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RECOIL MITIGATION MECHANISM

Field of the Invention

This invention relates to a recoil mitigation mechanism and refers particularly, though
10 not exclusively, to a recoil mitigation mechanism for use with weapons for firing large
caliber ammunition.

Background to the Invention

There are many existing weapons for firing large caliber ammunition such as, for
15 example, 40 mm high velocity grenade launchers ("launchers"). Commercial models
include SACO Defense Mk19, CIS 40 AGL, and H&K 40 GMG, and so forth. These
weapons usually use a single inertia mass coupled with recoil springs to dampen the
recoil impulse generated during the firing of a 40 mm high velocity grenade. The recoil
springs also form part of the firing mechanism. To be able to dampen the recoil impulse
20 the inertia mass will have to be quite heavy. This therefore increases the weight of the
weapon and the structural strength of the weapon (and thus its weight) for the weapon to
be able to handle the large weight of the inertia mass. The weapon mounts therefore also
require increased structural strength to withstand the increased weight. This further
increases the weight of the weapon system (weapon plus mounts plus ammunition). Even
25 so, the recoil impulse absorption achieved is not high. For example, the CIS 40 AGL can
achieve a recoil impulse absorption of slightly over 25% when firing a 40 mm high
velocity grenade.

Presently available launchers have a weight in the range of 30 to 35 Kg. They also have a
30 relatively high recoil force due to generally ineffective recoil mitigation mechanisms.

If a recoil impulse mitigation mechanism of reduced weight and greater effectiveness
could be developed, it would reduce the weight of the weapon system. This would reduce
the number of personnel required to carry the weapon system, thus increasing its
35 portability. This would increase its effective use by infantry.

- 5 It is therefore the principal object of the present invention to provide a recoil mitigation mechanism that has increased effectiveness in the absorption of the recoil impulse.

A further object of the present invention is to provide a recoil mitigation mechanism that is of reduced weight.

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Summary of the Invention

- With the above and other objects in mind, the present invention provides a recoil mitigation mechanism including a first mass adapted to be moved in a first direction as a result of a firing action, and a second mass adapted to be moved in a second direction as a result of the firing action; and wherein the first mass is caused to contact the second mass and to change the direction of movement of the second mass to the first direction to thereby mitigate a recoil impulse generated by the firing action.

- The first mass may be a front bolt and the first direction rearwards; and the second mass a bolt gear rack and the second direction forwards. The bolt gear rack may include a housing, the housing being that part of the bolt gear rack adapted to be contacted by the first mass. The housing may contain a firing mechanism; the firing mechanism including a bolt lever pivotally mounted with respect to the housing to maintain the front bolt and the housing separated.

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- The bolt lever preferably includes a front finger for engaging the front bolt to maintain the separation, and a bolt lever spring to bias the bolt lever to a position where the front finger engages the front bolt. A bolt lever cam is able to activate the bolt lever against the effect of the bolt lever spring to raise front finger to allow the front bolt to move rearwardly so that the front bolt can impact on the housing during the firing processes.

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- In a second form, the present invention provides a recoil mitigation mechanism including a second mass adapted to be moved in a first direction as a result of a firing action, a third mass driven by a drive means in consequence of movement in the second mass in the first direction, the third mass being driven in a second direction against the action of at least one resilient means to absorb energy of a recoil impulse.

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- 5 The second mass may be a bolt gear rack and the second direction forwards; and the first direction rearwards and the third mass a recoil inertia rack.

The drive means may be a pinion gear and the resilient means at least one spring mounted to an upper surface of the third mass. The at least one spring preferably is a pair
10 of compression springs having a rear end thereof attached to a top surface of the recoil inertia rack by a lug, and a forward end thereof attached to an end plate of a body securable to a barrel. The pinion gear may be mounted on a spindle, the spindle being mounted in elongate holes in a second housing for movement relative thereto in an axial direction, the movement in the first direction being to compress a recoil die spring.

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In a third form the present invention provides a recoil mitigation mechanism including a body attachable to a barrel, the body having a gas passage therethrough to receive propulsion gasses from a gas hole in the barrel and to pass the propulsion gasses to a recoil cylinder, the gasses entering the recoil cylinder behind a recoil piston to force the
20 piston in a forward direction to provide the recoil mitigation. The recoil piston may have a piston rod operatively connected thereto, the piston rod also being connected to a recoil inertia rack.

In a fourth form, the present invention provides a recoil mitigation mechanism for a
25 weapon having a barrel, the barrel having a muzzle brake including an internal front face for contact by propulsion gasses to provide a forwardly directed force and thus recoil mitigation.

In a fifth form the present invention provides a recoil mechanism for a weapon having a
30 barrel with a barrel bore, the barrel having a chamber at a first end thereof and a muzzle at a second end thereof, the first end being opposite the second end, the barrel bore having a first rifling extending from the chamber to the muzzle, the first rifling having a first number of first spiral grooves; there being a second rifling extending from a location intermediate the chamber and the muzzle to the muzzle, the second rifling having a
35 second number of second spiral grooves.

- 5 The second number is preferably equal to or greater than the first number, and may be a whole number multiple of the first number. In the preferred form, the first number is six and the second number is twelve.

10 The location may be adjacent to and slightly forwardly of a gas hole in the barrel. It may be 75% along the barrel. The first rifling and the second rifling may each have a break of twist that is the same. The first number of first spiral grooves may be equally spaced and the second number of second spiral grooves located between the first number of first spiral grooves. The second spiral grooves may be equally spaced between the first spiral grooves.

15 In a sixth form the present invention provides a recoil mitigation mechanism including a drive means mounted on a spindle, the spindle being mounted in elongate slots in a housing for axial movement in the slots in a first direction against the action of a resilient means during an initial stage of a firing process, and to move in a second direction in
20 response to the resilient means restoring itself to its rest condition at the completion of the firing processes.

The drive means may be a pinion gear and the resilient means a recoil die spring; and the movements being without the pinion gear rotating. The first direction may be rearwards
25 and the second direction forwards. Preferably, the movement of the drive means in the first direction is with both a first inertia mass and a second inertia mass and is at the very beginning of the recoil impulse mitigation action such that at least a part of recoil energy is absorbed by the resilient means to mitigate the recoil impulse.

30 The present invention also includes all possible combinations of the six forms – including: 1+2, 1+3, 1+4, 1+5, 1+6, 2+3, 2+4, 2+5, 2+6, 3+4, 3+5, 3+6, 4+5, 4+6, 5+6, 1+2+3, 1+2+4, 1+2+5, 1+2+6, 1+3+4, 1+3+5, 1+3+6, 1+4+5, 1+4+6, 1+5+6, 2+3+4, 2+3+5, 2+3+6, 2+4+5, 2+4+6, 2+5+6, 3+4+5, 3+4+6, 3+5+6, 4+5+6, 1+2+3+4, 1+2+3+5, 1+2+3+6, 1+3+4+5, 1+3+4+6, 1+4+5+6, 2+3+4+5, 2+3+4+6, 2+3+5+6,
35 2+4+4+6, 3+4+5+6, 1+2+3+4+5, 1+2+3+4+6, and 2+3+4+5+6.

5 Description of the Drawings

In order that the invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative example only a preferred embodiment of the present invention, the description being with reference to the accompanying illustrative drawings in which:

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Figure 1 is a perspective view of a recoil impulse mitigation mechanism incorporating the preferred features of the present invention when fitted to a launcher, the launcher being in a condition after triggering but just before firing (body removed);

Figure 2 is a vertical cross-sectional view along the lines and in the direction of arrows 2-

15 2 on Figure 1 (body in place); and

Figure 3 is an underneath perspective view of the recoil inertia rack of Figures 1 and 2.

Description of Preferred Embodiment

20 For the sake of consistency, the muzzle end of the weapon will be called the front, and the stock end will be called the rear. Although the parts of the weapon shown are of a 40 mm high velocity grenade launcher, the present invention may be used with other devices having weight and/or recoil mitigation problems. Only those parts of the weapon relevant for the recoil mitigation mechanism of the present invention are shown, for the sake of
25 simplicity.

As shown in the drawings there is a recoil impulse mitigation mechanism that uses two inertia masses that reduce the recoil impulse by simultaneously moving two different inertia masses in opposite directions.

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The two inertia masses are a bolt gear rack 1 and a recoil inertia rack 2. The bolt gear rack has integral therewith or securely attached thereto a housing 23. In the housing 23 is located the firing mechanism, generally designated as 19.

35 A motion transfer apparatus such as a pinion gear 3 is located between and operatively engages both the bolt gear rack 1 and the recoil inertia rack 2 so that movement of one will cause movement of the other. The pinion gear 3 is preferably of substantially the

5 same width as recoil inertia rack 2 so the gear teeth on pinion 3 can engage teeth 40 under recoil inertia rack 2. Although a pinion gear 3 cooperating with rack gears is shown, other systems may also be suitable. For example, pressure rollers on non-smooth surfaces, belt drive, chain drive, cable drive, toothed drive, and so forth.

10 Pinion gear 3 is mounted on a spindle 24, the spindle being mounted in a second housing 36 in elongate slots 25 therein. By having elongate slots 25, the spindle 24 and thus the pinion gear 3, can move in the axial direction – in the direction of the longitudinal axis of the bolt gear rack 1. This enables the pinion gear 3, with both the bolt gear rack 1 and the recoil inertia rack 2, to move axially rearwardly against the action of a recoil die spring 5
15 during the initial stages of the firing process, and to move axially forwardly in response to the recoil die spring restoring itself to its rest condition at the completion of the firing processes. All such movements may be without the pinion gear 3 rotating, depending on the frictional engagement between the pinion gear 3 and the recoil inertia rack 2. The rearwards movement of the pinion gear 3 with both the bolt gear rack 1 and recoil inertia
20 rack 2 is at the very beginning of the recoil impulse mitigation action and thus some of the recoil energy is absorbed by the recoil die spring 5 to mitigate the recoil impulse.

Two parallel and axially extending recoil springs 4 are mounted on the upper surface of the recoil inertia rack 2. At their rear end the springs 4 are securely attached to the recoil
25 inertia rack 2 by a lug 20. At the front end they are securely attached to an end plate 21 that forms part of, or is securely attached to, body 22. Body 22 is securely attached to a barrel 16 adjacent the front thereof. Body also constitutes a forward movement limitation for bolt gear rack 1 in that the bolt gear rack 1 will contact body 22 at the limit of its forward movement. Similarly for the end plate 21 and recoil inertia rack 2, the recoil
30 inertia rack 2 contacting end plate 21 at the limit of its forwards movement. This provides a forwardly-directed force that assists in recoil impulse mitigation. Although springs are shown, and other suitable resilient means may also be used, For example, a closed pneumatic or hydraulic cylinder with a small accumulator.

35 The firing mechanism 19 includes a two-part bolt - front bolt 6 and housing 23. A firing pin 7 is located within the housing 1 and obtains its striking energy from a firing pin spring 8. The firing pin 7 is held in a retracted position by a release pin 9 until a firing pin

- 5 cam 10 on the receiver body (not shown) releases the release pin 9 thus enabling the firing pin 7 to move axially forwardly under the effect of spring 8.

Before firing, the front bolt 6 and the housing 23 are held separated by a bolt lever 11 pivotally mounted with respect to housing 23 by a pivot pin 26. Bolt lever 11 has a front
10 finger 27 that engages front bolt 6 to maintain the separation. A bolt lever spring 13 biases the bolt lever to the position shown – being just before firing – when the finger 27 is engaging the front bolt 6.

- 15 A bolt lever cam 12 on the receiver body (not shown) activates the bolt lever 11 to pivot it around pivot pin 26 against the effect of spring 13 to raise finger 27 to thus allow the front bolt 6 to move rearwardly so that the front bolt 6 can impact on the housing 23 during the firing processes.

- 20 When the weapon is prepared for firing (i.e. cocked) the bolt gear rack 1 is moved fully rearwardly. The pinion gear 3 therefore rotates to move the recoil inertia rack 2 forwards to the limit of its movement. This compresses the recoil springs 4. A sear lever 14 engages an end step 37 of recoil inertia rack 2 to hold the recoil inertia rack 2, and thus the bolt gear rack 1 and housing 23, in position.

- 25 Barrel 16 has a gas hole 32 that operatively connects to a gas passage 34 in body 22. Passage 34 passes gasses to a recoil cylinder 35 behind a recoil piston 15 so the gasses can move the piston 15 forwardly. Piston 15 has a recoil piston rod 17 operatively
connected thereto at a front end of rod 17. Rod 17 has its rear end operatively connected to recoil inertia rack 2 so that forward movement of piston 15 by the gasses will cause
30 recoil inertia rack 2 to move forwards. This gives a forwards inertia to the recoil inertia rack 2 and assists recoil impulse mitigation. The gas hole 32 may be at any suitable position along the barrel 16. As shown gas hole 32 is approximately 75% along the barrel 16.

- 35 The barrel 16 also assists in recoil impulse mitigation. The barrel has first rifling 28 extending along the barrel bore from chamber 30 towards the muzzle 31. First rifling 28 has a first number of first spiral grooves in the barrel bore. As shown, the first number is

5 six. At a predetermined location along the barrel 16, there is added a second rifling 29 having a second number of second spiral grooves in the barrel bore, the second rifling 29 having the same break of twist as the first rifling 28. The second number should be equal to or greater than the first number. In the preferred form shown, the second number is twelve. Both the first and second numbers may be different, the only requirement being
10 that the second number is equal to or greater than the first number. Preferably, the second number is a whole number multiple of the first number. The first rifling 28 continues to the muzzle 31 and the first spiral grooves are equally spaced. The second spiral grooves of the second rifling 29 are added between the first spiral grooves of the first rifling 28 and are again equally spaced from each other, and the first spiral grooves.

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The location of the commencement of the second rifling 29 can be varied. Preferably, it is immediately after the gas hole 32 so the increase in gas pressure resulting from the second rifling 29 will cause an increase in gas pressure in gas passage 34 and thus cylinder 35. This will assist the piston 15 in its forward movement and thus assist in
20 recoil impulse mitigation. The forwards movement of the gasses also assists the mitigation of the recoil impulse due to the gasses contacting an internal front face 33 of muzzle brake 18, and due to the forward force generated by the slowing of the projectile due to the second rifling 29.

25 When the weapon is triggered, the sear lever 14 releases from the end step 37 of the recoil inertia rack 2. The recoil inertia rack 2 is then forced rearwardly by the springs 4. Sear lever 14 slides along a relatively smooth track 38 on recoil inertia rack 2. Simultaneously, the bolt gear rack 1 is moved forwardly by the pinion gear 3. The front bolt 6 moves forwardly with the housing 23 and de-links a round from the round feed
30 mechanism (not shown). The round is fed into the chamber 30 by the front bolt 6 that remains in contact with the round until firing. When the round is sufficiently located in the chamber 30, the bolt lever cam 12 unlocks bolt lever 11 and the firing pin 7 is activated by the firing pin cam 10 to strike the round primer.

35 When the firing pin 7 strikes the round primer, the front bolt 6 is still moving forwardly. This is known as advance primer ignition and is when firing occurs before the front bolt comes to a complete stop. At this instant the propellant gasses generated by the firing

5 propel the projectile from the cartridge, and propel the cartridge rearwardly (to thus expel it from the chamber) together with the front bolt 6. This forces the front bolt 6 rearwardly and into contact with the housing 23, which is still moving forwardly. This forces housing 23 and thus bolt gear rack 1 to move together rearwardly. The conversion of the forward movement of bolt gear rack 1 to a rearward movement absorbs a large amount of
10 energy and thereby provides a mitigation of the recoil impulse. Due to pinion gear 3, the recoil inertia rack 2 is propelled forwardly compressing the springs 4 in the process. This absorbs recoil energy and thus mitigates the recoil impulse. The forward movement of the recoil inertia rack 2 continues until the recoil inertia rack 2 contacts end plate 21 to provide a further forwardly directed force to also mitigate the recoil impulse. When the
15 recoil inertia rack 2 contacts end plate 21, sear lever 14 engages the end step of the recoil inertia rack 2 at the end of the recoil inertia rack 2.

At the start of the movement of the recoil inertia rack 2, the pinion gear 3 will move against the action of the recoil die spring 5 as is described above. Not only does this
20 mitigate some of the recoil impulse, but it also reduces the potential force being exerted on the teeth of the pinion gear 3, bolt gear rack 1, and recoil inertia rack 2.

When the sear lever 14 engages the end step 37 of recoil inertia rack 2, the recoil cycle is completed. The recoil impulse (or force or energy) is neutralized by the combined action
25 of the:

- (a) opposing movement of the front bolt 6 and the bolt gear rack 1 (via housing 23);
- (b) recoil inertia rack 2 compressing the recoil springs 4;
- (c) pinion gear 3 compressing recoil die spring 5;
- 30 (d) the forwardly directed force from the slowing effect of the projectile induced by the second rifling 29;
- (e) the forward movement of the recoil piston 15; and
- (f) the impact of the propulsion gasses on the internal front face 33 of muzzle brake 18.

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Whilst there has been described in the foregoing description a preferred embodiment of the present invention, it will be understood by those skilled in the technology that many

- 5 variations in details of design or construction may be made without departing from the present invention.

The present invention extends to all features disclosed either singularly or in all possible permutations and combinations.

5 The claims.

1. A recoil mitigation mechanism including a first mass adapted to be moved in a first direction as a result of a firing action; and a second mass adapted to be moved in a second direction as a result of the firing action; and wherein the first mass is caused
10 to contact the second mass and to change the direction of movement of the second mass to the first direction to thereby mitigate a recoil impulse generated by the firing action.
2. A recoil mitigation mechanism as claimed in claim 1, wherein the first mass is a front bolt and the first direction is rearwards.
- 15 3. A recoil mitigation mechanism as claimed in claim 1 or claim 2, wherein the second mass is a bolt gear rack and the second direction is forwards.
4. A recoil mitigation mechanism as claimed in claim 2, wherein the bolt gear rack includes a housing, the housing being that part of the bolt gear rack adapted to be contacted by the first mass.
- 20 5. A recoil mitigation mechanism as claimed in claim 4, wherein the housing contains a firing mechanism, the firing mechanism including a bolt lever pivotally mounted with respect to the housing to maintain the front bolt and the housing separated.
6. A recoil mitigation mechanism as claimed in claim 5, wherein the bolt lever includes a front finger for engaging the front bolt to maintain the separation.
- 25 7. A recoil mitigation mechanism as claimed in claim 6, wherein there is provided a bolt lever spring to bias the bolt lever to a position where the front finger engages the front bolt.
8. A recoil mitigation mechanism as claimed in claim 7, wherein a bolt lever cam is able to activate the bolt lever against the effect of the bolt lever spring to raise front finger
30 to allow the front bolt to move rearwardly so that the front bolt can impact on the housing during the firing processes.
9. A recoil mitigation mechanism including a second mass adapted to be moved in a first direction as a result of a firing action, a third mass driven by a drive means in consequence of movement in the second mass in the first direction, the third mass
35 being driven in a second direction against the action of at least one resilient means to absorb energy of a recoil impulse.

- 5 10. A recoil mitigation mechanism as claimed in claim 9, wherein the second mass is a bolt gear rack and the second direction is forwards.
11. A recoil mitigation mechanism as claimed in claim 9 or claim 10, wherein the first direction is rearwards and the third mass is a recoil inertia rack.
12. A recoil mitigation mechanism as claimed in any one of claims 9 to 11, wherein the
10 drive means is a pinion gear.
13. A recoil mitigation mechanism as claimed in any one of claims 9 to 12, wherein the resilient means is at least one spring mounted to an upper surface of the third mass.
14. A recoil mitigation mechanism as claimed in claim 13, wherein the at least one spring is a pair of compression springs having a rear end thereof attached to a top surface of
15 the recoil inertia rack by a lug, and a forward end thereof attached to an end plate of a body securable to a barrel.
15. A recoil mitigation mechanism as claimed in claim 12, wherein the pinion gear is mounted on a spindle, the spindle being mounted in elongate holes in a second housing for movement relative thereto in an axial direction, the movement in the first
20 direction being to compress a recoil die spring.
16. A recoil mitigation mechanism including a body attachable to a barrel, the body having a gas passage therethrough to receive propulsion gasses from a gas hole in the barrel and to pass the propulsion gasses to a recoil cylinder, the gasses entering the recoil cylinder behind a recoil piston to force the piston in a forward direction to
25 provide the recoil mitigation.
17. A recoil mitigation mechanism as claimed in claim 16, wherein the recoil piston has a piston rod operatively connected thereto, the piston rod also being connected to a recoil inertia rack.
18. A recoil mitigation mechanism for a weapon having a barrel, the barrel having a
30 muzzle brake including an internal front face for contact by propulsion gasses to provide a forwardly directed force and thus recoil mitigation.
19. A recoil mechanism for a weapon having a barrel with a barrel bore, the barrel having a chamber at a first end thereof and a muzzle at a second end thereof, the first end being opposite the second end, the barrel bore having a first rifling extending from
35 the chamber to the muzzle, the first rifling having a first number of first spiral grooves; there being a second rifling extending from a location intermediate the

- 5 chamber and the muzzle to the muzzle, the second rifling having a second number of second spiral grooves.
20. A recoil mitigation mechanism as claimed in claim 19, wherein the second number is equal to or greater than the first number.
21. A recoil mitigation mechanism as claimed in claim 19 or claim 20, wherein the
10 second number is a whole number multiple of the first number.
22. A recoil mitigation mechanism as claimed in any one of claims 19 to 21, wherein the first number is six and the second number is twelve.
23. A recoil mitigation mechanism as claimed in any one of claims 19 to 22, wherein the location is forwardly - adjacent a gas hole in the barrel.
- 15 24. A recoil mitigation mechanism as claimed in any one of claims 19 to 23, wherein the location is 75% along the barrel.
25. A recoil mitigation mechanism as claimed in any one of claims 19 to 24, wherein the first rifling and the second rifling each have a break of twist that is the same.
26. A recoil mitigation mechanism as claimed in any one of claims 20 to 25, wherein the
20 first number of first spiral grooves are equally spaced.
27. A recoil mitigation mechanism as claimed in any one of claims 19 to 26, wherein the second number of second spiral grooves are located between the first number of first spiral grooves.
28. A recoil mitigation mechanism as claimed in claim 27, wherein the second spiral
25 grooves are equally spaced between the first spiral grooves.
29. A recoil mitigation mechanism including a drive means mounted on a spindle, the spindle being mounted in elongate slots in a housing for axial movement in the slots in a first direction against the action of a resilient means during an initial stage of a firing process, and to move in a second direction in response to the resilient means
30 restoring itself to its rest condition at the completion of the firing processes.
30. A recoil mitigation mechanism as claimed in claim 29, wherein the drive means is a pinion gear and the resilient means is a recoil die spring.
31. A recoil mitigation mechanism as claimed in claim 30, wherein the movements are without the pinion gear rotating.
- 35 32. A recoil mitigation mechanism as claimed in any one of claims 29 to 31, wherein the first direction is rearwards and the second direction is forwards.

- 5 33. A recoil mitigation mechanism as claimed in any one of claims 29 to 32, wherein the movement of the drive means in the first direction is with both a first inertia mass and a second inertia mass and is at the very beginning of the recoil impulse mitigation action such that at least a part of recoil energy is absorbed by the resilient means to mitigate the recoil impulse.
- 10 34. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in any one of claims 9 to 15.
35. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in claim 16 or claim 17.
- 15 36. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in claim 18.
37. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in any one of claims 19 to 28.
38. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in any one of claims 29 to 33.
- 20 39. A recoil mitigation mechanism as claimed in any one of claims 9 to 15 in combination with the recoil mitigation mechanism as claimed in claim 16 or claim 17.
40. A recoil mitigation mechanism as claimed in any one of claims 9 to 15 in combination with the recoil mitigation mechanism as claimed in claim 18.
- 25 41. A recoil mitigation mechanism as claimed in any one of claims 9 to 15 in combination with the recoil mitigation mechanism as claimed in any one of claims 19 to 28.
42. A recoil mitigation mechanism as claimed in any one of claims 9 to 15 in combination with the recoil mitigation mechanism as claimed in any one of claim 29 to 33.
- 30 43. A recoil mitigation mechanism as claimed in claim 16 or claim 17 in combination with the recoil mitigation mechanism as claimed in claim 18.
44. A recoil mitigation mechanism as claimed in claim 16 or claim 17 in combination with the recoil mitigation mechanism as claimed in any one of claims 19 to 28.
- 35 45. A recoil mitigation mechanism as claimed in claim 16 or claim 17 in combination with the recoil mitigation mechanism as claimed in any one of claims 29 to 33.

- 5 46. A recoil mitigation mechanism as claimed in claim 18 in combination with the recoil mitigation mechanism as claimed in any one of claims 19 to 28.
47. A recoil mitigation mechanism as claimed in claim 18 in combination with the recoil mitigation mechanism as claimed in any one of claims 29 to 33.
- 10 48. A recoil mitigation mechanism as claimed in any one of claims 19 to 28 in combination with the recoil mitigation mechanism as claimed in any one of claims 29 to 33.
49. A recoil mitigation mechanism as claimed in any one of claims 1 to 8 in combination with the recoil mitigation mechanism as claimed in any one of claims 9 to 15, claim 16 or claim 17, claim 18, any one of claims 19 to 28, or any one of claims 29 to 33.