along the top of the gun, which, owing to the greater thickness of metal at the breech than at the muzzle, was not parallel to the axis. “ Some allowance had to be made for the inclination of the line of metal to the axis” (Lloyd and Hadcock, p. 32). The line of metal does not come under the definition of sights given above. In the year 1801 a proposal to use sights was sent to Lord Nelson for opinion, and elicited the following reply: “ As to the plan for pointing a gun, truer than we do at present, if the person comes, I shall, of course, look at it, or be happy, if necessary, to use it; but I hope we shall be able, as usual, to get so close to our enemies that our shot cannot miss the object ” (letter to Sir E. Berry, March 9, 1801). Three weeks later the fleet under Sir Hyde Parker and Nelson sailed through the Sound on its way to Copenhagen. In replying to the guns of Fort Elsinore no execution was done, as the long range made it impossible to lay the guns (Lloyd and Hadcock, p. 33).

The necessity for sights follows directly on investigation of the forces acting on a projectile during flight. In a vacuum, the pro­jectile acted on by the force of projection begins to fall under the action of gravity immediately it leaves the bore, and under the combined action of these two forces the path of the projectile is a parabola. It passes over equal spaces in equal times, but falls with an accelerating velocity according to the formula *h* = ½*gt*2, where *h* is the height fallen through, *g* the force of gravity, and *t* the time of flight. From fig. I it will be seen that in three seconds the projectile would have fallen 144 ft. to G; therefore to strike T the axis must be raised to a point 144 ft. vertically above G. This law holds good also in air for very low velocities, but, where the velocities are high, the retardation is great, the projectile takes longer to traverse each succeeding space, and consequently the time of flight for any range is longer; the axis must therefore be directed still higher above the point to be struck. The amount, however, still depends on the time of flight, as the retardation of the air to the falling velocity may be neglected in the case of flat trajectory guns. Owing to the conical shape of the early muzzle-loading guns, if one trunnion were higher than the other, the “ line of metal ” would no longer be in the same vertical plane as the axis; in consequence of this, if a gun with, say, one wheel higher than the other were layed by this line, the axis would point off the target to the side of the lower wheel. Further, the in­clination of the line of metal to the axis gave the gun a fixed angle of elevation varying from 1° in light guns to 2¼° in the heavier natures. To overcome this a “ dispart sight ” (D) was introduced (fig. 2) to bring the line of sight (A'DG') parallel to the axis (AG).

AG is the axis of the bore, *ab* the dispart, A'DG' is parallel to AG. D is the dispart sight, S the tangent sight, A'DS the clearance angle. At greater elevations than this the muzzle notch is used; to align on the target at lesser angles the dispart sight is so used. Guns without dispart sights cannot be layed at elevations below the clearance angle.

The earliest form of a hind or breech sight was fixed, but in the early part of the 19th century Colonel Thomas Biomefield proposed a mov­able or tangent sight. It was not, however, till 1829 that a tangent sight (designed by Major-General William Millar) was introduced into the navy ; this was adopted by the army in 1846. In the case of most guns it was used in conjunction with the dispart sight above referred to. The tangent sight (see fig. 3) was graduated in degrees only. There were three patterns, one of brass and two of wood. As the tangent sight was placed in the line of metal, hence directly over the cascable, very little movement could be given to it, so that a second sight was required for long ranges. This was of wood; the third sight, also of wood, was for guns without a dispart patch, which consequently could not be layed at elevations below the dispart angle.

Referring to fig. 1 it will be seen that in order to strike T the axis must be directed to G' at a height above T equal to TG, while the line of sight or line joining the notch of the tangent sight and apex of the dispart or foresight must be directed on T. In fig. 4 the tangent sight has been raised from O to S, the line of sight is SMT, and the axis produced is AG'. D is the dispart, M the muzzle sight, OM is parallel to AG'. Now the height to which the tangent sight has been raised in order to direct the axis on G' is evidently proportional to the tangent of the angle OMS = AXS. This angle is called the angle of elevation ; OM is constant and is called the sighting radius. If the dispart sight were being used, the sighting radius would be OD, but, as at the range in fig. 4, the line of sight through D fouls the metal of the gun, the muzzle sight M is used. The formula for length of scale is, length = sighting radius × tangent of the angle of elevation. In practice, tangent sights were graduated graphic­ally from large scale drawings. It will be seen from fig. 4 that if the gun and target are on the same horizontal plane the axis can be equally well directed by inclining it to the horizontal through the requisite number of degrees. This is called “ quadrant elevation,” and the proper inclination was given by means of the “ gunner’s quadrant,” a quadrant and plumb bob, one leg being made long to rest in the bore, or by bringing lines scribed on the breech of the gun in line with a pointer on the carriage ; these were called “ quarter sights.”

Such were the sights in use with smooth-bore guns in the first half of the last century. Tangent sights were not much trusted at first. Captain Haultain, R.A., says in his description of test­ing sights *(Occa- sional Papers, R.A. Institute,* vol. i.): “Raise the

sight, and if it keeps in line with a plumb bob, it can be as confi­dently relied upon as the line of metal, if the trunnions are horizontal. If the scale is only slightly out of the perpendicular, a few taps of the hammer will modify any trifling error.”

The introduction of rifling necessitated an improvement in sights and an important modification in them. It was found that projectiles fired from a rifled gun deviated laterally from the line of fire owing to the axial spin of the projectile, and that if the spin were right-handed, as in the British service, the deviation was to the right. This deviation or derivation is usually called drift (for further details see Ballistics). The amount of drift for each nature of gun at different ranges was determined by actual firing. To overcome drift the axis must be pointed to the left of the target, and the amount will increase with the range.

In fig. 5 (plan) at a range HT, if the axis were directed on T, drift would carry the shot to D, therefore the axis must be directed on a point D' such that D'T = DT. HFT is the line of sight without any allowance for drift, causing the projectile to fall at D. Now if the notch of the tangent sight be carried to H' in order to lay on T, the fore-sight, and with it the axis, will be moved to F', the line of fire will be HF'D', and the shot will strike T since D'T = DT. Left deflection has been put on; this could be done by noting the amount of deflection for each range and applying it by means of a sliding leaf carrying the notch, and it is so done in howitzers; in most guns, however, it is found more convenient and sufficiently accurate to apply it automatically by inclining the socket through which the tangent scale rises to the left, so that as the scale rises, *i.e.,* as the range increases, the notch is carried more and more to the left, and an increasing