Journal of Physics Special Topics

A4_1_War of the Worlds

David Winkworth, Vlad Tudor, Elliott Shaw

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

October 16, 2012

Abstract

H.G. Wells' popular novel 'The War of the Worlds' involved the invasion of Earth by Martians who arrived via cylinders fired from enormous space guns mounted on Mars. This report explores the logistics of such artillery based on the technology of the time. By calculating the required escape velocity of Mars and considering the mass of the cylinders, an estimate of the necessary gunpowder is found to be over 120 tonnes. The resulting acceleration is then explored and found to be upwards of 100g. It is hypothesised that, whilst this would prove fatal to humans, Martians may be able to survive and so Wells theory is not entirely without merit.

Introduction

In 1898 H.G. Wells published his popular science fiction novel "The War of the Worlds". He tells the story of an unnamed witness to the invasion of rural England by a destructive army of Martians. Written at a time before the development of rockets or even aeroplanes, Wells hypothesised that the most plausible technique for interplanetary space travel would be through the use of giant space guns. They would be mounted on Mars' surface and be capable of firing cylinders loaded with Martians and cargo to Earth [1].

The concept was popular at the time and was also described by Jules Verne in his 1865 novel 'From Earth to the Moon'.

This report examines the specifications of such a device before commenting on its viability.

Discussion

The first question to address is what escape velocity a projectile such as the cylinder would require. The escape velocity v_e can be described as the speed at which the kinetic energy plus the potential energy of a projectile is zero, allowing it to break free from the gravitational potential well of a planet. As Mars possesses only a very slight atmosphere, with a surface pressure less than 1% of Earth's [2], the effects of air resistance were neglected in the calculation. By considering the point at which the combined kinetic E_k and potential E_p energies approach zero, we can rearrange to find that

$$v_e = \sqrt{\frac{2GM}{r}}, \tag{1}$$

where G is the gravitational constant, r is the radius of the planet and M is the planet's mass.

The energy required to propel the cylinder to such a velocity can then be calculated after estimating its mass. Although the Martians themselves are described as merely being the size of a bear, the transport cylinders also contain a great deal of machinery such as the infamous 'tripods'. It seems plausible that such a cargo would weigh upwards of ten tonnes, so this was the estimate used for the combined mass.

Taking the kinetic energy of the cylinder at its initial velocity

$$E_k = \frac{1}{2} m_c v_e^2, \tag{2}$$

equations 1 and 2 are combined to give an expression for the minimum energy required to launch the vessel E_L to the necessary velocity of $5 kms^{-1}$

$$E_l = \frac{GMm_c}{r} \tag{3}$$

Substituting appropriate values into Equation 3, the mass of the cylinder results in a required energy of $1.3\text{x}10^{11}$J.

The gun can be considered a special type of piston engine. This calculation assumes the gun would be 33% efficient at converting chemical energy into kinetic energy, providing a lower limit for the amount of fuel needed. With equipment such as this, a large amount of energy is wasted via heating of the barrel due to friction with the projectile. The primary available propellant on Earth at the time was gunpowder, capable of producing only 3MJ per kilogram [4]. As such the giant space gun would require over 120 tonnes of gunpowder. Examining other contemporary propellants such as TNT (4.7MJ per kg) it is seen that a very large amount would still be required. Gunpowder has the advantage of being its own oxidant and so would not require access to oxygen to explode.

The length of the space gun was also considered. By assuming constant acceleration a to the escape velocity v_c within a barrel of length s, the resulting acceleration can be shown to depend on the barrel length according to

$$a = \frac{v_c^2}{2s}. \quad (4)$$

The required length can be plotted against the resulting acceleration as shown in figure 1. Although a constant acceleration would be harder to engineer than a much larger initial acceleration, it would be possible using a chain of explosions. A constant acceleration over a set length would provide the minimum instantaneous force on the occupant.

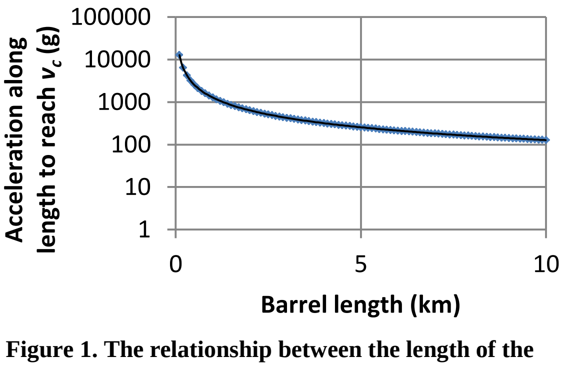

Figure 1. The relationship between the length of the barrel of the space gun and the acceleration of the cylinder

For example, an acceleration of 130g along the length of a 10km barrel (assuming a perfect seal around the cylinder) would result in the correct velocity. It should be noted that exposure to such a large acceleration for such a long time would undoubtedly kill a human, however other known animals have demonstrated adaptations to such high forces. This includes the woodpecker, whose brain has been shown to withstand accelerations of 1000g [3].

Assuming that the Martians would be capable of surviving the launch and the long travelling time to Earth they would then need to survive landing. After entering the atmosphere the cylinder would approach terminal velocity. The modern style of parachute had been popular since the late 18th century and so it is likely that Wells would have considered this technology for further slowing the Martian descent, however this is not made clear in the text.

Conclusion

In conclusion it has been shown that, should the Martians be able to withstand the unimaginable acceleration - upwards of 100g involved in take-off – Wells' theory of launch was viable. From Figure 1, it was concluded that if it was possible to constantly accelerate the cargo over longer distances, the contents would suffer more bearable forces. To achieve the necessary escape velocity of 5kms^{-1} for a large vessel of 10 tonnes, it is found that 120 tonnes of gunpowder would be required.

References

[1] H.G. Wells, 'War of the Worlds', Page 157, LLC ArcManor, 2008

[2] P. Withers, 'Empirical estimates of Martian surface pressure in support of the landing of Mars Science Laboratory', Boston University astronomy Department, 2011

[3] L.J. Gibson, 'Woodpecker pecking: how woodpeckers avoid brain injury', Department of Materials Science and Engineering, Massachusetts Institute of Technology, 2012

[4] Alexander Bolonkin, "Electrostatic linear engine", Aircraft Engineering and Aerospace Technology, 2006