CAPPED VS UNCAPPED SHOT—A DISCUSSION OF TACTICAL REQUIREMENTS

By Colonel B. N. Mitra

Chief Superintendent of Development, Technical Development Establishment (Ammunition), Kirkee

ABSTRACT

The success of defeating armour by a conventional armour penetrating shot lies in the delivery of a high kinetic energy on impact with the target. The efficiency achieved is directly linked up with the provision of two types of caps, penetrative and ballistic, in the design of such a shot. The author has shown that whilst a ballistic-capped shot can engage tanks successfully at the top half of the fighting zone, it is not so effective at close quarters. On the contrary, this limited tactical advantage brings in certain design and manufacturing problems which have been discussed in some detail.

The modern armour piercing projectile, known as APCBC shot, consists of a solid shot of alloy steel having a hardness gradient from the nose to the base, the nose being the hardest. A penetrative cap of steel with similar hardness gradient is fitted over the nose of the shot by monolising and/or crimping over the shot ogive; finally, a ballistic cap or wind shield of mild steel or aluminium is screwed over to the penetrative cap. The addition of a penetrative cap is of definite advantage in the attack of face-hardened (cemented) armour; in this case, the initial shock of impact against the hardened face of the armour is entirely taken by the penetrative cap, which shatters in the process, but not till it has destroyed the hardness of a portion of the plate surface and made a dent therein to facilitate penetration by the hard nose of the main shot without break up. As a matter of fact, trials carried out with capped and uncapped shot show that the capped shot has, in general, an advantage of about 450 f.s. in striking velocity, (equivalent) to an additional effective range of (500 yards) over the uncapped. The presence of such caps, however, constitutes a distinct disadvantage in the attack of homogeneous armour and an increased striking velocity is necessary for successful perforation of the armour at both 20° and 30° attack, particularly when the cap is not appropriately hardened. Even in the attack of cemented armour, it is the hardness of the penetrative cap which is the main criterion of success, a soft capped shot is found to be greatly inferior to hard capped shot against face hardened armour at 30° attack. Since soft caps, as compared with hard ones, exhibit a disadvantage against both cemented and homogeneous plate, we can, to the extent of discriminating between correctly and incorrectly hardened caps, carry out the proof of APC shot against homogeneous plate, when cemented plate is not available. Although the provision of the penetrative cap in the design of the AP shot can be justified by its functioning requirements only, this is not the case with ballistic cap, which is intimately connected with the tactical requirement in addition to improving the performance of the shot and the following discussions in this respect are therefore brought in to clarify this point.

The range zone for which maximum efficiency of A/T projectiles is demanded, varies from point blank to 1,000 yards. This is based on the fact that manoeuvring tanks are usually required to open fire at about 800 yards, but there will be occasions when enemy A.F.Vs are met suddenly round a corner of a wood or street at extremely close range, and the immediate knocking out of these enemy tanks is considered to be of vital importance. The addition of ballistic cap improves the shape of the projectile and effects a consequent reduction in the value of $\kappa\sigma$ thus helping in maintaining the velocity of the projectile over a longer range due to a reduction in its rate of retardation due to air resistance. This aspect is only one of the various factors affecting the use of a ballistic cap. The other factors which require equal consideration are:

(*a*) Care involved in the handling and transport of shot fitted with ballistic cap, so as to maintain the concentricity of the tip of the cap.

(*b*) Effect of lengthening the projectile on packages, equipments and vehicles.

(*c*) Effect of the ballistic cap on perforative performance.

(*d*) Problems of manufacture, involving availability of material, existence of competent operatives and plants and comparatively less output.

A loose cap, or a cap out of alignment with the shot proper, will considerably effect its accuracy. The penetrative efficiency of an armour penetrating shot is directly proportional to Cosθ, where θ is the angle of incidence. The angle of incidence of a shot fitted with an eccentric or non-rigid cap would be more than zero degree (normal impact), the actual departure from normal impact depending on the degree of eccentricity. Such a shot would, therefore, bring about a degradation in the penetrative performance. In order to realize maximum efficiency, it is essential that the cap must be securely attached to the shot body and also it should be co-axial with the shot proper. Before selecting the appropriate mode of attachment for any new design, it must be remembered that the security of attachment must be maintained even after the rigours of service handling and transport under the worst conditions. With this object in view, extensive travelling trials simulating the worst service conditions are carried out with any new method of attachment before finalization of the design. Once the security of attachment has been guaranteed by such trials, the maintenance of concentricity at all stages of manufacture is ensured by careful gauging by an approved gauge, designed specifically for this purpose. The addition of the ballistic cap approximately doubles the length of the projectile. This would have a consequent effect on the design of packages, containers and container fixtures on A/T gun carriages as also the stowage racks inside the tanks. Trials with certain calibres, e.g. the 6 Pr APCBC shot against 60 mm and 70 mm armour, have shown that the addition of a ballistic cap reduces the perforative capabilities of the shot. These trials have revealed that for any given thickness of plate that the plain shot can penetrate, it requires an additional striking velocity of about 100 f.s. to enable the shot with ballistic cap to penetrate through. The improved head contour of the ballistic-capped shot yields a much lower value of $\kappa\sigma$, implying retardation in flight due to air resistance, as compared to the uncapped variety. The remaining velocity of the ballistic capped shot at any range would, therefore, be more than that of the other type. But the difference in remaining velocity of the two types at short ranges, is not sufficient enough to offset the degrading effect of ballistic cap on the penetrative efficiency of the shot. On a scrutiny of data available from results of trials carried out in Q.F. 6 Pr. 7 Cwt. gun, it is found that the $\kappa\sigma$ value of the ballistic capped shot is $2\frac{1}{2}$ times less than that of the uncapped variety. Since the contribution of the ballistic cap to the total mass is negligible, the effect of $\kappa\sigma$ mentioned above would give a value of the ballistic coefficient, (of the capped shot) $C_o = M/\kappa\sigma d^2$, which is about $2\frac{1}{2}$ times more than the uncapped type. The average values of $\kappa\sigma$ in respect of the capped and uncapped shot for firing in flat, as obtained from the analysis of fired results are 0·495 and 1·20 (1940 resistance law) respectively for the 6 Pr. AP projectiles of calibre, d= 2·244 in. From the following simple calculation, it would be seen that at 400 yards range, the remaining velocity, v, of the ballistic capped shot is just about 100 f.s. more than the plain AP shot and the perforative power of the two types of shot is, therefore, equal at this range:

	lb. oz. dr.
Mass of shot (Capped and uncapped)	7 2 1=7·129 lbs.
Muzzle Velocity, V ..	2725 f.s.

(a) *Analysis for remaining velocity at 400 yds. of the capped shot*

$$C_o = \frac{M}{\kappa\sigma d^2} = \frac{7\cdot129}{0\cdot495\times(2\cdot244)^2} = 2\cdot86$$

$S_V = 34017\cdot9$ (From 1940 law tables)

$R = \frac{1}{3} C_o (S_V - S_v)$, Where S_V and S_v are the Siacci's space function values corresponding to the muzzle velocity, V and remaining velocity, v.

$$\text{or } S_v = S_V - \frac{3R}{C_o}$$

$$= 34017\cdot9 - \frac{1200}{2\cdot86}$$

$$= 33598\cdot3$$

Hence $v = 2656$ f.s. (1940 law tables)

(b) *Remaining velocity of plain shot*

$$C_o = \frac{7\cdot129}{1\cdot20\times(2\cdot244)^2} = 1\cdot18$$

$$S_v = 34017\cdot9 - \frac{1200}{1\cdot18} = 34017\cdot9 - 1016\cdot9$$

$$= 33001\cdot0$$

Hence $v = 2559$ f. s.

From the above analysis, it is, therefore, quite clear that the addition of the ballistic cap constitutes a definite disadvantage at all ranges below 400 yards. Compared with the fighting zone mentioned before, this would show that although the ballistic capped shot would engage tanks successfully at the top half of the fighting zone, it would fail to meet the other important criterion of defeating enemy tanks at close quarters. From the point of view of manufacture and supply, the extra processes involved in the manufacture and assembly of the ballistic cap would bring about a substantial reduction in the output.

From the above discussion, the general conclusion that could be drawn would reveal many reasons against the adoption of ballistic caps and only one in its favour.

The decision, therefore, regarding the provision of a ballistic cap in the design of an AP shot is to be based after careful consideration of the following pros and cons—

Pros—Increased striking power in the top half of the normal fighting zone.

Cons—(*a*) Loss of striking power in more important half of fighting zone

(*b*) Difficulty in manufacture—more men, additional machinery, more material and loss of output

(*c*) Problem of supply due to lengthy containers and boxes

(*d*) Necessity for elongated fixtures on gun carriages

(*e*) Stowage difficulties inside tanks

(*f*) Necessity for careful handling in action to prevent damage to caps

(*g*) Loss of accuracy if caps are damaged.