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The Theory of Shooting and the Evolution of the Spitzer Bullet.

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A knowledge of the fundamental laws governing the flight of the bullet fired from a rifle—the theory of shooting—while it is a necessity for the gun-makers and the gun-experts, ought to be also possessed by every shooter. The person possessing this knowledge, all other things being equal, will be superior in marksmanship to the one not acquainted with these fundamental laws. A proper teaching of the theory of shooting ought to be the foundation upon which to develop the greatest percentage of marksmen—of good shots.

The flight of the bullet from the muzzle to the point in its flight, where it loses the power imparted to it by the explosion of

the powder, is called trajectory. The length of the trajectory, in the main, is determined by the relative proportion of the weight of the projectile to the strength or expansive power of the developed powder gases. The bullet loses its power after leaving the muzzle, first "by the law of gravity," and second, by "the resistance of the air."

In order to overcome, or rather counter-effect the fall of the bullet, we elevate the muzzle by means of the difference in elevation of front and rear sight. The second we try to minimize, as much as possible, by rifling the barrel and shaping the bullet.

The law of gravity is a well known quantity. The bullet, from the moment it leaves the muzzle, falls at the square of the odd numbers; that is, it falls 16 feet, approximately, in the first second, it falls 3×16 feet in the second second, it falls 5×16 feet in the third second. Consequently, if we did not elevate the muzzle over the horizontal line, we would have to fire the rifle from a height of sixteen feet in order to hit a point perpendicularly below on the ground at the end of the first second of the flight of the bullet. In order to hit the same point at the end of the second second of the flight of the bullet, we would have to mount a scaffold $3 \times 16 + 16 = 64$ feet in height. At the end of the third second the scaffold would have to be $5 \times 16 + 64 = 144$ feet in height. This shows the necessity of accelerating the flight of the bullet as much as possible. Upon the space traversed in the first second, which we call the initial or muzzle velocity of the bullet, depends, in a large measure, the efficiency of the bullet.

To overcome the effect of gravitation upon the bullet, we elevate the muzzle by making the rear sight higher than the front sight. This creates an angle between the line of sight, formed by the eye on one end and looking in a straight line over the rear sight and front sight with the point aimed at at the other end, and the imaginary line drawn through the exact center of the barrel and elongated. The projectile follows this imaginary line just as long as it is in the barrel, but the very moment it leaves the muzzle the law of gravitation acts upon it and it falls, that is, it leaves the continuation of the imaginary center line of the barrel. The angle between the line of sight and the center line is formed the nearer to the muzzle of the rifle the higher the elevation of the rear sight.

The trajectory takes the form of an elongated, parabolic-curve,

which can be aptly illustrated by the outline of a hen's egg cut in half. The trajectory is divided into two parts, the one nearer to the muzzle being called the ascending arm, the one nearest the point aimed at the descending arm. The ascending arm forms about two-thirds of the length of the trajectory.

There is but one trajectory, and that is the one at the distance

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No. 3.

where the bullet ceases to have any power except the power of its own weight. This is important to keep in mind, for, whether we speak of a trajectory at 50 yards, at 150 yards or at 1000 yards, they are all a part of the same long trajectory only produced by stopping the flight of the bullet by an object interposed at a certain point in this never-varying flight.

The ascending arm of the trajectory rises to a certain point over the line of sight at a given distance and this highest point is

called the elevation. In speaking of a high or low trajectory we mean the highest point of that trajectory over the line of sight. The parts of the trajectory where the elevation is not greater than the size of the object aimed at is called the "danger zone." If, for example, you aim at a deer standing still, you have to judge the distance. We will say you judge this distance to be 150 yards. If you have a rifle where the elevation of the trajectory is 24 inches, you will have to judge very accurately, for if that deer happens to stand at 120 yards instead of at 150 yards, you are very apt to miss him by overshooting, or, if he stands at 170 yards, by undershooting. If, on the other hand, you have a rifle with a low or flat trajectory, say, for example, of nine inches elevation, you will hit that deer at any distance from you up to 150 yards, providing you aim at the belly part of the body, a deer presenting a killing surface of about ten inches.

The practical solution of the effect of the law of gravity upon the bullet is, as we have seen, easy. The practical overcoming of the resistance of the air is an entirely different and much more difficult matter. In my introductory remarks I said that we try to overcome the resistance of the air by rifling the barrel and shaping the bullet.

The first projectile of which we have any knowledge is a round ball of lead, whose sphere fitted the bore of a smooth barrel. If the ball did not fit, it was patched by a piece of greased cloth.

It was soon evident that, in order to produce results, we had to impart to the bullet a boring motion and also make it as light as possible. But in putting a twisted rifling into the barrel, while we imparted a screw-like motion to the bullet during its flight through the air and thereby enabled it to overcome the resistance better, we also greatly intensified the effect of the bullet's own center of gravity upon its flight. This effect of the center of gravity upon the flight of the bullet has forever been the bugbear of riflemakers. It threads its way through the whole history of the bullet, from its inception in the round ball to the present pointed bullet.

At first there was no proviso for upsetting the ball in the barrel, the ball being seated directly on the powder. The least irregularity in the sphere of the ball would let powder gases escape alongside of it. It is of common occurrence to-day for a gunmaker to be called upon to take the breech-pin out of a barrel

and find it nothing but a plug against which powder and ball rested, with just a vent for the entrance of the flash produced by the explosion of the powder in the pan or the percussion cap. The next step forward was the elongation of breech-pin so as to contain a receptacle for the powder with a rounded concave place for the ball. By seating the ball firmly with the ramrod it would spread until stopped by the sides of the barrel and thus produce an even fit.

This principle was employed until the breech-loading rifle superseded the muzzle-loader. The first known were straight grooves cut lengthwise into the barrel; this was done to enable the shooter to use both shot and ball in the same weapon. But the guiding power of the rifling upon the ball was very small on account of the small amount of contact between a round ball and the barrel; and the ball, after leaving the muzzle, would play all

kinds of pranks in finding its own center of gravity or equilibrium.

When we think that these balls were all cast in a mould, that this mould would enclose an amount of air, part of which would invariably be imprisoned in the wall without any way to determine where it was; when we think that in a ball, twelve to the pound, and which is a little over three-fourths inch in diameter, this air-hole might be clear to one side, you can readily imagine the funny motions of that ball in the air when it jumps around this eccentric-hole in the inside.

The uselessness of the ball was too apparent for it not to be soon abandoned.

In order to make the rifling effective it was necessary to create more contact; this led to the elongated ball—the bullet—and the diminution of the bore or calibre. If we talk of a bore we mean a barrel, the diameter of which is adapted to a ball, a given number of which make a pound in weight; if we talk of caliber we mean a barrel the diameter of which is expressed in inches. It is therefore proper to say, "A 12-Bore Gun" and "A 32-Cal. Rifle."

Shot-guns are made in bores from 4-bore to 28-bore, also called gauge; that means that the diameter of the true sphere of a ball weighing one-quarter pound or four ounces means a 4-bore or gauge, while the same relative measurements obtaining to twelve balls in a pound would mean 12-bore or gauge, etc. The diameter of the true sphere of a 12-bore gun-barrel is .729 inches.

But, the elongated bullet, while it offered a smaller front for the action of the air, still was just as freaky as the ball, for that little aforementioned air-hole might be in the extreme end of it, and the bullet, instead of flying straight, would describe a series of somersaults in the air, alongside of which the performances of Barnum's best clowns sink into insignificance.

The desire to force the bullet to fly in the direction imparted to it by the barrel created the twisted rifling. A great step forward had been accomplished, for not only had the gunmaker succeeded in forcing the bullet to revolve around its own axis, and thereby minimize the effect of the center of equilibrium, but the resistance of the air was materially reduced, especially as the improvements in the methods of rifling allowed the reduction of the weight and the diameter of the bullet. With the introduction of the stud into the breech-pin the maximum of efficiency in muzzle-loading

rifles was reached. This stud was a pin screwed into the exact center of the breech-pin and entering for the length of about $1\frac{1}{2}$ inches into the barrel. The flat end of the bullet would meet this stud, and by tapping with the ram-rod, would spread the bullet to fill out the grooves evenly. The open space between the bullet and the end of the breech-pin allowed the powder charge

Nos. 11, 12 & 13. Nos. 3 & 4. No. 6. Nos. 8 & 10.

to be changed *ad libitum*. This method, however, was only adopted where there was ample time for loading, and was therefore employed mainly for target-rifles. The degree of accuracy, however, obtained by these rifles up to 400 yards is astonishing.

We now enter the era of the breech-loader. When Dreyse, of Locmerda, Germany, invented the needle-gun, the muzzle-loading rifle had been developed to a high degree of efficiency, and the theory of shooting was well known to this inventor. His main

aim was to overcome the unevenness in the burning of black powder. For when black powder is ignited from the rear end of the powder volume, its ignition being slow, it develops sufficient gases to drive the bullet out of the barrel before all the powder had been ignited. The injurious effect of this uneven ignition upon the accuracy of flight of the bullet is apparent. In the muzzle-loading rifle with the breech-pin stud this had been overcome almost entirely by the fact that the powder was lying loose in a sort of chamber, and, as a matter of course, ignites quicker and more evenly. But powder could not be carried loose in fixed ammunition. Dreyse overcame this by placing the fulminate in front of the powder column, in the center of a paper cylinder, which was about one inch in length, and the other end of which formed a cavity which contained the bullet. This bullet was elongated with round ends, the front end being slightly more pointed. This bullet being smaller than the caliber of the rifle, never touched the inside of the barrel, but received its impetus from the paper cylinder. The needle penetrated the powder column the whole length, and pricking the fulminate, ignited it. As there was no chance for any powder not to burn before the bullet left the muzzle, the accuracy of this weapon at short range was very great, in fact, at short range it has never been surpassed by any rifle shooting a cartridge loaded with black powder. But at ranges over 300 yards the bullet went wild. On account of the shell being made out of paper, however, this style of cartridge never found much favor in either military or sportsmen's circles outside of Prussia.

An enormous stride forward has been made; we had the breech-loading rifle, and soon came the brass shell. As a matter of curiosity it may be remarked, that in the infancy of the brass shells a great many gunmakers shook their heads dubiously, for results with these shells were not easily obtainable, on account of the fact that a new factor had to be taken into consideration. For, following the physical law of the mutability of bodies, the bullet would upset; that is, on account of the suddenness of the shock, the front part of the now well elongated bullet would be still while the rear part was already in motion. This same effect is produced, for example, on a center-punch or a chisel in the upsetting of the head. In the muzzle-loading rifle this did not have any effect, for the bullet was contained by the rifling; but in

a breech-loader this at first proved a serious drawback, for the exact size of the bullet was not easily obtainable. Many a first-class rifle-maker has given up the making of breech-loading rifles in despair; a few of them, however, helped themselves in a curious way. They would make a steel shell; the inside of this shell was smaller than the caliber of the rifle and projected into the rifle in exactly the same manner as in the muzzle-loading rifle. The bullet was inserted from the muzzle, usually with the help of a false muzzle, and with a ram-rod seated on the projection of the steel shell. It is noteworthy that this same method is employed

Plate No. 1.

to-day in target-shooting, where time is plentiful. While the results obtained in this manner were very satisfactory as far as accuracy was concerned, they were of course useless for military or hunting purposes. It has taken a comparatively long time to ascertain the exact size of a bullet and the relative difference between the diameter of a bullet and the caliber of the rifle, for which it was intended. The density of the lead employed would alter the size, and as soon as this was apparent, the casting of bullets in a mould was abandoned and the bullets were made

out of lead wire of equal density drawn to size and stamped or pressed. As these bullets were without air-holes from casting, their center of equilibrium came to be as nearly in the same place as mechanical ability could make it. Breech-loading rifles commenced to shoot with surprising accuracy.

One element, of which I have not yet spoken, is the natural drift of the bullet, not the drift produced by the action of the wind. With the twist of the rifling the bullet would drift in the same direction. This was, however, not the only influence. The modus of fastening the sights, the fastening of the receiver and other like things would make the bullet drift. How intense these influences would act is illustrated by the following episode: When the German Government, after the victorious war of '70-'71, wanted to equip its army with the new Mauser rifle, known as Model 6, 1871, it pressed the gunmakers of the world, except the French, into its service. Birmingham, in England, held large contracts. And while all the parts, as well as the finished rifle, were inspected and proved in Birmingham by German officials, the finished arms were sent to the Government factory, Spandau, for their final shooting test. I happened to be a pupil at the Government shooting school, when it was discovered that out of a shipment of 1000 rifles from Birmingham over ninety per cent. would shoot to the extreme right. Here was a puzzler, for all of the proof stamps were on the rifles, the barrels were straight, the caliber exact, etc. Finally it was decided to test the material in the barrel. When the rifle was brought into the factory to have the receiver unscrewed from the barrel, it was found that they were screwed on exceedingly tight and had strained the metal in the barrel. This caused the drifting, and as soon as this strain was removed the shooting quality of these rifles proved to be normal. There are numerous little mechanical defects which cause the bullets to drift, such as rust spots, unevenness of muzzle, etc.

So far all the projectiles were made out of lead. But the usefulness of lead was limited by the fact that the moment you wanted to increase the muzzle velocity over a given point by increasing the powder charge, the developed force was too great for the softness of the material and the bullet would strip; that means it would not follow the rifling, but be driven straight through the barrel. This led to the moulding of the bullet with copper and

lead, the foundation of the present projectile. Still the trajectory showed high elevations.

This was changed, however, with the introduction of smokeless powder by Noble. Here was given an explosive force of hitherto unknown power, which, when reduced to safe standards, bade fair to fulfil the dreams of the gun experts as far as flatness of trajectory is concerned. While at first the construction of suitably strong rifles offered some obstacles, these were soon overcome by the combined efforts of the theoretical and the practical men. Nickle was substituted for copper, steel for lead as a core. The riflings were changed in all kinds of ways, until finally there was

Plate No. 2.

produced the ideal bullet, the sharp-pointed bullet, the Spitzer, which, owing to the fact that it offered the least resistance to the air, and through its perfect balance gives results in accuracy which are very gratifying to the ordnance officers of the army, as well as to the hunter and the marksman.

So marked is the difference between a round-nosed bullet and a Spitzer that the muzzle velocity produced by the same charge in our present Government rifles is 2000 feet in the first second by the round-nosed and 2800 feet by the Spitzer with a gas pressure of 42,000 pounds per cubic inch.

HARTMANN'S PAPER.

The accompanying table gives the number of cartridge, the caliber in inches, the weight of the powder charge in grains, the composition and weight of the bullets and the muzzle velocity of the bullets in feet per second.

Plate No. 1 gives the size of the orifices made in a wrought-iron plate by each bullet fired at the same distance; the orifices are all numbered to correspond with the number of the cartridge in the table. Plate No. 2 shows the depth of penetration in the same iron plate; each orifice in this plate is also numbered to correspond with the number of the cartridge in the table. For instance, cartridge No. 3, calibre .365, loaded with 56 grains smokeless leaf powder, full steel jacket, bullet weight 225 grains, with a muzzle velocity of 2,355 feet per second, made orifice No. 3 in plate No. 1, and penetrated to the depth of orifice No. 3 in plate No. 2.

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Cartridge No.	Caliber Inches.	Powder Charge.	Bullet composition and weight.	Muzzle velocity.
		Black Powder.		
1	.365	54 grs	Soft lead . . . 211.2 grs	1471 ft. per sec.
2	.365	54 grs	Hard lead . . . 206.1 grs	1500 " "
		Smokeless Leaf Powder.		
3	.365	56 grs	Full Jacket . . 225 grs	2355 " "
4	.365	60 grs	" " 225 grs	2446 " "
5	.315	40.5 grs	" " 220.5 grs	2003 " "
6	.315	43.5 grs	" " 187.5 grs	2380 " "
7	.315	45 grs	Part " 150 grs	2573 " "
8	.315	45 grs	Full " 144 grs	2676 " "
9	.315	46.5 grs	" " 144 grs	2738 " "
10	.315	48 grs	" " 144 grs	2733 " "
11	.315	45 grs	Spitzer 394 grs	2676 " "
12	.315	46.5 grs	" 394 grs	2774 " "
13	.315	48 grs	" 394 grs	2791 " "

PRODUCTION OF CRYSTALLINE QUARTZ AND FELDSPAR IN 1906.

In an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," Douglas B. Sterrett, geologist, of the United States Geological Survey, reports that the production of crystalline quartz and feldspar in the United States in 1906 amounted to 20,082 short tons, valued at \$121,671, as against 19,039 tons, valued at \$88,118, in 1905, an increase of 5043 tons in quantity and of \$33,553 in value. In quantity the production was exceeded only by that of 1903, which was 31,940 tons, while the value was greater than for any previous year. There was a large increase in the output of abrasive feldspar, which forms an important part of the total production. The crystalline quartz output was reported by three producers in Connecticut, one in Pennsylvania, and one in Wisconsin. Mr. Sterrett's paper contains a table showing the production of this abrasive since 1895.