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A4_16 Set Phasers to stun

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Abstract
This article considers the possibility of creating a 'stun ray' style weapon similar in concept to the phaser used in Star Trek when on a setting to stun its target. It is found that in order to create such an energy based stun weapon which was effective over a similar range to that of the phaser which did not simply kill the target should be technologically possible.

Introduction
In many science fiction settings, weaponry has advanced to the stage that it uses beams of energy rather than the solid or explosive projectiles used by contemporary military and law enforcement services. One example of a setting with such weaponry is Star Trek. In this show there are a wide variety of energy weapons present, but probably the most famous example is the phaser (some examples also known as 'phase pistol') used by many of the human characters. The phaser has settings capable of either stunning or killing (or in some cases disintegrating) the target. The smaller of these devices can be used as pistols and so this article will consider the possibility of using current technologies to create a similar device.

The technology behind the phaser is similar to many science fiction devices in that it sounds plausible at first glance, but on closer inspection is not possible (or necessarily even make any sense) with current technology, but it could well be possible to create an analogue. With current technology, killing or causing considerable destruction to a target is perfectly possible with ranged weaponry, but stunning a person is a much more difficult proposition from range.

At the current time, in order to incapacitate a person from range, either a tranquilizer needs to be administered (via some form of dart) or else via the use of a taser to deliver an electric shock from a distance. Both of these methods have their problems. Tranquilizer guns tend to need reloading after each shot and the dose administered beforehand needs to be tailored to the target. Tasers tend to fire barbed hooks which are the termini for wires that deliver an electric shock, which makes them short range weapons that are only good for one shot and causes (albeit minor) damage. If this restriction could be removed, then there might be a niche in the market.

Investigation
For the purposes of this investigation, we shall consider a taser like device, but without the wire connecting the weapon to its target. The restriction shall be imposed that the weapon should have a range comparable to the stated range for a star trek phaser, which is approximately 90 m [1]. In order for the electric charge from the taser to reach the target, it must overcome the dielectric strength of the air. This value (also known as $E_{\max}$) is 3×10^6 Vm^{-1} [2]. Eq. (1) [2] relates $E_{\max}$ to the maximum surface charge density of a conductor, $\sigma_{\max}$, where k is the Coulomb constant.

$$E_{\max} = 4\pi k \sigma_{\max}. \tag{1}$$

The maximum charge that can be stored on a conducting surface before the dielectric strength of air is overcome ($Q_{\max}$ is given by Eq. (2) where A is the surface area of the conductor). This can then be put into Eq. (1) to arrive at Eq. (3).

$$Q_{\max} = \sigma_{\max} A. \tag{2}$$

$$Q_{\max} = \frac{E_{\max} A}{4\pi k}. \tag{3}$$

The surface area of the average human body is about 2 m^2 [3] and the palm of the human hand is approximately 1 % of this [4]. If we assume that the surface area of the conductor will be about the same as the human hand then this makes the conductor surface area about 0.02 m^2. Putting this value into Eq. (3) along with the already stated dielectric strength of air, one obtains a value for the maximum charge on the conducting surface of 5×10^{-5} C of charge. In order to calculate the current that the target would be subject to, it shall be assumed that all of the charge accumulated on the conducting surface will be transferred to the target. The speed of a lightning bolt can be around 60,000 ms^{-1} [5], meaning it could cover the distance in 0.0015 s. Using this with the desired working distance of 90 m and using Eq. (4) (where I is the current, Q the charge and t the time over which the charge was being transferred) results in the target experiencing about 3 A.

$$I = \frac{Q}{t}. \tag{4}$$

Discussion

The potential difference required to incapacitate a person ranges depending upon the precise desired effect, but is normally of the order of a few hundred kilovolts [6] and the device described, with a field strength of 3×10^6 Vm^{-1} would be more than sufficient to render somebody unconscious or otherwise incapacitated. The other consideration therefore is whether or not the target would be killed by the shock.

The taser would deliver about 3 A of current at its maximum range (this current would only increase with proximity) and a current of the order of 0.5 A is normally considered fatal [7]. As a result, the device proposed would actually kill the target. If the area of the conductor were decreased by an order of magnitude, then so would the current at this range and the target would at least survive the experience. This article does of course ignore such issues as how the taser would choose its target rather than discharge on the nearest object, but in principle it seems possible to build a ranged stun gun.

Conclusion

Although the exact weapon described above would kill its target rather stun them, if the conducting area were decreased then it would seem possible to create a weapon capable of stunning the target over ranges comparable with that of the Star Trek phase pistol without killing them outright.

REFERENCES

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