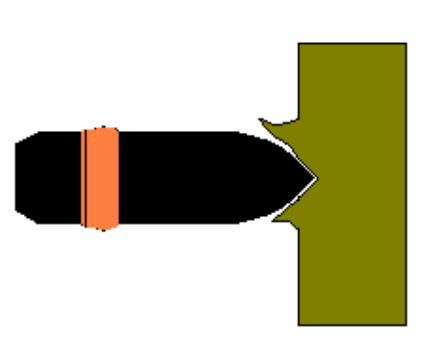
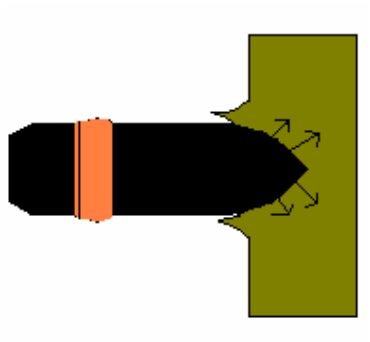
AP SHOT PENETRATIVE MECHANISM

The attack of an armour plate by an AP shot is a simple case of using the kinetic energy in a mass of steel projected against the face of the plate. Several assumptions are to be understood in the following discussion,

- The projectile remains unbroken throughout the attack
- The projectile has sufficient energy to achieve penetration.
- The armour is sufficiently able to resist the attack.



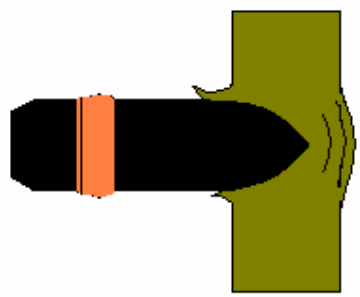
1. On arrival at the armour plate the projectile point commences the penetration by impressing itself into the plate. This initial impression causes the plate to begin to flow away from the shot raising a circular ridge concentric with the entry hole. Tensile stresses in this ridge cause it to break up into petals.



2. As the penetration increases the plastic flow of the metal becomes more difficult; it will cease when the projectile penetrates to about the shoulder region. To penetrate further the projectile needs to cause the plate to flow radially or axially away from the shot. If the armour plate is sufficiently thick and tough at this time the shot will fail to penetrate. The shot will be very tightly jammed in the armour.

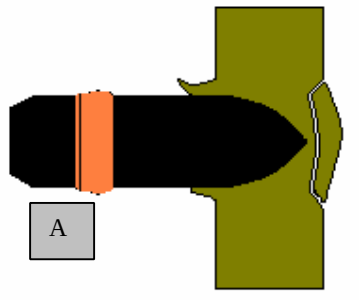
A piece of armour plate showing the effects of AP shot. The top shows a successful penetration, the middle shows a partial and the bottom shows failure with a jam. The two top holes also exhibit the petalling associated with the initial gouging of the plate. Photo courtesy of The Artillery museum Woolwich.

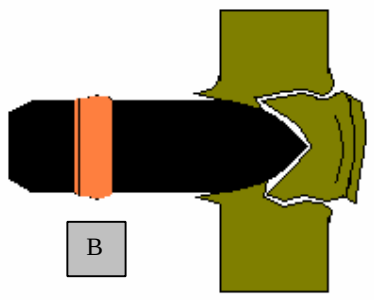
3. Given sufficient energy and penetration the projectile may cause the inner face of the plate to commence failing and exhibit bulging.



4. If the shot has enough residual energy to cause further radial or axial flow then the armour plate will fail in one of several ways.

(a), the bulging will cause a circular plate to separate from the inner face of the armour.
(b), given sufficient energy remaining in the shot it may punch out a cylinder of the armour plate.

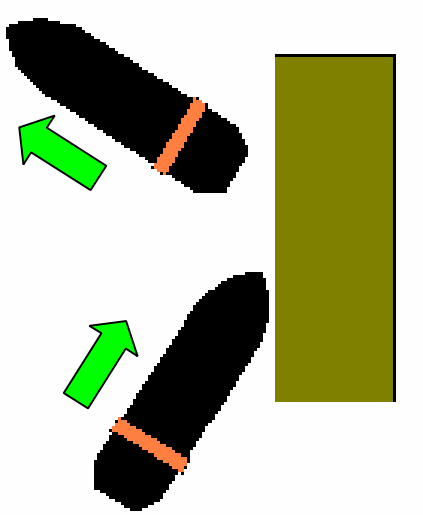


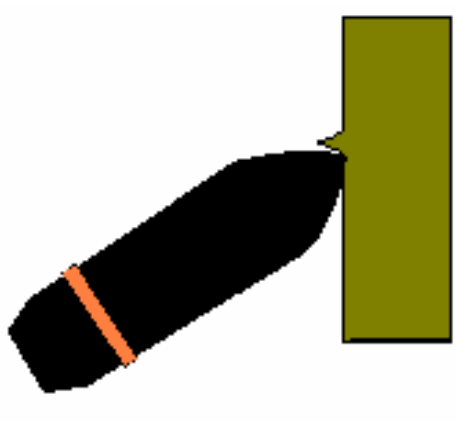


5. Some spalling from the inner face will occur if the shot penetrates to a great depth without actually defeating the armour. This spalling is caused by weaknesses built into the armour plate during manufacture and allows the pieces of armour to fly off into the vehicle.

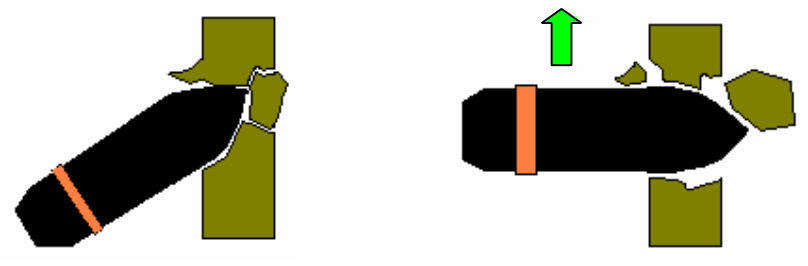
The above discussion considers the simple case of straight head on attack. The case is not always as direct as this. Where the projectile arrives at the armour face at any angle other that 90^0 one of several things may occur.

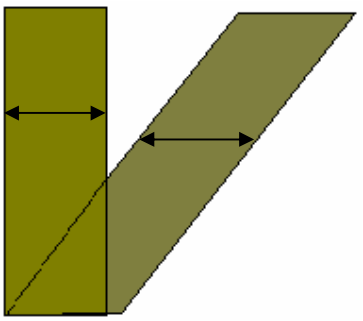
1. If the angle of arrival is very shallow then the projectile may bounce of the armour plate leaving just a gouge on the face of the plate.
2. If the angle is sufficient to permit the commencement of penetration the shot will begin to gouge the plate and cause petalling to occur on the side of the projectile in the direction of the shot movement.





3. The increased resistance provided by the gouging and petalling occurring begins to slow the point of the projectile but the base wants to keep moving thus producing a turning moment around the middle of the projectile. This levering action causes the plate to commence breaking up thus reducing the resistance to penetration. The reduction in resistance also causes the projectile to change its direction in doing so it usually punches out a plug.





A difficulty for the shot at an angled impact is a simple geometry problem. As the angle changes, the amount of material to penetrate increases. Sloped armour is one of the standard methods of increasing the armour protection of a tank.

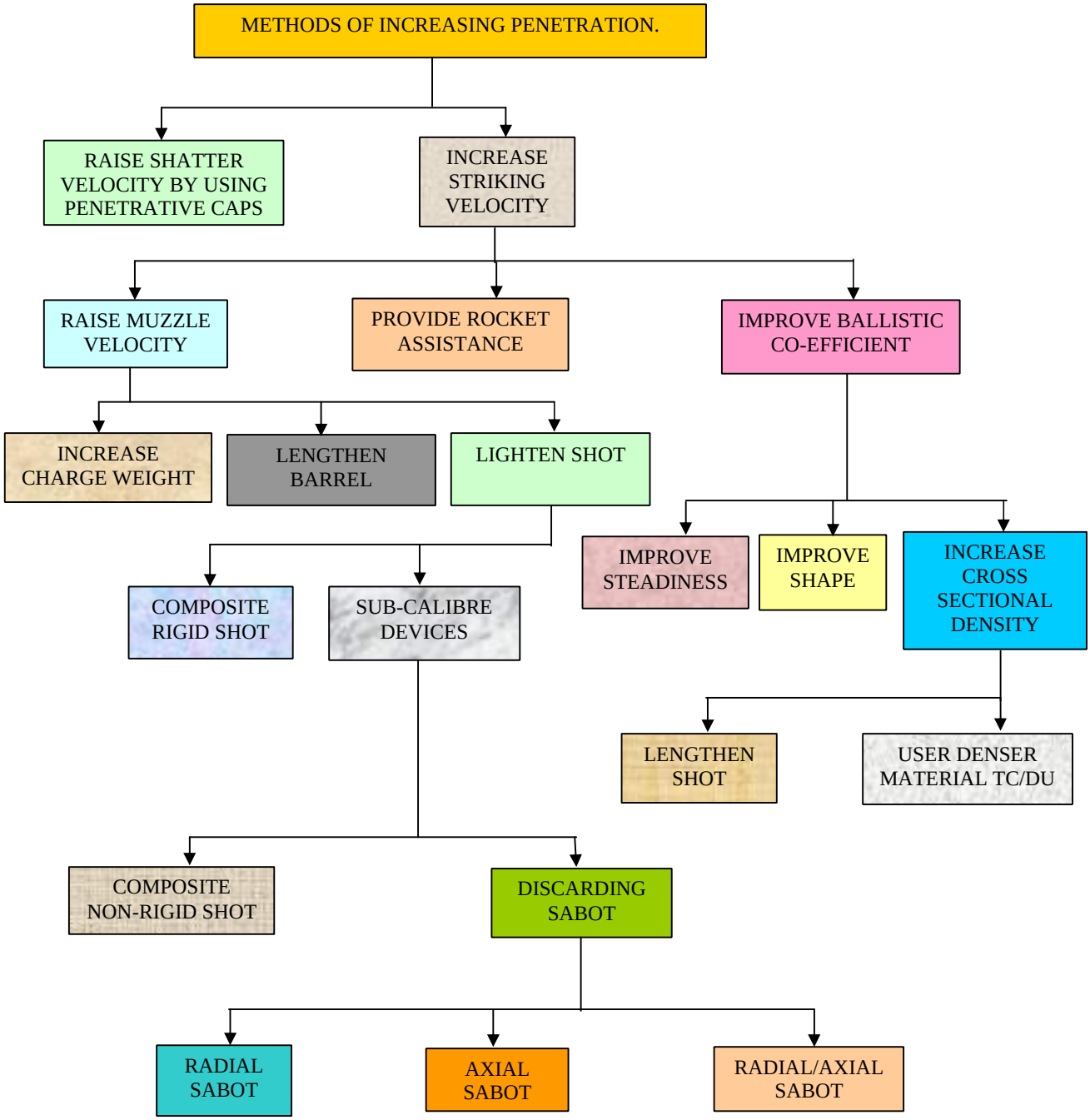
During the penetration process the shot undergoes several stresses that tend to limit the penetration achieved. These are:

Barreling. This is the tendency of the shot to actually compress and expand thus creating the problem that the shot is now trying to make a hole larger than the one that it was designed to do. In addition the shot is now fatter than the partial hole already made by the preceding, and narrower part of the shot. The method used to overcome the barreling problem is to regulate the hardness gradient along the length of the body decreasing from the tip to the base.

Shatter. The projectile tip and head area being too hard and simply failing under the forces of the impact cause this. The shape of the shot adds to this problem in that it has a point and this is where the impact forces are first applied all in a small area. This is overcome by the provision of a cap to absorb some of the impact forces and also to begin the initial engraving of the armour plate. The shape of the cap is arranged so that it has a flat head to aid in the initial engraving.

Lateral stress. During the penetration at an angle the shot is forced to turn through an angle and in doing so the side of the shot slaps into the edge of the hole being formed. The shot can actually break in half, as the forces are so high. This is also overcome by applying a hardness gradient along the shot body.

ARMOUR PIERCING SHOT PENETRATION



Having said all of the above there is a practical limit to the size and abilities of a kinetic energy projectile. There comes a time when the size of the weapon is ridiculous and very expensive. But there are other ways of penetrating armour without trying to smash a solid piece of metal through it. These are hollow charge and squash-head munitions. These are discussed in further articles.