In Figure 10, an alternative type of strut 100 is provided, in which little resistance to movement is provided by the strut piston and cylinder 104. Instead, the damping is provided by a closed-cell foam member 108 that is also the biasing member 41. This provides a structure that has few parts. The closed-cell foam member 108 has damping that takes place inherently during compression of the closed-cell foam member 108.

[0037] With both of the damping structures shown in Figures 9 and 10, the damping that is provided may be speed dependent. In other words, if the relative movement between the arms 30 and 32 is relatively slow, the damping force provided by the damping structure 84 may be relatively small. However, if the movement between the arms 30 and 32 is relatively fast, the damping force provided by the damping structure 84 may be relatively high. During torsional vibrations, the damping structure 84 may provide relatively high damping, thereby resisting relative movement between the arms 30 and 32. In the event that an isolator or similar device is provided, the isolator can assist in reducing the severity of torsional vibrations in the endless drive arrangement.

[0038] While hydraulic and closed-cell foam damping structures are shown in Figures 9 and 10, any other suitable type of damping structure can be used, such as pneumatic damping structure, a friction damping structure, or any other suitable type of damping structure.

Providing a selected coefficient of static friction

[0039] The first damping structure 80 is provided with a selected coefficient of static friction that provides a first selected resistance to movement away from being stationary (e.g. a first selected resistance to movement away from the stop surface 64). Similarly the second damping structure is provided with a second coefficient of static friction associated therewith so as to provide a second selected resistance to movement away from being stationary (e.g. a first selected resistance to movement away from the stop surface 66). The second coefficient of static friction may be greater than about 0.3. The second coefficient of static friction may be selected so as to inhibit separation of the second arm 32 from the second stop surface 66 during torsional vibrations or other conditions. This assists the stability of the second arm 32. Furthermore, providing damping to inhibit relative movement between the two arms 30 and 32 assists in dampening drive resonance, which can occur naturally due to the inertia associated with each of the components being driven in the endless drive arrangement 10.

Relationship between the first and second damping structures

[0040] In the tensioner 25, the damping torque provided by the first damping structure 80 may be higher than the damping torque provided by the second damping structure 82, particularly in embodiments in which the damping structures provide damping that is independent of the direction of rotation of the arms 30 and 32. As a result, the second arm 32 can pivot towards the belt 20 during a transition to the second mode of operation (when a fast transition is desirable) more quickly than the first arm 30 can pivot toward the belt 20 during a transition to the first mode of operation (when a slower transition is more acceptable). Optionally, the ratio of the damping torque to moment arm length for each of the first and second tensioner arms 30 and 32 is between about 0.02 Nm/mm (Newton metres per millmetre) and about 0.2 Nm/mm (Newton metres per millmetre). Optionally, the first damping torque is between about 2 Nm and about 15 Nm. The specific relationships between the damping torques can be determined by one skilled in the art after having the benefit of the present disclosure.

Providing a tensioner using two pivot arms on a stationary base

[0041] It will be noted that, providing a tensioner such as tensioner 25 which has two arms 30 and 32 which pivot relative to the stationary base 48 facilitates the positioning of first and second pulleys 26 and 28 relatively far from the MGU pulley 24a. This can be advantageous in two-pulley systems in which there is only a crankshaft pulley 16 and an MGU pulley 24a (and the tensioner 25) that are engaged by the belt 20. In such systems, the amount of belt wrap that is possible is relatively lower than in typical orbital tensioners which incorporate a ring and one or more pulleys on one or more arcuate arms that orbits on the ring. In such orbital tensioners, the pulleys are typically positioned very close to the MGU pulley and as a result, the belt undergoes significant two-way bending in a short period of time as it travels from one tensioner pulley to the

MGU pulley to the other tensioner pulley, which can damage the belt. By contrast, the longer arms of the tensioner 25 permit less severe bending on the belt 20, which can improve the operating life of the belt 20. Additionally, the long arms available with the tensioner 25 can result in large linear movements by the pulleys 26 and 28 from smaller angular movements, which can improve the wear life of certain components.

[0042] Additionally, orbital tensioners tend to have decoupling effect such that torques that are applied at the MGU pulley 24a will result in large swings of the orbital tensioner which in turn provide this decoupling (or isolating) effect. However, in some situations it may be desirable to use the MGU to provide torque smoothing. Thus, by providing the tensioner 25 which does not have large swings associated with it, a much reduced decoupling effect is observed. As a result, the MGU 18a can be used for torque smoothing.

[0043] While the description contained herein constitutes a plurality of embodiments of the present invention, it will be appreciated that the present invention is susceptible to further modification and change without departing from the fair meaning of the accompanying claims.

CLAIMS

1. A tensioner for tensioning an endless drive member, comprising:

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is configured for engagement with a first span of the endless drive member, wherein the first tensioner arm is biased in a first free arm direction;

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is configured for engagement with a second span of the endless drive member, wherein the second tensioner arm is biased in a second free arm direction; and

a second tensioner arm stop surface that is positioned to limit the movement of the second tensioner arm in a direction opposite the second free arm direction,

wherein the second tensioner arm stop surface is positioned such that, in use, the second tensioner pulley is engaged with the endless drive member while the second tensioner arm is engaged with the second tensioner arm stop surface throughout a first selected range of operating conditions.

2. A tensioner as claimed in claim 1, further comprising a tensioner biasing member that is positioned to bias the first and second tensioner arms in the first and second free arm directions.

3. A tensioner as claimed in claim 2, wherein the tensioner biasing member is a compression spring.

4. A tensioner as claimed in claim 2, wherein the tensioner biasing member is a torsion spring

5. A tensioner as claimed in claim 1, wherein the first tensioner arm is pivotable about a first tensioner arm pivot axis, and the second tensioner arm is pivotable about a second tensioner arm pivot axis.

6. A tensioner as claimed in claim 1, further comprising a first tensioner arm stop surface that is positioned to limit the movement of the first tensioner arm in a direction opposite the first free arm direction,

wherein the first tensioner arm stop surface is positioned such that, in use, the first tensioner pulley is engaged with the endless drive member while the first tensioner arm is engaged with the first tensioner arm stop surface throughout a second selected range of operating conditions that is different from the first range of operating conditions.

7. A tensioner as claimed in claim 6, wherein the first and second tensioner arm stops are positioned such that, in use, the first and second tensioner pulleys are engaged with the endless drive member while the first and second tensioner arms are disengaged from the first and second tensioner arm stop surfaces throughout a third selected range of operating conditions that is different from the first and second ranges of operating conditions.

8. A tensioner as claimed in claim 1, wherein the endless drive member is part of an endless drive arrangement that is operable in a first mode in which tension in a first span of the endless drive member is a lower tension than tension in a second span of the endless drive member and in a second mode in which tension in the second span of the endless drive member is lower than tension in the first span of the endless drive member,

wherein the first tensioner pulley is engaged with the first span and the second tensioner pulley is engaged with the second span.

9. A tensioner as claimed in claim 1, further comprising:

a first damping structure configured to dampen movement of the first tensioner arm, wherein the first damping structure has a first coefficient of static friction associated therewith so as to provide a first selected resistance to movement away from being stationary; and

a second damping structure configured to dampen movement of the second tensioner arm, wherein the second damping structure has a second coefficient of static friction associated therewith so as to provide a second selected resistance to movement away from being stationary,

wherein the second coefficient of static friction is greater than about 0.3.

10. An endless drive arrangement, comprising:

a crankshaft;

a secondary drive device;

an endless drive member connecting the crankshaft and the secondary drive device;

a tensioner, including

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is engaged with a first span of the endless drive member on a first side of the secondary drive device, wherein the first tensioner arm is pivotable about a first tensioner arm pivot axis;

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is engaged with a second span of the endless drive member on a second side of the secondary drive device, wherein the second tensioner arm is pivotable about a second tensioner arm pivot axis;

a tensioner biasing member that is positioned to apply a tensioner biasing force to bias the first and second tensioner arms in respective first and second free arm directions; and

a second tensioner arm stop that is positioned to limit the movement of the second tensioner arm in a direction opposite the second free arm direction, wherein the second tensioner arm stop is positioned such that, in use, the second tensioner pulley is engaged with the endless drive member while the second tensioner arm is engaged with the second stop throughout a selected range of operating conditions, and wherein

$$\frac{TR}{TL} > \frac{hF3}{hF1}$$

where

TR = TR2 – TR3,
TL = TR4 – TR5,
TR2 = the moment arm relative to the second tensioner arm pivot axis of a force T2 exerted on the second tensioner pulley by a first portion of the second span of the endless drive member,
TR3 = the moment arm relative to the second tensioner arm pivot axis of a force T3 exerted on the second tensioner pulley by a second portion of the second span of the endless drive member,
TR4 = the moment arm relative to the first tensioner arm pivot axis of a force T4 exerted on the first tensioner pulley by a first portion of the first span of the endless drive member,
TR5 = the moment arm relative to the second tensioner arm pivot axis of a force T5 exerted on the first tensioner pulley by a second portion of the first span of the endless drive member,
hF1 = the moment arm relative to the first tensioner arm pivot axis of a force FL exerted on the first tensioner arm by the tensioner biasing member, and
hF2 = the moment arm relative to the second tensioner arm pivot axis of the force FL exerted on the second tensioner arm by the tensioner biasing member.

11. An endless drive arrangement as claimed in claim 10, wherein the secondary drive device is a motor-generator unit.

12. An endless drive arrangement as claimed in claim 10, wherein the secondary drive unit is configured to apply a secondary drive unit torque to the endless drive member in a direction that is opposed to a crankshaft torque that is applied to the endless drive member.

13. An endless drive arrangement as claimed in claim 10, wherein the first tensioner pulley is on a first side of the first tensioner arm pivot axis, and the tensioner biasing member is positioned to apply the tensioner biasing force on a second side of the first tensioner arm pivot axis, and wherein the second tensioner pulley is on a first side of the second tensioner arm pivot axis, and the tensioner biasing member is positioned to apply the tensioner biasing force on a second side of the second tensioner arm pivot axis.

14. An endless drive arrangement, comprising:

a crankshaft;

a secondary drive device;

an endless drive member connecting the crankshaft and the secondary drive device; and

a tensioner, including

a base;

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is configured for engagement with a first span of the endless drive member, wherein the first tensioner arm is pivotally mounted to the base and is biased in a first free arm direction; and

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is configured for engagement with a second span of the endless drive member, wherein the second tensioner arm is pivotally mounted to the base and a second load stop position and is biased in a second free arm direction, wherein when tension in the endless drive member is between zero and a yield tension for the endless drive member, the first and second tensioner pulleys are movable along a first path and a second path respectively, wherein the first path and the second path are entirely spaced from one another.

15. A tensioner for tensioning an endless drive member, comprising:

a base;

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is configured for engagement with a first span of the endless drive member, wherein the first tensioner arm is pivotally mounted to the base for movement about a first tensioner arm pivot axis; and

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is configured for engagement with a second span of the endless drive member, wherein the second tensioner arm is pivotally mounted to the base for movement about a second tensioner arm pivot axis;

a biasing member that applies first and second biasing forces on the first and second tensioner arms in first and second free arm directions respectively;

a first damping structure configured to dampen movement of the first tensioner arm;

a second damping structure configured to dampen movement of the second tensioner arm; and

a third damping structure configured to dampen relative movement between the first and second tensioner arms.

16. A tensioner as claimed in claim 15, wherein the biasing member includes a helical compression spring that extends between the first and second tensioner arms and that surrounds a strut that includes a piston that is movable in a cylinder,

wherein the third damping structure inhibits movement of the piston in the cylinder.

17. A tensioner as claimed in claim 15, wherein the first and second damping structures apply first and second damping forces to resist movement of the first and second tensioner arms respectively, that are substantially independent of the first and second biasing forces.

18. A tensioner as claimed in claim 15, wherein the first and second damping structures apply first and second damping forces to resist movement of the first and second tensioner arms respectively, that are dependent on a direction of rotation of the first and second tensioner arms respectively.

19. A tensioner for tensioning an endless drive member, comprising:

a base, wherein the base is generally C-shaped and is configured to mount to a housing of an accessory that is drivable by the endless drive member;

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is configured for engagement with a first span of the endless drive member, wherein the first tensioner arm is pivotally mounted to the base and is biased for movement in a first free arm direction; and

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is configured for engagement with a second span of the endless drive member, wherein the second tensioner arm is pivotally mounted to the base for movement along a second path and is biased for movement in a second free arm direction.

20. An endless drive arrangement for an engine, comprising:

a crankshaft;

a secondary drive device;

an endless drive member an endless drive member that is engaged with the crankshaft pulley and the secondary motive device pulley, wherein the endless drive arrangement is operable in a first mode in which tension in a first span of the endless drive member is lower tension than a second span of the endless drive member and in a second mode in which tension in the second span of the endless drive member is lower than tension in the first span of the endless drive member;

a tensioner, including

a first tensioner arm that has a first tensioner pulley rotatably mounted thereto, wherein the first tensioner pulley is engaged with the first span of the endless drive member, wherein the first tensioner arm is pivotable about a first tensioner arm pivot axis;

a second tensioner arm that has a second tensioner pulley rotatably mounted thereto, wherein the second tensioner pulley is engaged with the second span of the endless drive member, wherein the second tensioner arm is pivotable about a second tensioner arm pivot axis;

a tensioner biasing member that is positioned to bias the first and second tensioner arms in respective first and second free arm directions;

a first damping structure configured to dampen individual movement of the first tensioner arm;

a second damping structure configured to dampen individual movement of the second tensioner arm; and

a third damping structure configured to dampen relative movement between the first and second tensioner arms.

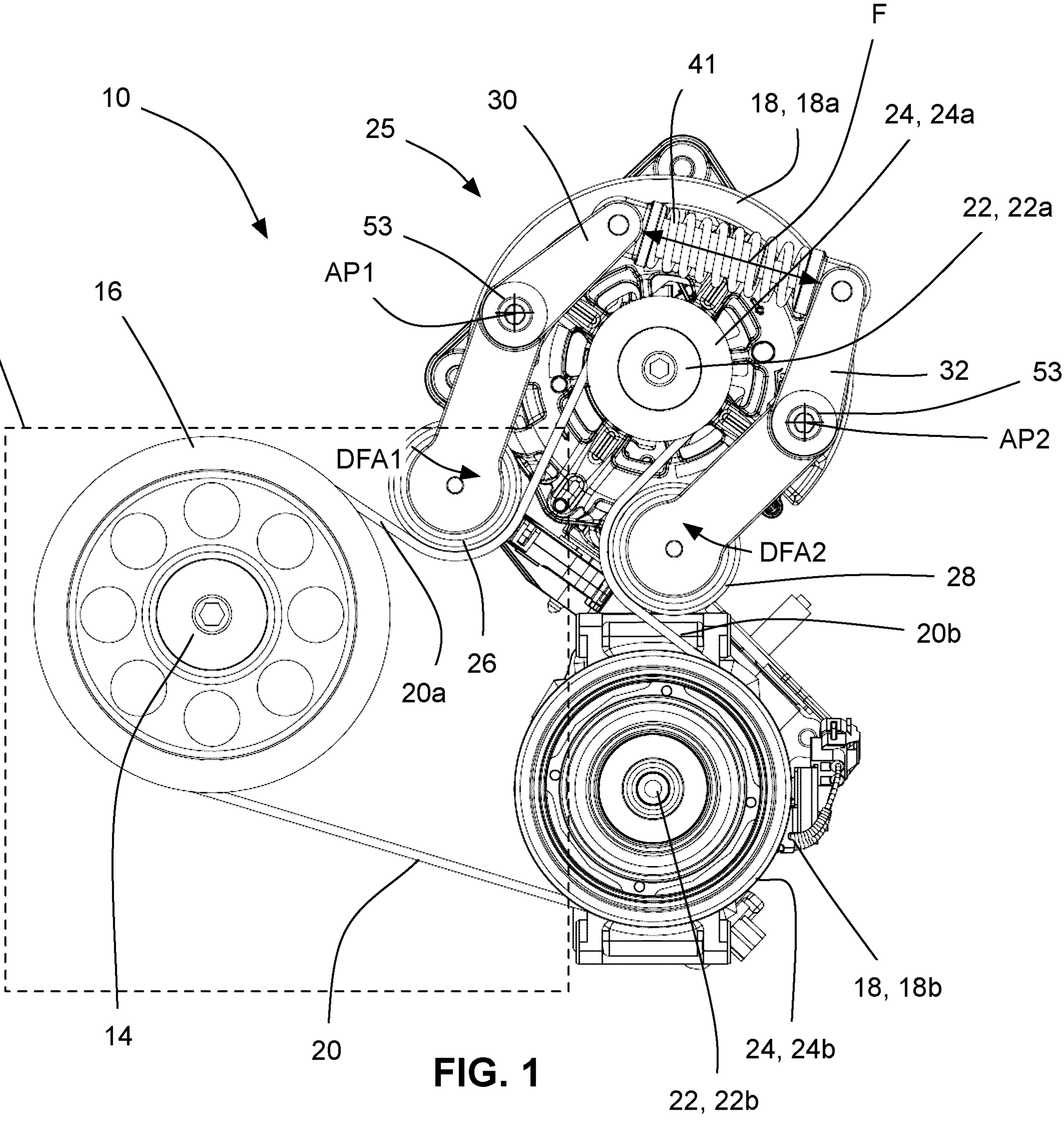
21. An endless drive arrangement as claimed in claim 20, wherein the first damping structure applies a first damping torque on the first tensioner arm, and the second damping structure applies a second damping torque on the second tensioner arm, wherein the second damping torque is lower than the first damping torque.

22. An endless drive arrangement as claimed in claim 20, wherein the first damping structure applies a first damping torque on the first tensioner arm, and

the second damping structure applies a second damping torque on the second tensioner arm, wherein the second damping torque is between about 10% and about 75% of the first damping torque.

23. An endless drive arrangement as claimed in claim 20, wherein the first damping structure applies a first damping torque on the first tensioner arm and wherein the first tensioner pulley has a first moment arm relative to the first tensioner arm pivot axis, and the second damping structure applies a second damping torque on the second tensioner arm and wherein the second tensioner pulley has a second moment arm relative to the second tensioner arm pivot axis, wherein the ratio of the damping torque to moment arm length for each of the first and second tensioner arms is between about 0.02 Nm/mm (Newton metres per millmetre) and about 0.2 Nm/mm (Newton metres per millmetre).

24. An endless drive arrangement as claimed in claim 20, wherein the first damping torque is between about 2 Nm and about 15 Nm.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AP1
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AP2
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22, 22b

FIG. 1

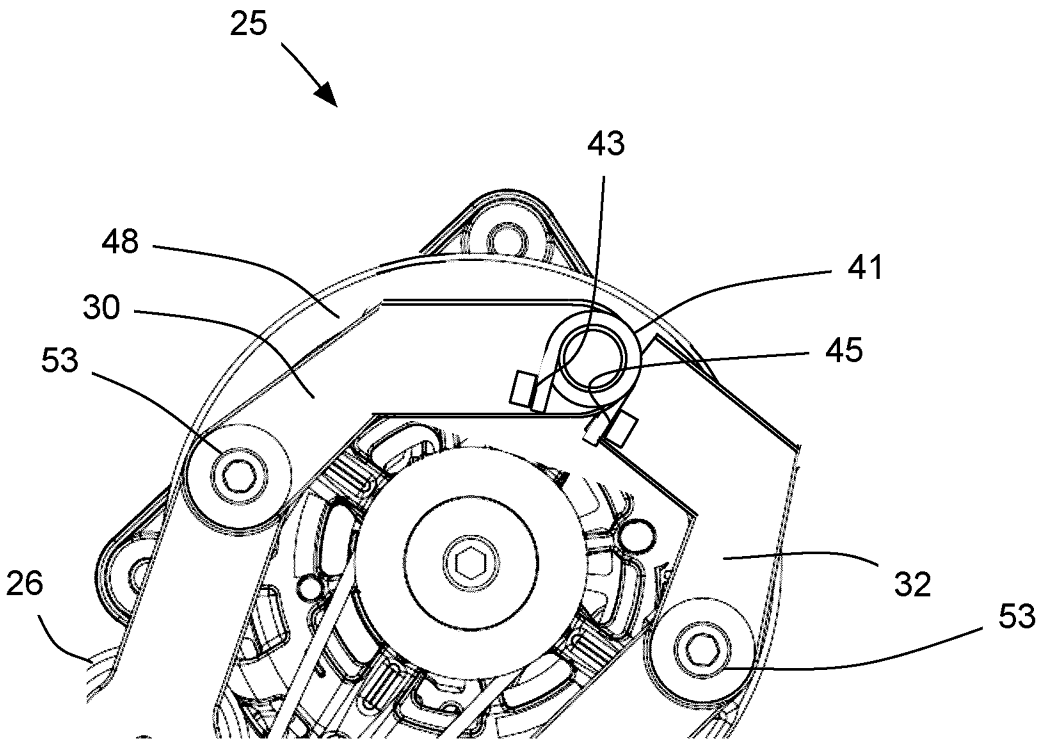


FIG. 2

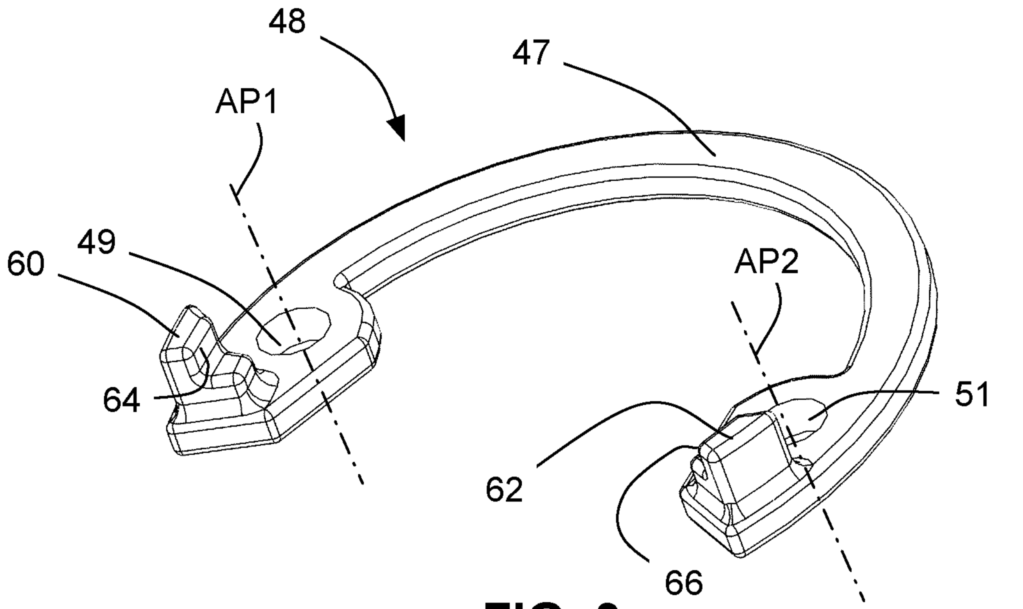


FIG. 3

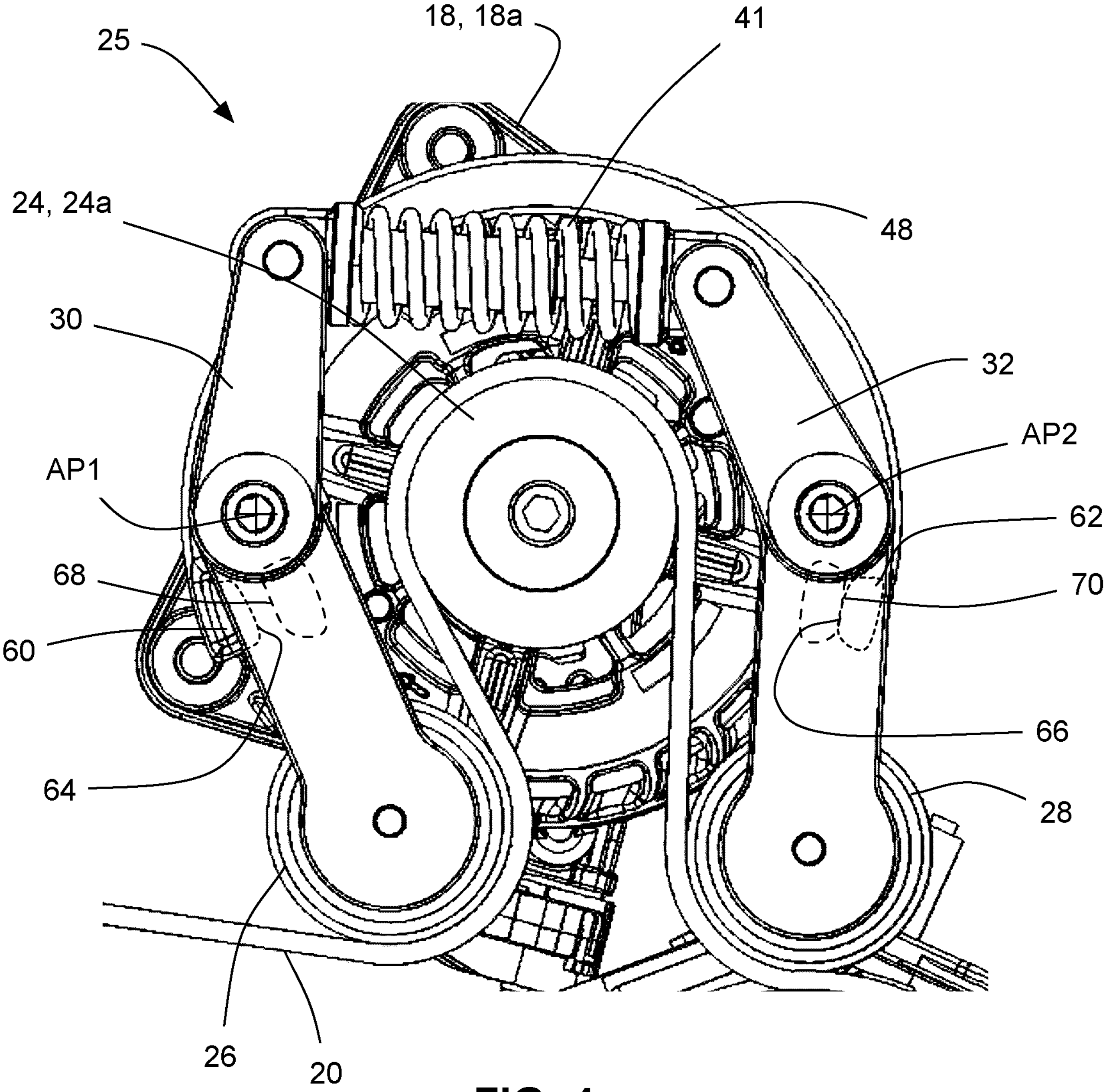
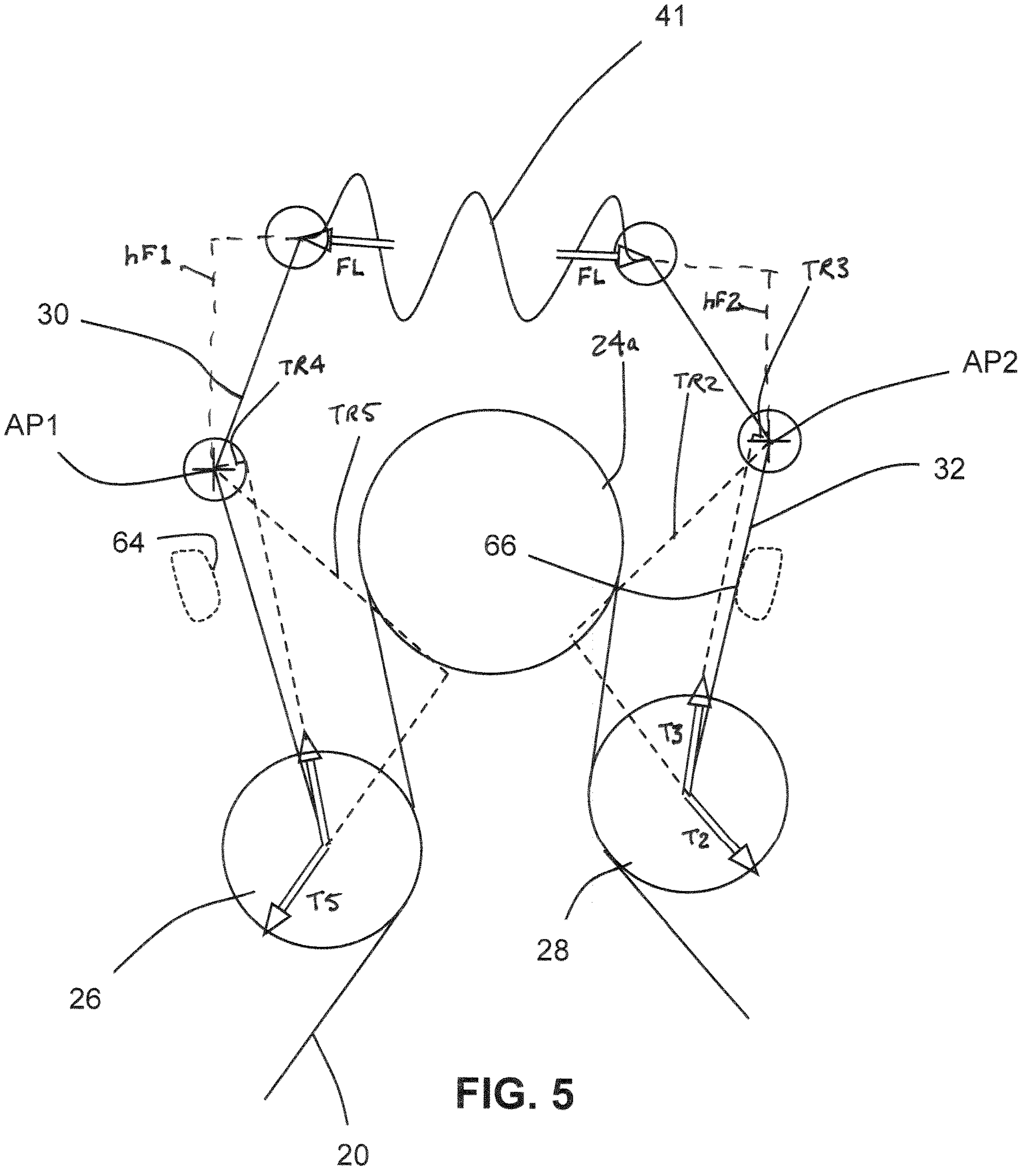


FIG. 4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hF1
FL
FL
TR3
hF2
30
24a
TR4
TR2
AP2
TR5
AP1
32
64
66
T3
T2
T5
28
26
20

FIG. 5

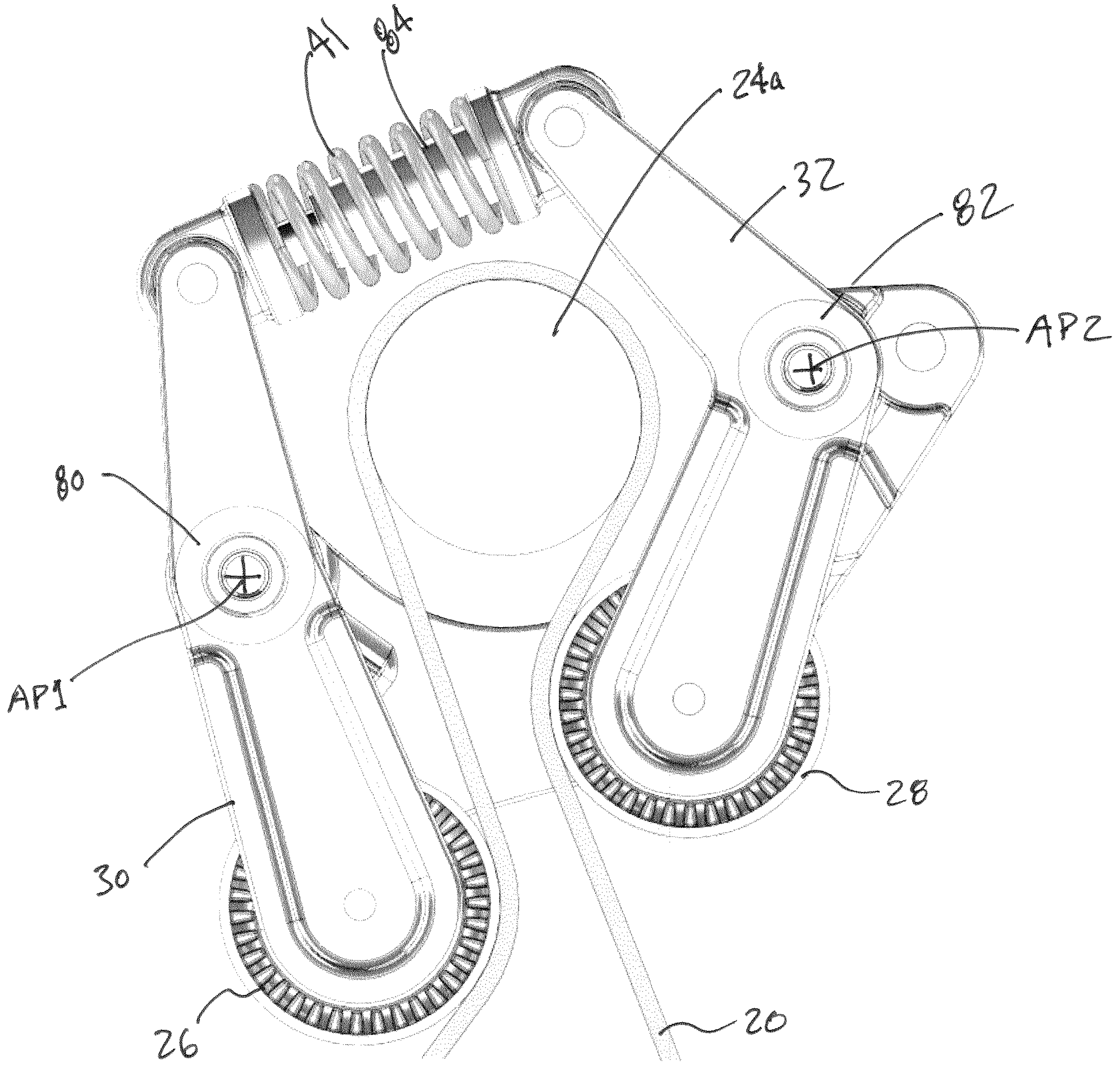

FIG. 6

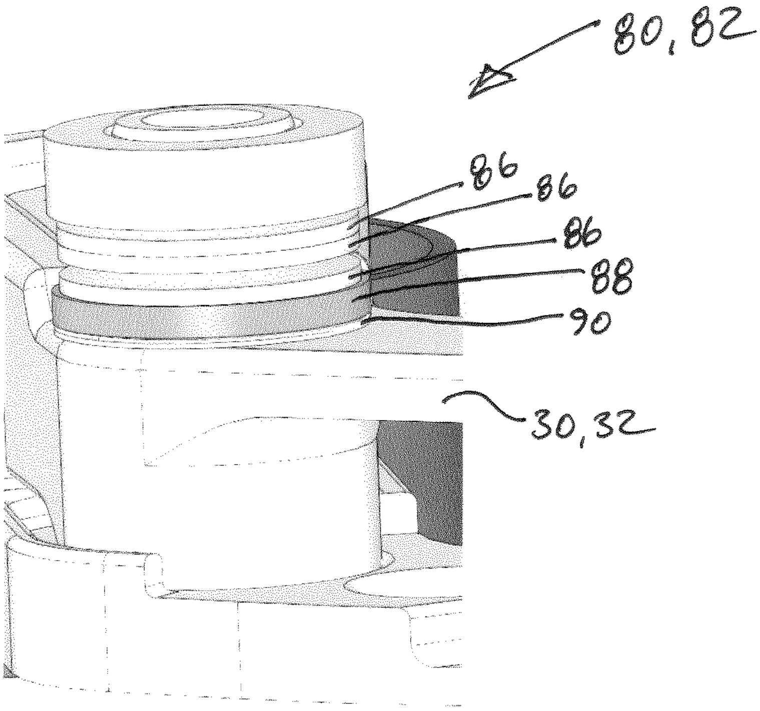

FIG. 7

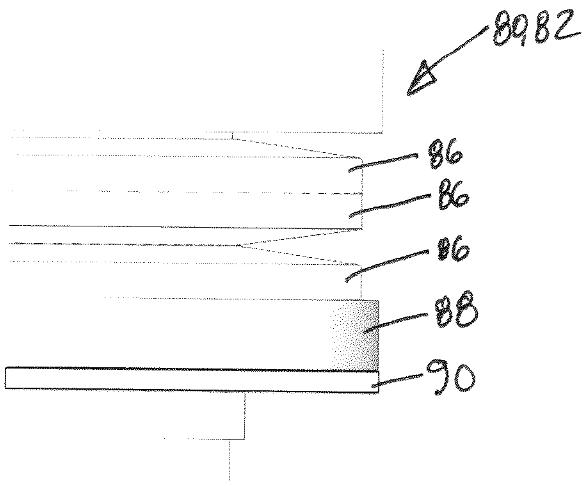

FIG. 8a

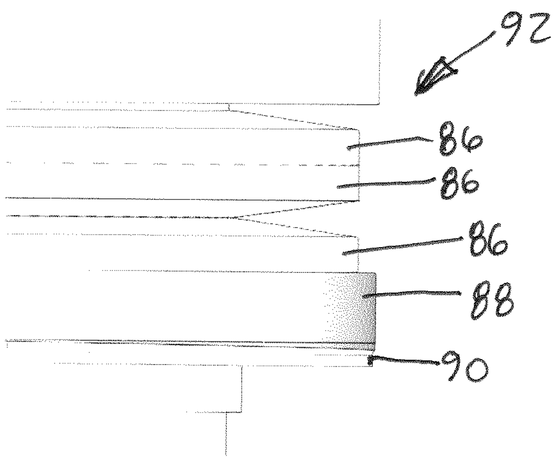

FIG. 8b

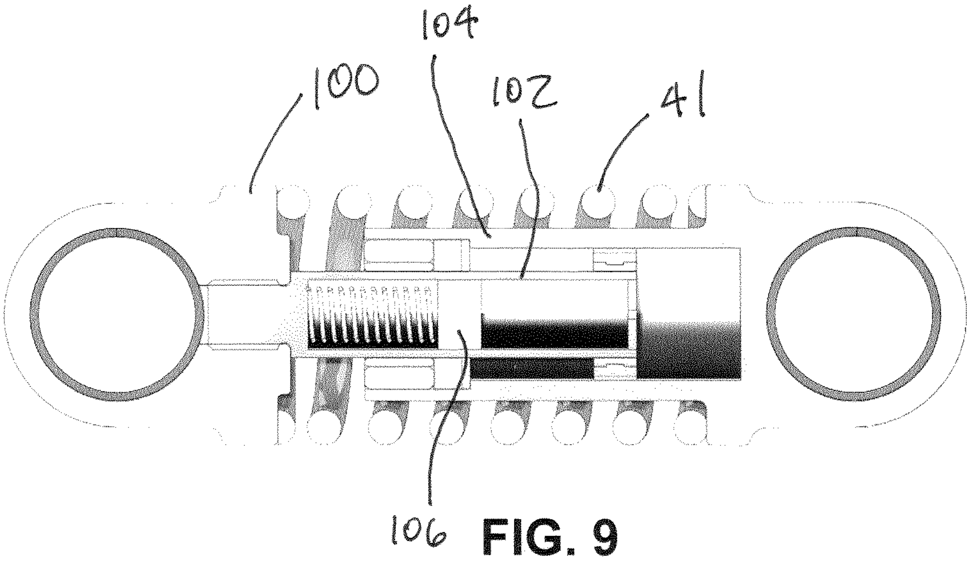

FIG. 9

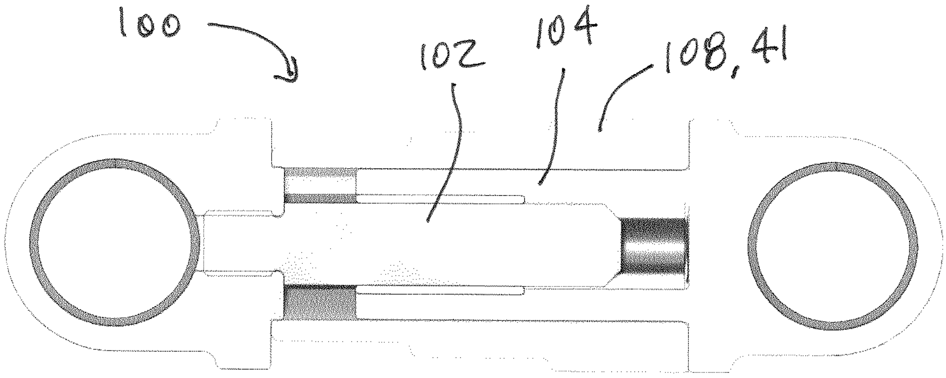

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2015/051067

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***F16H 7/12*** (2006.01) , ***B60K 25/02*** (2006.01) , ***F02B 67/06*** (2006.01)

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)
IPC: ***F16H 7/12*** (2006.01) , ***B60K 25/02*** (2006.01) , ***F02B 67/06*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Intellect (Canadian Patent Database), Questel-Orbit (FamPat Database)
Tensioner, arm, two, stop, spring, damp, pulley and span

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US7901310B2 (Lolli et al.) 8 March 2011 (08-03-2011) *whole document*	1-2, 4, 6-9, 14 and 19 3, 5, 15-18 and 20-24
Y	US2009/298631A1 (Jud et al.) 3 December 2009 (03-12-2009) *whole document*	3
Y	DE202008002279 U1 (Schaeffler) 30 April 2008 (30-04-2008) *whole document*	5, 15-18 and 20-24

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 20 January 2016 (20-01-2016)	Date of mailing of the international search report 03 February 2016 (03-02-2016)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Sorin Muntean (819) 639-7875

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