United States Patent

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[72] Inventors **Eugene Ashley**
Burlington, Vermont;
Douglas P. Tassie, St. George, Vermont

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[73] Assignee **General Electric Company**
a corporation of New York

[54] **SELF COCKING SPRING STARTER AND BRAKE**
12 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **89/1,**
89/1.804, 89/12, 89/159, 89/177
[51] **Int. Cl.** **F41d 7/02**
[50] **Field of Search** 89/1, 1.4,
12, 13, 157, 160, 177; 124/6–9; 74/750, 753

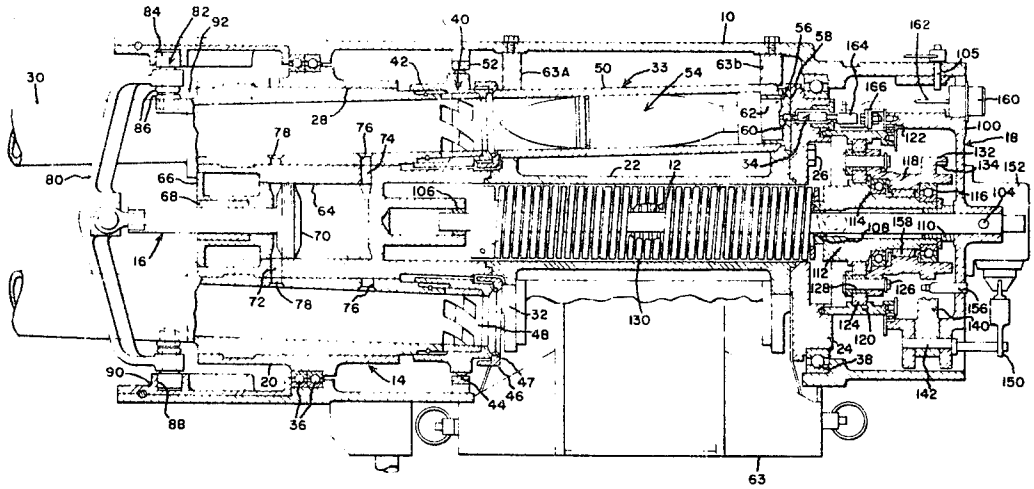
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Primary Examiner—Samuel W. Engle
Attorneys—Bailin L. Kuch, Irving M. Freedman, Harry C. Burgess, Frank L. Neuhauser and Oscar B. Waddell

ABSTRACT: A self cocking spring starter and brake for a Gatling-type rocket launcher includes a helical spring having one end anchored and the other end fixed to the sun gear of a single stage planetary gear train. The ring gear is fixed to the control cage of the launcher. The planet gear is journaled for unidirectional rotation and may be held stationary to brake the rotating launcher and recock the unwound spring; and may be released to permit the cocked spring to unwind to rotate the launcher.



Sheet 1 of 2

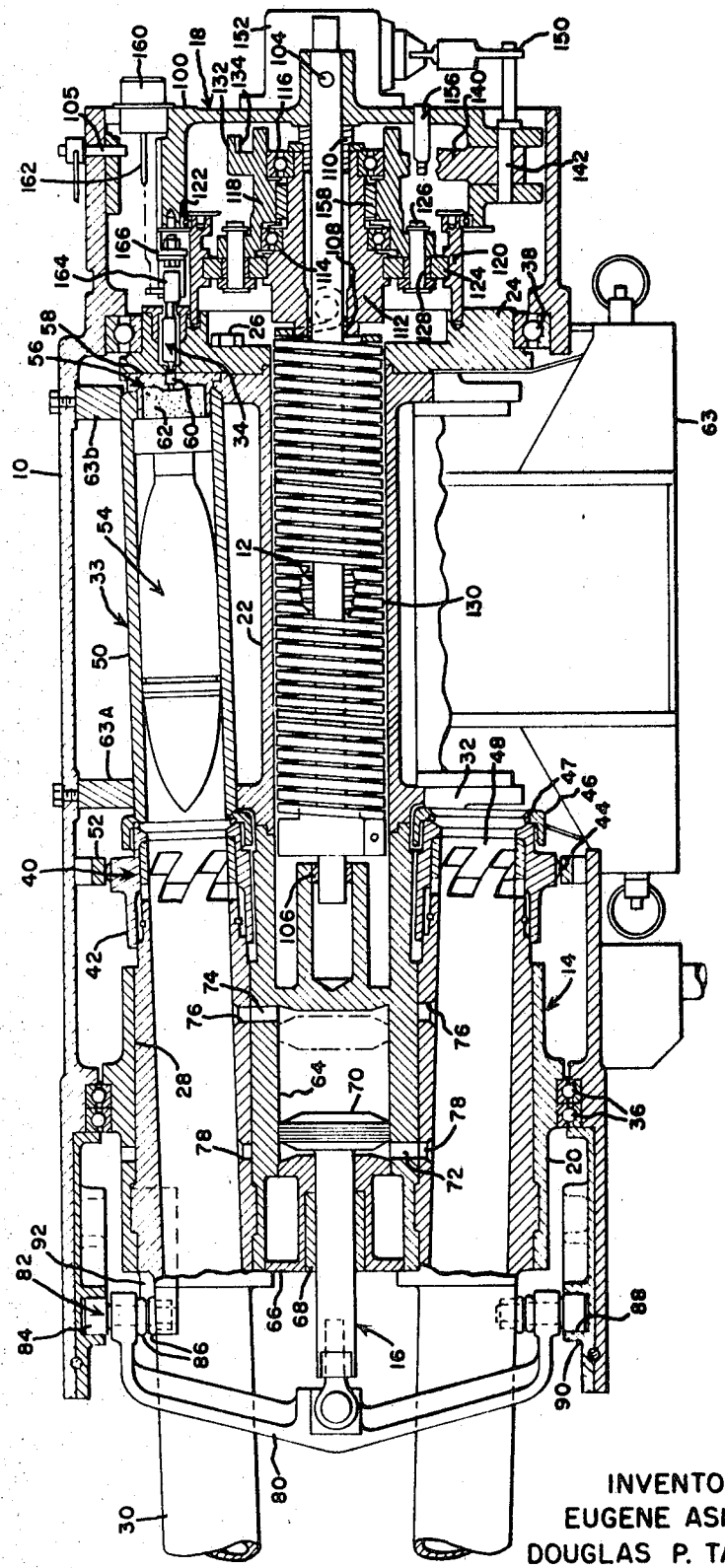


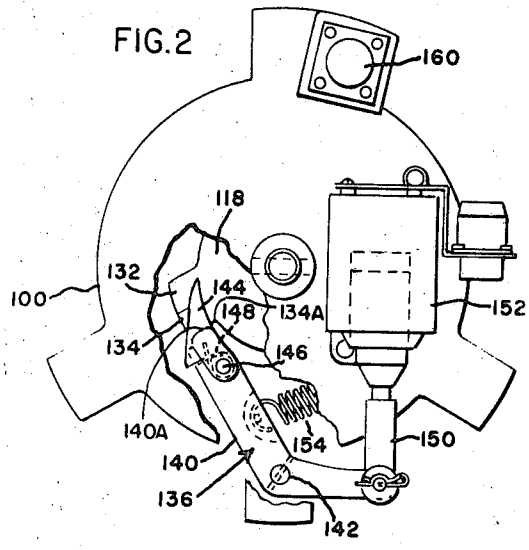
FIG. 1

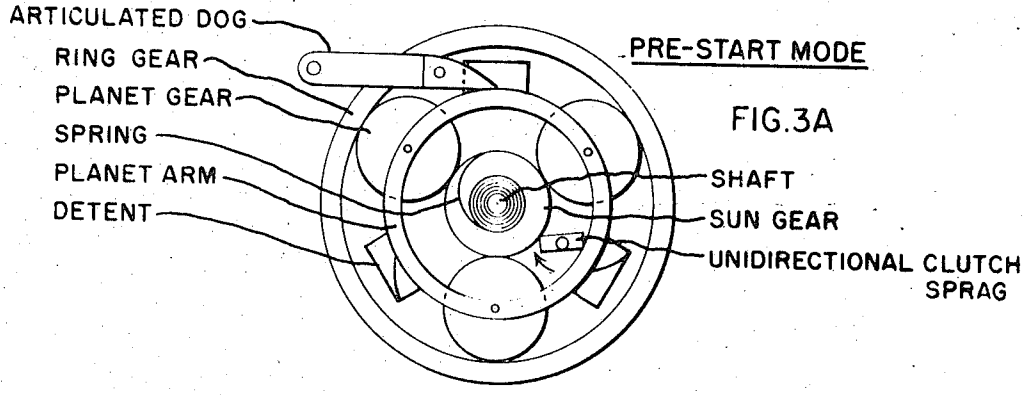
INVENTORS:
EUGENE ASHLEY,
DOUGLAS P. TASSIE,

BY

THEIR ATTORNEY.

FIG.2





PRE-START MODE

FIG.3A

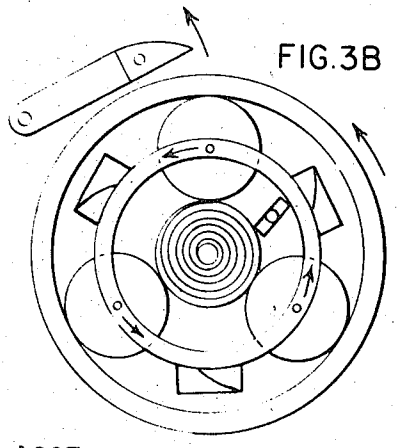


FIG.3B

ACCELERATION & FIRING MODE

REWIND & DECELERATION MODE

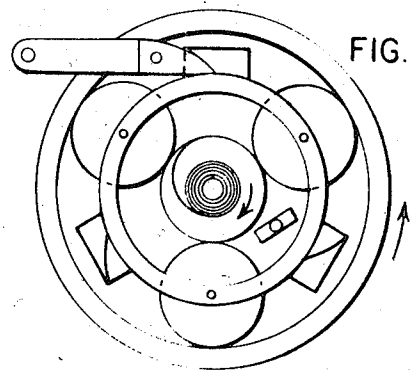


FIG.3C

INVENTORS:
EUGENE ASHLEY,
DOUGLAS P. TASSIE,

BY

THEIR ATTORNEY.

SELF COCKING SPRING STARTER AND BRAKE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to Gatling-type, projectile firing, weapons, and particularly to a self-cocking, spring starter and brake for such a weapon.

2. Description of the Prior Art

In a Gatling-type projectile launcher, a plurality of individual projectile guide barrels are mounted to a rotor about a common axis of rotation. Projectiles are serially fired through the barrels as they rotate about the common axis. Rates of fire on the order of 6,000 shots per minute may be obtained presently. The original Gatling gun utilized a hand crank to rotate the barrels on their rotor. The modern guns utilize one or more external sources of power for two functions: 1. to accelerate the rotor from stop to substantially firing speed, and 2. to maintain the rotor at firing speed. Braking devices may be provided to decelerate the rotor from firing speed to stop. The sources of power may include ram air turbines for the first function; electric motors for the first and/or second functions; and gun-gas operated pistons for the second function. Customarily, the gun is decelerated by withdrawing the power source, *e.g.*, the electric motor or the gun-gas.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a means for accelerating and decelerating a Gatling-type projectile launcher which does not require any external source of energy; nor require any energy from the launcher to the disadvantage of launcher's launching function.

It is a further object to provide such an accelerating and decelerating means which is economical in its cost of construction and maintenance, and troublefree in its operation.

A feature of this invention is the provision of an accelerating and decelerating system for a Gatling-type projectile launcher comprising a volute spring and a planetary gear train whose planet ring is journaled for unidirectional rotation and may be held alternatively stationary or released. One end of the spring is anchored and the other end is fixed to the sun gear. The ring gear is fixed to the rotor assembly of the launcher. Thereby, the planet ring may be halted to recock the unwound spring and decelerate the rotating launcher; and the planet ring may be released to permit the cocked spring to unwind to accelerate the launcher.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects, features and advantages will be apparent from the following specification thereof, taken in conjunction with the accompanying drawing in which:

FIG. 1 is a side view in elevation in a cross section taken through the longitudinal axis of a projectile launching weapon embodying this invention;

FIG. 2 is a rear end view in elevation of the weapon of FIG. 1; and

FIG. 3A, 3B and 3C are schematic views illustrating the principle of operation of the accelerating and decelerating system of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The embodiment illustrated in FIGS. 1 and 2 is a rocket launcher system for 40mm. rockets, having an open breech and six barrels. However, it will be appreciated that the same principle of operation of the accelerating and decelerating system may be incorporated into other Gatling-type weapons, such as a cannon system having a closed breech.

The launcher has a fixed outer annular housing **10**, a fixed, central longitudinal spring shaft **12**, a rotor assembly **14**, a piston assembly **16**, and a spring starter assembly **18**.

The rotor assembly **14** comprises a forward rotor **20**, a sprocket **22**, and an aft rotor **24**, all held in longitudinal alignment by a plurality of bolts **26**, disposed in an annular row. The rotor **20** has a plurality (six) of annularly spaced apart bores **28**, each of which receives one of a like plurality of projectile guiding barrels **30**. The sprocket has a like plurality of cutouts **32**, respectively aligned with the barrels **30**, and each adapted to receive and support a round **37** of rocket ammunition. The aft rotor **24** has a like plurality of firing pin assemblies **34**, respectively aligned with the sprocket cutouts **32**. The rotor assembly is mounted for rotation within the housing **10** by a forward pair of bearings **36** and an aft bearing **38**. A like plurality of sleeve assemblies **40** is respectively mounted on the aft end of the barrels **30**. Each of the sleeve assemblies **40** includes a sleeve **42** having a ball **44**, a nut **46** retaining a tubular metal O-ring **47**, and an internal helical sleeve **48**, which helical sleeve meshes with a helical cutout in the aft end of the barrel. Each ball **44** rides on an annular cam sleeve **52** fixed within the housing. The cam sleeve periodically rotates the sleeve **42** with respect to its barrels, which rotation is converted to longitudinal movement by the helical sleeve, to transverse the nut between a forward position whereat it is clear of a cannister **50** enclosing a respective rocket and an aft position whereat it and the O-ring abuts the forward end of the cannister to provide a gas seal between the cannister and the barrel. The nut is forward when the rocket is being on-loaded and off-loaded by the sprocket, and is aft when the rocket is being fired.

It may be noted that each rocket assembly **33** may comprise the cannister **50**, a rocket **54**, and an end cap assembly **56** including an end cap **58** with a primer cup **60** and a load of firing powder **62**; and that a plurality of assemblies may be serially belted together and supplied from a magazine **63**, and guided into and out of the sprocket by forward and aft guides **63A** and **63B**.

A bore **64** is provided in the forward end of the forward rotor **20** and receives a piston assembly comprising a cap **66**, a bushing **68** and a piston **70**. The head of the piston is slidable between a forward position whereat it is aft of a forward plurality of alternate gas ports **72** through the rotor, and a rearward position whereat it is forward of an aft plurality of alternate gas ports **74**. Some of the gas developed behind a rocket **54** as it is discharged through a barrel **30** initially passes through an aft port **76** in the barrel which is aligned with a respective port **74** in the rotor to traverse the piston forward. Some of the gas developed behind the next successive rocket as it is discharged through the next successive barrel passes through a forward port **78** in that barrel which is aligned with a respective port **72** in the rotor to traverse the piston rearward. The forward end of the piston is pivotally coupled to a trifurcated arm **80**, each of whose distal ends has journaled therein a respective cam follower assembly **82**. Each assembly has a respective centrifugal cam follower **84** and a pair of centripetal cams **86** mounted for rotation on a common shaft. Each of the centrifugal cam followers **84** is disposed in a three cycle cam track **88** formed in an annular sleeve **90** fixed within the forward end of the housing **10**. Each of the pairs of centripetal cams **86** is disposed in a respective one of three uniformly spaced apart cam follower slots **92**. Reciprocation of the piston results in the cam track **88** spiraling the centrifugal cam followers **84** and the pair of centripetal cams **86** rotating the forward rotor **20** and the associated rotor assembly **14**. By this system, supra, gun-gas from one plurality (six) of rockets is effective to rotate the rotor assembly one cycle, which assembly includes the projectile guiding barrels **30** and the projectile loading sprocket **22**. For a given gun powder charge and launcher moment of inertia, friction, etc. the gun-gas will rotate the rotor assembly at an eventually relatively constant velocity, *e.g.*, 1,000 r.p.m. For a launcher having six barrels, this will provide a rate of fire of 6,000 shots per minute. It will be appreciated that the launcher is customarily designed to have maximum accuracy at the design velocity, and for this reason it is desirable to bring the rotor assembly up to speed as rapidly as possible. Further, such weapons are normally fired for very short intervals of time, *e.g.*, the interval

that the weapon is actually laid on the target, and it is desirable to fire as many rounds as possible during this interval, and for this reason also, it is desirable to bring the rotor assembly up to speed as rapidly as possible.

For these reasons, it is an important feature of this invention to provide a system for rapidly accelerating the rotor assembly from stop to full velocity in a minumum time; and to do this repeatedly for closely spaced apart bursts of fire. Such a system is embodied in the spring starter assembly **18**, which will now be described.

The spring starter assembly **18** includes a housing **100** which is fixed to the aft end of the central shaft **12** by a pin **104** and is fixed to launcher housing **10** by a plurality of pins **105**. The shaft passes through a central bore in the sprocket **22** and at its forward end engages a bearing **106** which in turn journals within the aft end of the forward rotor **20**. Two spaced-apart bearings **108** and **110** are mounted on the shaft **12** and in turn journal a sun gear **112**. Two spaced-apart bearings **114** and **116** are mounted on the sun gear and in turn journal a planet arm **118**. A ring gear **120** is journaled to the housing **100** by a bearing **122** and is fixed to the aft rotor **24**. A plurality (three) of planet gears **124** is annularly spaced apart and journaled to the planet arm by respective shafts **126** and bearings **128**. Each planet gear meshes with the ring gear **120** and the sun gear **112**. A helical spring **130** is disposed about the shaft **12**, and has its forward end pinned to an enlargement on the shaft **12** and its aft end pinned to the exterior of the sun gear **112**. The planet arm has a plurality (three) of fingers **132** extending therefrom, each finger having a respective knife edged wedge detent **134** having a blunt supporting boss **134A** adapted to cooperate with an articulated dog or control gear assembly **136**. The articulated dog assembly includes a crank arm **140** which is pivotally mounted to the housing **100** by a shaft **142**. A knife edged wedge finger **144** is pivotally mounted to the knuckle **140A** of the crank arm by a shaft **146** and is biased centrifugally by a spring **148**. The other end of the crank axis is coupled to a link **150** which in turn is coupled to the plunger of a solenoid **152** which is mounted on the housing **100**. A tension spring **154** is pinned to and between the crank arm and a stud **156** fixed to the housing **100**, to normally bias the end of the crank arm mounting the finger **144** centripetally towards the detents **134**. Energization of the solenoid **152** will swing the finger **144** centrifugally from the detents **134**. A unidirectional clutch **158** is fixed to and between the sun gear and the planet arm. The clutch may be of the ball and sprag type wherein the balls journal the outer-planet arm race to the inner-sun gear race, while the sprags alternatively free the races for rotation in the permitted direction, and friction lock the races against rotation in the forbidden direction. An electrical connector **160** is mounted to the housing, and by means of a conductor **162**, supplies firing current to a cam contact **164** mounted on a bracket **166** which is also mounted to the housing. The cam contact will provide forward movement and firing current to the firing pin of the adjacent one of the plurality of firing pin assemblies to detonate the primer in the adjacent rocket.

To prepare the spring starter for operation, it must be initially cocked. This may be conveniently accomplished before a firing mission on the same occasion that the launcher is loaded. When the solenoid is deenergized, as shown in FIG. 3A, the spring **154** pulls the crank arm **140** and its finger **144** centripetally to engage one of the knife edged detents **134** and to thereby block rotation of planet arm **118** counterclockwise. The forward end of the spring **130** is at all times anchored to the fixed shaft **12**. Counterclockwise rotation of the rotor assembly **14**, as by the manual rotation of the cluster of gun barrels, will provide counterclockwise rotation of the fixed thereto ring gear **120**. The articulated dog assembly **140** will preclude counterclockwise movement of the planet arm. Planet gears **124** will thereby be driven in counterclockwise rotation about their respective axes, thus producing clockwise rotation of sun gear **112**, and winding up the spring **130** clockwise about the shaft. When manual rotation of rotor assembly **14** ceases, the unidirectional sprag clutch retains the sun gear in stationary position and maintains the spring in cocked condition by preventing rotation of the sun gear in the forbidden direction with respect to the planet arm.

To initate a firing burst, the solenoid **152** is energized and firing current is provided to the connector **160**. The solenoid plunger pulls the link **150**, which pivots the crank arm **140** against the bias of the spring **154**, to swing the finger end of the arm centrifugally, pivoting the finger under the bias of the spring **148** out from before the adjacent finger **132** to release planet arm for counterclockwise rotation. The spring **130** unwinds counterclockwise, rotating the sun gear counterclockwise. The unidirectional clutch is locked and causes the planet arm **118** to rotate counterclockwise. The planet gears, which do not rotate about their respective axes, rotate the ring gear **120**, and the rotor assembly **14** counterclockwise at the same speed as the sun gear. The spring unwinds rapidly, rapidly accelerating the rotor assembly to substantially firing velocity. Since rockets commence firing at the time of energization of the solenoid, gun-gas has been generated to drive the piston assembly **16**, which brings the rotor assembly up to firing speed at least by the time the spring has unwound. When the spring has unwound, as shown in FIG. 3B, the ring gear is driven counterclockwise by the rotor assembly, and the planet gears idle around the stationary sun gear.

To halt a firing burst and to recock the spring starter, as shown in FIG. 3C, the solenoid **152** is deenergized, the spring **154** pulls the finger end of the crank arm centripetally, the knife edge of the centripetally biased finger **144** rides under the knife edge of the next adjacent detent **134**, and locks up under the detent, halting the planet arm from further counterclockwise rotation. The ring gear **120**, driven up by the rotor assembly continues rotating counterclockwise, rotating the planet gears counterclockwise about their now stationary axes, thereby rotating the sun gear **112** clockwise to wind up the spring **130**. The spring is made of adequate strength so that when it is fully wound it halts the rotation of the sun gear and thereby the ring gear and the fixed thereto rotor assembly, overcoming the tendency of the gun-gas developed by the last rocket delivered adjacent the cam contact to further rotate the rotor assembly. At this time, or subsequently, firing current is removed from the connector **160**. The firing burst has ended; and the spring starter is cocked and ready for the next firing burst.

It will be appreciated that a significant advantage of the interacting knife edges of the finger and detent is that it is a go or no-go interaction. Either the knife edge of the finger clears the knife edge of the detent, in which case there is no interaction, or it does not clear, in which case the finger passes under the detent and the knuckle end of the arm **140** locks up. There is no partial or bouncing engagement with one or subsequent detents with mechanical damage thereto. The knuckle linkage is so proportioned that a relatively small rotary force can displace the knuckle joint into an out-of-line condition. The larger endwise load will continue to restrain the linkage thereafter until the planet arm is fully released.

The starter is not position sensitive in rewind. That is, the spring may stop in any angular position when its rewind is complete. The sprags engage to retain the rewind, and no further action is required to store energy for the next start. This feature eliminates the need for a torsional buffer, which would arise if the spring was seared directly with a positive latch-type engagement. In effect, the spring acts as its own buffer. A small margin of over capacity is designed into the spring to allow it to absorb, with safety, the highest rotational energy developed by the rotor assembly.

It will be appreciated that the planetary system provides an extended deceleration interval, with a mechanical advantage for the rewinding of the spring, according to the tooth ratio. In actual launcher operation, when environmental or other conditions act to vary the level of rotational energy developed by the rotor assembly, a varying angle of rewind will be the only result. The starter is designed to assure that the smallest an-

ticipated rewind angle will still provide sufficient starting acceleration. If, later conditions favor higher energies and greater rewind angles, faster starts will result without prejudice to the system.

When the ammunition complement is completely fired out, and the last rocket is fired from the launcher, the spring will not be rewound. If a rewind is desired, then a last-round detection switch can be used to open the solenoid circuit before the last rockets are fired.

We claim:

1. A starter-brake system for a rotating device comprising:
a housing;
a central shaft fixed to said housing defining a longitudinal axis;
a sun gear journaled for rotation about said axis;
a planet arm journaled for rotation about said axis;
a ring gear journaled for rotation about said axis, and adapted to be fixed to the rotating device;
a plurality of planet gears respectively journaled to said planet arm and meshed to and between said ring and sun gears;
spring means having two opposed ends, one of said ends fixed to said shaft, the other of said ends fixed to said sun gear, whereby rotation of said sun gear in one direction winds up said spring means and rotation in the other direction unwinds said spring means;
unidirectional clutch means operable between said planet arm and said sun gear for permitting relative movement therebetween when said planet arm rotates relatively in said spring windup direction and for precluding relative rotation in the opposite direction; and
sear means for alternatively permitting rotation of said planet arm and for precluding rotation of said planet arm in said spring unwind direction; whereby when the rotating device is fixed to said ring gear and is rotating, and said gear means precludes rotation of said planet arm, then said clutch means permits rotation of said sun gear in said spring windup direction, and said ring gear rotates said sun gear via said planet gears to wind up said spring means, which decelerates said rotating device, and when said rotating device is halted and said spring means is wound up, and said gear means permits rotation of said planet arm, then said clutch means permits rotation of said sun gear in said spring unwind direction, and said sun gear, driven by said spring means, accelerates said ring gear via said planet gears.

2. A starter-brake system according to claim 1 wherein:
said sear means is disposed in part on said planet arm and in part on said system housing; and
whereby said system may be coupled to or decoupled from the rotating device, when stationary, in either a spring wound or unwound condition.

3. A starter-brake system according to claim 2 wherein:
said sear means includes;
a plurality of detents on said planet arm; and
a locking dog which is normally biased away from said detents and which is operable to engage one of said detents to halt said planet arm from rotation in said spring unwind direction.

4. A starter-brake system according to claim 3 wherein:
each of said detents on said planet arm includes a substantially tangentially directed wedge; said locking dog has a wedge end which is substantially tangential to said planet arm; whereby when said dog is operated to engage one of said detents to halt said planet arm; and
said dog wedge end either positively centrifugally clears any detent or positively centripetally engages such detent.

5. A starter-brake system according to claim 4 wherein said dog wedge end is articulated with respect to the remainder of said dog.

6. A starter-brake system according to claim 4 wherein:
said dog is mounted for pivotal movement about an axis parallel to said longitudinal axis, and said dog wedge end subportion is mounted to the remainder of said dog for pivotal movement about an axis parallel to said longitudinal axis;
said dog remainder portion is normally biased in said spring unwind direction; and
said dog wedge end is normally biased in said spring windup direction.

7. A projectile launching system including:
a rotor system journaled within a housing for rotation about a longitudinal axis and adapted to load and fire projectiles while rotating about said axis; and
a starter-brake system for said rotor system including:
an additional housing fixed to said housing;
a central shaft fixed to said housing and concentric with said longitudinal axis;
a sun gear journaled for rotation about said axis;
a planet arm journaled for rotation about said axis;
a ring gear journaled for rotation about said axis and fixed to said rotor system for rotation therewith;
a plurality of planet gears respectively journaled to said planet arm and meshed to and between said ring and sun gears;
spring means having two opposed ends, one of said ends fixed to said shaft, the other of said ends fixed to said sun gear, whereby rotation of said sun gear in one direction winds up said spring means and rotation in the other direction unwinds said spring means;
unidirectional clutch means operable between said planet arm and said sun gear for permitting relative movement therebetween when said planet arm rotates relatively in said spring windup direction and for precluding relating rotation in the opposite direction;
sear means for alternatively permitting rotation of said planet arm and for precluding rotation of said planet arm in said spring unwind direction; and
whereby when said rotor system is rotating and said sear means precludes rotation of said planet arm, then said clutch means permits rotation of said sun gear in said spring windup direction, and said ring gear rotates said sun gear via said planet gears to wind up said spring means, which decelerates said rotor system, and when said rotor system is halted and said spring means is wound up, and said gear means permits rotation of said planet arm, then said clutch means permits rotation of said sun gear in said spring unwind direction, and said sun gear, driven by said spring means, accelerates said rotor system via said planet gears and said ring gear.

8. A projectile launching system according to claim 7 wherein:
said sear means is disposed in part on said planet arm and in part on said system housing; and
whereby said system may be coupled to or decoupled from the rotor system, when stationary, in either a spring wound or unwound condition.

9. A projectile launching system according to claim 8 wherein:
said sear means includes;
a plurality of detents on said planet arm; and
a locking dog which is normally biased away from said detents and which is operable to engage one of said detents to halt said planet arm from rotation in said spring unwind direction.

10. A projectile launching system according to claim 9 wherein:
each of said detents on said planet arm includes a substantially tangentially directed wedge, and said locking dog has a wedge end which is substantially tangential to said planet arm; and
whereby when said dog is operated to engage one of said detents to halt said planet arm, said dog wedge end either positively centrifugally clears any detent or positively centripetally engages such detent.

11. A projectile launching system according to claim 10 wherein said dog wedge end is articulated with respect to the remainder of said dog. axis; and

12. A projectile launching system according to claim 11 wherein:

said dog is mounted for pivotal movement about an axis parallel to said longitudinal axis, and said dog wedge end

is a subportion mounted to the remainder of said dog for pivotal movement about an axis parallel to said longitudinal axis; and

said dog remainder portion is normally biased in said spring unwind direction, and said dog wedge end is normally biased in said spring windup direction.