A rock pulverizer device based on a superconducting linear motor. The superconducting electromagnetic rock pulverizer accelerates a projectile via a superconducting linear motor and directs the projectile at high speed toward a rock structure that is to be pulverized by collision of the speeding projectile with the rock structure. The rock pulverizer is comprised of a trapped field superconducting secondary magnet mounted on a movable car following a track, a wire wound series of primary magnets mounted on the track, and the complete magnet/track system mounted on a vehicle used for movement of the pulverizer through a mine as well as for momentum transfer during launch of the rock breaking projectile.
APPARATUS AND METHOD TO PULVERIZE ROCK USING A SUPERCONDUCTING ELECTROMAGNETIC LINEAR MOTOR

GOVERNMENTAL INTEREST

The U.S. Government has a paid-up license in this invention, and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of a grant awarded by the National Aeronautics and Space Administration (NASA).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to a method and apparatus for pulverizing a formation including useable raw materials such as an ore, coal or the like using a high speed projectile accelerator to hurl projectiles at the formation to breakup or pulverize a portion of an exposed surface of the formation.

More particularly, the invention relates to an apparatus for hurling one projectile or a plurality of projectiles at an exposed surface of a formation including a projectile car mounted on a track having two parallel rails, where the car includes a trapped field magnet and the track includes a plurality of electromagnets that can be turned on and off as the car moves down the track accelerating the car to a desired velocity. The apparatus also includes a stop assembly at its distal end designed to engage and nearly instantaneously stop the forward motion of the car expelling the projectile or the projectiles disposed in a projectile holder on the car. If the distal end of the apparatus is positioned adjacent a surface, then the projectile would impact the surface breaking or pulverizing the surface. The invention also relates to a method for breaking up or pulverizing a surface using the apparatus of this invention. In one embodiment, the apparatus comprises a superconducting linear motor.

2. Description of the Related Art

The mining industry has a significant need for an apparatus and method to breakup large rock sections loosened during mining operations such as blasting or other means. These rock sections can be up to 30 cubic meters in volume, and require break up into smaller pieces for transport out of the mine. Several approaches have been tried including: (1) additional blasting—this is not necessarily cost effective due to the need for drilling new set-charge holes, setting new charges, evacuating the mine and removing the residual gas; (2) steam/compressed air hammers—this requires a source of steam or compressed air and is limited as to hammer size and velocity; and (3) rf induction heating to fractionate—this requires water porosity of the rock structure, large and inefficient rf transmitters and safety procedures to protect against high levels of rf radiation. To pulverize a 30 cubic meter section of rock, energy of approximately 1 Mjoule is required. As an example, for a projectile launcher, this would require a projectile of approximately 1,000 kg at a speed of about 33 meters/sec (about 75 miles/hr). These requirements show the inadequacy of using a steam/compressed air hammer approach to break rock.

Electromagnetic motors have been described for the acceleration of a mass for warfare applications as in a rail gun in U.S. Pat. No. 5,078,043 (column 5) which patent is incorporated herein by this reference. The inclusion of superconducting material to a rail gun has also been described in U.S. Pat. No. 4,901,621 (column 2), which patent is incorporated herein by this reference.

There is a need, therefore, for a system (such as an electromagnetic launch system) to accelerate a projectile to the required speed over moderate lengths compatible with mine dimensions and mine operations and cause pulverization of rock with the projectile.

SUMMARY OF THE INVENTION

The apparatus of the present invention is a trapped field superconducting secondary magnet mounted on a movable car following a track, a wire wound series of primary magnets mounted on the track, and the complete magnet/track system mounted on a vehicle used for movement of the pulverizer through a mine and for momentum transfer during launch of the rock breaking projectile. The method of the present invention accelerates a projectile via a superconducting linear motor and directs the projectile at high speed toward a rock structure that is to be pulverized by collision of the speeding projectile with the rock structure.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be better understood with reference to the following detailed description together with the appended illustrative drawings in which like elements are numbered the same:

FIGS. 1A&B depict an embodiment of a track system of this invention;
FIG. 1C depicts another embodiment of a track system of this invention;
FIG. 1D depicts another embodiment of a track system of this invention;
FIGS. 2A-C depicts another embodiment of a track system of this invention;
FIGS. 3A&B depicts another embodiment of a track system of this invention;
FIGS. 4A&B depicts another embodiment of a track system of this invention;
FIG. 5A depicts a vehicle apparatus of this invention;
FIG. 5B depicts another vehicle apparatus of this invention; and
FIG. 5C depicts a front view of a track shield of this invention.

DETAILED DESCRIPTION OF THE INVENTION

The inventor has found that a rock pulverizing system can be constructed including a rail system having a car adapted to move along the rail system via magnetic forces produced by primary winding in the rail system and a trapped field magnet in the car. The rail system also includes a car breaking or deceleration system which stops the car after its is accelerated via magnetic attraction between successively activated primary winding and the trapped field magnet in the car. The car supports a projectile, which can be retrievable or expendable, and which is ejected from the car when the car is decelerated by the deceleration system. The deceleration or breaking occurs in such as way that the projectile is dispelled from the car with sufficient momentum to pulverize a target earth/rock formation. If the projectile is retrievable, then after the projectile is ejected and impinges on the target, the projectile is retrieved and repositioned on the car. The car is then return to its start position so that the car can again be accelerated down the track and decelerate ejecting the projectile at a new target. If the projectile is expendable, then the car is repositioned and a new expendable projectile is loaded onto the car so that the
The superconducting rock pulverizer presented here uses a superconducting linear motor containing monolithic YBaCuO, trapped field superconducting magnet as the moving secondary magnet of the linear motor, and a series of wire-wound primary magnets located along a track on which the secondary superconducting magnet travels.

The secondary magnet is formed preferably from high temperature superconducting YBaCuO elements. It can also be formed from other bulk or thin film superconducting materials including BiSrCaCuO, ThSrCaCuO, HgSrCaCuO, MgB2, TiNb, or other high temperature or low temperature superconducting material. To form the superconducting secondary magnet, the superconductors are cooled to below their critical temperature, Tc, while in a magnetic field of appropriate magnitude for the rock pulverizer. Thus, the superconductors capture the magnetic flux and become magnets. They remain magnets as long as they are kept at a temperature below Tc. For the high temperature superconductor YBaCuO, it is preferable to cool with liquid nitrogen the boiling point of which (77K) is well below the critical temperature of 91K. Cooling can also be accomplished by various cryocooler means.

The superconducting elements comprising the secondary magnet can bestacked so as to maximize force applied to the secondary by the primary magnet. The size and shape of the secondary magnet elements are tailored for the required final velocity and mass of the projectile. The mass of the projectiles can range from about 50 kg to 2000 kg or more. The secondary superconducting magnet is attached to a car that moves on the track formed by the primary magnets.

The primary coil magnets are linearly stacked and are energized as the secondary magnet approaches, and are deenergized when the secondary magnet passes. The primary coil magnets can be energized with current by direct contact through brushes on the secondary magnet or via a contactless mode. The primary coils or electromagnets can be made ofwire comprised of copper, aluminum, or other metallic materials, or superconducting magnets or mixtures or combinations thereof.

The superconducting wire can be of high temperature superconductors such as YBaCuO, BiSrCaCuO, ThSrCaCuO, HgSrCaCuO, or other high temperature superconductors, or of other superconductors such as MgB2 or TiNb or mixtures or combinations thereof. Higher operating temperature wire can be more beneficial as costs of insulation and heat loss are reduced.

The superconducting linear motor has a track length along which the secondary travels, that is defined by the critical transit dimensions of the mine, and by the required force and resultant acceleration and final velocity applied by the secondary magnet to the projectile over the length of the primary coil and track system. The superconducting secondary magnet is attached to a car that follows the primary track and has accommodations for brush contact or non-contact energizing of the primary coil sections as the car passes. The car holds the projectile, and projectile retrieve system for tethered projectiles. The car rides on the track with sliding or bearing contact, or has the possibility of being levitated above the track through the application of additional superconducting or non-superconducting magnets.

The primary coil magnets along with the secondary magnet and car, comprising the superconducting pulverizer are attached to a vehicle such as a standard mine scoop, or a specifically built “mule” vehicle that is able to manipulate/move the pulverizer to wherever it is needed in the mine, to allow for connection of electrical power to energize the pulverizer, and to provide the inertia for momentum transfer to effectively operate the pulverizer. The momentum of the projectile upon release is projected for a 500 kg projectile @ 45 m/sec to be 22,500 kgm/sec. To minimize recoil of the pulverizer system attached to the vehicle, the mass of the vehicle is projected to be greater than 5,000 kg. Resulting recoil of the vehicle and pulverizer is then less than ~4.5 m/sec and can be accommodated by vehicle braking, anchoring the vehicle to the mine floor/walls through springs, or other confinement techniques.

**DETAILED DESCRIPTION OF THE DRAWINGS**

Referring now to FIGS. 1A&B, an embodiment of a superconducting electromagnetic projectile acceleration apparatus, generally 100, of this invention is shown to include a power supply component 102, a track component 120, and a projectile car component 160.

The power supply component 102 includes a current in cable 104 and a current out cable 106. The two cables 104 and 106 are connected to a DC power supply 108. The track component 120 includes a left side rail 122a, a right side rail 122b, and a central rail component 124. The left side rail 122a and right side rail 122b include central support members 126a&b and a plurality of conductive members 128a&b mounted on the support members 126a&b. The conductive members 128a&b include vertical sections 130a&b, a horizontal section 132a&b having top rail contacts 134a&b and L-shaped feet 136a&b having bottom rail contacts 138a&b. The conductive members 128a&b are all interconnected by the laterally extending conductive feet 136a&b. The top and bottom sides 122a are connected to the current in cable 104 at the left rail contacts 138a disposed in bottom surfaces 140a of the body 136a, while the right side rail 122b is connected to the current out cable 106 at right rail contacts 138b disposed in bottom surfaces 140b of the feet 136b.

The central rail component 124 includes a current in rail 142a having a current in bottom contact 144a disposed in a bottom surface 146a of a current in foot 148a and a current in top contact 150a disposed in its top current in rail surface 152a. The central component 124 also includes a current out rail 142b having a current out bottom contact 144b disposed in a bottom surface 146b of a current out foot 148b and a current out top contact 150b disposed in its top current out rail surface 152b. The current in bottom contact 144a is connected to the current in cable 104, while the current out bottom contact 144b is connected to the current out cable 106.

The car component 160 includes a projectile holder 162 mounted on a car body 164. The car body 164 includes a superconducting trapped field magnet 166 mounted laterally in an interior 163 of the body 164 near its proximal end 168 (FIG. 1B). The body 164 includes two current rail grooves 170a&b disposed in a bottom surface 172 of the body 164 having car bottom contacts 174a&b disposed in groove top surfaces 176a&b. The grooves 170a&b are adapted to engage the current in rail 142a and the current out rail 142b of the track component 140, respectively, so that the car bottom contacts 174a&b are brought into electrical contact or into electrical communication with the corresponding contacts 152a&b of the central rail component 124 of the track component 120. The car component 160 also includes two rail engaging U-shaped members 178a&b including car top contacts 180a&b. The U-shaped member 178a&b are adapted to surround and engage an upper section of the rails 122a&b, respectively, so that the top car contacts 180a&b are brought...
into electrical contact or into electrical communication with the top rail contacts 134a&b of the rails 122a&b. The body 164 also include a cryocooler 182 adapted to maintain the superconducting trapped field magnet 166 at or below it critical transition temperature, \( T_c \). The top car contact 180a is connected to the bottom car contact 174a via a wire 184a; while the top car contact 180b is connected to the bottom car contact 174b via a wire 184b.

Referring now to FIG. 1C, another embodiment of a superconducting electromagnetic projectile acceleration apparatus, generally 100, of this invention is shown to include a power supply component 102, a track component 120, and a projectile car component 160. In this embodiment, the car body 164 includes two superconducting trapped field magnets 166a&b mounted laterally in the interior 163 of the car body 164, one near its proximal end 168 and one near its distal end 169. Each magnet 166a&b is contained within a separate cryocooler 182a&b, but the cryocooler 182a&b can be combined into a single cryocooler. Unlike the embodiment of FIGS. 1A&B, the feet 136a&b are non-conductive. Instead, each conductive member 128a&b is connected to the appropriate electrical cable 104 or 106 as shown so that they can be separately controlled. Although two superconducting trapped field magnets are disclosed herein, the car can have a higher number of superconducting trapped field magnets with accompanying contacts, limited only by the size of the car and the amount of acceleration to be imparted to the car. Generally, the upper limit will be less than 10 superconducting trapped field magnets.

Referring now to FIG. 1D, another embodiment of a superconducting electromagnetic projectile acceleration apparatus, generally 100, of this invention is shown to include a power supply component 102, a track component 120, and a projectile car component 160. In this embodiment, the car body 164 includes two superconducting trapped field magnets 166a&b mounted laterally in the interior 163 of the car body 164, one near its proximal end 168 and one near its distal end 169. Each magnet 166a&b is contained within a separate cryocooler 182a&b, but the cryocooler 182a&b can be combined into a single cryocooler. The track component 140 includes isolated conductive members 128a and 128b. The car contacts are designed so that the magnets 166a&b are pushed by conductive members behind the magnets and pulled by conductive members in front of the magnets. The push-pull configuration is controlled by the current direction flowing through the conductive members. In such a configuration, alternating conductive members on each rail 122a and 122b have current flowing in the opposite direction. Moreover, the two tracks are not have the same current flow pattern, but one is one member offset so that the magnetic fields generated by the flowing current push and pull in unison. Although two superconducting trapped field magnets are disclosed herein, the car can have a single superconducting trapped field magnet or a higher number of superconducting trapped field magnets with accompanying contacts, limited only by the size of the car and the amount of acceleration to be imparted to the car. Generally, the upper limit will be less than 10 superconducting trapped field magnets.

Referring now to FIG. 2A-C, another superconducting electromagnetic rock pulverizer track system 300 is shown as a cylindrical shape. The system 300 includes a cut-cylindrical track component 302 having a left side rail 304a and a right side rail 304b. The system 300 also includes a plurality of lower portions 306 of primary windings 308. The lower portions 306 of the windings 308 are designed to be brought into electrical contact or communication with four upper portions 310 of the windings 308 disposed in a car component 312. The lower portions 306 and the upper portions 310 of the winding 308 are brought into electrical communication as the car component 312 travels down the track component 302 via track contacts, leads or brushes 314 and car contacts or leads 316. The car component also includes three superconducting trapped field magnets 318a-c. The windings 308a-d are closed by the contacts 314 and 316 and generate magnetic fields that push and pull the magnets 318a-c, when power is supplied to the four completed windings 308a-d. The magnets 318a-c are disposed in an interior 320 and contained within a cryocooler 322.

Referring now to FIGS. 4A&B, another superconducting electromagnetic rock pulverizer track system 400 is shown as a monorail. The system 400 includes a monorail track component 402. The system 400 also includes a plurality of pri-
The apparatus 500 also includes a deceleration system 544 disposed at its distal end 520 and attached to a distal end 252 of the track system 200. The deceleration 544 system can include electromagnetic windings (not shown) that can be energized to slow down and stop the car component 212 of the track system 200. The deceleration system 544 can also be a shock-in-spring deceleration system 546 as shown in FIG. 5A. The shock-in-spring deceleration system 546 includes a plurality of spring units 548, which can be traditional springs or shock absorbers including springs and/or air springs. The deceleration system 544 can also be an air compressions unit 550 including a piston 552 moving in a cylinder 554, where compressing air provided the deceleration necessary to stop the car and eject the projectile 540. The deceleration system 544 can also be of varying design from the shock-in-spring design. The deceleration system 544 includes a contact plate 556 that can be a rubberized pad to assist in shock reduction of the car system 212 upon contact with the deceleration plate 556 as shown in FIG. 5B. The deceleration plate 556 can be supported on slide bearings moving on rods attached to the track system.

The projectile 540 is carried in the holder 226 attached to the car system 212. The holder 226 can include a cable/reel system (not shown) for use with tethered projectiles. The cable/reel system for tethered projectiles is adapted to be mounted on the distal end 520 of the apparatus 500 so that the tethered projectiles can be retrieved after ejection and reused. If a rock is used, then the tethering can be to a wire mesh holding the rock, but generally, for dispensable projectiles such as rock, no tethering system is needed. Although several stopping and rewind system have been disclosed, the car itself as mentioned previously can have on-board braking systems that will brake the car once it has progressed a given distance down the track. The car can also be retracted by simply reversing the current path. This will push/pull the car from the distal end of the track to the proximal end of the track. The current flow can then be reversed for acceleration of the car down the track. If magnetic force is used to restore the car to its start position, then a boost unit can be positioned at the distal end of the track to start the car on its return to the start position.

The apparatus 500 can also include a car boost unit 558 designed to push the car 212 to start it in motion before or simultaneously with electromagnetic activation. The boost unit 558 can be a hydraulic ram unit, air ram unit, a compressed spring or other acceleration boost device, that includes a push member that is thrust out from the unit pushing the car in to motion. The boost unit 558 can an air or hydraulic ram, a compressed spring, or other acceleration device.

The operation of the superconducting electromagnetic rock pulverizing system 500 is as follows. The projectile 540, either tethered or un-tethered, is loaded onto the projectile holder 226 attached to the car system 212 located on the track component 202 positioned at the proximal end 250 of the track component 202. The superconducting trapped field magnet 208, which is at or below is critical temperature, Tc, is magnetized, if it is not already magnetized. There is also the possibility not shown of using a permanent magnet in place of the superconducting magnet especially in the cases where lower mass projectiles are to be used.

The vehicle 502 is connected to the mine electrical power system through umbilicals 530 or contains its own power generating system, and the electrical energy storage system 528 on the vehicle 502 is energized. The vehicle 502 is moved to place the projectile ejection end 520 of the apparatus 500 adjacent a surface to be pulverized. Exact placement of the...
track end will be defined by trained operators. Fine positioning of the end of the track can be accomplished through the hydraulic system 510.

Once the area around the pulverizer system 500 is cleared of personnel other than the system operators who are behind protective blast shields 524 and 526 on the vehicle 502, the primary magnet windings 206 are energized generating magnetic fields the act on the superconducting field magnet 208. This causes the car system 212 to move down the track 202 accelerating every time a new set of primary windings 206 are energized by the brush or brushless contacts on the car 212. This acceleration continues down the length of the track 202 with the car system 202 supporting the projectile 540 reaching a design velocity nominally 45 m/sec for a 500 kg projectile at the end of the nominally 10 m long track. The last 1 m of the track is a deceleration section where the car system is decelerated and the projectile 500 is ejected from the support basket 226 attached to the car 212. The deceleration of the car 212 can be accomplished by a passive spring over shock system, or by electromagnetic deceleration from reverse current applied to primary coils located at the last 1 m of track, or by a combination of both systems.

The ejection of the projectile 500 from the car basket 226 when the car system 212 reaches the distal end 252 of the track 202 is followed by reel-out of the projectile tether for tethered projectiles. After collision of the projectile 540 with the rock, the tether is used to reel the projectile 540 back onto the car basket 226. The car system 212 along with the tethered projectile 540 is then reeled back to the vehicle end 250 of the track 202 in preparation for the next pulverizing event.

Blast shields 524 and 526 are strategically mounted near the end of the track to protect the track and secondary magnet/car system as well as any primary magnet windings 206 from shrapnel from flying rock.

The vehicle 502 can include a DC power supply 528 and necessary control systems to allow the operator to turn on the power supply once the apparatus is properly positioned. The control system can also be used to change the current being delivered to the conductive members of the track. Thus, the current can start off at just the current necessary to start the car moving and increased to increase the acceleration being imparted to the car. Of course, the current density must be kept below the maximum current of the cables and the maximum current capable of being tolerated by the conductive members.

The apparatus operates by pulling the car to the proximal end of the track component. Next, one or more projectiles are placed on the projectile holder. The car is then accelerated by turning on the DC power supply so that current flows through the feet to the conductive member activated by the car contacts. The current flowing through the conductive members generates a magnetic field that pushes against the superconducting trapped field magnet. Each subsequently activated conductive member continues the acceleration down the track on the rails. The power supply can be adjustable so that the current density is increased as the car moves down the track. At the end of the track, the car is stopped by a breaking system that is generally biased. The stopping is sudden enough to propel the projectiles from the projectile holder at a surface or into a surface of a structure or formation to breakup or pulverize a portion of the surface contacted by the expelled projectiles. The projectiles can be stones or rocks or can be special projectiles designed to more effectively penetrate, breakup or pulverize the surface. The projectiles can be explosively changed. The projectiles can be shaped to spin once be expelled from the holder.
conducting phases, ThSrCaCuO in its various superconducting phases, MgB₂, TiNb, other superconducting materials and mixtures or combinations.

14. The apparatus of claim 13, wherein the superconducting electromagnets are enclosed in an insulated vessel which allows for cooling of the superconducting wires to a temperature below its critical temperature, Tc.

15. The apparatus of claim 1, wherein the electromagnets comprise multiple levels of primary wire wound magnets.

16. The apparatus of claim 1, wherein the field magnet and the electromagnets form a linear motor acceleration system adapted to accelerate the car to a speed of up to 100 m/sec.

17. The apparatus of claim 1, wherein the track system has a length between 3 meters and 15 meters.

18. The apparatus of claim 2, wherein the hydraulic system includes a hydraulic reservoir pump unit, a track raising/lowering unit and a hydraulically adjustable wheel assembly having a wheel and a hydraulic lift unit positioned near a distal end of the apparatus.

19. The apparatus of claim 1, wherein the car moves on the track rails on slides or bearings.

20. The apparatus of claim 1, further comprising a boost unit adapted to start the car system moving on the rail.

21. The apparatus of claim 1, wherein the moveable car is tethered to a reel at the fixed end of the track for return of the car to a start position.

22. The apparatus of claim 1, wherein the movable car has an integral braking mechanism adapted to decelerate the car before the car reaches the distal end of the track system.

23. The apparatus of claim 1, wherein the car system further includes a projectile holder mounted on a top of car and adapted to hold and partially confine a projectile placed therein.

24. The apparatus of claim 1, wherein the car system further includes a reel and tether attached to the holder or to the car, where a distal end of the tether is attached to the projectile so that the projectile can be retrieved for reuse.

25. The apparatus of claim 2, wherein the vehicle is a standard mine scoop vehicle.

26. The apparatus of claim 2, wherein the vehicle is a specifically designed support vehicle.

27. The apparatus of claim 1, further comprising umbilical cables to connect the apparatus to an external electrical power source.

28. The apparatus of claim 2, wherein the vehicle further includes an electric charge storage system to energize the electromagnets and the field magnet.

29. The apparatus of claim 2, wherein the vehicle further includes an integral generator or fuel cell system to energize the electromagnets and the field magnet.

30. The apparatus of claim 1, wherein the apparatus has a mass commensurate with realized recoil velocity of —4 m/sec and where the mass depends on projectile mass and ejection velocity.

31. The apparatus of claim 2, wherein the vehicle has an inertial transfer system, which is attached to a fixed surface through cables, springs or other mechanisms to absorb the inertial load of the vehicle after the projectile is ejected.

32. The apparatus of claim 1, the projectile is tethered and comprises tungsten carbide, WC, steel or other massive and durable material.

33. The apparatus of claim 1, the projectile is un-tethered and comprises a rock or other massive object.

34. The apparatus of claim 31, the projectile has a mass between 50 to 2000 kg.

35. The apparatus of claim 1, the deceleration system comprises of a shock-in-spring mechanism.

36. The apparatus of claim 1, the deceleration system comprises a mechanical braking mechanism.

37. The apparatus of claim 1, the deceleration system comprises wire wound magnet coils disposed in the distal end of the track system through which reverse current can be passed creating a repulsive force on the field magnet slowing the car to a stop.

38. The apparatus of claim 1, the deceleration system further comprises a flexible wire mesh extension netting to help capture and return a tethered projectile on to the car for re-activation.

39. The apparatus of claim 1, the deceleration system further comprises other flexible extension netting comprised of Kevlar, Teflon, polyethylene or other durable and tough fabrics.

40. The apparatus of claim 1, further comprising protective blast plates adapted to protect the track system and operating personnel.

41. A method for expelling a projectile into a target surface comprising the steps of:

positioning a distal end of a projection ejection apparatus adjacent the target surface, where the apparatus comprises:

• a track system including:
  • at least one rail, a plurality of electromagnets disposed along a length of the track system, and
  • a moveable car system including:
    • a car mounted on the at least one rail, and
    • a trapped field magnet mounted in an interior of the car and disposed parallel to a front and back of the car,
• a power supply system adapted to provide power to energize one or more of the plurality of electromagnets in such a manner as to accelerate the car system down the track system;
• a deceleration system adapted to decelerate the car at a rate sufficient to expel or eject a projectile mounted on the car so that the projectile impinges upon a target surface;
• placing a projectile on the car,
• positioning the car at the proximal end of the track system, energizing the field magnet, energizing in consecutive order to accelerate the car down the track,
• decelerating the car near a distal end of the track system at a rate sufficient to eject the projectile into the target surface at a desired projectile speed.

* * * * *