

AMMUNITION HANDLING SYSTEM

5 INTRODUCTION

This invention relates to an ammunition handling system for a gun and more particularly to such a system which accurately and automatically delivers a series of rounds to the breech of a gun, preferably a large calibre gun.

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BACKGROUND

Ammunition supplying systems are well known wherein a large calibre gun is mounted on a gun carriage. The barrel of the gun is controllable in elevation on the carriage and the carriage is controllable in azimuth. For example, in U.S. Patent No. 3,218,930, the invention relates to an ammunition handling system wherein stationary magazines provide a projectile to a hoist which lifts the projectile up to a carrier. The carrier receives the projectile and rotates to the azimuth position of the gun carriage. When the carrier reaches the gun azimuth position, the projectile is received from the carrier by a cradle in the gun carriage which is rotated about the gun support trunnion upwardly to a position such that the projectile is adjacent the rear of the gun and the cradle axis is parallel to the axis of the gun bore. The projectile is transferred from the cradle to a transfer tray and the tray is then swung downwardly to a position which is coaxial with the bore of the gun. The projectile is then rammed into the breech to complete the transfer from the magazine to the gun breech.

In recent years, projectile magazines have been used with large calibre artillery weapons to achieve a higher rate of fire, as compared to manual loading by human operators. The existing projectile magazines that are currently operating in the artillery weapon industry usually have separate projectile tubes linked by

means of a chain, a conveyor belt or any other means of linkage for the projectile indexing control. Although this design method may function well according to the specification, it may incur some adverse effects due to the fact that the individual projectile tubes are linked (and therefore dependent) on one another. Hence
5 when the system is subjected to harsh operating conditions and prolonged period of usage, some negative effects occur:

- 10 (a) Dynamic loading when the magazine is operating on a rough terrain, causing the tension of the chain to loosen and hence affecting the indexing accuracy of the system;
- (b) Backlash in the magazine due to the wear and tear of the chain or belt that is linking all the projectile tubes, hence affecting the indexing accuracy of the system;
- 15 (c) Periodic maintenance to maintain the required chain tension, hence incurring higher operating costs.

The objective of the present invention is to overcome the above defects of the
20 prior art.

SUMMARY OF THE INVENTION

According to the present invention there is provided an ammunition handling
25 system comprising a support for supporting a plurality of projectile tubes, each of said projectile tubes being adapted to house a projectile, guide means on the support for guiding the projectile tubes along a predetermined path, and first drive means for driving the projectiles tubes along the path, wherein the projectile tubes are juxtaposed close enough together so that when in movement along the path
30 they are capable of pushing each other along the path. Thus, the projectile tubes can be driven along the path without the need for any connecting chain or belt, as



the application of a sufficient driving force to one of the projectile tubes will automatically push all downstream projectile tubes along the path. It will be appreciated that the projectile tubes can be moved along the path by pushing them from behind the direction of motion, rather than pulling a chain or belt to
5 which they are secured.

It is preferred that the projectile tubes are arranged in engagement with one another. However, a small gap between the tubes may be acceptable, provided that the projectile tubes can be properly aligned with the drive means and with the
10 loading and discharge apertures described below.

Although it is possible, in principle, for the drive means to drive only one projectile tube at any time. we prefer that a plurality of projectile tubes are directly driven simultaneously by the drive means. However, we also prefer that the majority of
15 the projectile tubes are not directly driven by the drive means, i.e., we prefer that the majority of the projectile tubes are pushed along by adjacent projectile tubes. We generally prefer to drive directly at least 10% of the projectile tubes, more preferably at least 15% thereof. In general. we prefer that less than about 25% of the projectile tubes are directly driven by the drive means. Typically there would
20 be between 15 and 30, most typically 22, projectile tubes, and we would prefer that about 3 to 7, preferably 4 to 5, of them were directly driven by the drive means.

Preferably the predetermined path is in the form of a closed loop whereby
25 movement of any one of the projectile tubes along the path causes movement of all the other projectile tubes around the loop.

In the preferred embodiment the drive means includes at least one drive wheel having a plurality of circumferential recesses adapted to receive one of the
30 projectile tubes therein, the arrangement being such that rotation of the drive wheel drives said projectile tube along said path. The drive wheel may



conveniently be configured in the form of a sprocket wheel, i.e., a toothed wheel with the recesses located circumferentially between the teeth. The or each drive wheel may have, for example, 3 to 11 recesses, preferably 7 recesses, equi-spaced about its circumference.

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In one embodiment there are 22 projectile tubes and a drive wheel with 7 recesses, and at any given time 5 projectile tubes will be received within the recesses, whereby rotation of the drive wheel directly drives these 5 projectile tubes. The other projectile tubes will be pushed along the path by the directly
10 driven projectile tubes.

The path of a single projectile tube is as follows. When the projectile tube is outside of engagement with one of the drive wheel recesses, it is pushed along the path by the force of an adjacent upstream projectile tube, and it pushes an
15 adjacent downstream projectile tube along the path. As movement continues, the projectile tube eventually moves into one of the recesses of the rotating drive wheel. At this time the projectile tube is driven along the path by the force of the engagement with the drive wheel, i.e., the walls of the recess engage and push the projectile tube. The path is arcuate when the projectile tube is received with
20 the recess. After rotating through approximately 180° about the rotational axis of the drive wheel, the projectile tube moves out of the recess of the drive wheel, and is again driven by the upstream projectile tube.

In the preferred embodiment, the path is in the form of an elongate loop. The
25 projectile tubes are preferably closely packed along the loop so that it is not possible for any of the projectile tubes to move along the path independently of the other projectile tubes.

A gear reduction unit is preferably operatively arranged between the electric motor
30 and the or each drive wheel to drive the drive wheel in an indexed fashion.

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A hand crank is desirable for rotating the or each drive wheel manually. The ammunition handling system would normally be automated, and the provision of a hand crank enables the system to be operated manually in the event of a failure of the automation.

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In the preferred embodiment, the support comprises two spaced plates and the projectile tubes are disposed between the support plates. The guide means preferably comprises a guide track in each of the support plates, and each end of the projectile tubes is preferably retained in a respective one of the guide tracks.

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It is preferred that one of the support plates is provided with a loading aperture, and that the projectile tubes are selectively alignable with said loading aperture in order to load a projectile into the projectile tube aligned with the loading aperture. The loading aperture is usually known in the art as a fuse setting port, and it can be used for manually setting the fuse for the projectile and/or for loading the projectile into the projectile tube. It is also possible to discharge projectiles through the loading aperture.

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It is further preferred that the other of the support plates is provided with a discharging aperture, and that the projectile tubes are selectively alignable with said discharging aperture in order to discharge a projectile from the projectile tube aligned with the discharging aperture. The discharging aperture is usually known in the art as a transfer port, and it is used for discharging the projectile from the projectile tube onto a transfer arm.

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A discharging mechanism is preferably provided for discharging a projectile from one of the projectile tubes when it is aligned with said discharging aperture. The discharging mechanism preferably comprises a discharging member adapted to push the projectile out of the projectile tube, and a second drive means, preferably in the form of an electric motor adapted to drive the discharging member into and out of the projectile tube.

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The ammunition handling system desirably further comprises a sensor for detecting when the discharging member has been retracted from the projectile tube following discharge of the projectile. A control means may be operatively linked to the sensor and to the first and second drive means in order to control
5 activation of the first and second drive means in response to signals from the sensor.

The ammunition handling system according to the invention is preferably in the form of a projectile magazine in which the projectile tubes are arranged in a
10 carousel-like fashion.

In the invention disclosed herein, the indexing of the projectile tubes of the magazine is achieved without the means of a chain, belt or other form of linkage. The indexing is achieved by means of a "pushing force", produced when the
15 sprockets are driven by an electrical motor, that "pushes" the individual projectile tubes along the track path. This chainless/linkless design concept of this system will greatly minimize the effects of backlash, giving a better accuracy during the indexing of the projectile. It will also reduce the effects of dynamic loading when operating on a rough terrain and much less maintenance will be required. The
20 operating cost will be much lower since the frequency of maintenance is lower in this design, making it a more economical system on a long-term basis.

BRIEF DESCRIPTION OF THE DRAWINGS

25 The drawings herein relate to one preferred embodiment of the invention.

Figure 1 shows the rear cross-sectional view of the projectile magazine. In this drawing, the layout of the projectile tubes and the sprocket can be seen;

30 Figure 2 provides an isometric view of the projectile magazine. In this drawing, some of the projectile tubes are removed so that the track path can be clearly



seen;

Figure 3 is an enlarged picture showing the sprocket driving the projectile tubes along the track path.

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Figure 4 is a close-up perspective view of the locking sleeve and restrainers

Figure 5 is a cross-sectional view illustrating the transfer of the projectile from the projectile tube to the bridge, which will in turn lead to the transfer arm and the
10 firing chamber of the gun.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION
WITH REFERENCE TO THE DRAWINGS

- 15 With reference to Figures 1, 2, 3 and 4 of the drawings, a projectile magazine (1) which has the capacity to store up to 22 projectiles (20) is disclosed. The projectiles (20) are stored horizontally in individual projectile tubes and each projectile is held in place in the tube by the locking sleeve (10).
- 20 The projectile tubes (2) are placed together in an adjacent manner, forming a rigid closed loop carousel system. Cam followers (3) are incorporated on the sides of each projectile tube (2), which run on the track path (4) that is machined onto the two track plates (5). These projectile tubes (2) are rotated bi-directionally by a pair of sprockets (6) that are splined on the sprocket shaft (7). An electric drive unit
25 or motor (8) drives the sprockets which in turn moves the projectile tubes (2) in the projectile magazine (1). The electrical motor (8) drives the sprocket shaft (7) via a gear reducer (22) for the indexing of the magazine (1). The rotation of the sprocket (6) produces a "pushing force" to drive the projectile tubes (2), which in turn pushes on another in the closed loop since they are packed closely in an
30 adjacent manner.

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The locking sleeve (10), which slides on the projectile tube (2) is actuated by a solenoid (23). It has two sets of restrainers (17), which are designed to accommodate the four types of projectile configurations. The function of these restrainers (17) is to prevent the projectiles (20) from moving forward while the
5 projectile stopper (18) prevents it from moving in the backward direction. In this way, the projectile (20) is held in place in the projectile tube (2).

The restrainers (17) are designed to remain at their locked position by means of torsion springs. When the locking sleeve (10) is shifted in place with the lock face
10 of the restrainers (17), it restricts the restrainers (17) from opening out, thereby locking the restrainers (17). Upon activation of the solenoid (23), the locking sleeve will return to its initial position by its spring, and the restrainers (17) are now free. The various stopping positions for the locking sleeve are catered for due to different projectile configurations.

15 The projectile stopper (18) is designed to remain in its locked position by means of torsion springs. During replenishment, the projectile is pushed through the resupply port (25). In the process, it releases the projectile stopper (18) and allows the projectile to enter into the projectile tube (2). After the projectile is fully
20 seated inside the projectile tube (2), the projectile stopper (18) will automatically spring back and lock at its position, to prevent the projectile from sliding out.

In the event of a power failure, a detachable hand crank (24) is provided to recover projectiles (20) from the projectile magazine (1).

25 Figure 2 illustrates that there are two openings on the projectile magazine track plate (5). One of the openings (13) is located at the top, which is for transfer of projectiles (20) out from the projectile magazine (1) to the transfer arm. It is known as a "transfer port". The second opening (12) is located at the bottom centre of
30 the track plate (5), which is known as a "fuse setting port". It is used for manually setting the fuse, and for the download or upload of projectiles (20). There may



optionally be a third opening located outside the vehicle (25), at the bottom position of the projectile magazine track plate. It is known as a "resupply port" which is provided for projectile replenishment from the resupply vehicle.

- 5 When a particular type of projectile is required, the Ammunition Handling Control Unit (AHCUC), comprising a computer microprocessor, checks the projectile's inventory stored in its memory. It then sends a signal to activate the motor to index the projectile tubes (2). The electric motor (8) drives the sprocket shaft (7) holding the sprockets (6) through a gear reduction unit. The projectile tubes (12)
- 10 are moved to index the desired projectile (20) to the transfer position.

With reference to Figure 5, the transfer mechanism for transferring the projectile (20) to the bridge (16, in Figure 2) is shown. Transfer of the projectile (20) to the bridge (16) is achieved by using a mechanical jack assembly (19) that is bolted

15 externally to the rear panel of the projectile magazine. The mechanical jack assembly (19) houses a rigid chain (15) which has a pusher attached to the end of the chain. The motive power to the assembly (19) is provided by an electric motor for the rigid chain (21) mounted to the flange adapter (9) on one side of the rigid chain unit.

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When the correct projectile (20) has been indexed to align with the transfer port (13) in the magazine, the AHCUC will signal to the transfer mechanism to push the projectile into the bridge (16) and transfer arm (not shown). The electric motor (21) will be activated to drive the rigid chain (15) in the mechanical jack assembly

25 (19) through a gear transmission. Extension of the rigid chain (15) and pusher (14) from the mechanical jack assembly (19) pushes the projectile (20) out of the projectile magazine (1) over a bridge (16) and finally into the transfer arm (not shown).

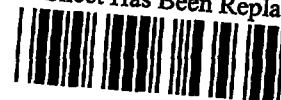
- 30 Once the projectile (2) has reached its destination, the rigid chain (15) will retract into the mechanical jack assembly (19) by the reversal of the rotation in the



electric motor (21). A sensor at the parked position of the pusher (14) will indicate to the AHCU that the rigid chain (15) has fully retracted for the indexing of the magazine for the transfer of the next projectile (20).

- 5 The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

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PARTS LIST WITH REFERENCE TO THE DRAWINGS

Part No.	Name of Part
1	Projectile Magazine
2	Projectile Tubes
3	Cam Followers
4	Track Path
5	Track Plate
6	Sprocket
7	Sprocket Shaft
8	Electric Motor
9	Flange Adapter
10	Locking Sleeve
11	Sighting Aperture
12	Fuse Setting Port
13	Transfer Port
14	Pusher
15	Rigid Chain
16	Bridge
17	Restrainers
18	Projectile Stopper
19	Mechanical Jack Assembly
20	Projectile
21	Electric Motor for Rigid Chain
22	Gear Reducer
23	Solenoid
24	Hand Crank
25	Resupply Port



CLAIMS:

1. An ammunition handling system comprising a support for supporting a plurality of projectile tubes (2), each of said projectile tubes (2) being adapted to house a projectile (20), guide means on the support for guiding the projectile tubes (2) along a predetermined path, and first drive means for driving the projectiles tubes (2) along the path, wherein the projectile tubes (2) are juxtaposed close enough together so that when in movement along the path they are capable of pushing each other along the path.
2. A system according to claim 1, wherein the predetermined path is in the form of a closed loop.
3. A system according to claim 2, wherein the projectile tubes are closely packed along the loop so that it is not possible for any of the projectile tubes to move along the path independently of the other projectile tubes.
4. A system according to claim 1, 2 or 3, wherein the first drive means is arranged to drive directly at least one of, but not all of, the projectile tubes (2).
5. A system according to claim 1, 2, 3 or 4, wherein the first drive means is arranged to drive directly less than 50% of the projectile tubes (2).
6. A system according to any preceding claim, wherein the drive means includes at least one drive wheel (6) having a plurality of recesses each adapted to receive one of the projectile tubes (2) therein, the arrangement being such that rotation of the drive wheel (6) drives the projectile tubes (2) received within said recesses along said path.
7. A system according to claim 6 wherein the first drive means further includes an electric motor (8) arranged to drive rotation of the or each drive wheel (6).



8. A system according to claim 7, further comprising a gear reduction unit operatively arranged between the electric motor (8) and the or each drive wheel (6) to drive the drive wheel (6) in an indexed fashion.

9. A system according to claim 7 or 8, further comprising a hand crank for rotating the or each drive wheel (6) manually.

10. A system according to any preceding claim, further comprising a locking sleeve (10) held by restrainers (17), and a projectile stopper (18) on the or each projectile tube (2) to hold the projectile (20) in place.

11. A system according to any preceding claim, wherein the support comprises two spaced plates (5) and the projectile tubes (2) are disposed between the support plates (5).

12. A system according to claim 11, wherein the guide means comprises a guide track (4) in each of the support plates (5), and each end of the projectile tubes (2) is retained in a respective one of the guide tracks (4).

13. A system according to claim 11 or 12, wherein one of the support plates (5) is provided with a loading aperture (12), and the projectile tubes (2) are selectively alignable with said loading aperture (12) in order to load a projectile (20) into the projectile tube (2) aligned with the loading aperture (12); and the other of the support plates (5) is provided with a discharging aperture (13), and the projectile tubes (2) are selectively alignable with said discharging aperture (13) in order to discharge a projectile (20) from the projectile tube (2) aligned with the discharging aperture (13).

14. A system according to claim 13, further comprising a discharging mechanism for discharging a projectile (20) from one of the projectile tubes (2) when it is aligned with said discharging aperture (13).



15. A system according to claim 14, wherein the discharging mechanism comprises a discharging member (15) adapted to push the projectile (20) out of the projectile tube (2), and a second drive means in the form of an electric motor (21) adapted to drive the discharging member into and out of the projectile tube (2).

16. A system according to claim 15, further comprising a sensor for detecting when the discharging member (15) has been retracted from the projectile tube (2) following discharge of the projectile (20), and further comprising a control means operatively linked to the sensor, and to the first and second drive means in order to control activation of the first and second drive means in response to signals from the sensor.

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