if we could assume (1) that the projectile was not subject to gravity; (2) that it had no tendency to deviate if passing through a calm atmosphere; (3) that the object aimed at was stationary; (4) that the weapon discharged was stationary; (5) that the atmosphere was still.

(1) The first condition is never realized: the projectile begins to drop towards the earth the moment it leaves the gun, and therefore to make it strike at a given level its first direction must be above this level. Hence the hind-sight must be raised to make the necessary correction, and the angle between the axis of the piece and the straight line connecting the elevated hind-sight with the fore-sight and object is called the “angle of elevation.” Supposing the projectile to move *in vacuo* and to drop simply under the action of gravity, the calculation of the amount of eleva­tion to be given for any range at any velocity would be easily made, but the resistance of the air renders the problem an exceedingly complicated and difficult one (see Gunnery), and only approximate solutions have as yet been discovered. Next, supposing the hind-sight to be correctly elevated, it is evidently necessary to keep it up­right; deviation to the right will cause the projectile to strike to the right of the object and deviation to the left to strike to the left of it. The amount of error is given by the equation

*d* = *r* tan *θ* tan *ϵ*,

where *d* = error in direction, *r* = range, *θ* = angle made by plane of elevation with the perpendicular, and *ϵ* = angle of elevation. The rifleman should study to keep the hind-sight as upright as possible, and indeed little error is likely to occur with a good shot from this cause. But the case is very different with a gun mounted on an uneven or mov­ing platform, and many devices have been resorted to for automatically overcoming the difficulty. They all, however, belong to either the spirit-level or the pendulum type.

(2) Secondly, the projectile deviates of its own accord from the vertical plane. If it is unrifled, its imperfections of manufacture cause errors which may be in any direc­tion, and which, therefore, cannot be compensated by any method of sighting. If it is rifled, the spin given to it renders these imperfections of little consequence, but, on the other hand, confers a constant tendency to deviation. If we lay a gun on the face of a clock, and the rifling causes a point on the surface of the shot to turn in the same direction as the hands, the shot will deviate to the right, contrariwise to the left. The cause and extent of this motion have never been thoroughly worked out. It appears to arise from the circumstance that the axis round which the shot rotates points always above the trajectory, since the principle of least resistance causes the direction of the axis to follow tardily the ever-changing curve; hence the pressure of the air, which of course acts in the direction of the trajectory, is greater on the lower than on the upper surface, and the unequal friction thereby set up causes the shot, as it were, to roll sideways; here also the principle of least resistance turns the axis slightly out of the vertical plane of fire towards the actual direc­tion of the projectile. The path is doubly curved,—first, downwards by gravity, secondly, sideways by the rotation; the latter curve, seen in plan, is nearly a parabola. In order to correct this tendency of rifled projectiles to shoot round the corner, as it may be said, the hind-sight is in­clined at an angle with the vertical, so that the more it is raised to give elevation the greater becomes the correc­tion, which assumes the form of a curve not very dis­similar to that due to rotation. The amount of error is practically determined on the firing ground, and the proper angle for the sight is given by the formula

(3) Every one who shoots birds on the wing is acquainted with the difficulties appertaining to the non-fulfilment of the third condition. The expert game-shot aims ahead of the object more or less, according to his judgment of the relative velocities of the projectile and the target and of the distance of the latter. Practice makes this compara­tively easy at the short ranges of ordinary sport; but in the case of a heavy fort gun firing at a vessel under full steam 3000 yards off, it becomes evident that considerable allowance must be made. Put the mean horizontal velo­city of the shot over a 3000 yards range at 1000 foot- seconds, the time of flight will be 9 seconds; if the ship is running past at the rate of 20 foot-seconds it will have traversed 180 feet during the shot’s flight, and it will be necessary to direct the gun so much ahead of the desired point of impact. The angle of divergence in the case just given is tan-1∙02; and, supposing the horizontal velocity of the projectile to be constant throughout its flight, this angle would be correct for a ship running at a speed of 20 foot-seconds whatever the range.

(4) The fourth condition is rarely met with except on board ship, and it is evident that it obeys the same laws and is subject to the same kind of correction as the third. The correcting angle, however, is here given by the ship’s speed across the line of fire and the starting velocity of the projectile.

(5) The fifth source of error differs from the others in being variable and uncontrollable. A gust of wind may spoil the best shot; and, though it is possible in practice to allow for deviation due to a steady breeze, yet the force and even the direction of the moving air differ so fre­quently at different parts of the trajectory that it has hitherto been found impossible to devise any satisfactory correction beyond that obtainable from knowledge of the point of impact of a previous shot. The effect of wind on direction may be calculated from the formula

where D = deflexion in feet, W = velocity of wind in feet per second, *t* = time of flight in seconds, *ϕ* = angle between direction of wind and line of fire, A = area of longitudinal section of shot in square feet, *w* = weight of shot in pounds, *g =* force of gravity. This formula assumes that the wind steadily carries the shot sideways without changing the parallelism of its axis, an assumption not greatly in error with heavy projectiles having the centre of gravity nearly coincident with the centre of figure. The effect of wind on range may be arrived at by adding or subtracting the velocity of the air, resolved in the direction of the object, to or from the horizontal velocity of the projectile and calculating by the tables (see Gunnery) the loss or gain due to the increased or diminished resistance.

The accompanying diagrams (figs. 1, 2) represent what are called “speed-sights” in the royal navy, as applied to a 4-inch breech­loading gun. The gun is shown elevated at 8° for a range of 4600 yards. The hind or “tangent” sight is sloped sideways at an angle of 1° 30' to correct the constant tendency of the projectile to deviate to the right. The sight is raised in the socket till the lowest visible graduation on the bar reads the required range on the face towards the breech and the elevation in degrees on the face towards the muzzle. A crosshead carries a leaf, which is traversed to the right or left by a double-threaded screw; this leaf is provided with a fine wire strung horizontally between two uprights; hence this form of sight is sometimes known as the H sight. The crosshead is gra­duated with two scales, one on the muzzle-face reading minutes of deflexion for giving any desired correction for wind or uneven plat­form, the other on the breech-face for allowing for the speed of the enemy in knots across the line of fire. The fore-sight is fixed in the gun, and cannot be raised or lowered. It has a crosshead provided with a traversing leaf, which carries a round bead on a thin support. The crosshead is graduated to allow for the speed of the firing vessel across the line of fire. In practice the gunner makes all these adjustments as nearly as he can judge, then takes up his