Dear Colleague

**The origins of rifle shooting in physics**

**Problem:**rifle shooting is based upon principles of physics as taught today in schools. In 1859, when this sport began in Great Britain, some of the most renowned scientists and physicians willingly provided their skills to assist this initiative. Their contributions enhanced shooting techniques through the principles of physics. An understanding of physics was used to devise techniques to keep groups as small as possible

One of the scientists was James Clerk Maxwell (1831-1879), a Scottish mathematician who specialised in physics. Maxwell’s greatest contribution, acclaimed by Albert Einstein (1879-1955), resulted from his recognition of the electromagnetic theory of wave motion, which is today the basis for communications around the world. However, he is also remembered at Bisley, where each year the Maxwell Aggregate is the combined aggregate of scores in both Match Rifle and Target Rifle. When rifle shooting began at Wimbledon, Maxwell devised for all range distances the lines to be marked on the vertical arm of the rear sight. To do this he calculated the trajectory of a projectile at various distances along its path to the target. Rifle shooters have as a result been able to wind the elevation on a sight in order to shoot at a target from 200 to 1200 yards.

Today, rifle shooters seek to achieve the smallest possible groups, 0.5 MOA (F Class) and 1.0 MOA (TR), Yet, many are still unsure of the physics principles behind the techniques to achieve such groups.

**Discussion:**as a result of a better understanding of the principles of physics, the following techniques are used, shown in order of those having the greatest effect upon a group:

1.0 GRAVITY

* use of the skeletal structure of the arm and a sling, to support the rifle vertically while held dead still, offsetting the expected failure of muscle tissues under gravitational stress,

2.0 FORCES

2.1    (ACTING AGAINST A PROJECTILE IN MOTION)

* release of a projectile toward the side of a target, to compensate for the full force of wind blowing at 90 degrees toward the aimed path of the projectile
* release of a projectile toward the side of a target, at an angle less than 90 degrees, to compensate for a lesser force of wind blowing at an angle to the path of the projectile
* release of a projectile with increased trajectory, to counter a decrease in the trajectory that results from a frontal force which slows the projectile
* release of a projectile with decreased trajectory, to counter an increase in the trajectory that results from a rearward force, which increases the velocity of the projectile
* rifle ranges since at least the early 20thcentury have been equipped with flags of different lengths and weights, to enable wind velocity to be read with considerable accuracy; e.g. at Stickledown, Bisley, at 900x and 1000x, the smallest of a set of 3 flags is used to read small wind velocities that deflect a projectile from 1 to 7 MOA; whereas a larger flag design is used to read wind velocities from 7 to 15 MOA; while a much larger flag is used to read wind velocities from 15 to about 26 MOA

2.2    (DUE TO REDUCED AIR DENSITY AT HEIGHTS ABOVE SEA LEVEL)

* the elevation of a particular rifle range located at 1045 m above sea level, requires the vertical arm on the sight to be set several MOA less at 1000x than required at sea level
* when wind deflection at sea-level requires about 18 MOA at 1000x, it is found on this particular rifle range (elevation 1045m) to be 9 or 10 MOA at 1000x

2.3    (UNIFORMITY OF MOMENTUM OR ENERGY UPON SHOT RELEASE)

* at the moment of release of a projectile, recoil of the rifle needs to occur uniformly for each shot, with the shooter ensuring that recoil only occurs to the rear without variations due to: the absorption of recoil due to the position of the thumb behind the stock (e.g. a carved or a thumb-hole stock), the positions of fingers firmly around the rear of the action, the tension of the loading hand against the action, the tension of the butt against the shoulder, contact of the forward hand against the front sling swivel or a hand stop, the thumb and index finger pinching the trigger against the trigger-guard (F Class) and uniform friction of the rifle stock against a slide upon the rifle rest (F Class)
* at the moment of release of a projectile: it is necessary to ensure that the shooter’s body remains motionless and nearly the same for every shot of the shoot, otherwise the group will change upon changing the natural point of aim e.g. as occurs upon change of muscular position and tension

3.0 REFRACTION OF LIGHT

* a need to adjust the elevation arm of the sight because light refraction causes light seen by the shooter to bend vertically, which results from having passed through air masses of different density (due to differences in temperature), i.e. due to warm air above a rifle range being cooled by incoming air at a lower temperature

4.0 ROTATION OF EARTH ON ITS AXIS (THE CORIOLIS EFFECT)

* long range shooters need to correct for the sideways deviation of a projectile from its path to the target, which depends upon the position of a shooter on the rotating Earth surface and the time of travel (or distance) of a projectile, which leads to a change in the path of the projectile.

**Practice:**rifle shooters tend not to think about the principles of physics. which have effects different from those of other factors. There is otherwise a single list of techniques that affect the path of a projectile. The criterion for taking precautions against particular effects is the limiting error. Some effects are greater irrespective of whether the factor arises from the laws of physiology, physics or other principles. Such factors typically exhibit their effects in combination with one another.

A leading shooter tends to apply precautions depending upon when a factor has an effect during a shoot. For example, holding the rifle with the forearm perfectly upright has an effect for every shot, so that this precaution is requiredall the time. Since arm muscle effectiveness varies from shot to shot, it is necessary to test sling tension and adjust it before thestart of every shoot. Whereas, changes in body position (of which the shooter can be unaware) occur at any time during a shoot, require a re-estimate of the natural point of aimfor every shot.

Most importantly, a shooter should be aware of the extent of the limiting error of each factor. Holding the rifle dead still, with the forearm positioned vertically has one of the greatest effects upon a shoot. A shooter should then give this technique a high priority. On the other hand, the Coriolis effect is small and of little consequence. Corrections for this effect are made without thinking, based upon the sighter shots at the start of a shoot.

**Conclusions:**a skilled shooter understands that the effects of the principles of physics upon a shoot arelargely academic. They certainly do not include all the techniques required to achieve a small group. Hence, a shooter should work from a list of all the techniques that have a significant effect upon a group. For example, the nervous system tremor has by far the greatest effect upon a group. It is high among the techniques which should be followed, but is not listed here because it is regarded as arising from physiology rather than directly from physics.

Merry Christmas

Geoff