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Electromagnetic Projectile Launcher

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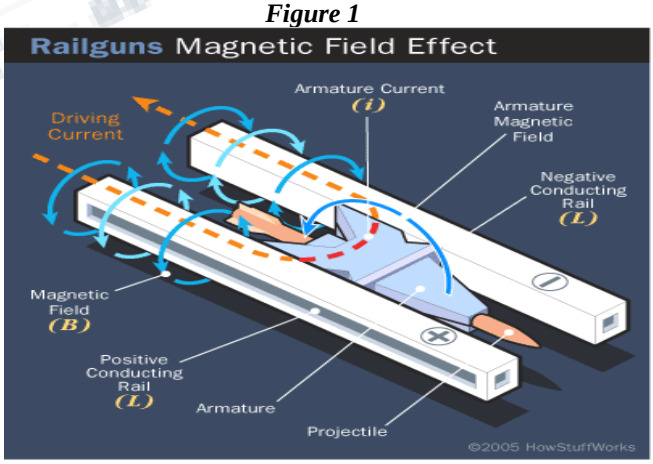
Abstract: **- An electromagnetic projectile launcher (EMPL) system accelerates and launches a projectile by converting electric energy into kinetic energy. There are two types of EMPL systems under development: The rail gun and the coil gun. A rail gun comprises a pair of parallel conducting rails, along which a sliding armature is accelerated by the electromagnetic effects of a current that flows down from one rail, into the armature and then back along the other rail, but the high mechanical friction between the projectile and the rail can damage the projectile. whereas A coil gun launches the projectile by the attractive magnetic force induced by the electromagnetic coil. A greater projectile muzzle velocity needs multiple stages of electromagnetic coils, that will make the coil gun EMPL system longer. As a result, the installation cost of a coil gun EMPL system is high because of the large installation site needed for the EMPL system. We present a coil gun EMPL system that has a new structure and arrangement for multiple electromagnetic coils to reduce the length of the system. A mathematical model of the proposed coil gun EMPL system is developed in order to calculate the magnetic field and forces, and to simulate the muzzle velocity of a projectile by driving the electric pulsed current into multiple stages of electromagnetic coils. Using the proposed design, the length of the coil gun EMPL system is shortened by 31% compared with a conventional coil gun system while satisfying a target projectile muzzle velocity over 100 m/s.**

***Index Terms*— Artificial Intelligence, Camera Module, Image Processing, Raspberry Pi.**

I. INTRODUCTION

In convention chemical launcher systems, chemical form of energy is converted into mechanical form of energy. In conventional launcher system such system must have to redesign and remanufacture if the desired velocity of the projectile is changed. also such conventional chemical launcher systems are not eco-friendly. In contrast, the electromagnetic projectile launcher (EMPL) systems convert the electric of energy into the mechanical form of energy. Thus, these systems are eco-friendly and thus we can control the projectile velocity just by controlling the electric current flowing in the electromagnetic copper coils. Now a days EMPL systems are under active research and development for a variety of applications worldwide. There are two types of EMPL systems presently have been studied. The first type of EMPL is based on the rail gun type EMPL system, in such system the projectile is kept in between the pair of rails which are excited by the direct current power supply. Then this DC current flows through the brushes of the projectile and the rails of the rail gun EMPL system. The two conducting rails and a conductive projectile forms a very strong magnetic field by generating a loop in between the first and second rails. This field further creates a Lorentz force with the flowing current through the projectile. A force F = J × B generates, where J is the current density present on the rail and B is the magnetic flux density generated. Due to this the projectile is driven by this force. In this way, such system possesses very good efficiency even in high velocity. The schematic diagram of a rail gun EMPL system is shown in Figure1. Tremendous heat is generated because of the friction of the projectile while moving from the rails. So there are number of chances of wearing out the rails, barrel, and all the equipment physically attached in the rail gun.

Figure 1



The second type of EMPL system is the coil gun type EMPL system, which ejects the ferromagnetic projectile by electromagnetic force generated by Fleming's right hand rule where the electric current excites the electromagnetic copper coils. Here the electromagnetic force generated in the copper coils attracts and ejects the projectile. The ferromagnetic projectile does not have any physical contact with the flywheel tube because the

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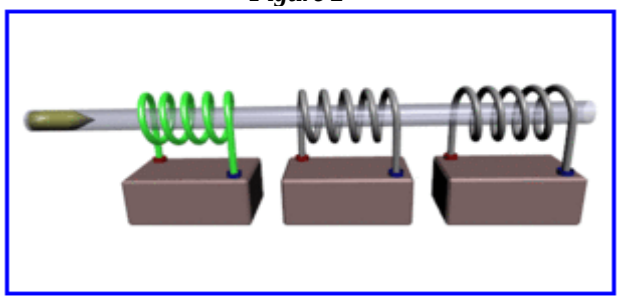
projectile is guided at the center of the flywheel tube as shown in figure2.

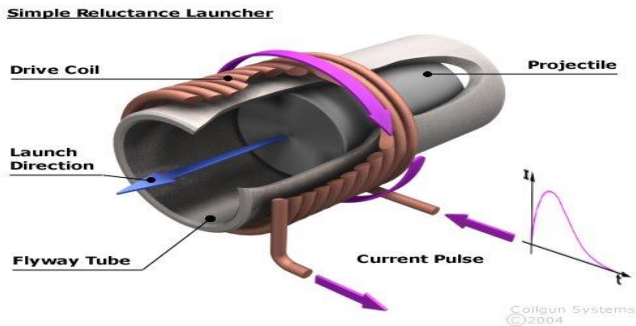
Figure 2



When the ferromagnetic projectile is launched from the coil gun the projectile get radial force by gravity to the mass of projectile. Presently, there are numerous techniques proposed to minimize the radial force by gravity to the mass of projectile. As the projectile is forced at the center of the flywheel tube, that's the reason the coil gun EMPL systems does not possesses any friction between the projectile and the flywheel tube and hence there is no such problem of generation of heat at the time of launching the projectile. But, the main drawback of a coil gun EMPL system is the single coil is not capable to produce that much high muzzle velocity to launch the projectile at greater velocity. Thus, multi-stage coil guns are required to accelerate the projectile sequentially to gain a higher muzzle velocity. But due to such use of multi-stage coil guns the length of the coil gun system is extended, so the cost of the installation of the coil gun based EMPL system also increases. The EMPL system (for a space shuttle launcher) is very high because of the very large installation site. We are introducing such a coil gun based EMPL system which have a new structure and arrangement of multi-stage electromagnetic coil guns which reduces the length of the EMPL gun whereas keeping projectile launching velocity it its maximum.

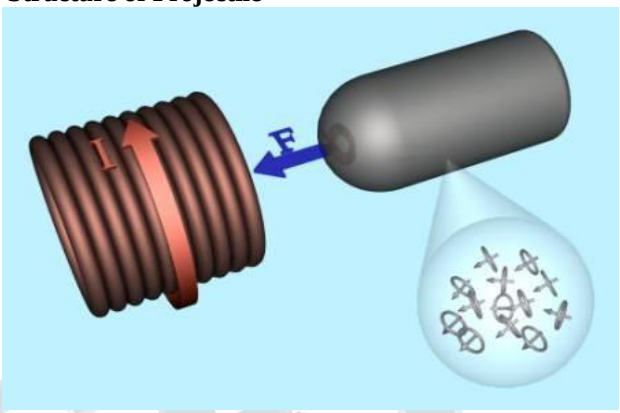
II. COIL GUN EMPL SYSTEM

A. Structure of coil gun



A coil gun, as the name implies, it consists of a coil of wire with a ferromagnetic projectile payload kept at one of its ends. A single-stage coil gun uses one electromagnet to propel the projectile. A large pulse of current is passed through the coil and hence a strong magnetic field is generated within it, which pulls the projectile at the center of the coil.

B. Structure of Projectile

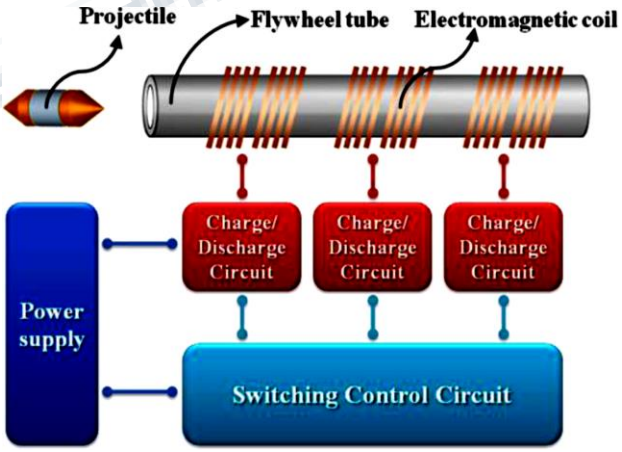


The proposed projectile is as shown in Figure, consists of a magnetic substance made of ferromagnetic material for attractive interaction with the electromagnetic coil.

C. Stages of Launching

When the projectile approaches exactly at the center of the first coil it will be switched off and the next coil will be switched on progressively accelerating the projectile to successive stages

Figure 3



In Figure 3 the structure of the proposed multistage coil gun EMPL system is shown, which accelerates a projectile in sequence. This system consists of a projectile, a flywheel tube for the projectile to pass through, number of electromagnetic coils, capacitors for charging and discharging the electric energy, a control circuit, and a power supply.

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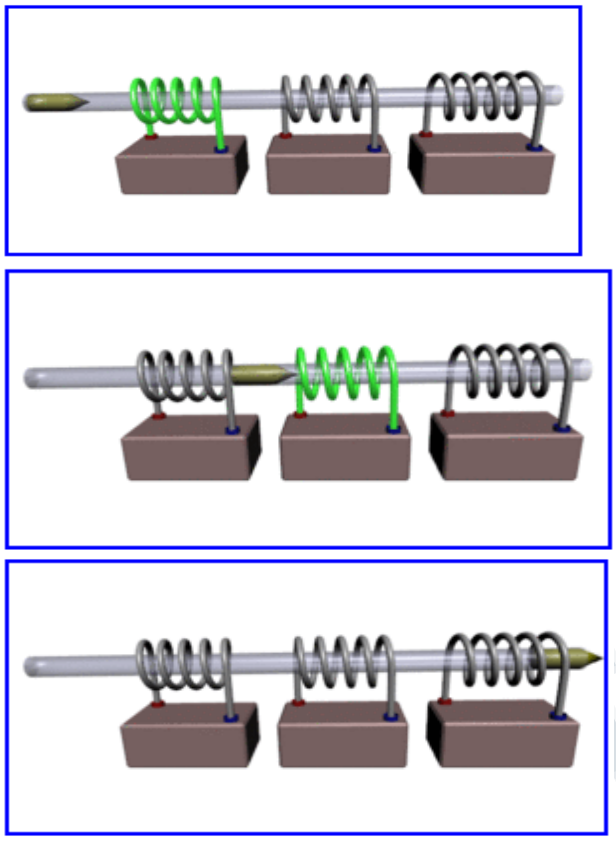


III. NEW STRUCTURE AND ARRANGEMENT OF MULTI-STAGE ELECTROMAGNETIC COILS

D. Prototype of the new EMPL system

Figure 4

Figure 4 shows the prototype of the multi-stage coil gun Electro Magnetic Projectile Launcher system. This multi-stage coil gun EMPL system energizes the electromagnetic coils in sequence to accelerate and launch the projectile. To prevent 'suck- back' effect, the electric current on the electromagnetic coils must be cut off just before the projectile passes the center of the coil.

Figure 5

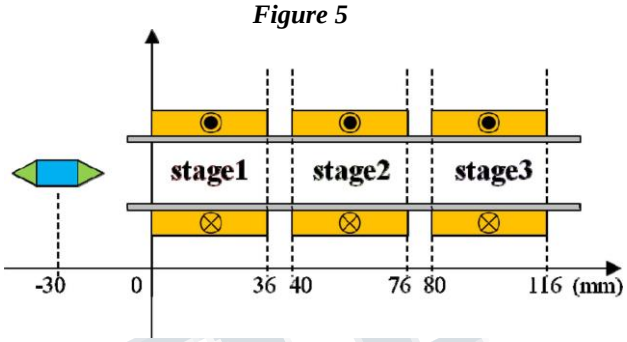
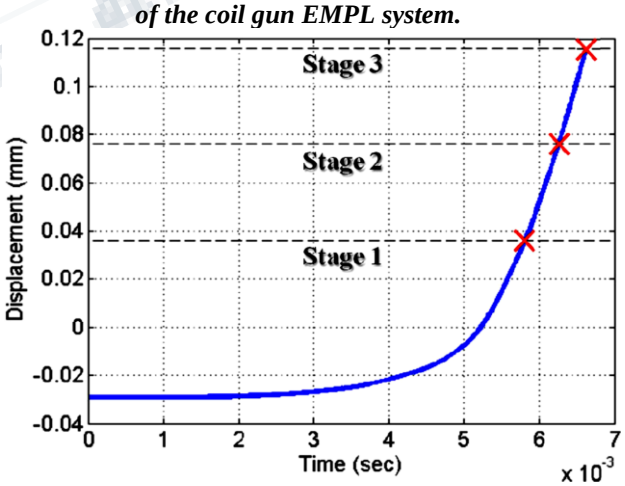


Figure 5 shows a schematic diagram of the proposed coil gun EMPL system. This structure is designed by focusing on the fact that the electric current in the electromagnetic coil is cut off when the projectile passes through the center of each coil winding. The specification of the coil gun EMPL system is shown in Figure 6 and Figure 7 show displacement and velocity versus time, respectively, for the coil gun EMPL system. "x" in Figure 6 and 7 represents the displacement and the velocity of the projectile at the end of each stage of the electromagnetic coil.

Figure 6 Displacement profile of the projectile of the coil gun EMPL system.



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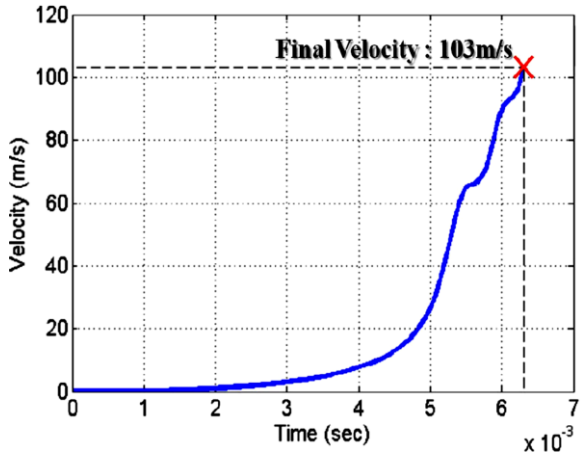

Figure 7 Velocity profile of the projectile of a coil gun EML system.

Figure 7 shows that the muzzle velocity out of stage 3 is 103 m/s. The results show that the proposed system reaches over 100 m/s muzzle velocity of the projectile. Coil gun length and muzzle velocity performance of the system and the length size of proposed system is reduced by 31% than the conventional one.

IV. CONCLUSION

A coil gun EMPL system uses multi-stage electromagnetic coils to accomplish a very high muzzle velocity of the projectile. A multi-stage electromagnetic projectile launcher coil gun structure extends in length in accordance with the number of stages increases. We have designed a coil gun based EMPL system with new electromagnetic copper coil structure and the arrangement to reduce the length of the launching system. Our prototype shows that the new system achieves the muzzle velocity of the projectile with a 31% reduced length of the launching system compared to the conventional system.

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