BARREL VIBRATIONS, JUMP, AND COMPENSATING RANGE

A few notes on these theoretical aspects should give the reader an insight into the behaviour of rifles. The shock of the exploding charge in the breech causes a wave to travel along the barrel to the muzzle. The wave is propagated in steel at a much higher velocity than that of the bullet up the bore, and therefore reaches the muzzle first and influences the direction in which it is pointing at the moment of shot ejection. The important factor is the direction that the muzzle is *moving* in at the instant of shot ejection, and not whether it is plus or minus of the laid line. The only movements of importance are those in the vertical plane.

The muzzle velocity of the .303 in. Mk. 7 bullet is approximately 2460 feet per second. A limit is set on the deviation of the individual shots from the mean velocity of a 10-round series at proof. This results in a maximum spread of about 120 feet per second between the fastest and slowest shots. A variation of velocity causes a change of range, but if the variation of velocity is accompanied by a change in the angle of projection of opposite sign, some degree of compensation will occur. Take the case of a rifle muzzle moving up, due to barrel vibration, at shot ejection. The form of the wave motion does not vary with the change in velocity of the bullet, although the amplitude does to a small extent. A bullet moving below the mean velocity will take longer to traverse the bore, and will reach the muzzle later than a faster moving bullet. It will therefore be projected at a slightly greater angle of elevation, since the barrel is moving upwards. Conversely a fast bullet reaching the muzzle in a shorter time will emerge sooner, and at a lower angle of projection, thus the higher velocity is compensated for by the lower angle of projection, and vice versa.

A rifle possessing these characteristics is said to be compensated. The No. 1 Rifle compensates at about 900 yards range, which means that a group of shots, aimed at the same point, will be smaller than would be the case, if there was no compensation. The ideal is to arrange for complete compensation a little short of the maximum effective range of a rifle, and so reduce the size of the group at the range where it would normally be spreading unduly.

If the barrel muzzle is moving down at the instant of shot ejection the errors will be additional, i.e., the slower bullet will be longer in the bore and will be projected at a lower angle of elevation than a faster bullet, therefore, it will range even shorter than the low velocity dictates. In the same manner the higher velocity bullet ranges further. A rifle with these characteristics is uncompensated, and would be expected to group badly at the longer ranges.

The angle of jump is defined as the angle between the axis of the bore produced, as laid, and the line of departure of the projectile. It is evident that the barrel vibration causes jump, because the *muzzle* changes its angle during shot travel. The recoil of the weapon, although small during shot travel, may also influence the angle of jump. The attachment of a bayonet often alters the angle of jump and necessitates a change in the sight setting. All small arms are subject to jump.

Jump is determined as follows. The weapon is fixed securely in a mounting and sighted through the bore on to a small aiming point on a screen at a range of 71.6 feet. At this range 4 minutes of angle subtends 1 inch. A group of shots is fired, and the mean point of impact carefully marked. The position where the shots would have struck, had there been no jump, is calculated from the formula, gravity drop $= \frac{1}{2}gt^2$, where g is the gravitational acceleration and t is the time of bullet flight over 71.6 feet, as measured by a chronograph. The formula gives the vertical drop due to gravity during the time of flight over 71.6 feet. A mark is made on the screen at the appropriate spot below the aiming point and the distance of the mean point of impact of the group is measured with respect to this mark. It is now a simple matter to calculate the angle of jump, using this distance. Vertical jump is counteracted when the sights are fitted at the factory. In any case jump is automatically compensated for when the sights of a weapon are zeroed, because the line of sight is matched to the group on the target