THE GUN BOOK

FOR BOYS AND MEN

BY

THOMAS HERON McKEE

WITH NUMEROUS ILLUSTRATIONS

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THE LEWIS MACHINE GUN IN ACTION

Scene at the Observers' School in Aerial Gunnery.

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PREFACE

When man or boy becomes interested enough in firearms to want to know what sort of an instrument the gun really is, and how it performs its work, he is not made much the wiser by reading that: "A gun is a thermodynamic machine by which the potential energy of the explosive is converted into the kinetic energy of the projectile." Nor will the curious-minded beginner get much useful information on the subject by questioning poorly informed adults who may tell him, as they did the author in his youth, that the bullet does not "get up speed" until it is some distance from the muzzle; or that the missile does not begin to drop in obedience to gravity until late in its flight. Such misinformation takes on so many forms that the more of it the inquirer listens to the greater grows his bewilderment. Between these two extremes of overexactness buried in mysterious scientific terms, and of false theories carelessly uttered, the seeker for light on the elementary problems of gunnery suffers almost as much today as he ever did.

The purpose of this book is to set forth accurately, but in simple words, the essential principles of the gun as a projecting apparatus, illustrating more difficult points by reference to familiar objects. As this end seemed best attained by tracing the upbuilding of the gun step by step, from its primitive form to its more complicated and powerful modern successor, the plan has been adopted. It is not claimed that the work adds anything new to the science of gunnery, though in those matters where opinion is allowable the author has drawn a little upon his own experience, which has covered a long period of time.

In order that the novice may, early in his study of gunnery, learn the fact that the hand gun is something more than a mere efficient machine of wood and metal, emphasis has been laid, so far as the limits of the book would allow, upon the vital influence which firearms have had upon the lives of men. The gun is really a great human institution, an intimate knowledge of which is necessary to the understanding of history. If this book helps to inspire more reverence for our venerable weapon friend, its main purpose will be achieved.

As the reader may care to know why he should place reliance on the author's statements about guns, the following brief statement is offered "in extenuation."

The author is a graduate of Columbia University, a lawyer by profession, and has in his work been required to delve rather deeply into the sciences of physics, chemistry, and mathematics upon which gunnery is based. The author's preparation for the writing of this book, upon its practical side, began when as a youth on the Western frontier he helped in a small way to open for settlement the regions of the upper Missouri against the Indians and lawless whites. The adventures of the author at this period have been in part chronicled in a book published some years ago entitled *Cattle Ranch to College*. Those who have read that biography of a Western boy need not be told that a very complete practical knowledge of guns and shooting was necessary to one who succeeded in maintaining his existence through those troublous days.

But though the pioneer knew the powers and limitations and peculiarities of his weapons, the scientific principles involved in the firing of a successful shot were far beyond his ken. From this lack of understanding the author himself long suffered, and that in spite of zealous efforts to gain a deeper insight into the mysteries of the gun as a projecting machine. The time came, however, when the author found himself in huge libraries, and admitted freely to the files of current literature on guns. He thought then that the end had come to his long period of earnest inquiry as to why things in gunnery were done thus and so. But the hope was not to be so easily gratified. The desired information was all within those stacks of books and magazines, to be reached and acquired, however, only by laborious search and a piecemeal sifting process that few laymen could afford to carry on. This situation, in the author's opinion, called loudly for remedy. We owe too much to the gun to permit its honorable past and more recent wonderful attainments to rest in practical obscurity. Hence the writer began keeping a series of notebooks in which he entered from time to time information and suggestions about guns from every source that came under his eye, with the hope that in some future day leisure would permit preparation by him of the sadly needed book.

The opportunity to further his own education in gunnery and to compile the present volume came unexpectedly to the author when three years ago he was ordered, for health considerations, to take up an indeterminate residence amid the dry wastes of the great Mojave Desert. Since that time an exile otherwise almost unbearable has been made not only profitable but most interesting by the companionship of guns, books relating to them, and simple—often home-made—apparatus by means of which many experiments new and old have been carried out. The first-hand information so gained, added to the facts previously accumulated, is now gathered together in THE GUN BOOK, all so simply set down, it is hoped, that he who runs may also read.

In order to confirm its accuracy the manuscript has been submitted to and examined by a trained expert in gunnery, who made a few minor suggestions, but to the work as a whole kindly gave his enthusiastic approval.

THOMAS HERON MCKEE.

Los Angeles, California.

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THE GUN BOOK

CHAPTER I

EARLY USE OF POWDER AS A DRIVING FORCE

When a boy engaged in the old-fashioned but joyful pastime of shooting firecrackers comes across one that refuses to explode, does he resentfully cast it aside and reach for another? No indeed! That stubborn paper tube will still furnish sport. For the sake of variety it is even the better for having failed to go off. It is laid on the ground, gently bent until it cracks open, some of the dusky powder grains falling in the gap; then lighted match or glowing punk is applied, and—Sizz! A spiteful hiss, a stream of flame, and the boy's nervous hand is snatched away, perhaps with a burnt finger or two. It was a fine exploit!

But when that sizzer went off a more important thing happened than the searing of fingers or the mere making of fire and smoke and noise. Observe another and almost magical result. Where are now the smoldering remains of the cracker?

Not where they were so carefully placed a moment ago, but several inches or perhaps feet away, thrown there violently by the escaping powder gases. Here is a simple demonstration of a great idea; a fact of tremendous importance! This playing boy with a modest sizzer has done the thing that lies at the root of the whole science of gunnery, for he has used powder as a driving force—a propellant.

The sizzer, or squib as it should be called, a powder-filled tube, open at one end and closed at the other, is really the direct parent of the great modern gun. From this simple source sprang the weapon which can throw a destroying projectile into the bowels of a battleship tens and even scores of miles away, or at equal distances play havoc with the stoutest forts men can contrive. Many centuries had to pass before the humble squib finally taught men to make and use the mighty artillery of today; but long as the record is, and in spite of the blank spaces appearing here and there, we are able quite clearly to trace the family relationship between the squib and cannon.

Look for a moment at the pinwheel, one of the oldest of powder-driven devices. It is simply a series of squibs made fast to the rim of a wheel.

One tube at a time is lighted, and as the powder gases rush out of the open end they press against the closed end of the tube, and thus the wheel is pushed round and round. The force that does the work is that which we call recoil or kick when speaking of guns, and of which much more is to be said later on. But even though the pinwheel may be said to travel backward, it uses powder as its propellant, and so is an important link in tracing the history of the gun. Indeed the conduct of the squib and its related devices might lead us to declare that gunpowder literally *backed* its way into the world and into the affairs of mankind.

Older than the pinwheel, perhaps, is another variation of the squib—the rocket. The ancient Edison who invented it may have been an almond-eyed Chinaman or a turbaned Hindu, for among one or the other of these peoples the rocket seems to have originated. Remarkable as this contrivance is, we know little or nothing of the time and place it first appeared. It came to us from the Orient before our Middle Ages began. At that we have to let the matter rest, at least for the present. The genius who produced it has likewise been long forgotten.

But we can easily picture in our minds the delight and amazement of the dark-skinned inventor as he fastened a stick to his squib to serve as a guiding tail; and then touching off the powder, saw his apparatus go soaring into the sky, leaving a wake of flame and smoke. Not even the modern discoverer of the incandescent light or moving picture could have been more elated over the success of his plans than was this experimenter of old who first used powder to drive a missile through the air in any direction he chose. The rocket was not a gun, but it resembled the gun in that it used the explosive power of powder to propel a missile in some definite direction. And if the whole truth were known we should probably find that it did much to inspire that vision which finally led to the discovery of the gun itself.

The most frequent, though probably the least important, use to which the rocket has been put all through the ages it has existed is that of providing night spectacles to delight the eye. Most of the early references to it describe the awe and wonder it created in the minds of onlookers who saw it at public exhibitions. But in the Orient in times long ago the rocket was turned to account as a weapon of war. Sent rushing into the ranks of a hostile army, scattering fire and smoke, it served well to frighten horses and even men, to whom it seemed a product of black magic. When aimed at camp or besieged town it carried conflagration and destruction. Europe too has often since used the rocket for similar purposes. As late as our war of 1812 the British fired rockets amongst the men of Jackson's army at the Battle of New Orleans. As a method of signaling at night the rocket still plays an important part, especially at sea, and on the modern battle front. The soldier even uses it to light up the blasted "No Man's Land" beyond his trenches, thereby preventing surprise attacks by the enemy. No fireworks display even in our day is complete without its thrilling ascent. The very age of this marvelous contrivance attests the fact that its ancient inventor by producing it did a noteworthy thing.

The squib fastened to a stick, however, never succeeded well as a weapon. Its approach was too noisy and too well marked to strike down an alert enemy, for avoidance of it, except at close range, was always comparatively easy. Then again it burned too much powder for the work obtained. To get power from gas there must be pressure and with one end of the tube open high pressures were impossible. So the rocket has never been able to compete with the more efficient gun barrel as a fighting machine.

Compared with the ancient rocket the gun is still a sprightly youth. While the former, using recoil as its motive power, is as old at least as the Christian Era, the fixed tube which blows a missile from its mouth has seen only six centuries of existence. The step from the one principle to the other seems so easy and simple that we wonder why men were so long in catching the idea. While it is probable that the stationary tube was used as a toy before Europe called it a gun and began to use it as a weapon, all the evidence we have indicates that the gun had its birth in Europe and not until after the year 1300 A.D.

For a long time it was supposed that the gun was much older than it really is. But the art of reading history has advanced as much as any other of man's accomplishments; and later, more cautious search has caused us to change our views considerably regarding the age of the gun. For instance, the words *artillery* and *gun* (*artillerie* and *gonne*) are far older than the weapons we know by those names. Originally they referred to the battering rams which even in Old Testament times were used to break down walls; and also to those huge throwing machines, some with levers like a human arm, and some with bows, by which heavy stones were cast in battle and siege. When firearms came, the old names were borrowed for them and careless writers and readers afterward confused the two classes of weapons. A second cause of confusion in tracing the early history of the gun lay in the failure to distinguish between mere combustibles and gunpowder. The throwing of burning liquids, solids, and noxious gases into the ranks of an enemy, as is now being done in Europe, is one of the most ancient of warlike resorts. The chief differences in this mode of attack and defense are in the materials used and the methods of their employment, which have constantly changed from age to age.

When Alexander the Great marched into India in 327 B.C. his army was assailed with burning compounds of pitch, sulphur, oil, and suchlike inflammables, either dropped upon the soldiers' heads from city walls, or tossed into their ranks by hand and with machines. When the Greeks came home they also began to use the same stubbornly burning materials in their European wars. Hence the name "Greek fire" by which all warlike combustibles thereafter became known.

Greek fire was often put into earthen pots or wooden kegs, ignited, and then thrown. There are in existence a number of accounts of battles in which these blazing missiles are described, but we do not now make the mistake of supposing that, because machines called "gonnes" propelled fiery bodies through the air, it was guns that were being used. In fact the earliest guns we know about were entirely too small in caliber to be used for such bulky projectiles.

Warriors and merchants and adventurers who penetrated the Orient both before and after Europe began to use guns tell us about finding the natives using explosive powder and fireworks made from it, but say nothing about guns being seen there. In the later days of Rome's glory, fireworks of explosive powder were commonly set off in that city for the entertainment of emperors and populace; but no mention of firearms is found in the records of that period. Neither is it likely that through all the history of those warlike times guns would have escaped mention if they had then existed.

But the most convincing evidence we have that guns were not known in Europe, at least until after the year 1267, is that in that year the Englishman, Roger Bacon, wrote a long treatise on explosive powder, describing its manufacture and the uses to which he had seen it put. This book we have today. In 1233 Bacon, a young priest, went to Paris to study, and there learned the art of making the explosive. Being especially interested in the natural sciences he spent many years in France, not only learning what the people there had to teach about his favorite subject, but conducting laborious experiments and investigations in these matters on his own account. In 1265 Bacon was again in England, now a mature-minded man, no longer a mere seeker for the wisdom of others, but himself a great teacher. In that year the good Pope Clement directed him to write in full all the facts his studies had revealed concerning the laws of nature, with which request the learned priest eagerly complied. He spent nearly two years at the task, turning out in 1267 a bulky manuscript with a long Latin title, including in it his knowledge of explosive powder and describing minutely the things he had seen it do.

While it is often said that guns were used by the Moors before the thirteenth century, the writings of Bacon seem clearly to disprove this. We do not know positively that he visited the cities of that remarkable Mohammedan people who then inhabited most of the lands we now know as Spain, but we do know that he gave special study to the Moorish scientific learning. Of this his works furnish abundant proof. It is most unlikely that Bacon would have overlooked mention of so new and wonderful a weapon as the gun, had he learned of its existence even at a distance.

Crackers, squibs, and bombs seem to be the only explosive contrivances of which Bacon knew, or thought worth describing. But aside from those things he had actually seen, he went on in prophecy and told the wonders he expected explosive powder to perform in the future. How sound a prophet he was may be seen when he said that with powder as a motive power, "There may be flying machines, so made that a man may sit in the middle of the machine and direct it by some device." Again he expects powder to move "ships that may travel without rowers with greater velocity than if they were full of rowers"; and also "wagons that may be moved with great speed." All these things have come to pass and by the aid of explosives too, as Bacon foretold, though petroleum and not gunpowder turned out to be the best means for the purpose.* When a

* It is interesting to note here that in the first internal combustion engines, the piston was driven by an explosion of

learned man, probably the wisest and most open-minded of his day, goes into detail of expected future events like these, and also tells us that he has set down all he knows about powder and its works, we can quite safely decide that he never saw or heard of a gun, since he omits reference to it entirely.

This negative testimony from the writings of Bacon is further strengthened by like evidence from the books of Albertus Magnus, the teacher of Bacon, who also, about the same time, wrote of explosive powder, crackers, squibs, and rockets. He likewise gives details of these instruments, but his writings contain no word or even hint of guns. Albertus, too, wrote of practically everything he knew of the wonders of nature, and also of some things he did not know; as, for instance, his solemn statement that he had often seen horse hairs turn into snakes when immersed in water. With these two earnest men silent on the subject of firearms it is safe to say that there were no guns in Europe at the middle of the thirteenth century.

So far as we know the gun had no inventor. The honor has been ascribed to several, but their

gunpowder within the cylinder. But because more than half of the products of the burned powder remained in the combustion chamber as solids, the device could not be made practical.

title to it has not borne even casual scrutiny. It seems to have been a slow growth, perhaps from a preceding toy of similar form. The squib of paper or wood, if made fast, would shoot a stone a little distance. Then by making the tube larger and stronger some man or men saw the chance to convert an interesting plaything into a dangerous weapon. When the thing was done they called it a cannon.

This, if it happened at all, took place prior to 1326; for in that year the Italian Republic of Florence, as its records show, ordered several metal cannon, including balls for them, to be made at the public expense, for the defense of the state. Whether these guns were ever turned out or not is not told, but this is the earliest reliable reference to firearms that has yet come to light and shows that guns had then passed the experimental stage of their growth. It is not to be supposed that a nation would adopt an arm that had not been proved to some extent at least, so we must conclude that the gun graduated from the roll of toys into the weapon class at least a little while before the year 1326.

In England there is undoubted evidence of the possession and use of guns in 1327, one year after the Italian guns were ordered; and in 1338, when

Edward III invaded France, he took a few cannon and their ammunition with him. We are left with the strong conviction, therefore, that the gun as a weapon sprang into use during the period between 1267, when Roger Bacon wrote, and 1326, when the Florentines saw its merits and added it to their national armament. But it was in a great battle which took place about the middle of the fourteenth century that the cannon, the first firearm, made its formal bow to the world.

CHAPTER II

BEGINNINGS OF THE GUN

The famous Battle of Crécy, fought in France in 1346, between the French and an invading army of English, is a landmark in the annals of the gun. Though the part played by the new instrument in that bloody combat was a very modest one, it there proved the right of firearms to a place among man's warlike weapons—a place to which it has ever since held fast.

Crécy was the real beginning of the Hundred Years' War, which kept all France desolate for a century, and even brought England herself to the verge of ruin. The English were led by their king, Edward III, a bold, headstrong man, ably assisted by his young son, the Black Prince. In 1338 he had landed on the shores of France with an army, claiming title to the throne of that country, and according to French stories he had with him some cannon, which he used in the skirmishes which followed. English records also show that guns and ammunition were shipped to

France in that year. But nothing much came of that expedition, for affairs at home soon caused its abandonment.

Eight years afterward, however, he came once more with more guns and with a larger and better equipped army to try again to make good his claims. Shortly followed the Battle of Crécy, in which his infantry achieved a sweeping victory over the mail-clad cavaliers of France.

The cannon which Edward brought with him and trained upon his foe at Crécy were probably small in size and few in number. Of them we have no particulars, nor does history tell how often they were fired, or with what effect. The French, in excuse for their grievous defeat, said that it was the cannon that beat them and that no army could win against such devilish weapons; but this was not the truth, as the events of the battle clearly show. The fighting was principally done between the English bowmen and French cavalry, and considering the many charges and counter-charges made across the battlefield during the fight, the clumsy, short-ranged little cannon could not have been handled quickly enough to do much damage. It is altogether probable that, beyond frightening horses and some of the ignorant Frenchmen, Edward's tiny guns accomplished little. The French defeat was due to other causes, which will be mentioned presently.

This small beginning made by the English cannon at Crécy was but a prelude to the part firearms were to play in the Hundred Years' War. The French, thus assailed by the new and frightsome weapon, quickly overcame their scruples against its use. They not only armed themselves with artillery, but in skill in making and using it even outstripped their Anglo-Saxon enemies. As the war went on year in and year out the gun grew in importance. Its size and power increased rapidly. The powder used in it became stronger and more reliable and the gunners themselves gained in confidence and dexterity. From being a mere maker of noise and smoke, the "fire tube" entered into the class of deadly weapons.

It was not in fighting in the open field, however, that cannon first gained the soldier's trust and affection. It was too slow in firing, while pieces small enough to be moved about were, with the weak powder of that day, too puny to be of much service. They were carried into the field, of course, but were only expected to fire a shot or two at the beginning of a contest and hastily retire, making room for the infantry and cavalry whose part it still was to do the heavy fighting. In sieges alone the early guns gave real efficiency.

In those days nearly all the towns in France, as in the rest of continental Europe, were guarded by strong castles or were surrounded by high and heavy walls, to protect them against the constant attacks they suffered from hostile neighbors. Hence warfare then consisted largely of attacking and defending fortified places. At this work cannon became almost supreme. In consequence they grew to enormous size, sometimes attaining a bore of two or three and occasionally of four feet. The attacking party needed heavy balls to batter down walls, and as stone was the principal ammunition used, instead of the metal of our day, projectiles had to be bulky in order to give the necessary weight. The battering ram, which had hitherto been used for breaching walls, had to be operated immediately at the wall itself, exposing the operators to fire and missile from above. But the cannon could be set up at a safe distance and huge balls thrown deliberately at a section of masonry until it fell, permitting the infantry to rush in. With the coming of cannon, therefore, the ancient ram was displaced forever, and with it went stone walls as defenses.

While the defenders of a besieged city used smaller-sized guns swiveled on the tops of their walls, to shoot at attackers, they also used tubes of huge bore. Single stones from the wall pieces could do little to check a determined rush of infantry, but a tube two or three feet in diameter, filled with a bushel or more of gravel stones, could scatter death broadcast in their oncoming ranks. The defensive side therefore also found the big gun best for its heavy work.

Most of these mammoth guns were made of wooden staves bound with bands of iron, for we must remember that in those days metals of all kinds were very scarce and very costly. Being of wood, such old-time weapons have all decayed, so that we have no examples of their workmanship to examine now. But they could not have been very strong and probably did not throw their projectiles large or small over a hundred yards or so; whatever distance they made beyond that was perhaps only from ricochet. A few big guns, however, like the "Dardanelles" and "Mons Meg," were made of metal and of these some remain to this day to astonish us by their great dimensions.

The Hundred Years' War dragged on through its weary course of battle and siege, guns both large and small growing constantly in importance

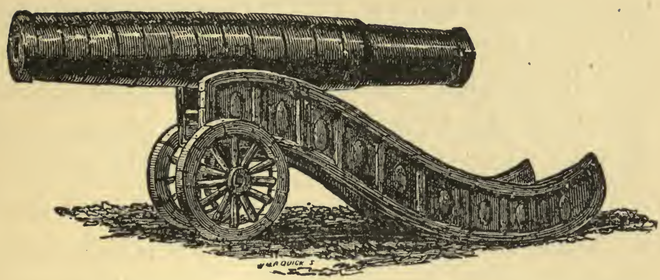


FIG. 1.—THE "MONS MEG" (Edinburgh Castle)
Made about the middle of the 15th century, this huge iron gun remains to us a most interesting relic. Its bore is 20 inches, though the powder chamber is of less diameter to decrease the bursting effect of its charge. It fired balls of stone weighing about 300 pounds.

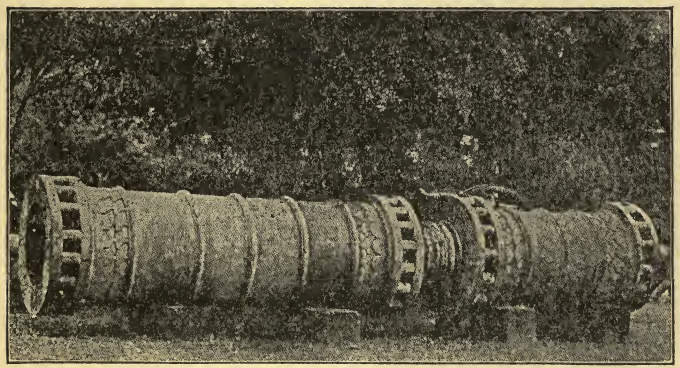


FIG. 2.—THE "DARDANELLES" BRONZE GUN
In 1867 the Sultan of Turkey presented this gun to Queen Victoria. It was made at Constantinople in 1468, is of bronze, 17 feet long, and weighs 18 tons. Its bore is 25 inches, with the powder chamber reduced to 10 inches. It is made in two sections which screw together, thereby making it more portable. Its projectile of stone weighed over 500 pounds.

and becoming more and more commonplace in the minds of men until 1427, when Joan of Arc rode onto the scene on her black palfrey. Taking command of the French armies, this strange and heroic girl warrior inspired her beaten and discouraged countrymen to such energy and deeds of valor that the English invaders were soon forced to sue for peace. Those familiar with Joan's almost miraculous career need not be told of the great part which firearms played in her battles. The gun, though still crude, and in our eyes inefficient, had by that time gained for itself a worthy reputation in the affairs of the soldier.

About the time of Joan of Arc a different kind of cannon begins to appear commonly—the hand gun, a firearm so small and light that a single man can carry it about and discharge it while holding it in his hands. It was not a new thing even then, for here and there all through the later years of the Hundred Years' War these tiny weapons are mentioned. It is natural for us to wonder why this type of gun did not sooner come to the front, for it clearly had many points to recommend it. For the cause of its tardy recognition we shall have to go back again to the Battle of Crécy nearly a century before.

In that fight the French used cavalry almost exclusively, men clad in armor, riding horses also partly encased in steel. Up to that time the warfare of the Middle Ages had been principally carried on by that class of fighting men. Of those, however, the English had few, for by that time

Fig. 3.—Early Hand Gun

A diminutive cannon fastened to a stick, ignited by a hot wire. From this simple, though clumsy weapon, all our hand guns are descended.

knighthood had largely faded out of England, and then too the transporting of many horses across the Channel, in that day of few and small ships, was too difficult to be attempted. Edward therefore was forced to rely on foot-soldiers to make up the bulk of his army. But these were well-trained, cool-headed veterans who had learned the art of fighting in long wars with their Scottish neighbors. They were outnumbered, too, more than four to one, and in addition to that had only bows and arrows to oppose the lances and horses of the fiery French cavalry. But the result of the battle proved not only that their confidence in their own prowess was well founded, but that their simple weapons were astonishingly superior to any the French had, or ever saw before.

The bows and arrows then common in continental Europe were of almost no value against mailed knights, the light short missiles glancing off harmlessly from both man and horse. The French cavaliers expected therefore to charge the despised little English army and ride them down, as they had always before done in opposing bow-armed infantry. But a rude awakening was in store for these haughty cavaliers. The bow with which the Englishman was armed was much longer than the continental weapon of that class, its regulation length being the height of the man who carried it, while the arrows it shot were three feet in length. These were the famous long bow and cloth-yard shaft which were to make history, and, incidentally by their wonderful powers, help to keep the hand gun in the background for centuries after.

Twelve times the French knights valorously charged the English line at Crécy, each time to be driven back with great slaughter. The long

FIG. 4.—ENGLISH LONG BOWMAN

The supple long bow with its string drawn far back gave great impetus to the arrow. In the same manner, our slow-burning powder propels our bullet slowly at first but with increasing speed. Note the mallets for use, and even being used, in despatching the enemy wounded. Before the gun came the holding of a large body of prisoners was so difficult that they were frequently killed in droves by the captors as a measure of self-defense.

flexible bow of the Briton, its string drawn to the archer's ear, discharged its heavy shaft with such speed and accuracy that the armor of the charging knight was pierced through and through. After each onslaught the field was covered with armored men pinned inside their metal plates, while skewered horses charged madly about, increasing the dismay and confusion. When night came the French drew off in acknowledgment of a terrible defeat and of the superiority of the long bow and cloth-yard shaft over lance and horse and plates of steel.

The bowstring of the English weapon, drawn back through a long distance, stored up tremendous power, as compared with the ordinary short bow. When the arrow was loosed the taut string carried it forward with increasing speed and it departed with higher velocity than could be given it by any short bow that the strength of the human arm could bend. This same principle will appear when we reach the subject of our so-called "smokeless powder," for it achieved for the gun what the long bow did for weapons of its class. Both are examples of the value of the long thrust over the short sudden stroke in propelling a missile.

It was not alone the range and power of the cloth-yard shafts that won for them their reputation, but even more the rapidity with which they could be discharged. It is said that a skilled English bowman could shoot twenty arrows a minute from his long bow and aim every one. He stuck the shafts in the ground in front of him, and by long training could reach them, place, and shoot them without taking his eyes from the target. The power of those arrows would carry them three hundred yards and knock down a man or horse at two hundred. Such performances would rank well even in our day of repeating rifles. It is not strange, then, that the little hand gun, capable of being fired only once in two minutes and with a range of a hundred yards or less, had a hard time finding men to use it.

At the Battle of Crécy, furthermore, still another weapon practically new to Europe made its appearance—the crossbow. This had a short, strong bow of steel fastened to a stock, its bowstring drawn back by a small windlass at the butt and released by a trigger. It shot a short, heavy arrow called a "bolt" with range and power about equal to the cloth-yard shaft. The Crusaders had used the crossbow in their wars against the Mohammedans in the Holy Land, but until 1346 it had not been seen on European battle-fields. To help them against the English raiders, the French had hired a number of Italians, mail-clad, mounted, and armed with crossbows. It was these mercenaries with their far-flying and hard-hitting bolts that dealt to the

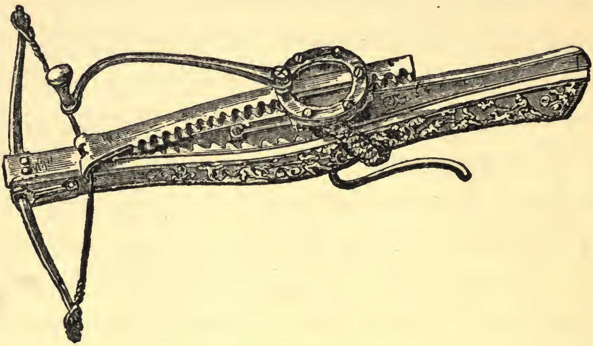


FIG. 5.—CROSSBOW, OR ARBALEST

The strong steel bow was bent by means of the windlass, the weapon being simply a small type of the old Roman ballista. It was first seen in Europe at the Battle of Crécy in the hands of Italian cavalry. Cortez used it with effect during his conquest of Mexico. It was a bolt from one of these weapons that wounded Joan of Arc at the siege of Paris.

Britons the severest injuries they received at Crécy.

But the crossbow was too slow in operation to compete well with the English weapon, for though it had the power and accuracy, only about one shot per minute could be launched from it. The preparatory winding-up process made it far slower in operation than the long bow. In its favor, however, was the fact that its stock and trigger allowed accurate aiming even in the hands of a novice, while the skilled English bowman was compelled to practise from boyhood to gain command of his weapon. With such an advantage in its favor the crossbow from the date of Crécy on became, and for two centuries remained, one of the standard arms in every European army, as well as a favorite weapon of private citizen and sportsman. In Great Britain alone the long bow held its own against the foreign rival.

The hand gun, in the meantime, though greatly overshadowed by the two bow weapons, was making slow but sturdy growth in the limited duties allotted to it. Its bearers in armies were sentinels and outpost men, the discharge of whose pieces gave quick warning of danger. In actual combat these were stationed on the army's wings and flanks to shoot from behind cover, for when attacked in force hand gunners could do little to protect themselves. But one fact standing out prominently in the history of warfare from the later Middle Ages on is the gradual increase in the proportion of hand guns to other small arms, until they finally ousted all the rest.

In the case of the crossbow, heavy and slow-shooting as it was, it is not hard to see why the hand gun gained ascendency, but military and other students of arms have long been puzzled as to why the long bow in time surrendered so abjectly to the apparently inferior weapon. Even at the time of our Revolutionary War, when arms and ammunition were so scarce in the Colonies, Franklin wrote to Charles Lee, who was then fortifying the port of New York City:

> But I still wish that pikes could be introduced, and I would add bows and arrows. These were good weapons, not lightly laid aside:
>
> (1) Because a man may shoot as truly with a bow as with a common musket.
>
> (2) He can discharge four arrows in the time of charging and discharging one bullet.
>
> (3) His object is not taken from his view by the smoke of his own side.
>
> (4) A flight of arrows, seen coming upon them, terrifies and disturbs the enemies' attention to their business.
>
> (5) An arrow striking in any part of a man puts him hors-du-combat till it is extracted.
>
> (6) Bows and arrows are more easily provided everywhere than muskets and ammunition.

When a level-headed man like Franklin could write thus as late as 1776, we may be sure that the hand gun had some virtue not readily recognized that gained for it preëminence over the bow. The generally accepted view is that the gun with its fire and smoke and noise created fright in the hearts of an enemy being fired upon, which qualities were wanting in the bow; that these things got on men's nerves and made them want to run away rather from panic than from fear of the actual destructive powers of the leaden missiles. And while there certainly is much truth in this theory, other and different factors too often forgotten must at the same time be considered.

Among our American Indians, one of the most enjoyed games of the boys was to stand off fifty yards or so and shoot blunt-headed arrows at each other, the fun for both players and onlookers being in the antics of the human target in avoiding the well-aimed shafts. Seldom, if ever, did an arrow strike its mark. At times the older youths, wanting more hazard in their sport, would exchange shots with arrows steel-pointed and razor-sharp. So skilful were these fellows in judging an arrow's course that by a single step to one side or by merely standing still the deadly missile was cheated and whizzed innocently past. The same dangerous pastime was also indulged in with tomahawks and knives instead of bows and arrows, but always with the same harmless results. The writer has often witnessed these games and has at times taken part in them, but never saw an injury occur. Is it not probable, therefore, that a few minutes' observation of these Indian boys at play would convince military critics that the bullet, even though short-ranged and inaccurate compared with the arrow, had advantages other than accompanying smoke and noise? It is invisible. There is no dodging of it. The arrow can be seen and avoided, but the man in front of a gun, and within range, is helpless after the missile starts on its way.

Of course when arrows were shot in great numbers, dodging them was out of the question, but this situation, even to the soldier in war, was infrequent compared with the many other occasions when the threatened man, seeing a shaft or two approaching him, could avoid injury by changing his position. How can we doubt, therefore, that the ability to fly to its mark unseen was the bullet's chief advantage in its contest against the arrow?

The bullet was superior to the arrow, too, in another vital respect; it was less affected in its flight by cross winds. The arrow, while presenting only a small area to the atmosphere in its forward progress, presented a large surface to winds coming at it from the side or at an angle. The bowman, therefore, had to estimate the probable extent of deflection by the wind and allow for it in aiming. This introduced an element of guesswork practically insurmountable. The bullet of course felt the effect of cross winds in its flight, but in far less degree than the long wooden shaft.

The earliest hand gun was a simple tube of iron or bronze fastened to a stick, by which it was held. The firer seems to have held the weapon with one hand, the stick passing under his arm, the free hand being used only to apply igniting fire. The recoil of this crude hand cannon must have been severe even with weak charges, for the bore was large in proportion to its weight; and the projectiles, to fill the tube, had to be of substantial size. To meet the shock of recoil the shape of the wooden piece was soon changed, its butt end being made short and broad, which permitted its being placed against breast or thigh in firing, thus using the body to resist the backward thrust.

The first great change appeared in the form of the hand gun shortly before Columbus sailed for America, when the stock was bent and its length increased to allow firing from the shoulder. This was the "hack-butt" or "hack-bush," meaning "hook gun," which the French afterward

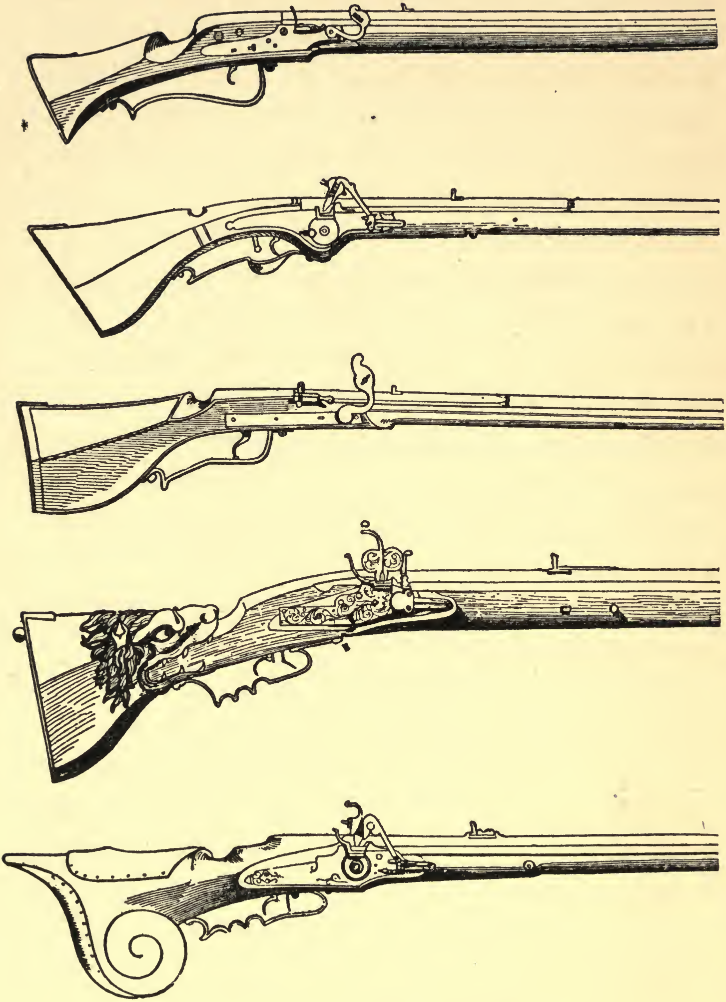


FIG. 6.—EARLY TYPES OF STOCKS
Used on arquebus and musket. They include both wheel-lock and snaphance igniters.

named the *arquebuse,* the word "arque" being the French equivalent for "hook," or "hack," as the Germans pronounced it. So valuable was the curving stock which distinguished the arquebuse that we use it today and count it one of the greatest inventions relating to hand gunnery, because it not only permits the firer to get his eye down parallel with the barrel for sighting, but another benefit conferred by it, one probably unforeseen by its originators, is that it has the peculiar effect of softening the shock of recoil against the body. How this comes about we shall see in a later chapter.

The arquebuse quickly displaced the simple hand cannon that preceded it, and down to the middle of the sixteenth century remained the standard small firearm. It was generally about three feet long over all, had a bore of about three-quarters of an inch, and weighed about ten pounds. Its range could not have been over a hundred yards, while a shot in two minutes was a fair average of its rapidity in firing. Hunters used it a little, and in every army a few arquebusiers were present; but the sword, pike, and arrow were the chief military weapons through all the days of the arquebuse.

Not until about 1540 did the hand gun become a very formidable weapon. It was then that the Spaniards produced the arm they called the "moschetto," after a small hawk, which name has come down to us in the word *musket*. The

FIG. 7.—SPANISH MUSKETEER, 16TH CENTURY

The Spanish musket was of large bore and very heavy. It was the parent of our modern rifle. Note the soldier's bandolier with cartridges attached; also his sword, to be used for fighting at close quarters. The match is held in the left hand.

Spanish musket departed widely from the arquebuse, though principally in size. Instead of being a mere yard in length, weighing ten or twelve pounds, the new arm was from six to seven feet long and weighed forty or fifty pounds. Two men were required to use it to best advantage; while a necessary part of its equipment was a forked stick, upon which to rest its ponderous barrel in firing. Loading it, of course, was slow, and accuracy was not one of its assets; but in power and range it was a weapon not to be lightly regarded.

In outward form our gun of today is practically a copy of the Spanish musket, reduction in size being the principal alteration in its general appearance. Better workmanship and stronger metal in the next three hundred years made the musket a lighter, more accurate gun, but the bore never became less than about three-quarters of an inch; while the effective range remained about the same as that of the old Spanish weapon, two hundred yards or less.

As it is our design in this book to treat of general principles rather than to make a catalogue of ancient relics, we must here ignore many of the curious and interesting firearms and attachments produced during the early centuries. These experimental guns and devices varied in all possible respects, as inventors tried out this or that idea, which was frequently ingenious and possessed of worthy features, though adding nothing in the end to the development of the standard gun.

Besides bending its stock and lessening its weight and size, the only notable changes made in the hand gun from its earliest days down to about 1800 were in the methods of ignition. Of these there were several of great importance, which will be viewed in detail in the next chapter.

CHAPTER III

PROGRESS IN IGNITION

On no part of the gun has more thought and labor been expended than upon the means of touching off the charge after the weapon is loaded. Indeed, for the first three or four centuries this seems to have been the chief subject over which gun inventors pondered, and it was here that they gained the most ground in overcoming the difficulties with which nature has beset firearms from the beginning.

It is likely that the very birth of the gun was delayed by the failure to solve the puzzle of getting fire into the powder charge behind the projectile. Support is given this view by the recent finding of ancient cannon which had apparently no means of ignition other than by a train of powder leading in at the muzzle, and past a loosely fitting projectile. While the making of a small hole at the breech, through which only a comparatively slight proportion of the whole body of gas could escape, seems a ridiculously simple contrivance, the same can be said of any invention after it is made. As an example of this truth, consider how many thousands of years the world waited vainly for a machine that would sew cloth, until Elias Howe accomplished the fact, chiefly by transferring the eye of the needle from its blunt end to a place near its point. At any rate, the existence of those old ventless cannon proves the interesting fact that their makers did not know of or did not have faith in ignition through a small hole in the breech of the piece. Furthermore, the relationship between cannon and squib is made clear because both were ignited in the same way, that is, from the open end of the powder tube.

As for the hand gun, however, the first ones were fired by means of the vent at the breech, through which a heated wire was inserted. So far as simplicity and certainty are concerned this was the best mode of ignition ever devised, not even excepting our own method by use of the percussion primer. The igniting heat was carried directly to the place where it was wanted, without any intermediate step or complication, thus avoiding the aggravating misfires which were the bane of gunners from the time the hot wire was abandoned down almost to our day.

This trouble we are practically free from, though only through the use of firing apparatus which is costly and produced only by skilled hands and delicate machinery.

But the hot wire was subject to the obvious objection that, unless a fire were handy in which to heat it, the whole gun became useless and its bearer remained practically unarmed. For hand gunners who were expected to move about the maintaining of this fire was troublesome at best and frequently impossible. Cannoneers, however, did not find the obstacle so serious, for their pieces were more or less stationary even in battle, which permitted the keeping of a convenient blaze with wires or rods of iron constantly red hot. Hence this mode of ignition was used successfully with artillery long after the hand gunner had found another and, for his purposes, a more satisfactory device.

About the year 1500 the wire igniter was discarded for small arms, being succeeded by the "match," which was really a fuse made of a piece of twisted hemp or tow four or five feet long, soaked in saltpeter solution, and dried. The match ends, when lighted, smoldered for an hour or more, keeping a live coal ready for use, and a number of them in succession would burn for an entire day if required, though in rainy weather the keeping of the match alight was practically impossible, at which times hand gunners took an enforced vacation. There have been battles where the tide of success was turned by an

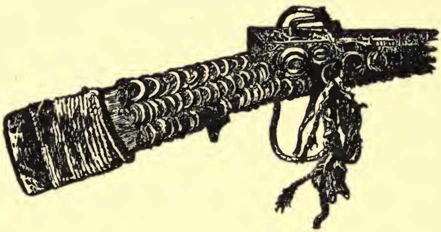


FIG. 8.—THE MATCH-LOCK

An old form of gun lock in which a "match" in the form of a twisted cord of tow or hemp, soaked in saltpeter solution and dried, was used for firing the priming.

oncoming shower which wet the matches of the soldiery and put them temporarily out of action.

Aside from its uselessness when wet, the match brought with it other tribulations not known in the days of the hot wire, to vex and disappoint the gunner. The vent-hole in the breech of the gun had, of course, to be kept small, or else ruinous gas leakage would occur, and in the use of the wire the small vent was no objection. To make the orifice large enough to admit the end of a thick fuse into the powder charge would have given the gas opportunity to waste its strength at the breech. As the vent had therefore to be kept small at all cost, the plan adopted was to form on the top of the gun barrel a bowl-like depression called a "pan," from the bottom of which the vent led down into the powder charge below. Into this pan the gunner, in preparing for his shot, poured a little fine powder, called priming powder, some of which dropped into the vent connecting with the charge. When the match end touched the priming in the pan there was a flash, the flame following down the powder-filled vent, discharging the piece.

This process is described rather fully because that tiny train of priming powder in the vent-hole, simple and unerring as it would seem to be on mere inspection, brought the gun into more disrepute through five centuries of its existence than any other feature connected with it. Throughout all the firing devices we are now about to examine, this minute but important train of explosive is present, though so constantly failing to work that up to a century ago it was a lucky hand gunner whose weapon did not misfire more than once in ten shots. If the priming had always formed an unbroken column from the pan to the powder charge, of course a misfire would have

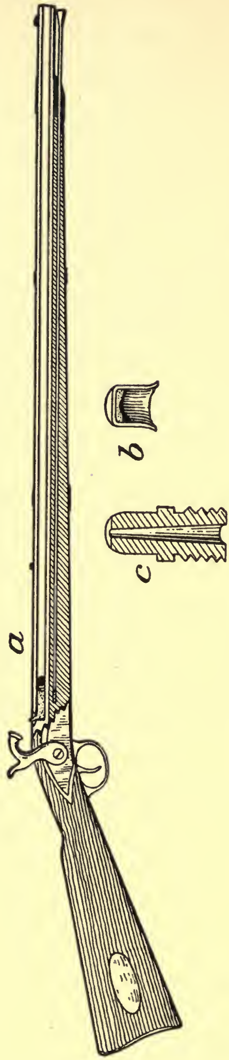


FIG. 9.—*a*, The type of musket in common use by soldiers from 1830 to 1860; *b* shows a cross-section of Shaw's percussion cap, first made of steel and then of copper; *c* is a cross-section of Shaw's nipple upon which the cup was exploded and through which the igniting flame was led into the charge in the breech of the barrel.

been practically impossible, but its continuity was being constantly broken either by failure of the priming to fill the hole completely, or by the accumulation of powder ash in the orifice which choked it up. The result was that unless extreme care were taken in the preparation of every shot the gunner never could be sure whether or not his weapon would go off.

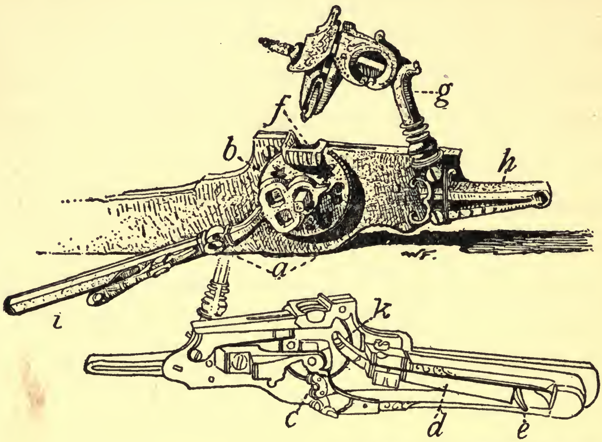
The unreliable qualities of this little powder column have played an important part in history. In 1745 the great Clive, sick and despondent in India, twice snapped a flint-lock pistol at his head and, failing to make it go off, decided to give life another trial, with the result that his further career probably saved India to the British Empire. Again, in our Revolutionary War, Washington once escaped with his life because a British soldier's musket missed fire and without our great Revolutionary leader we might have remained a British province. Even in the days of percussion caps the evil of misfires continued, as will be recalled by those familiar with Parkman's *California and Oregon Trail,* wherein he describes his chagrin at having his weapon fail him from this cause, while hunting buffalo on the plains. It is only by such recollections as these that we are made to appreciate duly the great boon we enjoy in our present, practically infallible ignition.

Until late in the fifteenth century the gunner held his weapon in one hand and touched it off with a match held in the other. Shortly before Columbus sailed for the Indies, however, a great improvement was made over this crude system of manipulation. The match was fastened to a large hook pivoted to the side of the gun, the lower end serving as a trigger by which the nose of the hook carrying the lighted match could be thrown down into the priming-pan. The obvious value of this contrivance was to allow the gunner to support the weapon with both hands, effecting the ignition by a finger, instead of a whole arm and hand. At first the hook was placed in front of the pan, though its position was afterward at the rear of it. Then the pan itself was shifted from the top of the barrel to its side, where the priming powder it contained gained better protection from wind, always before that a serious detriment in blustery weather. From its resemblance to a snake's head and neck, the hook derived the name, "serpentine," which title soon became not only a common name for the weapon thus equipped, but also for the dust-like powder of those days used both in small arms and cannon.

We must be careful, therefore, in reading all writings about the gun, for the name serpentine applied to three separate and distinct things. The better name for the gun with hook and trigger, and the one best known, is "match-lock," describing its means of ignition, which remained the standard firing system until well into the seventeenth century.

During all the intervening time, however, men remained satisfied with the match-lock only because they had nothing better in its place. The keeping of the match alight through rain or storm was a great care even when possible at all, and in those days fire was so difficult to obtain that even the first lighting of the match was not easy. As stone and steel struck together were then the original source of all combustion, an unknown German, about the beginning of the sixteenth century, decided that if he could arrange these materials so as to strike fire directly into the pan of his gun, instead of first lighting a fuse for the purpose, he could thereby eliminate the troublesome match altogether. He tried it and succeeded, producing the wheel-lock.

This device was regarded as extremely complicated in its day, and even seems somewhat so to us when explained in writing, though the principle upon which it worked can be readily understood by any one who has seen sparks fly from a dry grindstone when a steel tool is held against



Courtesy of the Century Company

Fig. 10.—The Wheel-lock

a, Lock plate, supporting all the lock mechanism; *b*, wheel, with grooves of V-section to form circumferential edges; *c*, chain connecting the axle of *b* with the extremity of the mainspring *d*; *e*, trigger; *f*, flash-pan; *g*, the serpentine holding the flint; *h*, spring which presses the flint upon the wheel in firing, or holds it away when winding up the lock; *k*, sear and sear-spring, the sear engaging the wheel by a short stud entering recesses in the side of the wheel; *i*, wrench, fitted to the axle of *b*, for winding up the chain, and having a hollow handle for measuring out the priming powder.

its face. In the wheel-lock, however, the stone itself did not revolve, but a rough-edged wheel of steel spun against it, driven by a spring. A key wound it up, and when the trigger was pulled the stone (pyrites), attached to a lever, came down into the pan, pressing against the wheel, which protruded upward into the pan from below. Thus sparks were produced in the pan itself, where lay the priming powder, and when it flashed the gun went off.

But the wheel-lock was too costly and too frail to win a large place in warfare—then the principal use made of guns. The average soldier in that day was unfamiliar with machinery of every kind, and the springs and levers of the new device were more than he could manage and keep in working trim. Yet in spite of its defects, Gustavus Adolphus armed a large number of his men with these weapons, obtaining good service from them, and at the same time they became almost instantly popular with those in private life who wanted guns for self-protection. Furthermore, with the coming of the wheel-lock, hunting with guns may be said to have begun—one of the chief uses ever since for firearms.

There was one position in all European armies of that time where the wheel-lock, and the snaphance which grew up practically alongside of it, had peculiar value. This was in connection with artillery and artillerists. The heavy guns were commonly handled by laborers who were not soldiers at all but were picked up wherever they were handiest, bound and forced, usually against their will, into the fight. A chief gunner and a few apprentices in control commanded these "roustabouts," as we should call them, but when a battle began they had to be unbound and some one had to help keep the poor fellows from running away. Hence with every train of artillery was a squad of guards, whose duty it was to keep

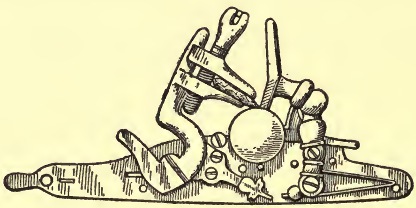
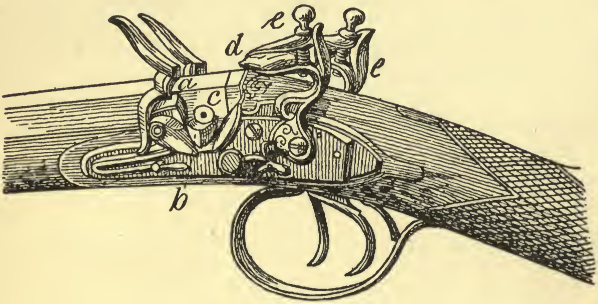


FIG. 11.—THE SNAPHANCE

the frightened crew at work and to shoot them down if they tried to escape. Thus also grew up the marine corps on shipboard.

As it was necessary when in action to keep open powder barrels standing around the guns, and even customary through a long period actually to mix the powder ingredients on the battle-field, soldiers with lighted matches were dangerous companions. When the powder was being mixed, too, it gave off a dust that was highly inflammable. Thus the desirability of the stone and steel igniting devices for muskets of the guards is apparent. These squads immediately adopted the new arm, and from them as a nucleus the use of the friction igniter gradually spread until the smoldering match was elbowed out entirely.

The "snaphance," which appeared shortly after the wheel-lock, and the flint-lock were really



Courtesy of the Century Company.

FIG. 12.—THE FLINT-LOCK

one and the same, the latter being only an improved form of the other. In them a piece of rough-faced steel sloped down into the pan, while the stone, pyrites in the first and flint in the latter, was snapped down against it with a scraping action, throwing sparks into the priming powder. In the final form taken on by the flint-lock the steel scraper became part of a cover which protected the pan from wind and dampness, and which the flint pushed up as it came down. The flint-lock proper, which came into common use shortly prior to 1700, lived and gave good service for a hundred and fifty years, though when the chemist gave us the percussion cap in 1830 it began slowly to disappear. With it were fought our French and Indian Wars, as well as those of the Revolution and of 1812. Even as late as 1880 the writer has seen flint-locks carried and used on the northwestern frontier, mostly in the hands of Indians from the wilds of Canada. In secluded districts in our Southern states the ancient arm is still carried by old backwoodsmen, who continue to find virtue in it, chiefly because a flint can be picked up almost anywhere, while for caps or cartridges a store must be sought. This great advantage kept flint-locks in the hands of the frontiersmen long after the caps were introduced, though as the country settled up this reason failed and the flint-lock is now only a relic.

NOTE:

The following extract from a list of arms sent from England to Plymouth, published in the *Records of Massachusetts,* volume 1, page 6, gives an excellent description of the arms (as well as of the spelling) of the early colonists:

1628 A.D.

Armes ffor 100 men.

80 Bastard musketts wth snaphances, 4 foote in the barril, without rests.

06 longe ffowling peeces with bastard muskett boare, 6 foote longe.

4 longe ffowling peeces with bastard muskett boare 5½ foote longe.

10 fful musketts, 4 foote in the barril with match cocks and rests.

90 bandoleeres for the musketts, ech wth a bullet bag.

10 Horne fflasks, for the longe ffowling peeces to hould a X apeece.

(The ''ffull muskett boare'' was about one inch. The bastard bore was about one-fourth smaller.)

CHAPTER IV

ABOUT GUNPOWDER

In an ancient writing on the art of gunnery we read that: "A cannoneer must always love and serve God, for every time he fires a gun or makes powder, he may be killed." Whether we agree with this reasoning or not, the statement calls to our attention two facts of interest—the occupation of a gunner was a hazardous one, and in addition to his duty to train and fire his guns on the enemy, he was also a maker of powder.

It will be noticed, too, that this old writer does not mention the danger of being killed by the enemy's shot; it is his own creations he most fears. And it did take a brave man to be a gunner in those perilous days, when faulty cannon burst without warning and defective powder would explode fiercely at one shot, and perhaps fail even to drive the projectile from its tube at the next. James II of Scotland was blown up while watching a cannon being tested. As we are following the course of the hand gun and not that of the cannon, we are interested in this old-time hero only as he filled his function of official powder maker of his army. On him the arquebusier and musketeer for many years relied for their dole of explosives.

For the first three hundred years of the gun's existence, cannoneers all belonged to a secret society much like a union, the principal objects of which were to keep wages up, to guard from the public the secrets of the art they followed, and to exchange information among themselves. They were not soldiers and did not wear uniforms, their sole badge of office being the leathern apron they wore when mixing powder. Apprentices were admitted to the union and allowed to advance through several "degrees" until they finally achieved the high honor of "master gunners."

But as none of these men had the slightest knowledge of the basic principles of gunpowder, it is not surprising that the art of gunnery advanced so slowly. Some of them claimed for their powder the virtue of much smoke, some declared their product would give great noise, while others vowed that they could mix a charge of such magic qualities that it would shoot projectiles unusually straight. Indeed the general ignorance which long prevailed regarding the explosive was surprising. As late as 1702 De la Hire, a French scientist then eminent, gave as his mature opinion that the projectile was expelled from the gun because of the expansion of the air among the grains when the powder burned. The creation of gases during the explosion seemed to be even unguessed. It is only within the last hundred years that the gas-making qualities of powder have become to any extent common knowledge, while only within sixty years, commencing with the labors of General Rodman of the United States Army just prior to the Civil War, has the study of explosive propulsion taken on the dignity of a science.

The procuring of saltpeter was ever a serious problem with the powder makers of former times. In the Oriental countries it was plentiful, but transportation of the material from that source was so difficult that supplies nearer home were much to be desired. Though nature is constantly producing saltpeter everywhere that plants abound to give decayed vegetable matter, Europe never seemed to produce it very plentifully; by dint of hard labor and much ingenuity, however, considerable quantities of the salt could always be had. It was found that the stone walls of old stables contained good percentages of saltpeter absorbed from manure, which could be extracted by soaking the broken mortar from the masonry in water and evaporating the liquor. The sides of ancient underground vaults encrusted with the white deposit were scraped and washed to get the small contributions they afforded. In every European country where firearms were used, official squads existed whose duty it was, both in peace and war, to search for these scanty sources of supply and to garner the precious chemical. Slow and laborious as the process was, tens of thousands of pounds were by such methods annually brought into the national arsenals.

The presence of saltpeter in those old walls and in deposits formed by waters seeping through decaying vegetable matter, led men later on to try producing the drug by imitating nature's methods. Thus came into existence the industry long important in Europe, known as niter farming. In this process beds of mingled manure and earth were prepared, each so arranged that it could be kept warm and dark; and to permit free admission of air to the mass the contents of the bed were frequently stirred. Experience taught that these steps brought best results.

After a few weeks of this treatment, wood-ashes were added to the mixture, and then the whole soaked in water. The liquor obtained when evaporated left in the bottom of the containing vessel a coating of white crystals of saltpeter.

The niter farmer of olden times did not know why he did things in this manner, but only that in so doing he in the end obtained a small quantity of the prized chemical. Science has since taught us that the process produced saltpeter chiefly through the action of certain bacteria, tiny plants which thrive in decaying vegetable matter which is kept damp, dark, and warm. What we call decay is simply the destruction of vegetable fibers by other plants feeding upon them. The bacteria in question, in thus sustaining their own lives, caused nitric acid (HNO_3) to form; and as wood-ashes contain potassium (K), the acid seizes it when the two come in contact, forming potassium nitrate (KNO_3), or saltpeter. The nitrate farmer had invented nothing new, but, by creating favorable conditions, allowed Nature to hurry her processes faster than when human hands did not interfere.

During the century and a half preceding 1850 niter beds produced a large part of the saltpeter used in European countries. But about the latter date a new, cheap, and abundant supply of the chemical became available for the powder maker. In northern Chile occur immense deposits of sodium nitrate ($NaNO_3$), which, it will be noted, is like saltpeter, except that it contains sodium instead of potassium. Sodium nitrate, with sulphur and charcoal, makes almost as good an explosive as the saltpeter mixture, but has the undesirable quality of seizing moisture from the atmosphere, which renders its burning powers variable. The Chilean chemical standing alone therefore did not aid in the search for a cheap explosive. In Germany, however, there existed huge quantities of another earth-bearing potassium chloride (KCl); and it was discovered, when the Chilean earth and that from Germany were dissolved together in water, saltpeter and common salt formed as follows: $NaNO_3+KCl=KNO_3+NaCl$. Thus when brought together these two earths, placed by nature almost on opposite sides of the globe, voluntarily exchanged their atoms to form two different compounds, the one to help destroy human life and the other to preserve it.

The Chilean and German chemicals were to be had in untold amounts and were easily mined and transported; so that at last the powder maker was supplied with saltpeter cheap and plentiful. The powder used in our Civil War, as well as that used in all of the great European wars in the latter half of the nineteenth century, came from this source. The niter farm was no more and the farmer who tended it had to turn to other means for livelihood.

The scarcity of saltpeter led the early powder makers to form their explosive mixtures with too little of this ingredient and with an excess of charcoal or sulphur; the powder so made was weak, and because the elements were only partly burned, much smoke and ash resulted. As saltpeter became more plentiful in later days, through better methods of production and cheaper transportation, the percentage of it used was increased, with consequent improvement in the explosive. But this custom of changing the proportions of the ingredients according to the supply of each at hand, gives an insight into the rule-of-thumb methods which long governed the manufacture of powder.

A good black powder mixture for firearms, and the one now generally used for arms requiring that kind of explosive, is made of six parts by weight of saltpeter and one part each of charcoal and sulphur.

The chemical symbols for these substances are: saltpeter, KNO_3, carbon, C, and sulphur, S. Upon burning, these ingredients change into two solids, potassium carbonate (K_2CO_3), and potassium sulphate (K_2SO_4), and three gases, nitrogen (N), carbon dioxide (CO_2), and carbon monoxide (CO). Expressed as a chemical formula or reaction, what takes place when the explosive burns is approximately: $4KNO_3+C_4+S=K_2CO_3+K_2SO_4+N_4+2CO_2+CO$.

It will be noticed that all of the carbon has united with oxygen from the saltpeter, producing either gases or different solids. Fifty-seven per cent of the powder we began with remains as solids or ash, while forty-three per cent has turned into the three gases indicated. The space occupied by the new products, however, has so wonderfully increased that one cubic inch of powder will now fill 280 cubic inches at ordinary atmospheric pressure. That means that in burning gunpowder we multiply its bulk 280 times.

The pressures thus created are remarkable. Powder exploded in a small chamber strong and tight enough to prevent leakage will press against each square inch of the cavity's surface with a force of over thirty tons. What this mighty power is we may slightly comprehend when we remember that the strongest steam boilers do not carry pressures of more than three hundred pounds to the square inch. When fired in the gun, of course, no such force is exerted, for the cold metal walls of the tube cool and shrink the gases considerably and the projectile moving forward before the whole charge is burned gives space for expansion. But ten to fifteen tons is an ordinary pressure for black powder fired in rifle or cannon.

The burning of powder in a gun is much the same operation as burning wood in a stove, except that with the latter air must be admitted or there will be little or no combustion. In both cases we cause carbon to unite with oxygen to produce heat and to form gas. The carbon in the wood takes its oxygen slowly from the air and we get a fire. The peculiarity of gunpowder, however, is that it carries with it its own carbon and oxygen, both in solid form, and atoms of the two when slightly heated jump suddenly together, producing not a slow fire but a quick one, which we call an explosion. The gases produced by the wood fire pass leisurely up the chimney; those formed by powder in the gun barrel, firmly resisted by iron walls on all sides except one, rush violently out of the muzzle, carrying the obstructing bullet ahead of them. Thus we have a shot.

While we have learned much about *how* the atoms of carbon and oxygen come together to produce a bulky gas, we know little about *why* they so act. We only know that the minute particles have a strange desire to leap into each other's arms when brought close together and slightly heated. In the operation they produce heat and create a new gaseous compound. For the sake of giving a name to this force, we call it "chemical affinity." The sulphur in the powder mixture seems to aid the atoms of carbon and oxygen in coming together; it ignites readily and produces the required preliminary heat. Increase of sulphur makes the explosion much more violent, while a smaller percentage allows the powder to burn more slowly. By varying the sulphur content, then, we can, to a certain extent, make quick or slow powder as we wish.

Whether the ancient "fire powder" which preceded the gun, and of which crackers and rockets were made, was the same as our gunpowder is not altogether certain. If you will put a dab of saltpeter on the end of a splinter and hold it in the fire it will sputter in a lively manner as the oxygen from it unites with the carbon of the wood, for even without sulphur, carbon and saltpeter will make a mild explosive. We are quite sure that the Orientals used saltpeter and charcoal in their powder, for we have never found them using anything else, and they had these materials in abundance. It has been argued, however, that they did not use sulphur in their mixture because their two chief types of fireworks, the cracker and the squib, could both be made of saltpeter and charcoal alone, while if sulphur had been added the rocket and pinwheel would have burst without moving. But this contention loses sight of the fact that gunpowder, if slightly dampened, will burn slowly enough to make excellent rockets; again, if the powder be ground very fine and tamped tightly into a rocket tube it will burn so slowly as to carry the apparatus up without bursting it. But the most we know concerning the matter is that about 1265, when Roger Bacon first described gunpowder for us, sulphur was an important part of the compound.

Although Bacon distinctly stated that the three ingredients were to be finely ground, mixed, and wetted in order to get the best results, the powder makers, for more than two centuries after guns came into use, insisted in omitting the wetting process and using the stuff in dry dust-like form, calling it, as we have seen, "serpentine." When mixed beforehand and hauled about in jolting carts, or carried in powder flasks, the ingredients had the disagreeable habit of forming themselves into layers, the heavier saltpeter going to the bottom and the fluffy charcoal rising to the top. To prevent this, the materials had to be carried separately and not mixed until actually ready to go into action; thus, as we have seen, giving rise to danger of premature explosions, and making welcome the advent of the guards armed with wheel-lock muskets instead of match-locks.

"Thrust the poudre home faire and softly," said an old writer in giving advice on the loading of guns. The warning was then important, for when serpentine was rammed hard into the barrel it would not explode. The mass was too solid for fire to penetrate it and the bullet might or might not be pushed out. This behavior of serpentine was very puzzling to the gunners of that day, for they knew only the result and not the cause of it. It is no wonder they called it "devilish stuff." The peculiarity, however, was due to a very simple principle of all burning.

When flame attacks a solid it must consume it from the outside inward toward the center, and this action, even with gunpowder grains, takes time. In general the bigger the lump the slower will be the combustion, just as we see a large chunk of coal lie smoldering in the fire long after the smaller pieces, the same in total quantity, are reduced to ashes. The tightly rammed serpentine became a compact lump burning leisurely or not at all. When "thrust home faire and softly" it burned rather satisfactorily, but in clumsy hands faulty loading of the black dust gave constant trouble. One shot would be violent and the next a failure, according to the force applied in loading the gun.

In the latter part of the sixteenth century the practice began of wetting the powder during manufacture, and this in time became the standard method. The dampened powder when dried into cakes and broken up remained in tiny lumps or flakes, from which the dust was sifted. It was then called " corned powder." Transported, it did not cause separation into layers as with serpentine; and the loading of guns, too, became a less delicate operation, for the granular powder could not easily be rammed too tight. Corned powder proved to be much more violent in its explosion than serpentine. This fact was due to the principles governing burning materials already alluded to. The finely pulverized serpentine retarded the circulation of flame through it, and hence its rate of burning was slow; while the grained powder had vacant spaces between the granules, which allowed free access for the igniting fire, resulting in rapid combustion. In hand guns the tubes could rather easily be made strong enough to withstand the shock of the more sudden explosive, because a small tube, having fewer square inches on its interior, presents less surface to the pressure of gases. But the use of corned powder in cannon was not permissible for a long time after its manufacture began, because the great guns burst or swelled under the increased strain. It was half a century before cannoneers discovered that corned powder could also be used in their weapons, provided the grains were made so large that they were rather slowly consumed. Thenceforth powder for large and small guns differed chiefly in the size of their grains, and serpentine passed out of use for all purposes.

The making of powder into grains has become an important and rather complicated process in our day. The effort is made not only to make all kernels the same size, but of the same shape as well; for the spherical grain will not burn as fast as one made more nearly flat, since the latter exposes more surface and therefore burns more quickly. Unless the grains are uniform the burning will vary between one charge and another, and inaccurate shooting will result. Our powder is also much less bulky than that of days gone by; for in the process of manufacture it is subjected to heavy pressure, which not only makes it very compact, but the hardened grains burn more slowly than soft grains would. After the compressed cakes are broken up into grains, this hardness also permits their surfaces to be polished until they shine, and they thereby resist dampness far more successfully than did the old serpentine or corned powder. But gunpowder (with all its virtues, old and new) has never been a perfect propellant. Its explosion is either too fast or too slow, and there has been no successful middle ground yet discovered. When made to burn slowly the proportions of its ingredients are not right for perfect combustion; hence a large percentage of its mass remains in the weapon unburned, being not only wasted, but clogging up the bore, to the detriment of the next shot. If correct proportions of the materials be used the explosion is like a sudden blow against the projectile, tending to crush it and burst the gun, instead of giving the long push down the barrel that gives speed with minimum of shock. Merely changing the size, shape, and hardness of the powder grains gives considerable leeway in regulating the force of the explosion, but not enough to gain the desired results.

This great defect in gunpowder has led to the invention of nitro or smokeless powders which can be made to burn as slowly or as fast as may be wanted. The astonishing improvements in gunnery brought in by the new explosives are too many to be mentioned here and will therefore have to be reserved for a future chapter.

Hence gunpowder is now on its way to oblivion along with serpentine and the arquebuse. Though we welcome the new explosives that take its place, there is something solemn about this passing of our long-time friend. It is one of the few links that remain to connect our modern with the ancient world, and though it has wrought much woe to mankind at times, it has, on the whole, been a faithful worker for human liberty. Let us therefore give it at least a kindly thought as it fades into the distance behind us.

CHAPTER V

GOOD WORKS WROUGHT BY THE GUN

At the Battle of Crécy in 1346 the long bow, crossbow, and cannon all began their careers as arms of world-wide importance, but that contest witnessed another revelation of more far-reaching effect than the mere introduction of new and deadly weapons. It was proven on that hard-fought field that common men, when armed and trained, had the heart to stand up and fight against aristocrats, a fact that the latter class in continental Europe had long refused to believe. Crécy marked the beginning of the rise of the infantry soldier and the downfall of the mailed horseman. The reversal did not all come at once, of course, but when started kept on until completed.

The effect of this change of positions was very great. It meant that a king or petty prince could no longer declare war at his own caprice, and with a small band of mounted, steel-protected knights proceed to ravage the territory and murder the inhabitants of a neighboring state. The sound beating the English footmen administered to the French nobles at Crécy gave new courage and confidence to every peasant and artisan, men who for centuries before had been compelled to cringe in the presence of those they had been taught were their betters.

The truth is that infantry properly armed and trained to act in unison has always been stronger than cavalry; for the latter's best weapon is the horse, and horses have always been vulnerable to the spear or strong-shooting missile weapon. But in the Middle Ages the leisure classes kept to themselves the sport of fighting, and there was no one to drill the footmen, who therefore did not know their strength. A man who worked with his hands was not permitted to become a knight; he was an inferior with whom no comradeship was possible. The art of fighting on horseback with lance and sword required long practice; and even if the common man had possessed the elaborate equipment necessary, this practice could not be gained in secret. For a farmer or carpenter to be caught with arms was in itself a crime, frequently punishable with death. In cold fact, the peasant actually belonged to the lord who owned the land upon which the peasant lived, and was bought and sold with the land, just as were the cattle in the pastures of the domain. The poor fellow did not even own his own body and could not leave his master's farm boundaries with-

Fig. 13.—A Knight in Armor

out special consent. It is no wonder then that the ordinary man lived cowed and humble for so long.

Being a knight was an expensive business, for each had to have several horses, with servants to care for them; besides, an attendant, called a squire, was necessary to help the steel-encumbered great man into his saddle, and hand him his weapons after he was up. The mail worn, too, cost a small fortune, for it had to be hammered by hand out of fine steel, which was then almost a precious metal; the engraving upon it alone often took a year's time of a skilled worker. The warrior class, therefore, came to be made up wholly of the rich or well-to-do, separate and apart from the common people, who had to work to live.

While song and story tell us pleasing legends of the courtly conduct of these knights, the sad truth is that their fine manners were kept principally for members of their own high-born class. As a rule, they treated the common people shamefully at home, while the peasants they sometimes drove into the field with them in their wars to act as servants and to guard camps and supplies, were often ruthlessly sacrificed to the enemy. Indeed there is more than one instance on record where they deliberately rode down their own footmen in order to gain some slight advantage in battle, or to save their precious necks in retreat.

These shameful things they could do with impunity, for their armor protected them from damage by the ordinary weapons then in use. It was difficult even for one knight to overcome another in fair fight because of the strength of the mail they wore. Their actual battles were almost bloodless at times, for the most one could usually do was to unhorse the other, and the vanquished one, burdened with armor, then lay still until the fight was over, and either his friends had time to come and pick him up or his foes to rescue him and hold him for ransom.

The appearance of the long bow, however, put an end to all this arrogance of the knights. The cloth-yard shaft punctured their armor, pierced their bodies, and humbled their insufferable pride. They then tried making their steel plates so heavy and strong that arrows could not break through. In this they succeeded moderately well, but the horse could not be so protected, hence armor was finally almost entirely thrown aside. The aristocrat then, if he wanted to go to war, might still ride his horse, but he took his chances in battle with the humblest. He had lost his monopoly of the trade of fighting and became a mere assistant of the formerly despised foot-soldier.

The good work thus begun by the long bow in displacing armor and the aristocratic warrior class was taken up and continued by the hand gun. But before firearms assumed the full burden, the ancient spear of the Greek and Roman was again to come back to earth and serve, as before, as an infantry weapon for over a century. Cavalry was still an important part of every army, though the trained foot-soldier was now relied upon to bear the brunt of the fighting. The spear, or pike, as it was called, could not only repel a cavalry charge, which the sword could not do, but at hand-to-hand fighting with other infantry was also a formidable weapon. The hand-gun man could shoot only a single ball, while a charging enemy either on horse or foot was advancing two or three hundred yards; and as his weapon was useless at close quarters, not much reliance could be placed upon him. Therefore in the sixteenth century Spanish armies, which were of the best, contained only a few musketeers. In time, however, the number was gradually increased. It became customary to have the front line of spearmen open their ranks, allowing hand gunners to advance, fire, and retreat; one after another advancing and repeating the operation until the enemy charged, when the line of spears was again closed up. The slowness of these guns can be estimated when we are told that, in order to keep up a continuous fire through one gap in the spear line, five musketeers were necessary, one actually shooting and four behind in the various stages of loading their pieces. This complicated process required so much training and was so generally unsatisfactory that the hand gun, though never abandoned, remained largely in the background until the middle of the seventeenth century.

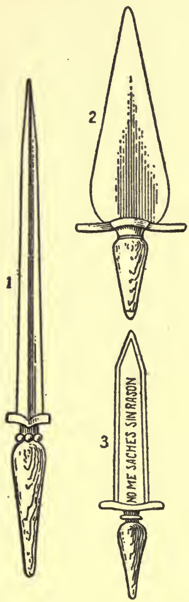


Fig. 14.—Bayonets, 17th Century

1. Wooden-handled tri-angular-bladed bay-onet-poniard.
2. English langue-de-bœuf plug-bayonet.
3. Spanish wooden-han-dled knife-bayonet.

The arrival of the bayonet in 1640 is what really raised the hand gun to the first class as an arm for infantry, and put an end to these cumbersome tactics. This important instrument got its name from the little town of Bayonne in France, where it is supposed to have originated. At first it was simply a knife with a round shank to be stuck into the muzzle of the gun, which, of course, could not be fired until the bayonet was removed. This objection was soon done away with by making the shank hollow, to slip over the outside of the barrel. The effect of the bayonet was to drive out the pike, because with this attachment the musketeer, whose weapon had by this time been reduced in weight to about fifteen pounds, now became a pikeman as well as the bearer of a missile weapon. With his bayonet-pointed gun he could shoot from long range or fight at close quarters, as with a spear, and even successfully cut down the horses of cavalry that might charge upon him. The results which followed were startling, for instead of having, say, a thousand men armed with pikes for close fighting, and another and different thousand for shooting balls to a distance, there were now two thousand men who could be sent in at the same moment to fight either kind of battle. The strength of the force was thereby instantly doubled. Of course the pike and sword were no longer necessary and the gun with its bayonet became the sole reliance of infantry.

But mere changes in military tactics were far overshadowed in importance by other results following the introduction of new arms and the substitution of the foot-soldier for the knight as the chief fighting unit in armies.

The powers of government immediately began to shift from a very small and exclusive class in nations into the hands of the majority of the people, where such powers actually belong. The king was thereafter compelled to go to the common people of his land, who were to do the real fighting and who had always paid the bills, and persuade them to follow him into the field; he had also to ask them for the money to finance his wars, whereas in previous centuries ordinary folk came and went as they were bid, and gave up their earnings in taxes whether they liked it or not. Though kings continued at times to lead their infantry armies into occasional unjust wars, they had to do it by cajolery or deception; they could no longer force their men into action. This shifting of power and the changing of government from master to servant, though begun at the Battle of Crécy and not even yet entirely completed, have been among the world's greatest events. In bringing them about the gun has had no small part.

It had long been a proverb in English law that a man's house was his castle, which none could enter without his consent. But until the coming of the gun the claim was rather an empty boast, at least on the part of the humble citizen. With only the strength of his arm to repel an intruder such a man had small chance to carry out the fine principle. Firearms gave the advantage to the man who, behind his door, acted on the defensive.

With a gun in his hand the defender became as strong as several men on the offensive, and entrance to a house against its owner's will was a hazardous affair. The result has been, as we see it continued to this day in the most enlightened countries, that one man, no matter how high his station, cannot lawfully enter the home of another without his consent; and if he tries it he may be shot down, if that be necessary to stop him. The only exception is where the people themselves, through their officers, for good cause shown, require the invasion. Thus, security of the home, a thing unknown in the days of the valiant knights who strode in and out as they chose among the common people, became established not as a mere saying but as a fact. For this blessing we must also thank chiefly the gun.

As the right to make laws gradually came into the hands of the people themselves, other reforms greatly needed came about. Some of these we enjoy today, perhaps without fully appreciating them. When governors owned the people, they of course found their subjects easier to handle if kept poor, ignorant, and in fear. So the taxes which the workers paid were not devoted to the building of schoolhouses and the providing of teachers to instruct the youth, but were spent by the overlords in silly wars, which were not much more than hunting expeditions gotten up for sport, and on foolish display in dress, as well as eating and drinking in ease and luxury. The rich were very rich, while the poor were kept very poor and ignorant, and there was almost no middle class. The laws of the country were made by the masters and applied vigorously to the common people, but lightly or not at all to the men who made these laws. A farmer's boy caught trapping rabbits in a great man's game preserve could be lawfully hung for the offense, and this was frequently done. There were hundreds of offenses punishable by death when committed by those not of "blue blood." Sometimes the sentence called for the quartering of the body of the victim, the parts to be swung over the city gate or from a tree by the roadside to warn others of the terrible fate which would follow the breaking of laws in the making of which the people affected had no part.

If these barbarous laws had been applied to all alike they would not have lasted long; but the sad fact was that they were made by one class, powerful and heartless, and enforced against the lowly. It was not until the peasant had a gun in his hand, fashioned secretly perhaps at the village forge, and was being asked for favors by king and nobility, that such abuses passed away. All men were created equal, but only the gun made that equality real or lasting.

The ordinary European boy of the Middle Ages was doomed to be always a peasant, living by hard labor, the only reward of which was poverty and privation. What his father was that he must remain, no matter how strong the urge of ambition might be within him. The accident of birth controlled his destiny. While this unjust social system kept the individual man from bettering his position, the blight had a still deeper effect in depriving the national affairs of the intelligence and force of the thousands of able men who in a true democracy rise to leadership from all classes of the population. Brains, honesty, and energy have not proved to be the birthright of any class, but spring up from the most unexpected sources, as in the cases of our beloved Lincoln and so many others. In some European countries a social system somewhat similar to that of the old days still exists, but with the important difference that the dissatisfied ones can pack up and leave for more promising lands. Formerly, as has been said, the lowly-born man was the property of another and hence the right of free movement was denied. Therefore the affairs of the world lagged in their progress, bringing the period we now call the Dark Ages, when Europe seemed hopelessly sunk in ignorance, lethargy, and dirt. It is surely more than a coincidence that these depraved conditions changed when the poor man was given a comparatively powerful weapon like the gun. Equality of rights has seldom existed without equality of arms.

Still other far-reaching events came in the wake of the gun. There is no doubt that the necessity for metal with which to make guns, both large and small, had much to do with ushering in the age of iron, which really began with the advent of firearms. Iron and steel were known even in Old Testament days, but down to the fourteenth century they had been produced by hand bellows blown upon iron stone, in an open fire of charcoal. The quality of the metal produced by this laborious process was good, but the cost was almost prohibitive. Good iron was worth something like a thousand dollars a ton in our money, while now, in normal times, it is worth but twenty. In large quantities the metal could not be had at all. With the coming of the gun and the necessity for good metal in making it, iron production advanced by leaps and bounds; furnaces with air blasts were invented to replace the old hand bellows; favorable ore deposits were sought out; the heating value of coal was discovered, and the mining of these two great staples of our day became substantial industries. Even modern improvements in composition and manufacture of metals have received great impetus from the demands of gun builders for better materials for use in their work. It is but a generation ago that Bessemer, in searching for a cheap method of producing steel for gun making, discovered the famous process that bears his name, and which reduced the price of steel from $300 per ton to almost the price of common iron. How much the great metal industry of our times owes to the gun and to the body of ceaseless workers who have always striven to make guns cheaper, stronger, and more reliable, we shall probably never know; but the debt is not a light one.

We have space here only to mention a few of the substantial benefits which the gun has brought, directly and indirectly, into the lives of men; but we cannot pass over in silence one other series of the world's greatest events, in which vital service was rendered by firearms. Without them the discovery, exploration, and settlement of the Western Hemisphere would have been impossible or at least long delayed.

One cannot, for instance, read of the famous voyage of Columbus without realizing how much reliance he and his wavering crews placed upon the arquebuse and cannon carried upon their venturesome little ships. Sailing into unknown seas toward lands they half dreaded to approach, the perils of which only their imagination gave them warning, the great captain must often have pointed to the sturdy guns upon the decks and calmed the fears of his men by boasting of their powers. Whether the foe should prove to be horrid sea monster or gigantic cannibal, the shot and roar and belching smoke of those black tubes would subdue or frighten him away. Thus reassured, the quaking men could always be led a little further onward, until at last the rising and falling light on the shores of San Salvador appeared, and morning revealed a new and beckoning continent.

It is doubtful, too, whether the brave and persistent Magellan could have led or forced his unwilling followers around the globe, had they not possessed the weapons that assured them of at least a chance to fight against and probably escape the half-expected onslaught of savage man and beast. Without firearms indeed it is not too much to say that neither Columbus nor Magellan could have induced men to enlist in their crews, even to begin their adventures, let alone carrying them out to successful completion.

However it may have been with the early explorers, we know certainly that Cortez could not have subdued Mexico without guns; and what would have happened to our own North American colonists, had they trusted only to bows and spears against the Indians, can be more than guessed. The fate of the brave Norsemen who settled on the same coasts about the year 1000 gives us a hint of what would have happened. These, having no advantage in arms in their contests with the "Skraelings," were hounded and abused and finally driven off.

The whole advance of white men across our continent from the Atlantic to the Pacific in the last century has been stubbornly contested by the retreating red men and has succeeded only because of constant superiority in the arms employed against them. The muzzle-loading smooth-bore at first overcame the bow and arrow; then the Indian used the smooth-bore, but was met by the longer, straighter shooting rifle. When at last he became possessed of the muzzle-loading rifle he found himself confronted by breechloaders and repeaters. Thus the brave and warlike natives have been pushed ever and ever back by weapons against which they were unable to contend.

In the later frontier battles the Sioux and Cheyenne and Apache showed what the Indian could and would do when possessed of weapons to match those of his white foes. He stood up and fought so desperately that, no matter what may be said of his other defects, his adversaries no longer spoke slightingly of his courage. Equality in arms, however, came to the Indian too late, and the waves of white people overwhelmed him.

Is it, then, stating the case too strongly if we say that, in addition to the many other benefits it conferred upon its possessors, the gun gave them also the continents of the two Americas?

CHAPTER VI

RECOIL—A CONTEST WITH NATURAL LAWS

Having briefly sketched the advance of the hand gun from its earliest form, a simple tube fastened to a stick, until it has become a fairly serviceable weapon, in outward shape much as we see it today, the further progress of the arm will be traced in more detail. This can best be done by taking up one by one the very interesting problems underlying the art of gunnery, and showing how little by little they have, in part, been overcome. We shall, therefore, begin by considering that bane of all guns, old and new—recoil.

Next to the grave difficulty of providing a reliable ignition system perhaps the most baffling task of the gun maker has been to produce a weapon light in weight, powerful in shooting qualities, but still with mild recoil. A hard-kicking gun will not only bruise the shoulder of the firer, but will jump so at the shock of the explosion that its accuracy is almost destroyed.

From the very beginning the user of guns has demanded that his weapon be made light enough to be easily carried, while insisting also on high power and low recoil—thereby demanding a combination of qualities which is almost impossible to produce. Yet we shall see how his contradictory requirements have been fairly well complied with.

When the powder gas expands in the gun barrel it simply forces gun and bullet apart, the lighter obstacle flying forward far and fast, while the heavier gun is driven backward less violently and for a much shorter distance. The *power* exerted on each, however, is about the same. The greater the speed imparted to the bullet the greater will be the recoil of the gun, for each must share the increased shock necessary to give the higher velocity. So, too, as the gun is made lighter or the bullet heavier, unless speed is sacrificed, the kick will become more severe. To abolish recoil entirely, therefore, we should require a gun of great weight, a tiny bullet, and low speed, which are exactly the conditions the gun-bearer resents. Hence we must accept some recoil, striving, however, to keep it within reasonable bounds.

To get a clearer idea of how gun and missile are driven apart at the explosion, the one slowly, the other fast, let us try a simple experiment. Get a piece of coil-spring and two blocks, one considerably larger than the other. Compress the spring between finger and thumb, place it between the blocks, as in the cut, and release both ends at once. The smaller block will be sent spinning

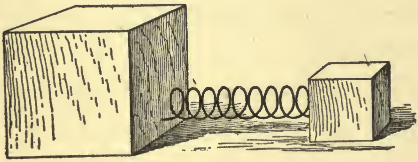


FIG. 15.—PRINCIPLES OF RECOIL

while the larger one will be moved only slightly, if at all.

It is thus that gun and bullet are sent in opposite directions, for the elastic gases in expanding act much like the coil-spring. As the difference increases between the weights of the two blocks the results will be more marked; if one be very much smaller than the other it will be thrown more violently, while the larger one will show less disturbance. If a stronger spring be tried the movement of both blocks will be intensified, just as gun and bullet both respond to the explosion of a larger powder charge.

In the actual firing of a gun, however, another principle is at work which is not present in the experiment with the blocks. Let us see what this is and the results it produces. Say the gun weighs ten pounds and shoots a bullet of half an ounce; the weapon will then be three hundred and twenty times heavier than its missile. On firing, the gun will recede from a quarter to half an inch, until it comes hard against the shoulder of the firer; the shoulder itself will then give back an inch or more, depending on the position and balance of the firer, when the backward thrust of the gun will cease. The weapon has then been halted partly by its own weight and partly by the weight of the flesh and bone behind it, the whole journey backward having been less than two inches; the bullet, however, has gone forward perhaps a mile.

The half-ounce of lead is very much lighter than the combined weights of gun and shoulder, but even this difference is not great enough to account for the mildness of the recoil at the butt of the gun. It is here that the bent stock comes to the rescue. Without this device neither the old-fashioned smooth-bore nor the modern high-powered rifle could be successfully fired from the human shoulder. At the discharge the gun moves back the short distance we have seen, but when it comes hard against the body the angled stock throws the muzzle sharply upward, and this secondary motion uses up a substantial part of the recoil force, to the great relief of the shooter.

To illustrate for yourself the value and effect of the bent stock in lessening the shock against the body of a man firing a gun, take an ordinary carpenter's square, setting the short end against

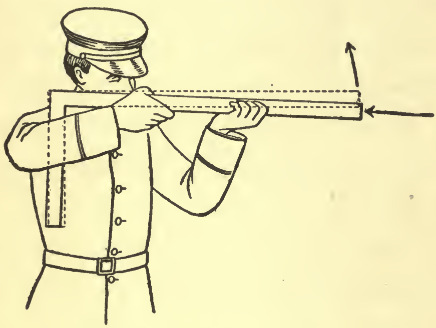


Fig. 16.—Value and Effect of the Bent Gun Stock

the shoulder, the long piece extending forward as in the picture. When a sudden thrust backward is given on the long part of the square, it will be seen to travel slightly to the rear and then rise, describing a curve. This is just what happens when the explosion takes place in the gun; the butt end, being lower than the barrel, comes against the shoulder first and the leverage it exerts tips the muzzle upward. We can now see why the old hand gun with its straight stock had to be very heavy in proportion to its rather mild explosion; the force of its recoil being wholly backward. It is apparent, too, how the arquebuse with its bent stock could shoot harder and further and still weigh much less than its predecessor.

By increasing the angle at which barrel and stock join, making them conform more nearly to the position of the two parts of the carpenter's square, we may produce a gun that will have little or no backward thrust, the bulk of the recoil expending itself under the barrel in pushing it up. But other considerations require that only a moderate angle be used. It is necessary that the muzzle remain almost stationary until after the bullet has departed, for otherwise accuracy is interfered with. The ideal combination is to have the gun traveling straight back while the bullet is passing down the barrel and the upward throw begin only after the missile is clear. Thus the shot is made as intended, while the later part of the recoil force is transmitted to the barrel instead of the butt of the gun. As a very substantial part of the recoil is produced by the gases which continue to rush out of the tube after the bullet is on its way, the shock to the firer is greatly lessened.

It must be particularly noticed that the bending of the gun stock does not reduce the total force of the recoil, but only divides its effect into a double motion, sending the whole gun straight back and then the muzzle upward.

In most modern rifles, however, the angle of the stock is so sharp and the barrel so short and light that the muzzle of the piece does rise a trifle before the bullet is free; the gun, therefore, will shoot high unless adjustment of the sights is made to correct the error. This plan has been found to work quite well in practice, for when the ammunition used is uniform the upward jump is always the same and a good degree of accuracy is maintained; while a more powerful explosion is permitted than if the stock and barrel were more nearly straight. Where the ammunition varies even slightly, however, good shooting with guns of the present day is impossible.

Only within twenty-five years have the real facts about recoil in small arms come into general knowledge. A hundred years ago men believed that their guns kicked because of the sudden rush of air into the barrel after the bullet had left it. The truth that gas in confinement presses equally hard in all directions, so that gun and bullet receive shocks of equal force in opposite directions at the explosion, was either unknown or entirely ignored.

Even for a long time after the principles of recoil had become pretty well known it was contended that the force ceased to work on the gun the moment the bullet left the barrel. This error would have been apparent, however, if the conduct of the skyrocket had been considered for a moment. In it the open end is entirely unobstructed by a bullet, yet the escaping gases still cause sufficient recoil to carry the apparatus high into the air. Its powder burns much more slowly than that in the gun barrel, but—and here is a fact that must never be forgotten—the burning of all powder and the expansion of the resulting gases take time. The interval which elapses between ignition of the first particles of powder and the final escape of the gases produced by the whole charge may seem very short, as we ordinarily think of minutes and seconds; but in gunnery that space of time must be carefully reckoned and considered. Recoil, therefore, is to be looked upon as a force acting through a substantial period of time, and not as an instantaneous shock. Indeed the gun, so far as recoil alone is concerned, may be looked upon simply as a skyrocket with a tube so strong that quick-burning powder may be used without bursting it; the force of recoil continues just as in the rocket until all the powder has burned and the gases created have escaped. The part played by the bullet in the barrel is simply to hold back the gases until high pressure is created; then when these do escape it is with high velocity, sending bullet forward and gun back. Except as the bullet, therefore, creates gas pressure, it does not affect recoil; hence not its departure from the barrel, but the departure of the gases themselves causes recoil to cease.

In recent times, as guns grew lighter and powder charges more powerful, a new and mysterious element appeared in the effects of recoil. One of the easiest ways of cutting down the weight of the arm was by making the barrel thinner at the forward end where the gas pressure was low and the tube did little more than guide the projectile. In theory these guns should have shot high, because of the more violent explosion and the upward thrust of the angled stock under the lighter barrel. The muzzle should have started upward before the bullet was out of it; but, on the contrary, the bullet regularly struck below the bull's-eye. Why was it? To make the puzzle still more difficult, it was found that the same gun using small powder charges would shoot true. What the solution was, for a long time no one could guess.

The truth finally appeared, however. What had seemed mere wilful disobedience on the part of the bullet, turned out to be a perfectly natural effect of the bent gun stock acting suddenly on the under side of a somewhat flexible barrel. When an ordinary bar of steel is struck hard it will bend a little, and the hollow bar is no exception. Therefore, at the explosion, the stroke produced under the barrel forced up the middle of it, causing the muzzle of it to tip downward, just as the outer end of a whip stock dips when raised by the hand at the butt. Any flexible rod held in the hand at one end and jerked up quickly will show you how this happens. In the bending of the thin barrel the muzzle is pointing slightly downward when the bullet departs, and hence the missile flies low. The true shooting of the gun when small charges were used was then easily explained, for the milder explosion did not flex the barrel, and so the bullet passed out straight. As this bending effect is naturally more marked on long barrels than on short ones, you will notice that as the length of the tubes is increased they are made thicker and stronger, or else supported by a thick piece of wood underneath. The short barrel, on the other hand, may be, and usually is, quite thin toward the muzzle, as compared with its longer neighbor.

But no matter what means be adopted to affect the various disturbing effects of recoil, it is, and always has been, a great nuisance. In recognition of this the rifle intended for target shooting

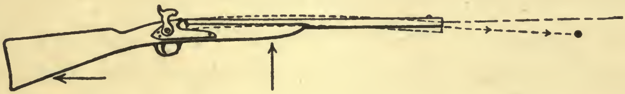


FIG. 17.—To prevent the bending of gun barrels under the shock of firing they are reinforced with a piece of wood. On most military rifles this extends nearly the full length of the barrel.

is made considerably heavier in proportion to its bullet and powder charge than the military or sporting arm. The weight of the gun lessens the recoil shock. On the rifle range a few pounds of extra weight are no objection, because the weapon is not carried long or far. For the other purposes, however, low weight is so essential, both for quick handling and easy carriage, that both power and accuracy must give way to some extent to lightness.

The force of recoil, however, cannot be foretold in any gun even after we have the weight of the weapon itself, the weight of the bullet and its speed. A dirty gun will kick much harder than if the tube is smooth and bright; anything that clogs the path of the leaden missile down the barrel increases the gas pressure behind it, and adds to the recoil. Therefore where the rifle grooves turn sharply, the bullet making its way along and around their course is considerably retarded, gas pressure is augmented, and both tube and bullet are acted upon more violently. The longer the body of the bullet, the greater will be this increased friction. On the other hand, if the gun be sighted to allow for the disturbance of a certain amount of recoil, accuracy will be destroyed if the bullet be slightly smaller or even softer than intended, for then the missile will slide out of the tube more easily than expected, recoil will be less than allowed for, and if the range be long, the shot will be far too low.

As the gun barrel grows hot it expands, allowing the bullet to slip out more readily. Even when the sunshine is allowed to fall upon an open box of cartridges the heat absorbed by them causes their powder charges to burn more suddenly, thus increasing the force of the explosive and accentuating the recoil. Therefore it is desirable to keep both gun and ammunition at a uniform temperature for successive shots. We see, then, what an exacting master is this force of recoil and how carefully its requirements must be complied with.

Understanding of the principles of recoil, then, teaches two important lessons to the shooter who would make bull's-eyes:

First, the ammunition used must be made with great accuracy, must be uniform in every particular, and not tampered with in any way after being manufactured; otherwise no two shots will be the same, for the gun will act differently each time; second, the barrel must be kept clean and shiny throughout its length, or the gas pressures will vary behind the bullet, and indifferent shooting invariably result.

CHAPTER VII

THE OLD SMOOTH-BORE AND ITS SPHERICAL BULLET

The day of the leaden marble, shot from an ungrooved gun barrel, is past, probably never to return. But if we are to know why our modern bullet looks more like a sharpened pencil than like a marble, and how our rifle has gained its wonderful accuracy at long distances, the ancient smooth-bore and its workings must be briefly mentioned.

The story of the smooth-bore has to do chiefly with its defects, but at that there is no more interesting chapter in the biography of the gun. From the fourteenth century, when hand firearms first came into use, down to our own Civil War, a period of over four hundred and fifty years, the smooth-bore was the usual type of gun barrel for the soldier. The missiles first used in it were stones and arrows, but these quickly gave way to the bullet of lead. That metal, fairly plentiful even in those days, and soft enough to be easily worked, had the great weight with small bulk so necessary in an object that was to be driven far and fast through the air. The ancient gunner was not long either in finding out that if he made his bullet into the form of a true sphere it would reach its mark oftener than if its surface were irregular. There is nothing remarkable about this, because every boy knows that a jagged stone or a lopsided ball is hard to throw straight. Indeed when young David went out to meet the giant Goliath it was *smooth* stones from the brook that he chose for the perilous encounter.

But even the perfect sphere when shot from the unrifled barrel had so little accuracy that we of today are inclined to look upon its performance with scorn. While the ball itself could be made to travel a half-mile or more, the hitting of a mark the size of a man at two hundred yards was as much a matter of luck as of skill. Even in its palmiest days the smooth-bore was never reliable at a range of over one hundred yards. Its one virtue was that it could be loaded quickly and easily, and on this account it held its place against the rifle for several centuries after the advantages of the grooved barrel were well known.

The great objection to the rifle in the days of muzzle-loading lay in the difficulty and delay in forcing the bullet into the barrel. The ball had to be slightly larger than the bore in order to make it catch the grooves, and the gunner had to use main strength on his ramrod to get the lead down the barrel, into its place. After the firing of a few shots the bore had to be cleaned out, for the grimy tube then refused to receive the bullet at all. To the soldier in battle this operation was almost impossible, though the hunter did not find it so difficult. With the musket the ball was made two sizes smaller than the bore, which permitted it to slide into place without effort, even when partly clogged up with powder ashes. The time thus saved, to the soldier at least, was very important.

The inaccuracy of the smooth-bore at long ranges had the effect of keeping a large bore and bullet in use long after it would otherwise have been abandoned. The gunner said to himself: "If I use a smaller ball I can shoot a greater distance, but if I can't hit anything with it over two hundred yards away, what is the use? My twelve-pound musket will carry a big ball for that distance, without severe recoil, and hit a harder blow when it gets there than the small one, so I might as well use the big hard-hitting bullets." Following out this thought, therefore, the ancient musketeer never reduced the bore of his weapon much below that of one of our larger-sized shotguns.

The use of the spherical bullet had this peculiar and interesting result: if a man wanted to use a ball of a certain weight it had to be of a certain size; he had no control whatever over its dimensions. The elongated bullet of today can be increased in weight by simply adding to its length, without enlarging the caliber of the gun. With the sphere, however, this was impossible. Thus if you decided that you wanted a gun that would shoot a ball weighing one ounce, you turned to a table showing that such a sphere of lead would be .652 of an inch in diameter, and made your gun, or had it made, accordingly.

It was these curious facts that gave rise to the custom of describing different sizes of bore by reference to the weight and not to the diameter of the bullets used. A gun shooting an ounce ball, for instance, was "sixteen gauge," because a pound of lead would provide sixteen balls, and so on. This system we still use for the shotgun; though in our rifles, with their long bullets, the plan will not work, and we designate the various bores by their diameters, in fractions of an inch. There is considerable confusion in this system at present because calibers are sometimes given to include the depth of the rifling and sometimes not; the practice is growing, however, to designate bores by their dimensions before being rifled.

The musket ball often failed to reach its mark, except at short ranges, because of the violent resistance and friction of the air as it whizzed along. While we are inclined to think of the bullet as "flying" or "sailing" through the atmosphere and frequently use such airy-fairy words to describe its passage, in real truth its headway is won only by furious contest. The air which seems so soft and yielding when we move slowly through it, becomes stubborn and almost rigid to an object forced into it at high speed. Those who have struggled in breasting a gale blowing fifty miles an hour can form some faint idea of the resistance the bullet has to meet and overcome in speeding at the rate of fifteen to thirty miles a minute. Only by recalling these facts can we realize what a difficult thing it is to drive a missile truly to a distant mark.

Of course the musket ball was never round to a hair's breadth, and was frequently a little rough on one side or the other. Sometimes, too, unequal cooling would make one part of it denser or heavier than the rest. All of these defects helped to make precise shooting impossible.

But the most powerful and persistent agency that caused the spherical bullet to wander from its true course was the spinning motion it almost

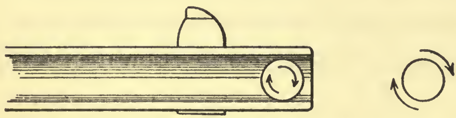


FIG. 18.—Musket ball leaving the muzzle with spin imparted by the final scrape it receives against the bottom of the barrel. Being smaller in diameter than the tube there is no telling which side of the barrel will touch the missile last and hence the direction of spin imparted is always doubtful.

always had and which produced unequal pressures in the air in front of it. Let us see just how this unfortunate result came about. It will be well, however, first to point out how the smooth-bore imparted to its bullet the damaging spin. For ease in loading you will remember that the ball was always smaller than the bore, and this permitted it to rattle back and forth from side to side and from top to bottom during its whole journey down the gun barrel. When it arrived at the muzzle the final scrape it received against the side of the tube gave it a whirling motion which it would retain during its flight. Probably no bullet ever left the muzzle of a musket without revolving more or less, but there was no way of telling beforehand how fast or in what direction this motion would be.

A glance at the accompanying illustrations will make this process clear.

The effect of air pressure against a spinning ball will be more readily understood if we begin with a general view of the contest between the

FIG. 19.—BULLET FORCING ITS WAY THROUGH THE RESISTING AIR

two opposing forces. In Fig. 19 the bullet is seen forcing its way through the resisting air. The latter, being elastic, is compressed to a greater density directly in front of the missile, and being also fluid, flows as rapidly as it can to the rear.

Herein lies the particular point now to be remembered—the air passing from front to rear at great speed scrubs hard against the outer edges of the ball, causing heavy friction there. No matter how smooth the surface of the lead may be, this friction is still severe. Now suppose that in addition to the violent forward motion of the ball, we give it a rapid spin from the top downward. The situation will then be as in Fig. 20. The upper surface of the ball will be throwing air forward while the lower side will be casting it toward the rear. The result, of course, is that the air is "piled up" near the top of the missile while at the bottom the air is being thrust out of the way. There being more air pressure, therefore, at the top of the ball than below, following

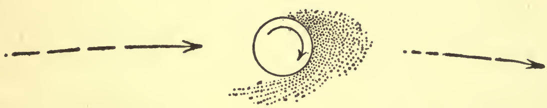


FIG. 20.—EFFECT OF DOWNWARD SPIN OF BULLET

the line of least resistance, it tends to curve downward; in other words, the ball, finding its path more obstructed above, chooses the easier way below.

So great is this curving effect that a golf ball with its rough surface can be made to describe almost a semicircle by imparting to it a very rapid spin with the face of the club in striking it. While the musket ball probably never curved to this extent, it is not difficult to see how even a slight bending of its course would make straight shooting difficult, if not impossible.

If the spin be from the bottom upward, as in

Fig. 21, the course of the ball will be just the reverse of that shown in Fig. 20 and the ball will tend to rise. The effect of a spin from left to right will be readily grasped if you imagine yourself standing above the ball in Fig. 20, instead of at the side as it passes you. It will curve toward the right. Similarly the ball in Fig. 21,

Fig. 21.—Effect of Upward Spin of Bullet

viewed from above, will show the result of a spin from right to left. In this case the missile will deviate to the left-hand side. A study of these illustrations and explanations leads us to the general rule, as follows: a spinning sphere, traveling forward in the air, tends to curve in the direction in which its front surface is revolving.

While we have described only what may be called four of the cardinal spins, that is, upward, downward, and from right and left, it is obvious that numberless combinations of these motions are possible. It may be partly up and partly to the left, or down and toward the right, each change in the direction of the spin giving a different course to the bullet. In the light of this great variety of paths which the musket ball may take the wonder is not that it shot so badly, but that it could hit any mark whatever.

But, as the baseball pitcher knows, the rapidly spinning ball does not begin to curve greatly until its forward speed begins to slacken. The spinning motion is more enduring than the motion forward, and while the ball is slowing up in its advance its rapid revolutions continue to pile up the air on one side and to scatter it at the other, causing a greater deflection within a shorter distance. Thus it can be seen how a musket ball could travel fairly straight for a hundred yards or so and then begin to wander off on a path of its own.

There are, however, two important directions the spin can take which we have not yet discussed. These are produced when the ball is made to revolve around an axis parallel with the gun barrel; that is, the top of the missile passes toward east or west, when the gun is pointed north or south. In these two spins it will be noticed that the face presented by the bullet to the air never changes, so that the curving effect we have just studied in the ball from the smooth-bore is entirely avoided. The astonishing difference is that whereas all of the myriad of spins from the smooth-bore tend to carry the bullet out of its course, the two spins last mentioned serve to keep the missile steadfast on its intended way. This is the marvel worked by the rifled gun barrel, which is the subject of the next chapter.

CHAPTER VIII

THE SPHERICAL BALL AND THE RIFLED BARREL

As long ago as the year 1500 there seem to have been men in Europe who realized that the spherical ball would travel straighter if it could be made to spin at right angles to the gun barrel. We believe this because about that time mention begins to be made of grooved barrels called "riffeln," then known and being used in Germany and Austria.

It has been said that these first grooves were not of spiral form, but were cut straight down the barrel merely to catch and hold the powder ash, which was very abundant in the faulty powder of that day, and thereby keep it from clogging the bore. There does not seem to be much evidence, however, to sustain this theory. At any rate not long after the date mentioned we know certainly that guns were made with the true spiral grooves of the rifle.

Whether these early rifle makers knew the reasons why their new invention shot straighter than the smooth-bore, or whether they simply discovered the fact and put it to use, we cannot say. But among men who knew nothing of Newton's theories of gravity and laws governing spinning bodies, it is not hard to believe that the conduct of the rotating bullet, in detail at least, was still a mystery.

Of course they had that most ancient of revolving toys, the top, which stood up and spun upon its point. From this some inkling may have been had of the principle involved. But if much was known about the forces of rotation and air friction on spinning bodies four hundred years ago, the knowledge was lost for a time because it is only within the memory of men still living that satisfactory explanations have been given to us regarding these things.

It is easy to understand from what has been said in the last chapter that a ball sent forward, keeping the same face toward the front, will gain the great advantage of having its air friction more nearly equal all around its outer edges. The spins imparted by the smooth-bore came, as we have seen, from the final scrape of the barrel against one side of the ball as it left the muzzle, all of which possible spins caused the front of the missile to keep changing. The secret of straighter shooting lies in the avoidance of these chance spins and the imparting to the bullet of a rotation from left or right, about an axis parallel with the gun barrel.

The manner in which the rotating rifle bullet tends to keep a single face forward while traveling to its mark can best be understood by a brief study of the top.

When spun on table or floor the top has a strange desire to stand up until its speed fails, when it yields to the force of gravity and tumbles over on its side. If dropped through the air from a high place while spinning its point will also tend to remain in the same direction it was when released. If dropped point downward the top will strive to stay in that position until it lands. If tilted to one side or the other the same peculiarity continues. These singular laws are obeyed by all spinning bodies, including the bullet.

If unfamiliar with the forces of rotation, it will be well for the reader actually to take a top of the spring type and drop it, while it is in rapid motion, from a height. Stand on a chair and drop it upon a bed, or better still get up on a house and let it fall upon turf below. The prac-

FIG. 22.—Experiment with a spinning top, showing how the spinning body tends to maintain the position assumed when released. It must be remembered that this is only a tendency, which can be overcome when any force or obstacle of sufficient power intervenes. A new position thus given will then be maintained until some exterior influence again interferes.

tical experiment will be better than pages of description.

First drop the toy without spinning it at all and see how it wavers unsteadily in falling. Then set it to spinning and drop it point downward and observe its steadiness, and how it lands nearly in the same position as that in which it started. Then try the experiment with the point extending at different angles. If the distance fallen through be not too great the top will always alight without changing its position. Even if the point be turned upward the same behavior will be noted.

Now, if that top were made of solid lead, put into a gun barrel, and fired while spinning, it would try to keep its original position just as when it fell through the air from a height. If it started point forward and were spinning rapidly enough it would reach the target that way. If the shank and point were cut away and the body reduced to spherical form, you would have an old-fashioned bullet which once set spinning would act just as it did when, having point and shank, you called it a top and dropped it from your hand.

Many plans have been devised for giving to the bullet the desired spin at right angles to the barrel, though the only successful plan has been the spiral groove. The bullet has been made in auger-like shape to be spun by the air as it passed along; it has been given wings to accomplish the same result; and has even been arranged with twisting holes through it, by means of which the air in rushing through was expected to give the turning impulse. All these devices have, however, had to give way to the simple channels cut into the gun barrel.

The spherical bullet, when used in the muzzle-loading rifle, was slightly larger than the main bore, so that it had to be rammed down the barrel. This operation forced the soft lead into the grooves and made the missile follow the winding course until it reached its place above the powder at the breech. Then when the gun was fired the ball came out still gripped by the spiral channels which made it turn rapidly in the desired direction—at right angles to the barrel. Sometimes the grooves turned toward the right and sometimes to the left, either direction serving the purpose.

For two hundred and fifty years after the merits of the rifled barrel became known it lay practically unused because of the difficulty of loading it. By the exertion of much muscular power a man could force the lead down a clean barrel, but after a shot or two had been fired the inner surface of the tube became gummed up by powder ash, and a thorough cleaning was immediately necessary. Even the starting of the bullet into the muzzle was so hard that sometimes a wooden mallet was carried by the rifleman with which to hammer the ball into the mouth of the tube, and a heavy iron ramrod was always necessary to jam the projectile down into place. So, remarkable as the rifle was known to be in giving accuracy to its bullet, these drawbacks kept it out of common use.

It was in North America that the rifle was first to come into its own. In Europe the principal use made of guns was in warfare, in which the soldiers were accustomed to come close together before commencing to fight. Here quick shooting was of far more importance than accuracy at long ranges. The smooth-bore, with its loose-fitting bullet, could be loaded and fired twice as fast as the rifle, and a begrimed barrel gave little hindrance. Its bullet always traveled with the curving flight already described, while the open space around it in the barrel allowed so much gas to escape that high speed and hence great distance were impossible. Therefore, though the smooth-

FIG. 23.—LOADING A SPHERICAL BULLET WITH A PATCH.

The use of a bit of greased rag called a patch in loading the rifle with a spherical bullet, discovered about the year 1700, gave added ease in ramming the bullet home and greatly increased the accuracy and range.

bore answered the European purposes very well, it did not serve for Americans, who used the gun in a different manner.

The Indian was fought, not in the serried ranks common on the other side of the Atlantic, but in so-called "irregular formations," every man taking cover and advancing from tree to tree or along the ground, shielded by undergrowth. Volley firing was out of the question, for the usual target was simply an enemy's head. Marksmanship at considerable ranges was called for here, and the straight-shooting rifle gave conspicuous service at this work. The French and Indian War was fought largely on the same plan. Then, too, the needs of the hunter in firearms were almost identical with those of the pioneer soldier, for it was the true flight of a single bullet, and not the quick firing of many, that filled the camp kettle with food.

Sometime about the year 1700 the American, in his search for an arm to fit his special requirements, discovered a way to load his rifle more quickly and easily than before. He found that if he made his spherical ball just the size of his gun bore, or perhaps a shade smaller, and then wrapped it in a bit of well-greased rag, called a patch, it could be slipped into the barrel much more readily than could the larger ball of plain lead. On firing, too, it proved to have spin enough to keep it on its course during a fairly long flight. The fabric thus pressed into the grooves not only prevented leakage of gas at the side of the bullet, but served to twist the missile as well. It was not, of course, as tough as the channeled lead would have been, so the grooves were given a more gradual slope, causing a rather slow rotation, but even such as it was, giving results far beyond those possible in the smooth-bore. The loading was still a slow process, but for the needs of the pioneer a very satisfactory arm was obtained. From this time the rifle was for a century to be a distinctively American weapon.

The patched rifle bullet would hit a mark of definite size at double the distance the musket ball was capable of. The latter could be generally relied upon to strike a man or a deer at one hundred yards, while the rifle extended the distance to two hundred, an advantage so great that a little thought is necessary here to reveal the full value of the new arm.

The bullet being tight-fitting, the gas pressure behind it was much greater than the smooth-bore permitted. This resulted, of course, in higher velocity for the missile. But at the same time, as we might expect from what we have learned in the chapter on recoil, the gun kicked hard. To obviate this, powder charges were at first reduced; but as this gave a slow, short-ranged bullet, the caliber was finally made smaller than that of the smooth-bore and the ball thereby speeded up again. For we must remember the rule that to keep down recoil a heavy bullet must be sent off slowly, while only a light one can be given high velocity without excessive shock to gun and firer. So small did the bore of the improved rifle appear beside the more capacious barrel of the musket that the name " squirrel gun " was applied to it in derision.

In those days guns were made in small shops by gunsmiths, and frequently also by village blacksmiths at the same forges where they molded horseshoes and mended wagons. Consequently there was little uniformity in the guns turned out in caliber, length of barrel, slope and depth of rifling, or weight of the piece. Each artisan followed either his own ideas or those of his customer. The rifle of the early pioneers, however, was anything but a "squirrel gun" in fact. It usually shot a bullet of half an ounce, which at the high velocity given it was far more powerful and of longer range than the ball delivered by the more formidable-looking but really inefficient musket.

In the Eastern states, as Indian fighting waned and big game was killed off or was driven away, the caliber of the native rifle grew quite small, sometimes even moderate-sized buckshot being used as projectiles. The smaller size of the game to be killed and scarcity of ammunition brought this about. But these weapons must not be confused with the more powerful rifle which preceded them and was used in pushing the Indian and buffalo westward for a hundred years after the Atlantic seaboard states became well populated.

For the soldier fighting in the ranks the smooth-bore, however, remained the standard arm, even in America, down to the time of our Mexican War in 1845. There were some used also as late as the Civil War. The military idea was still to get up close to the enemy and blaze away as fast as possible, while the rifleman in the forest chose to fire more slowly and make his hits sure. He was really far ahead in the end so far as execution was concerned. But then, in organized war, the object is not so much to try to kill all your enemies promptly as to frighten them, make them break their ranks and run, then to capture prisoners and materials. For this purpose the quick-shooting, noise-making smooth-bore was, of course, better fitted than the rifle operating more slowly.

In Washington's little armies in the Revolution the bulk of the men were armed with smooth-bores, but numbers of the best shots were sent out with their rifles to act as sharpshooters. These venturesome, clear-eyed fellows wrought great damage to the British forces by picking off officers at distances which surprised the Europeans. As there were no rifles at all in the invading armies at first, the Americans had a great advantage in long-range fighting; but as the war went on the British, too, manufactured rifles and used them, thus by imitation flattering the home-made arms of their adversaries.

The British, by their own admissions, were never able to cope with the patriot riflemen in accuracy of shooting, for the native had been brought up from boyhood with firearms in his hands. In fact the rifle can be said to have had its real birth in North America both as a hunting and a military weapon. Braddock was defeated because he thought his solid ranks, firing smooth-bores at short range, could drive from his path the rifle-armed French and Indians. He was bitterly undeceived, and the Yankee sharpshooters, by their accustomed long-range, straight shooting, prevented a massacre. The English military men did not learn the lesson there that Washington already knew and saw again exemplified. But from the time of the later days of the Revolution, the rifle-armed sharpshooter became an important part of all European armies.

It was not, however, until the bloody battle of New Orleans in 1815 that the rifle revealed to the world its true value as a weapon of war. Repeatedly as the British had suffered from rifle fire on this continent before, they were still unable to grasp the fact that a new weapon had to be faced in America. The surprise they were to get at the mouth of the Mississippi was much like that they administered to the French with their long bows at the Battle of Crécy.

The Americans were intrenched behind earthworks (only a very few cotton bales were used), and General Packenham expected to march up close, as usual, and then with a bayonet rush clear out the defenders. His plans would have worked out correctly, in all likelihood, had Jackson's men been armed with smooth-bores; but must of them carried rifles, the range and accuracy of which the British general did not foresee. Instead of having only a hundred yards to run forward under heavy fire, as Packenham anticipated, the American bullets began to cut down the advancing men at three hundred yards, with the result that they never got close enough to use their bayonets. Thus the rifle proved again its value against regular troops, as it had done before against Braddock; and as it had been doing for a century on this continent, in hunting and in irregular warfare.

When the American boy, therefore, takes up his rifle he may rest assured that he is in good right entitled to use it as his own, for it was his ancestors who found it, a cast-off European experiment; and by thought, invention, and skilful handling brought it to such a high state of perfection that the world was compelled to give it attention and finally adopt it as the standard firearm.

CHAPTER IX

THE LONG BULLET AND THE MUZZLE-LOADING RIFLE

When a stake is to be driven into the ground everybody knows that it will go down more easily if pointed and not too thick. This simple truth applies equally to the missile that is to be driven at high speed through the air. The greater its cross-section and the blunter its nose, the slower and shorter will be its journey; for it has not only to displace more air, but does it more clumsily than an object that is thin and sharp.

Upon the same principle the power of a man's arm will send the slender arrow several times as far as the same strength can cast a stone of like weight. Knowing this, the gunner had always realized that, if he could shoot a projectile more like the arrow in form and less like the bulky stone, he could greatly increase the efficiency of his weapon. In the smooth-bore, however, elongated bullets could never be used because of their tendency to fly end over end, and consequently anywhere but to their target. The well-balanced sphere, therefore, was the only permissible form of bullet for the old-fashioned musket. But the merits of the pointed bullet were so evident and so great that inventors working on firearms, especially in America, never ceased trying to adapt it to use in the gun. Accordingly then, after the rifled barrel had showed its ability to spin the spherical ball far and true, it was only natural that the effect of the spiral groove upon the long bullet should be tested out. These experiments were in part highly pleasing, for it was found that the spin imparted by the rifle—at right angles to the gun barrel—would hold the new missile point foremost, just as it kept the same face of the sphere always to the front. This discovery was one of the most remarkable in the annals of the gun, for though not put to practical use until long after, the principle proved was in time to give us our modern rifle.

It was easy, of course, to make the long, pointed bullet, for lead could be melted and molded into any form. But after being made, how was it to be loaded? There was the rub. The leaden sphere, which only touched the barrel at its extreme outer edges, was forced into the muzzle and rammed home with difficulty. How, then, was the hurried rifleman to force into his grooved barrel the cylinder-shaped missile with long straight sides, requiring channels to be cut into it throughout its full length? The task was plainly impossible. On this account the sphere kept its place long after the superiority of the pointed projectile had been demonstrated.

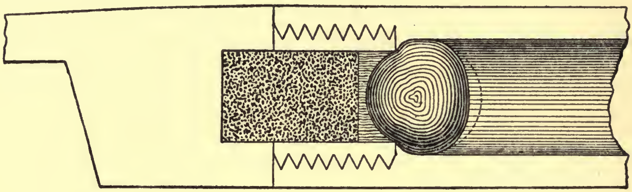


FIG. 24.—DELVIGNE BULLET

And breech chamber, showing how by ramming the missile against the constricting shoulder it could be spread so as to come into contact with the walls of the barrel and be spun by the rifling. The bullet thus deformed would not keep its course.

Up to 1840 there were many attempts to produce an easy-loading rifle, and especially one that would use the long bullet. The French had invented two guns using spherical balls that went into the barrel loosely, to be expanded after reaching the bullet chamber at the breech. These, the Delvigne and the Thouvenin types, were named for their inventors. In the first the barrel narrowed at the powder chamber, forming a shoulder. Against this the bullet, after being dropped into the tube, was pounded with a heavy ramrod, which caused it to spread and thus fill the grooves. The Thouvenin had a stem which projected upward from the breech end to serve as an anvil, against which the bullet was struck with the ramrod to expand it. Both of these systems were used to some extent even in French

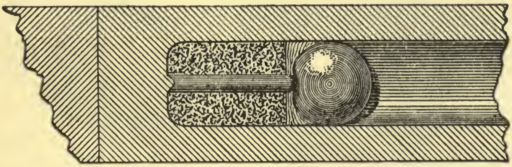


FIG. 25.—THOUVENIN CHAMBER WITH BULLET IN PLACE
The rod projecting through the powder formed an anvil which caused the bullet to expand when struck by a heavy ramrod.

armies, but were finally given up, for the bullet was so deformed in the expanding operation that it would not fly straight.

In 1725 a Spaniard had invented a new type of rifling and bullet which a century later attracted much attention under the name Brunswick system. It had only two grooves, but these were deep and placed opposite each other in the barrel. The bullet was of the spherical type, but had a ridge around its middle to fit into the grooves. The idea here was to prepare the twisting appliances beforehand and so avoid the necessity of cutting channels into the body of the bullet by main force in loading. The idea was excellent; but the gun gave poor results, because the bullet, being of an irregular form, did not fly truly. The gun itself passed into disuse, but the idea lived to occupy attention for a long time after.

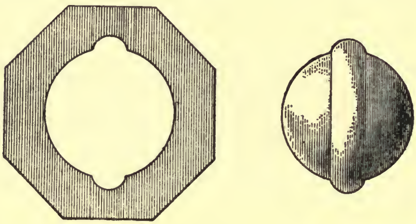


FIG. 26.—BULLET AND MUZZLE OF THE BRUNSWICK RIFLE

The barrel had two grooves opposite each other, into which the belted sphere fitted. These grooves proceeding in spirals from breech to muzzle caused the projectile to rotate. Fouling of the barrel made the bullet hard to load and its unbalanced form caused it to fly wildly.

The Brunswick system led to two noteworthy efforts in making long bullets that would load easily. These were the "Lancaster," in which both bore and bullet were oval in shape, and the "Whitworth," in which both were hexagonal. Both guns were English inventions, and gave startling results in accuracy and distance. They, too, like the Brunswick, did away with the cutting of channels in the lead while loading, but the bullet had to fit exactly, or the gas would leak around its sides. This necessity of close fit spelled their doom in practical use; for after the firing of a shot or two the powder ash clogged the barrel, so that reloading was impossible.

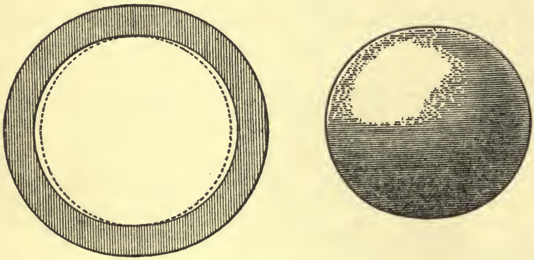


FIG. 27.—BULLET AND MUZZLE OF THE LANCASTER RIFLE

The oval shape of the barrel progressed spirally from breech to muzzle and the oval-shaped projectile in following this twisting path was caused to rotate. Fouling of the barrel quickly made loading difficult, while the odd-shaped bullet did not fly as accurately as the true sphere.

Both Lancaster and Whitworth guns, for that reason, fell by the wayside.

It was in America, about 1830, however, that the first fairly successful bullet of the long type appeared. Who discovered its secret we do not know, but in that period our riflemen began commonly to use a new form of missile with which extraordinary shooting was done. Over ranges of five and even six hundred yards it carried with a certainty that seemed almost miraculous in that day. Indeed its performances in the hands of experts would rank well alongside the scores of our modern marksmen. The new bullet was fired from a grooved barrel, and was of the long type and sharp pointed. It was called the "sugar loaf," because its lines rounded from base to point, like the peculiar lumps in which the sugar

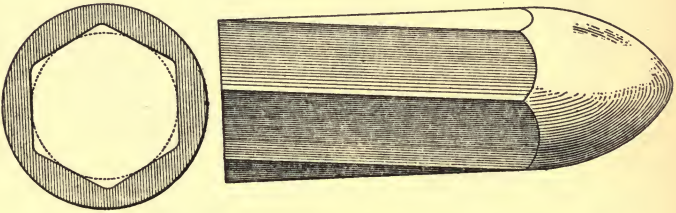


FIG. 28.—BULLET AND MUZZLE OF THE WHITWORTH RIFLE
Both six-sided. The interior of the barrel progressed spirally from breech to muzzle as indicated by the form of the projectile. This gun worked well for a shot or two, but after becoming slightly corroded with powder ash, could not be loaded. Its rotation, too, was impeded by the outside corners.

of those days was bought and sold. As may be seen from the cut, this shape permitted only the extreme base of the bullet to come in contact with the barrel, so that the channels cut in its surface by the rifling were very short. Thus the sugar loaf was almost as easy to load as the sphere.

The greased patch, however, was absolutely necessary with this new bullet, not only to make it a gas-tight stopper and to help to spin it, but to support the cone and keep its point centered in the barrel. In fact the gravest fault of the sugar loaf was this very tendency to tip to one side or the other in the barrel, from which faulty position good shooting was out of the question.

FIG. 29.—Illustrating the rifling used in our Springfield model 1906,—four lands and four grooves. The grooves are only four one-thousandths of an inch in depth, five to ten times less than those used in old-style barrels, intended for bullets of pure lead. The caliber of the bullet of course must be large enough to fill the grooves on each side; the Springfield bullet is therefore .308 caliber, while the barrel before rifling is .30 caliber.

To insure its being seated squarely on the powder below a special ramrod was devised with a cup-shaped head, which, fitting over the point of the projectile, forced it truly into place. The loading, therefore, though not difficult, was always a rather precise operation.

But the extra care required in charging with the sugar-loaf was well repaid in the results it gave. With it the muzzle-loading rifle reached the highest point of efficiency it was ever to attain. There were at this time fairly good breechloaders, but with them the escape of gas at the breech made the use of full powder charges inadvisable; so the American muzzle-loader with

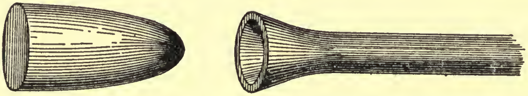


FIG. 30.—Sugar-loaf bullet, with ramrod of special form to insure correct position in the gun barrel.

the rounded cone for a missile remained supreme until the metallic shell brought in the successful breechloader.

The sphere, however, was by no means abandoned by the introduction of the sugar-loaf bullet. For shots up to two hundred yards, which is as far as the hunter usually tries for game, the ball was still good enough, and was at the same time less likely to go astray when carelessly loaded. Yet for long, straight shooting the sharp-pointed projectile had taken a place from which it was never again to be overthrown. But so far as the soldier was concerned, especially in Europe, the muzzle-loading rifle was left to the scout and sharpshooter until 1853, when the British armies carried upon the battle-fields of Crimea rifles loaded from the muzzle and which gave excellent satisfaction. Up to that time these soldiers had clung to the old smooth-bore "Brown Bess" musket, improved since the days of Wellington only by the change from flint to percussion ignition.

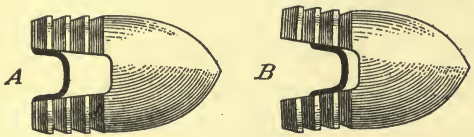


FIG. 31.—THE FAMOUS "MINIÉ BALL"

The hollow butt with its iron wedge in place is shown in *A*. By the force of the explosion this wedge was driven deep into the hollow, spreading the walls, as in *B*, until they came into close contact with the barrel and so were caught and spun by the rifling. The air acting upon the hollow base during flight, produced the peculiar whistling sound which assailed the ears of our fathers who fought in the battles of the Civil War.

It was a new and most ingenious bullet invented in France that induced the British trooper to part with his well-beloved old weapon.

This bullet was the "Minié ball," named for its inventor, and was afterward to play an important part in the fighting of our own Civil War. Its chief peculiarity was the cavity at its base into which an iron plug was fitted. Its diameter was small enough to allow it to slip readily into the barrel, but at the explosion the shock forced the plug deeper into the cavity, thereby spreading the leaden sides tightly against the walls of the barrel and into the grooves. Thus had arrived at last a muzzle-loading bullet which entered the barrel loosely and came out tight, forming a perfect gas stopper and giving the rifle grooves a firm grip on the lead. Hence the long-sought prize of the military man seemed to be gained.

But the story of the improvements of the gun is one of a single real success to ninety-nine disappointments. The Minié ball, which at first gave promise of making the muzzle-loading rifle a highly satisfactory weapon, with use revealed unforeseen defects. Though used by the soldier for ten years after its introduction, they held to it simply for the lack of a better type, which soon came. One trouble was that in rapid firing with a foul gun the rear end of the Minié bullet would sometimes tear off, leaving a leaden ring sticking in the barrel, a thing very difficult to remove in the field. Then again, the iron plug would not always push its way into the bullet's cavity evenly, thus jamming one side of the lead more tightly against the barrel than the other, which caused wild shooting. The chief objection to the Minié ball, though, was its large size in proportion to its weight, for its caliber was very large, sometimes even up to three-quarters of an inch. We have seen that lead was chosen for bullets because of its great weight and small bulk; therefore when a cavity is put into a projectile the effect is the same as if another and lighter material were used; that is, the bulk is increased without adding to the weight. Such a missile, then, has to displace much air in going forward and has not the momentum to carry it. All hollow bullets are also very sensitive to cross-winds, which sweep them readily from their course. This combination of shortcomings in the Minié ball was too much, and finally forced its retirement.

Thus it will be seen that the long, sharp rifle bullet achieved great success for accuracy and distance, especially in the sugar-loaf form, and when of the Minié type was an easy loader. But no muzzle-loading bullet of long form was ever produced to fulfil both conditions; for when it loaded readily it shot poorly, and when accurate in action was hard to put down the barrel. With all its failures, however, the long bullet had proven two things decisively: there was no doubt left that it was by far the most efficient type of missile, and that the spiral grooves of the rifle had the power to keep it point foremost through a long flight. With these truths established, inventors were left with the single problem of getting the projectile into the gun barrel quickly and easily. In this quest they came gradually to the conviction that success lay not in further experiments upon the bullet, but rather in modifications of the gun itself. In these efforts, methods of loading at the breech instead of the muzzle occupied their attention for some time, though, as we shall see, only with fair success.

CHAPTER X

THE LONG SEARCH FOR A BREECH-LOADER

The gun itself had scarcely been invented when men saw the advantages of loading it at the breech, instead of at the muzzle. Pushing a charge of powder down a long cannon tube was not an easy task, and, furthermore, was a risky one if the piece had been fired but a moment before. There was always likely to be a spark lingering in the barrel to set off the charge prematurely, endangering the man standing in front, operating the ramming stick. This constant menace gave rise to the custom prevalent throughout all the days of muzzle-loading cannon of sponging out the bore after each shot, with a damp swab, an operation taking time and particularly difficult in big guns.

Breech-loading, therefore, if it could be successfully done, would give more rapid firing and be much safer. The system earliest adopted to accomplish this was to make the gun with a separate breech-piece, which after receiving the charge, was wedged in place at the rear of the main tube. By using several of these breech-pieces, the loading process could be going on in the spare ones while the gun was being fired. The plan seemed to work fairly well, for there still remain enough of these relics to show that they were tolerably plentiful through the fifteenth, and even in the fourteenth century.

But besides these cannon with removable end sections, there were also guns made in early times which had breech plugs merely to close the bore at the rear after the charge had been inserted. Some of these attachments were kept in place by wedges, some with pins, while still others were screwed in and out like bolts.

In hand guns the same methods were followed in producing breechloaders. The removable chamber was common and breech plugs of various forms were tried. The hinged barrel which drops down, as is now common in our shotguns, is one of the earliest of breech-loading ideas. With the hand gun breech-loading was even more important a problem than with the cannon. It was almost impossible for the cavalryman to charge his muzzle-loading gun while in action, and he was therefore robbed of part of the benefit of firearms. Nor could the infantryman well reload his piece while lying down; and having to stand up while loading made him much more vulnerable than he would have been had he been able occasionally to take the prone position during a fight.

But in spite of the advantages of breech-loading over charging from the muzzle, the search for a

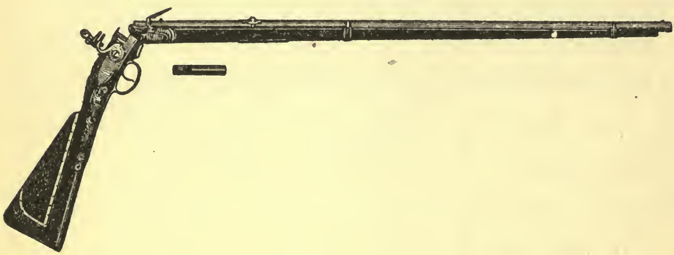


FIG. 32.—Breechloader of date about 1700, handed down as a relic of Philip V, King of Spain. The iron cartridge it used is shown; a hole in its wall near the base admitted the igniting fire from the snaphance igniter.

successful solution of the problem was to be carried on through five hundred years of practical failure. Though the quest began shortly after the Battle of Crécy in 1346, it was not brought to triumph until about the year 1850.

The baffling problem was to find some closing device that would work simply and quickly, but which would at the same time keep the rear of the gun tube tight. The tremendous pressure created at the explosion made confining of the gases most difficult. Leakage not only diminished the power behind the bullet, but scorched the hands and face of the firer, and carried powder ash into the working parts, soon clogging them to uselessness. Again, if the opening and closing parts were complicated and worked slowly they gave no great advantage over the muzzle-loader; while if one part expanded from the heat of firing, so that it would not engage with its neighbor, the gun became a club and nothing more. It was a task inviting to any inventor, and during the long period of experiment many men of high ability tried and failed in the undertaking.

It was the rifle, however, in later times which called most persistently for means of loading at the breech. After the American had demonstrated its possibilities, even with the slow muzzle-loading process, and had adopted it as his favorite weapon, every one knew that the smooth-bore would have to step down and out for all purposes when a satisfactory method of loading came in. With the one exception, its leaky breech, the merits of the gun loaded from the rear of its barrel were clearly paramount.

During the Revolutionary War a promising type of breech-loading rifle appeared in America, but in the hands of British soldiers. It was the invention of Major Patrick Ferguson of a Highland regiment, who produced it to help his men contend more successfully against American sharpshooters. It was a flint-lock, of course, and

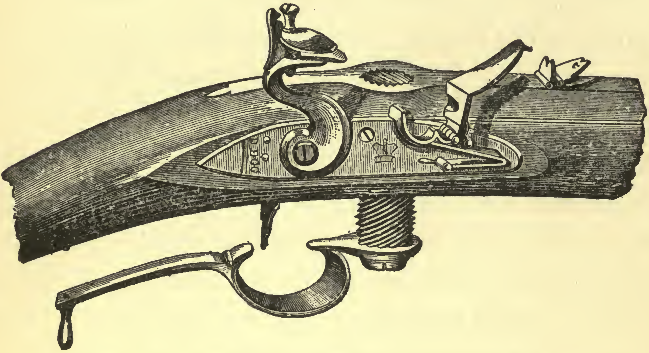


FIG. 33.—FERGUSON BREECH-LOADING RIFLE

The first notable breechloader to appear on the American continent. It was used by the British in the Battle of Brandywine, but disappeared upon the death of its inventor at King's Mountain.

opened and closed by means of a screw bolt that worked up and down at the breech. The trigger guard served as a lever, which, by swinging around to the right under the gun, turned the bolt and caused it to lower, thus exposing the breech. After the bullet and powder charge were inserted the bolt was returned to position by swinging the lever back in place. Only a single turn of the lever was necessary to complete the operation. A hundred or more of these guns were turned out, and with them a company of sharpshooters was equipped and sent south under command of the inventor himself, to combat the patriots fighting there. At the Battle of King's Mountain this command was wiped out and their commander killed. With him his ingenious rifle passed from view and was never again revived.

Though we do not know just how great was the efficiency of the Ferguson gun, it is entirely probable that leakage and unequal expansion of the parts gave serious trouble. Its prompt disappearance after the death of its enthusiastic inventor would suggest that the operation of the new device was far from satisfactory.

The first breech-loading rifle to be given more than local attention was that invented by John H. Hall, an American, in 1810. Many of these were manufactured by the United States Government and issued to the troops who took part in the Seminole and Blackhawk Indian wars. Some of these guns even survived to be used in the war with Mexico. The Hall rifle was not new in principle, for it was of the very old type in which the charge was put into a separate chamber worked up and down on a hinge at its rear end. By tilting the breech tube upward the powder and ball could be put into it, and when depressed the gun was in position for firing. It was also a flint-lock, but peculiar in that the ignition device was not attached to the barrel but to the oscillating powder chamber and worked up and down

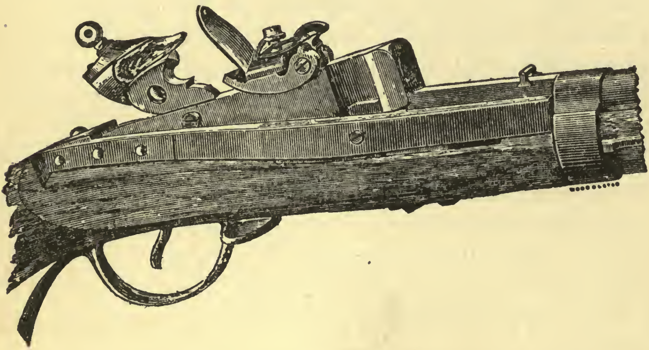


FIG. 34.—HALL'S AMERICAN BREECH-LOADING RIFLE

This was the first successful breechloader, a remarkable gun in its time. The combustion chamber was a movable part which tilted upward for loading and was then depressed for firing. The flint-lock igniter was affixed to the tilting chamber.

with it. While gas leakage must have been considerable in this arm, yet it gave great satisfaction to those who used and wrote of it. No breechloader of that time could shoot the heavy charges which the solid-ended, muzzle-loading barrel would withstand, so that the latter still stood alone when it came to straight long shots. But where shorter range would answer and quick firing was desired, the Hall rifle was the favorite in America, down to the time of the Sharp's Old Reliable, which came into popularity about 1850.

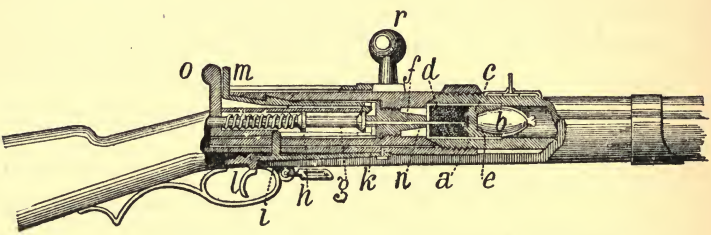
Hall, the patentee of this rifle, gave voice to an idea which has had a more important effect upon firearms than had even the production of his excellent gun. This was the plan of having military weapons made with parts so uniform that they would be interchangeable. Always previous to that time parts of guns of even the same make and type were manufactured by hand, each piece for its own weapon, and not likely to fit into any other. The United States adopted Hall's suggestion, thus making a new departure in gun manufacture. The letter written by Hall in 1827 to the War Department setting forth his views on this, as well as his conviction that the rifle was then a perfect weapon, follows:

"Only one point now remains to bring the rifles to the utmost perfection, which I shall attempt, if the Government contracts with me to any considerable amount, viz.: to make every similar part of every gun so much alike that it will suit every gun; so that if a thousand guns were taken apart and the limbs thrown promiscuously together in one heap, they may be taken promiscuously from the heap and all come right. . . . A favorite and important part of the American small arms would then be at the height of perfection, and would vastly excel those of any other nation. They would be strong, durable, and simple, easily kept in order, easily repaired when out of order, perfectly accurate, and capable of being fired with the greatest quickness which a gun can admit of, and we have more marksmen than can be found in the army of any other nation."

In 1836 Samuel Colt, a New Englander, invented his famous revolving breechloader. This system we now see in use today in revolvers, but it was at first applied to the larger type of hand gun as well. The Colt method is so familiar to us all that description is not necessary. It must be recalled, however, that though the idea of a revolving cylinder of many barrels and cylinders containing a number of chambers firing through a single barrel, were tried, and even used to some extent, centuries before Colt was born; but he was the man who at last made the plan workable. The arm attached to the trigger, which causes the cylinder to rotate to its proper position, and the device under the cylinder that locks it in place while being fired, were the principal means of giving a new and useful arm to the world. While the Colt method did not live long in rifles, it was to have a long and honorable career in the smaller weapon fired from one hand.

Turning now to Europe to see what was going on there in breechloaders, our attention is immediately arrested by the needle gun with which the Prussian armies overwhelmed Austria in 1866, and which they used against France with great effect four years later. It was patented in

Prussia in 1836 by a German gunsmith, Johann Nicholas von Dreyse, who had spent many years in the gun shop of M. Pauli, a Swiss, in Paris, learning his trade and helping to make arms for the great Napoleon. In 1827 he went back to



Courtesy of the Century Company.

FIG. 35.—NEEDLE GUN

a, Cartridge; *b*, bullet; *c*, paper wad carrying detonating compound in recess; *d*, charge of powder; *n*, needle passing through and sliding in the breech-piece, and striking on the detonating compound; *f*, breech-piece; *g*, sliding spring-bolt which carries and operates the needle; *h*, a collar on the bolt, *g*, which engages the sear when *g* is drawn back; *i*, the sear; *k*, spring on which the sear, *i*, is formed, and which is pressed downward by the trigger to release the bolt, *g*, when the gun is fired; *l*, the trigger, which engages the spring, *k*, by a forwardly projecting lip; *m*, thumb-piece of spring-catch, which latter holds the breech-piece in place during the firing and which, pressed downward, releases the breech-piece; *o*, thumb-piece of lock-tube; *r*, handle of the breech-piece.

Germany and took out a patent on a new method for percussion ignition, which invention M. Pauli afterward pretty clearly proved was his own and had been purloined by von Dreyse. The main idea involved in the needle gun was the placing at the butt end of the bullet a well-known chemical mixture that would explode upon being struck, thus firing the powder charge. A long needle extended through the breech of the gun and through the powder charge, parallel with the barrel, so that when the hammer of the gun struck the needle it would be driven against the base of the bullet, setting off the ignition mixture. The first gun which von Dreyse made using this idea was a muzzle-loader, but he later adapted the principle to the breechloader, for which his patent in 1836 was granted and which the German armies adopted slowly during the next twenty-five years.

The breech of the needle gun opened and closed by means of an iron rod, which slid straight back from the opening of the barrel, thus making it one of the true "bolt type" of rifles. It was one of the first breechloaders to use the percussion method of firing and used the pointed bullet, the ammunition being made up in the form of a paper cartridge, thus permitting the needle to pass freely through the powder charge to the primer at the base of the bullet. This ignition method will be mentioned again, the important point for us to notice here being the efficacy of the von Dreyse gun in preventing escape of powder gas from the rear. The fact is that it was no better in this respect than its predecessors. In 1855 the Prussian armies adopted it exclusively, but largely on account of its merit in firing rapidly. Only small charges were permissible in it, so that its range was less than that of the muzzle-loading rifle. The needle gun proved to be so rapid in action that it greatly assisted the Germans to overwhelm the Austrians in the war of 1866, the vanquished armies being equipped only with old-fashioned muzzle-loaders. Against such weapons the von Dreyse gun proved greatly superior.

In the meantime the French had taken up the needle gun, greatly improved it, and made it their official military rifle in 1866. In the war with the Germans in 1870 the French type outstripped the von Dreyse gun in every way. It could not only be fired with equal rapidity but had greater range and accuracy. Besides putting the percussion cap at the extreme base of the cartridge, instead of upon the wad between powder and bullet, the French reduced the caliber from .66, as in the Prussian gun, to .43 caliber, and added to it a breech stopper like the de Bange apparatus, then and even now used in artillery to prevent leakage of gas. When in good condition, this device reduced the amount of leakage considerably, and so permitted the use of heavier powder charges, but was never an entire success in the hand gun. Some gas would still get past, especially after the rubber ring used in the stopper became hardened by the heat of long-continued firing. The

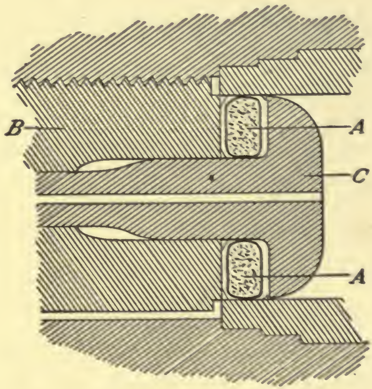


FIG. 36.—THE DE BANGE GAS STOPPER

The de Bange gas stopper is used in artillery. A form of this device gave to the French chassepot its mild back-flash. *A*, *A*, a ring of elastic material; *B*, breech bolt of gun; *C*, cap, which at the discharge moves backward, compressing and expanding *A*, *A*.

needle gun as thus improved by the French was called the chassepot.

The de Bange gas stopper is simple, though quite interesting. By it an elastic ring, usually of rubber in the smaller weapons, but of more resistant composition for cannon, is made to expand inside the breech of the barrel, shutting off more or less escape of gas rearward. By reference to the accompanying picture its operation will be seen at a glance.

It was claimed as one of the great merits of the German needle-gun cartridge that its ignition, commencing as it did at the front end of the charge, gave more complete combustion to the powder because the grains were less likely to be blown out of the barrel unburned. The French, however, disproved this theory by continuing to get excellent results with the primer at the rear of the charge instead of its front. The needle gun and the chassepot were, up to that time, Europe's most important breechloaders.

One early breechloader, the general adoption of which preceded that of the needle gun and chassepot by several years, and which cannot be omitted from special mention here is the American Sharp's rifle of .52 caliber, weighing sixteen pounds, invented by Christian Sharp in 1848. To our pioneers of the last generation its name was a household word, for this weapon was to many of them a faithful companion in their journeys and dangers. Before the Civil War Sharp's rifles, in the hands of the men of John Brown of Ossawatomie, helped to make history in the border trouble stirred up by slavery; and during the war itself were issued to Northern soldiers, principally to cavalry, who found in it a weapon admirably fitted to the needs of the fighting horseman. In the Indian wars which followed in the seventies the Sharp's, then changed to use metallic cartridges, was largely used and gave an

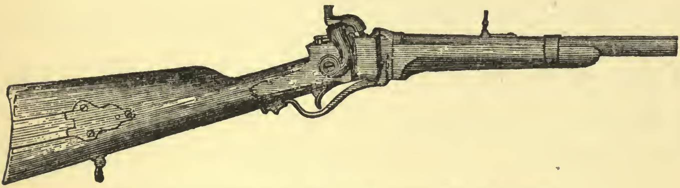


FIG. 37.—SHARP'S BREECH-LOADING CARBINE
One of the world's most famous guns. Its virtues are recited in the text.

excellent account of itself. The buffalo hunter of those days also found it the best of all weapons for his purpose; in range, accuracy, and hard-hitting qualities its like had never been seen in breechloaders. The Sharp's Old Reliable it was nicknamed, and well deserved the title.

The Sharp's in its first form used cartridges of paper or linen, which were inserted directly into the breech of the barrel, the envelope being consumed with the powder, and ignited by a percussion cap. The closing device was a block worked by a lever below, sliding straight down to expose the breech for loading, and rising again into position to close the gun for discharge. By a clever device attached to some of the models a fresh cap was placed upon the nipple when the lever was operated, allowing ten aimed shots per minute to be fired, which was a remarkable feat in those days.

The early Sharp's, however, was famous more for its rapidity and power than for its ability to prevent leakage of gas at the breech. In this respect it was not much better than its contemporaries, for the back-flash at each shot was great enough to burn a hole in a handkerchief placed over the lock in firing. Upon the introduction of the metallic center-fire cartridge shell, about 1870, the gun was altered to use that kind of ammunition; and thus passed the last of the old American breechloaders that used a mere iron stopper to confine the gases at the breech.

CHAPTER XI

ARRIVAL OF THE PERFECT BREECH-LOADER

In a previous chapter we traced the important steps in the progress of ignition down to the flint-lock, where, for the time being, we rested the subject. We are now to take it up again and learn how the new method of igniting the powder charge already touched upon in describing breech-loaders in the preceding chapter, together with the invention of the brass cartridge shell, was to give us at last the faultless gas stopper for breech-loaders.

Discovery of the new igniter came about, as so many other great inventions have occurred, while men were searching for something else. During the years near 1800 Napoleon, in carrying on his wars, being most of the time shut off from sea traffic by British fleets, found it hard to get enough saltpeter to make powder for his armies. As he always used many cannon in his battles, large quantities of explosives were necessary for his purposes. To the French chemists of his time, who were very able men, Napoleon appealed for a substitute for saltpeter which would permit the making of powder from ingredients which might be found more plentifully and near at hand, thus avoiding resort to foreign sources.

At this task the distinguished chemist Berthollet, in particular, labored long, but in vain. The compounds he experimented with were chiefly chlorate of potash ($KClO_3$) and the fulminates of mercury and silver (CNOHg and CNOAg). Of the latter he himself was the discoverer, while the former had been originated by the English chemist, Howard, in 1799. All these were highly explosive substances, the very violence of which defeated the chemist's purposes. No gun barrel could withstand their shock; while they were so sensitive that the handling of them was dangerous in the extreme. The mercury compound proved to be most stable of the three, but even this was too sudden in its operation to serve as a propellant. After several years of hazardous experimenting, in which he several times barely escaped with his life, Berthollet gave up the problem as impossible.

In Scotland about the same time there was a clergyman, Alexander Forsyth, who liked to hunt, and who also in spare moments dabbled a little in chemistry. He, too, in a small way, joined in the search for a new powder, using also the same compounds the Frenchmen were working with. While he succeeded no better than they in finding a satisfactory substitute for saltpeter, his experiments in this field gave rise in his mind to a new, and perhaps even more valuable idea. Though the strange explosives proved too ungovernable for use as propellants, he saw in them possibilities of a revolutionary method of ignition, which would do away with flint and steel and all the evils connected with them.

Both of the fulminates and the chlorate had in common one peculiar trait—they would explode at a slight blow of a hammer. Forsyth's plan was to utilize this feature by putting a small portion of the mercury compound in the pan of his gun with the priming powder and causing it to be struck by a snapper or hammer affixed to the weapon and operated by a spring. Thereupon he removed flint and steel from his shotgun and substituted for them the new device. To his dismay, however, when the hammer was snapped, the fulminate exploded so suddenly and violently that the priming powder was thrown out of the pan without igniting. But he persisted, trying various methods for the accomplishment of his purpose, until at last he succeeded.

In 1805 Forsyth hunted with the first gun that fired without actual application of fire at its vent. He had removed the priming pan entirely, using in its stead a tube screwed into the breech of the barrel. Priming powder put into this tube was ignited by fulminate placed beside it and struck by a plunger pin—which, in its turn, was tapped by a spring hammer on the outside. By this means the priming was held fast in the tube, and thus confined, caught fire and discharged the gun. In 1807 a patent was granted Forsyth, not only for his device, but for the idea behind it—ignition by percussion.

The invention was crude, slow in operation, and not of much practical use as Forsyth left it; but willing hands and fertile brains were not lacking to help bring the invention into real service. It was admitted by all that great things were in store for the gun when percussion ignition would become perfected, which indeed was the truth, as we shall see.

It was quickly perceived by other inventors that Forsyth's apparatus with priming tube and plunger pin was too complicated ever to give good results. After many attempts to simplify it the whole contraption was abandoned. An interesting development then occurred. The vent-hole was shifted from the side of the barrel to its top, from which it had been taken centuries before; and even the old bowl-like depression around it restored. In this was placed fulminate, which, on being struck by a spring hammer, exploded, firing the fine priming powder in the vent-hole; thus setting off the main charge in the barrel. Admirably simple as this plan seems, it had an equally simple but almost fatal defect. The sticky ash of the fulminate clogged the vent so quickly and was so hard to dislodge that, though many guns so equipped were made and used, they never lived up to the promises at first made for them.

Other and less hopeful schemes were tried from time to time, only to fail, until 1816, when Shaw, a Philadelphian, conquered the stubborn problem.* He devised a hollow nipple, screwed into the top of the gun barrel, its cavity leading down into the powder chamber. Over the top of this tube he placed a copper cap, containing some fulminate of mercury. When the hammer came down upon the cap, the percussion compound was exploded, shooting a stream of flame directly into

* See Fig. 9 for illustration and description of Shaw's invention.

the barrel. Thus for the first time since the days of the hot wire, igniting heat was sent into the charge without priming the gun, for the powder of the main charge could be rammed hard enough from the muzzle to force some of it up into the nipple. The author recalls though that, when a sure shot was wanted and time permitted, it was customary to put a little powder into the nipple from the outside. As the quantity of fulminate thus necessary was very small, clogging of the vent was practically avoided; while elimination of the priming operation saved time in loading and made misfires more rare. Not the least, either, of the benefits derived from the use of Shaw's cap was the relief from bad effects of wind and rain, which had long vexed the gunner. The cap was almost waterproof and the wind could no longer play its usual pranks with priming powder, which results alone were sufficient to assure the gun a new era in its career. In justice to others it must be said that Shaw was not the first maker of percussion caps, but he first succeeded in making them workable and was granted patents for his devices.

The days of the flint-lock were now numbered, but it disappeared only very slowly. Men have always been loath to throw away their old and well-tried guns for new and even better ones. For this reason the new system of firing, which required either new guns or radical changes in the old ones, was only gradually adopted in spite of its great merits, though it came faster in the United States than in Europe. Here almost every man is an inventor of some sort; and in the early part of the nineteenth century Americans were accustomed to make their own guns, or have them made under their own supervision. Consequently new ideas were readily taken up. Then again, in Europe the gun has been chiefly used as an arm for the soldier, or as a hunting weapon by a few men of leisure; while in our country, with its wilderness and broad plains, the gun has from the beginning been the familiar companion of the common man. It is perhaps for these reasons that such new things as percussion ignition, the rifled gun barrel, and the pointed bullet were tried out and adopted among us long before other nations took them up.

While percussion caps were commonly used in America from 1816 on, and in a few years had practically driven out the flint and steel as an igniter, it was not until 1834 that Europeans awoke to the fact that they were behind the times in this respect. In that year the British Government, in long tests, found that the best flint-lock missed fire twenty-three times for each miss by the American copper cap and nipple. Shortly after this the new plan received the seal of European approval by being adopted as the official system for the British army. At the period about 1840 muzzle-loading was still the standard method both for smooth-bore and rifle; but breech-loading rifles were then, as we have seen, knocking persistently for admission. The Hall gun exchanged its flint and steel igniter for nipple and cap, but the great drawback of leakage at the breech still remained. When the Sharp's rifle came in 1850 the same defect hampered its bids for popularity. The von Dreyse needle gun, produced in 1836, was no improvement in this important respect. All leaked, and leaked badly.

But there was one development that began about this time which led in the end to results of first magnitude in solving the problem of successful breech-loading. This was the production of the new metallic cartridge.

From time immemorial soldiers and hunters had tied ball and powder together, so that in loading the piece in the field the proper charge would be ready without measurement, thus saving time. The paper was torn, the powder poured into the barrel, and the bullet, still wrapped in the paper envelope, pushed after it. The fit was then snug enough to prevent the ball from rolling out of the smooth-bore tube. The ancient hand gunner wore a shoulder strap, or "bandolier," to which such prepared charges were attached, to be carried. Sometimes, as with the French, a pouch was used for the same purpose, called a *cartouche,* from which the very word cartridge is derived.

With the advent of the breechloader the cartridge took on added importance. The rapid firing which the new arm permitted required the gunner to have his ammunition carefully prepared for quick insertion into his weapon. The powder charge was rolled in a paper capsule, with the bullet pasted into its open end; the rear of it to be torn or pierced for ignition only after being actually in place in the gun chamber. In the Sharp's even this puncturing operation was avoided by making the butt end of the cartridge of thin paper, which offered no obstacle to the igniting fire. Thus the paper cartridge became an instrument of great exactness.

In 1827 the Swiss inventor, Pauli, if we believe him in his dispute with von Dreyse, produced the paper percussion cap much like those now used in toy pistols, to be placed in a prepared cartridge and exploded by an intruded rod or needle driven against it. This cartridge proved very successful through fifty years of use; though the needle,

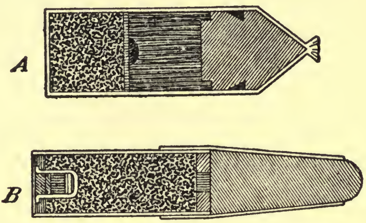


FIG. 38.—*A* and *B* are the cartridges used, respectively, in the needle gun and chassepot. The outside wrappings are of paper, the first having its primer at the base of the bullet, the other at the rear of the cartridge. A great fault with these cartridges was that the needle which exploded them quickly became corroded from contact with the burning powder, thereby often failing in operation.

remaining in the powder charge during the explosion, corroded and gave much trouble by sticking and breaking. This was one of the reasons why the German needle gun and the French chassepot, which used this system of ignition, were abandoned even while they remained, otherwise, very good weapons. As a cartridge, however, the advance thus made was quite important.

In 1847 the final step was taken in uniting percussion ignition with the metal shell, from which successful breech-loading was to spring. In that year Houiller, a Paris gun maker, produced the new device, probably the greatest single stroke ever made in the advancement of the gun. He used for his cartridge, instead of paper, a thin copper tube closed at the rear, containing the powder charge, with the bullet protruding from its mouth. The virtue of this arrangement was that the metal envelope under the strain of the explosion stretched until it pressed so tightly against the walls of the gun barrel that egress of gas backward past its sides was entirely prevented. After accomplishing this the copper contracted enough to permit the shell to be easily withdrawn for the insertion of a new one. Thus the problem of centuries was solved, and so simply that we are amazed at the tardy appearance of the solution.

We have seen that long before this time metal shells were used to contain the powder charge in breechloaders, as, for instance, in the gun of Philip IV of Spain, in date about 1650. But prior to Houiller's invention the tube was made of iron and had to be thick and strong enough to withstand the full force of the explosion; otherwise it would stretch or burst and stick fast. Furthermore, the thick iron shell, if fitted tight enough to keep back the gases, would expand from the heat of the explosion, and could be withdrawn only after it had cooled. Copper, on the other hand, expands very little by heat and, being quite elastic, stretches readily at the explosion and then shrinks again to its former size. Houiller's great discovery, therefore, lay chiefly

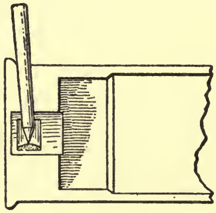


FIG. 39.—HOUILLER'S PIN-FIRE IGNITION METHOD

The hammer of the gun striking the protruding pin set off the percussion cap within the shell. This shell was expensive, dangerous, and was slow in loading because it had to be inserted into the gun with the pin exactly perpendicular. On account of these defects, its career was short-lived.

in the substitution of copper for iron in making the cartridge shell.

The ignition device which Houiller used with his copper shell did not prove a great success. It was what afterward became known as the pin-fire, a variety of the needle-gun cartridge, and worked by means of a plunger inserted in the side of the shell near its rear end, acting against the percussion compound placed inside the cartridge. Of course the hole through which the plunger slid allowed escape of some gas, and, when dropped or accidentally struck, the unprotected pin frequently caused dangerous explosions. The French genius, recognizing these defects, set immediately to work to correct them. His efforts shortly brought forth the rim-fire cartridge, almost as we

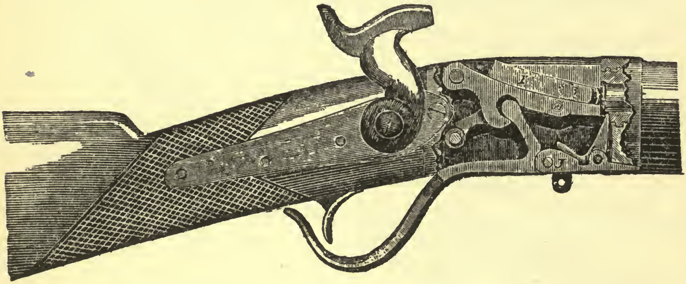


FIG. 40.—PEABODY BREECH-LOADING RIFLE

In the Russo-Turkish war of 1877 the Turks, armed with this excellent American rifle, inflicted fearful punishment upon their more numerous adversaries. It has been said that the Peabody rifle in the hands of the Turks at Plevna convinced the military men of the world that pick and spade would soon supplement the gun on the battle-field—a true prophecy, as we have since seen. The breech block drops down to admit insertion of the new cartridge, when the lever below is operated.

know it today, in which the powder charge is sealed entirely. As this plan also proved to have certain objections, principally due to weakness of the shell, the untiring Houiller invented the center-fire system, which with some improvements serves us at the present time.

The value of Houiller's inventions was first appreciated in America, for between 1855 and

1865 more than twenty different kinds of breechloaders were invented and put on the market here. Of these half a million and more were sold, all using the new cartridge and all guns of great efficiency; while in France, the home of the distinguished inventor, we find German and French

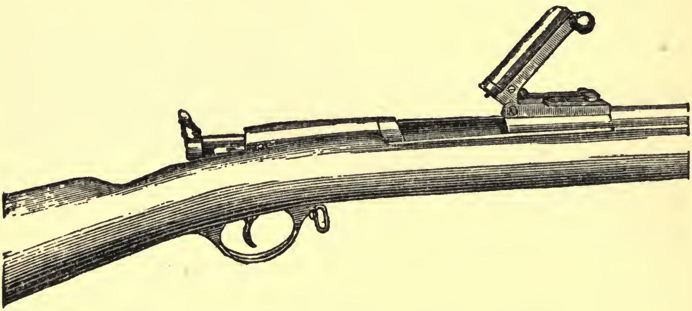


FIG. 41.—BERDAN BREECH-LOADING RIFLE

The Russians used this American rifle as their military arm for many years. At Plevna it was far outmatched by the Peabody used by the Turks. The breech block is raised by the firer's hand to eject the empty shell and permit a new one to be inserted.

armies even in 1870 battling with leaky needle guns and chassepots, using paper cartridges.

Of the swarm of new breechloaders built up around Houiller's copper shell we have space here only for a single comment. They were divided into two general types, the "block" and the "bolt" system. Of the former class the Peabody is a good example. It has a solid breech block that works up and down on a hinge at the rear of the barrel, dropping for the admission of the cartridge and rising again to hold it in place while being discharged. These blocks in different guns were made not only to work on hinges, swinging up, down, and to either side to expose the cartridge chamber, but were in some cases made to slide up and down as in the Peabody and

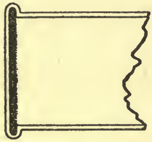


FIG. 42.—BASE OF RIM-FIRE CARTRIDGE SHELL

The fulminate is thrown into the fold by spinning the shell rapidly while in an upright position, at the same time dropping the chemical slowly into the mouth. The centrifugal force throws the dust-like fulminate into the fold evenly all around its circumference.

Sharp's. The "bolt" guns differed from them in that they opened and closed by means of a strong rod that slid straight back and forth lengthwise behind the barrel. This type, of which the needle gun is an example, proved the more successful of the two, especially in the repeaters which followed; in consequence, the block system, except in guns of small caliber, has at this time entirely disappeared.

Houiller's rim-fire cartridge was at first the favorite ignition device in the new American breechloaders. This also was not entirely satisfactory, for when handled carelessly or accidentally dropped, it frequently exploded, like the pin-fire, especially in heavy ammunition. Nor was the metal strong enough to withstand well the explosions of large charges, because the crimping of the rim weakened the material so much that the heads were occasionally torn open or blown off the shell entirely. Then again, misfires were not uncommon in its use, for unless the percussion mixture is distributed around every portion of the rim, the hammer is likely to fall upon the spot that happens to be skipped, when the shot fails. These defects, far more prevalent and serious in large cartridges than in small ones, called so loudly for remedy that a better method was sought and promptly produced.

To give a stronger shell, but one still elastic enough to expand and contract readily in firing, brass was substituted for copper. Then in order to make the cartridge safer, more certain in ignition, and to reduce the quantity of fulminate required, the center-fire system was developed and applied, in place of the rim-fire method. Houiller's center-fire shell never succeeded because his tube was too weak and the percussion method he used was imperfect; but his idea was sound, needing only the right means to carry it out.

The first brass center-fire shells were made in a number of parts, which greatly increased their cost. The primer had to have an anvil in front of it in order to explode when struck by the hammer or firing pin of the gun. How to supply this anvil and still produce shells cheaply was the

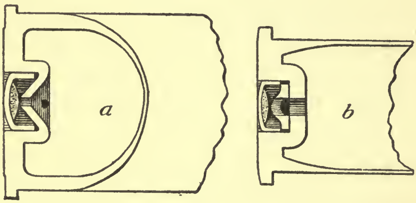


FIG. 43.—BERDAN'S SOLID HEAD CENTER-FIRE CARTRIDGE SHELL Of brass, invented in 1870. Earlier center-fire shells were made up of a number of parts which rendered them so costly that soldiers were trained to recover their empty shells even on the battle-field for reloading. By the Berdan method the shell was stamped out in one piece with an upraised anvil in the primer cavity, thus greatly improving the shell and cheapening its manufacture. Originally the igniting fire was admitted to the charge by several holes around the edge of the anvil, as in figure *a*, but with the coming of smokeless powder, requiring a more concentrated igniting flame, the form in figure *b* was adopted, having a single orifice and a separate anvil.

knotty point. It was solved by General Berdan of the United States army about 1870. He originated the idea of stamping the shell out of a single piece of brass, at a few strokes of a machine, having in its primer cavity an anvil which was a solid part of the shell itself. With that invention center-fire entirely displaced rim-fire cartridges, except in those of small sizes.

In paper cartridges for shotguns we still have the old, complicated system of center-fire ignition, in which several different pieces must be

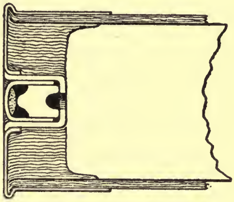


FIG. 44.—BASE OF A MODERN SHOTGUN SHELL

Made of paper reinforced with metal. The igniting apparatus, as appears, is in three distinct parts—the containing tube upon which the anvil rests, the anvil and the primer proper. The thick butt of the paper shell makes this complicated construction necessary to insure ignition.

employed. The paper shell with the thick butt end necessary to close the rear of the tube makes the Berdan idea unworkable. But the virtue of the paper cartridges, chiefly their cheapness as compared with the great cost of such large-sized shells if made of brass, warrants the continuance of the old-fashioned ignition devices in these weapons.

With the coming of smokeless powder (a subject to be dealt with later) shell and primer had again to be slightly changed in order to successfully ignite the new explosive. The latter requires a more powerful igniting fire than gunpowder calls for and in order to concentrate the primer's flame the Berdan anvil, which met the primer in its center, allowing the flame to enter the shell through perforations at its sides, has been discarded. We now find the shell made with its cavity perforated at its center with a single hole, the anvil being a part of the primer and seated at the bottom of the cavity when in place. Thus when the primer is struck, the igniting flame all

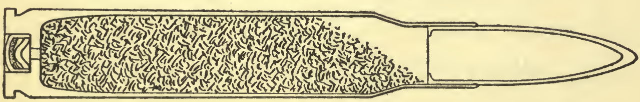


FIG. 45.—U. S. GOVERNMENT CARTRIDGE NOW IN USE

This is the famous .30-caliber cartridge used in our Springfield service rifle, model 1906, and in the new Springfield-Enfield, model 1917. In both guns the cartridge is showing remarkable results. It produces a chamber pressure of 51,000 lbs. per square inch and will kill at over two miles distance. As the bullet leaves the muzzle it spins at the terrific rate of 3,240 revolutions per second. In the old .45-caliber guns 800 revolutions per second were considered a rapid rate of rotation.

enters the cartridge through the one orifice, giving the concentration necessary in setting off the slow-burning charge.

Such, therefore, is the story of the successful breechloader, the final fruit of ages of endeavor, aided in one way or another by men of many different nations; but indebted more particularly to Forsyth, the Scotchman, and Houiller of France.

Though the full value of efficient breech-loading is not easily estimated, a few points stand out clearly. Through it the rifle became an easy and quick-loading weapon; the long-pointed bullet, with its low air resistance and consequent long flight, became the common missile; while misfires were reduced to less than one in a thousand shots. Then again, of the powder prepared for use in the old-time musket nearly half was spoiled and wasted from dampness or misfires, and from being spilled upon the ground in use; while now the hand gunner, with his waterproof metallic shells, uses his full supply in producing gas behind his bullet to drive it forward. Furthermore, with this improved ammunition the breechloader soon became a repeater, the growth of which we shall next consider.

CHAPTER XII

ARRIVAL OF THE REPEATER

A GUN that would deliver successive shots rapidly has from the beginning been one of the chief goals of inventors in firearms. Especially for the soldier was this quality desirable, for on the battle-field the man who could shoot twice while his opponent was shooting once became almost doubly effective. The superiority of the bow and arrow in rapidity of shooting, as has appeared, kept the hand gun in the background for the first two centuries of its existence; while the smooth-bore, for the same reason, claimed priority over the rifle for centuries after that. But great as were the advantages of quick firing, little progress was made in this respect until recent years.

The first person who seems to have tried methodically to quicken the firing of the musket was Frederick the Great, about 1750. Limited in the number of his soldiers and beset on every hand by enemies much more numerous than he could bring into the field, he was compelled to increase the efficiency of his small armies in order to hold his own. By teaching his men to load systematically, performing the operation in a definite number of movements, each timed exactly, he succeeded in increasing the number of shots from one in a minute to twice that number. This

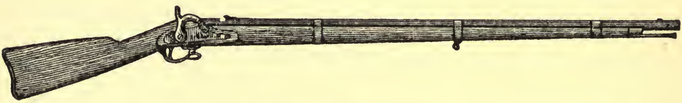
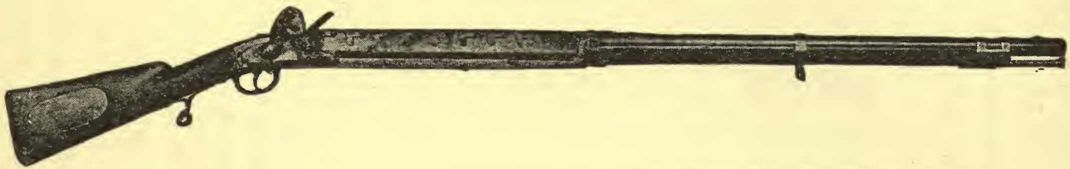


FIG. 46.—MUZZLE-LOADING SPRINGFIELD SMOOTH-BORE

Used, with slight variations, down to and through our Civil War. It shot spherical balls usually 14½ to the pound. Observe how for over a hundred years we have tenaciously clung to the name Springfield for our standard military weapon. The British have similarly been wedded to the name Enfield. Now the two names have joined in the Springfield-Enfield rifle—symbolizing the unity of purpose of the two great peoples in their present fight for freedom.

gain was in no small measure due to the introduction of a ramrod made of iron, an idea of one of Frederick's officers, which gave more weight and strength than the wooden sticks formerly used for that purpose. The pace thus set by the Prussian soldiers was never much bettered with muzzle-loaders, for in our Civil War this type of gun, even with percussion caps, was not expected to be fired more than twice in a minute.

The earliest attempts to make rapid-shooting guns was by adding one or more additional bar-



Courtesy Winchester Repeating Arms Company.

FIG. 47.—NORTH FLINT-LOCK RIFLE

(From Norton's *American Inventions*)

An early American attempt to produce a repeater. Powder and lead in alternate layers separated by thick wads were put down the barrel, the powder charges being opposite priming holes in the barrel. The flint-lock igniter slides along the side of the barrel to come opposite the priming holes. Of course the forward charge was fired first, then the rest in turn. The plan did not work for reasons explained in the text.

rels to the weapon, to be fired in succession, a practice still continued by us in shotguns. Then there were guns made with revolving cylinders placed behind a single barrel, just as our revolvers are made today. The multi-barrel guns, however, were too heavy for ordinary use; while those of the cylinder type not only leaked gas badly at the junction of cylinder and barrel, but their workmanship was too imperfect to place the cylinder always in the correct position for firing. Nothing much, therefore, ever came of these ideas.

There was also another type of weapon designed for rapid shooting which appeared from time to time, only to be as often discarded. It used a single barrel, but would receive a number of loads, one on top of the other, separated by thick wads. Each charge usually had its own flash pan, while the firing device was slid along on a shelf-like projection at the side, opposite the pans. In the arquebuse this device was the match, while in the musket type flint and steel were used. These guns must have been dangerous, for even though the separating wads between the charges might be tight and thick enough to prevent explosion of more than one load at a time, there was always danger of igniting fire jumping from one flash pan to another. Then, too, the powder in the rearmost charges must have been jammed into solid masses by the previous explosions before they were reached in their order, thus making ignition almost impossible. At any rate, such

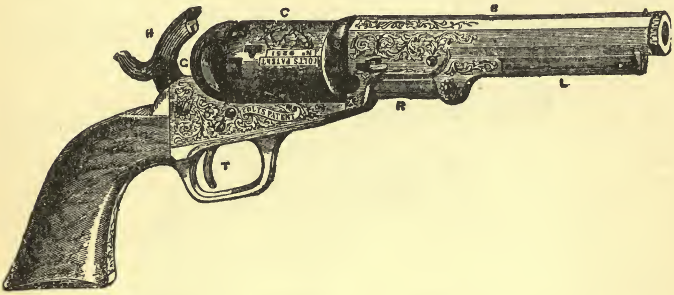


FIG. 48.—ORIGINAL COLT REVOLVER
The weapon that displaced the sword as the common weapon of self-defense.

guns, ingenious as they were, did not get beyond the experimental stage.

In 1835 Samuel Colt of Connecticut produced the first gun which successfully fired more than one shot without reloading. That was of the cylinder and single-barrel type and has already been mentioned. Its mechanism is more particularly described in a later chapter on revolvers, in which class of weapons Colt's invention achieved its triumph. The Colt rifle was used by United States troops with excellent results, as well as by hunters and plainsmen on the frontier, continuing for several years after its appearance a popular arm. Some say it was not a repeater, but only a modification of the multi-barreled weapon, but this contention depends only upon whether or not the cylinder can be called a magazine. The distinction is too fine to be important.

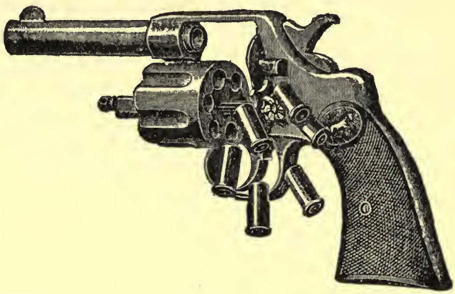


FIG. 49.—A LATER TYPE OF COLT REVOLVER
Showing cylinder hinged to fall to one side for easy extraction of shells and reloading.

The solid fact was that Colt could with his gun fire as many shots from his single barrel as there were chambers in his cylinder, without stopping to reload; and this had never before been successfully done. Colt's system, however, allowed too much leakage of gas with the heavy powder charges necessary in rifles, so that the want of a good repeater was left unfilled until the breech-loader with fixed ammunition arrived. Then in the year 1860 the long sought for weapon appeared.

In that year the American gun called the Spencer came, a true repeater, capable of firing sixteen shots per minute. The Civil War began shortly after its introduction, so that many thousands of them were made and issued to Union cavalry for use in that struggle, in which they

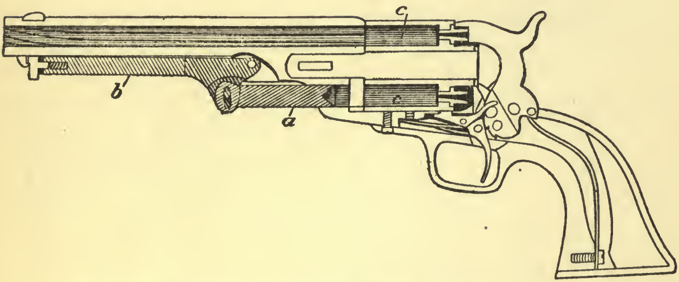


FIG. 50.—COLT'S REVOLVER, WITH JOINTED RAMROD

One of Samuel Colt's most valuable improvements in firearms was the loading device he affixed to his rifles and revolvers. A representation of it is given here. *a* is a short ramrod which entered the mouth of the cylinder chamber *c* opposite it, ramming down the powder and then the ball as the lever *b* was drawn downward. Thus one by one the several chambers were loaded with great dexterity as such things went with the muzzle-loader of 1840.

gave remarkable results. It was calculated that one man armed with the Spencer, and acting on the defensive from cover, was equal to six men advancing upon him with muzzle-loaders. A lever swinging backward under the barrel, after the manner of the Sharp's, threw out the empty shell and inserted a fresh cartridge, which operation could be performed without removing the gun from the shoulder or taking the eyes from the target. The magazine, a tube passing lengthwise through the stock, was filled at the butt. This held seven cartridges, which, with the one in the chamber, made eight in all. The hammer, how-

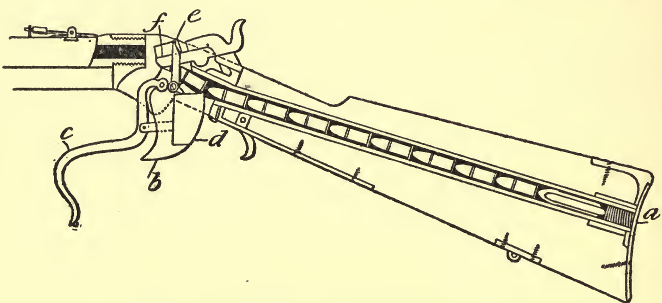


FIG. 51.—SPENCER REPEATING RIFLE
a, follower; *b,* carrier block; *c,* lever guard; *d,* breech block; *e,* extractor; *f,* guide.

ever, had to be drawn back with the thumb after each shot. The closing device was of the block type, sliding up and down at the breech, as in the Sharp's. The gun used rim-fire ignition, with .56-caliber bullets. The missile was short, pointed, and stumpy looking, and weighed 400 grains, with only 45 grains of powder to propel it, because the shells were of copper, which rendered them too weak to resist heavy charges of powder. In its day, nevertheless, the Spencer was considered a marvel.

The writer as a boy in the early eighties was the proud possessor of one of these guns, even then growing old-fashioned, and distinctly recalls one aggravating defect in it, which often marred his pleasure in hunting. The frail copper shells had a habit of frequently sticking in the chamber after firing, for copper corrodes when damp, making the surface of the shell rough; then the extractor would bend back the soft rim, leaving the shell in the gun. It often took much self-control not to lose one's temper when, with gun out of commission, another shot was wanted at once, to bring down an escaping deer or antelope. In spite of its defects, however, the Spencer had great popularity among the rifle-carrying frontiersmen until late in the seventies, when it was forced to make way for a better gun.

The Henry repeater, another American product, came into existence not long after the Spencer, and, like it, was used to some extent by Northern troops in the later days of the Civil War. Its breech-closing device was of the bolt type, and the magazine was a tube attached to the under side of the barrel, holding fifteen cartridges put in place from the front end. Thirty shots per minute were possible with this gun. The cartridge shell was of copper and had rim-fire ignition, as in the Spencer. A lever underneath threw out the empty shell, put a new one in place, and at the same time, going the Spencer one better, cocked the gun, all at one operation. The sliding bolt, too, proved to be a more effective closing device than the Spencer's block, because the shell was backed up better and made bursting of rims at the explosion less common. These superior features awarded the Henry precedence over the Spencer, the latter giving up the field before 1880. Upon being changed from rim-fire to center-fire, and so built as to permit charging the magazine from the breech instead of the front, with some important improvements which permitted a heavier charge of powder to be used, the Henry a year or two after the Civil War was rechristened the "Winchester," under which name we know it well today. As improved again with an operating mechanism devised by Browning, it stands as one of the best of several other good repeaters which have grown up beside it, and differ from it only in details.

The repeating rifle as a sporting weapon remains, as it began, a distinctively American institution. Europeans who in private life use guns chiefly for target practice and for killing birds and small game find the single-shot rifle and the double-barreled shotgun sufficient for their purposes; while those daring individuals who venture into the fastnesses of Africa or India seeking big game, such as elephants, tigers, and lions, seem to find the single-shot or double-barreled rifle of large bore, using heavy powder charges, best for that purpose. Those who carry repeaters on these expeditions usually choose those of American manufacture. In our country, however, the repeater is the standard weapon for nearly all purposes.

In the South American war in 1890 the Winchester revealed the power of repeating arms on the battle-field, and gave a hint of the great changes which such weapons were to bring about in warfare. There the Chileans, attacked by the joint armies of Peru and Bolivia, were armed with Winchesters, while their adversaries used single-shot breechloaders. Largely by the aid of their faster shooting guns the Chileans overwhelmed their enemies almost every time they could be made to stand and fight, and quickly imposed peace on terms to suit themselves. The value of the repeater to the soldier thus demonstrated, forced military authorities the world over to give grave heed to that type of weapon, with the result that it was soon after adopted by all armies.

Military experts had, since the introduction of good breechloaders, pinned their faith to the single-shot variety on account of its simplicity for one thing, but more especially upon the claim that the soldier carrying a repeater would fire away ammunition too lavishly; thus reversing their age-long appeal for a faster-shooting weapon. This objection has been met, however, partly by teaching the trooper to exercise self-restraint in the use of his cartridges and partly by increasing the number of rounds carried into battle, this latter recourse being made possible by the light weight of the modern bullet. The production of a simple repeater of few parts was, on the other hand, a more difficult proposition. The soldier's gun must always be simple in construction, with parts as few and as strong as possible. Rough usage is unavoidable in campaigning; and then the soldier in the excitement of battle is not likely to treat his weapon as gently in operating it as a man calmly shooting over a target range. Hence such arms must be so built as to work without either balking or breaking under even savage use. As with all other machines, the gun with fewest and strongest

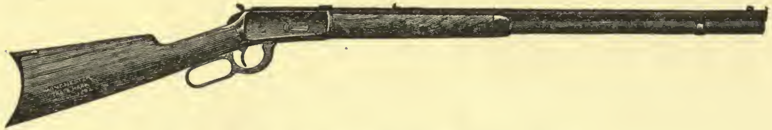


FIG. 52.—WINCHESTER REPEATING RIFLE

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FIG. 53.—SPRINGFIELD-ENFIELD RIFLE

Adopted by the U. S. Government and now in use by our army abroad parts will be found the most reliable, therefore the modern military repeater, considering the work it will do, is an exceedingly simple instrument.

The Winchester type of repeater has never gained much favor with military men, because they claim it to be too delicate for warfare, which probably is true. They object also to the tubular magazine under the barrel, for the reason that, as it empties, the remaining cartridges slide to the rear, thus shifting weight and affecting the gun's balance. It is said that this seriously affects the aim during continuous firing, which is partially true, though the average sportsman finds little to complain of on this score. The hunter and target shooter, however, are not often called upon to stand and shoot a dozen shots one after another as the soldier may have to do, and hence both parties may be right in judging their several needs.

About 1890 there sprang up in Europe a new repeating system which has been generally adopted in all modern military arms. The cartridges, instead of being slipped into a magazine one by one, are prepared for the soldier in groups of about five fastened together by a metal clip, so the gun is charged by having one of these packages thrust into it from below the lock. Thus while the total charge is less than that of the tubular magazine, and the loading operation necessarily more frequent, yet the time saved by the inserting of a number of cartridges at one time renders the two methods about equal in rapidity of fire. Twenty aimed shots per minute are easily possible with either.

Along with the general adoption of the clip-charging system, a breech mechanism has been developed for military arms which does not differ greatly in any country. This is the top bolt system, a very old idea, but first commonly seen in the von Dreyse needle gun of Prussia, by which the breech-closing bolt is drawn back directly by the hand instead of a lever. The operation throws out the old shell, inserts a cartridge, and cocks the piece, all in one motion. The mechanisms of the principal military guns now in use differ little from each other in principle.

The introduction of the repeating rifle in warfare has not increased slaughter on the battlefield, as many dire predictions held. The result has been that armies now begin to fight at greater distances and only approach each other by stealth, or under cover. The old frontal attack has been rendered obsolete, except after heavy battering of the enemy's line by artillery; but flanking movements where space permits are still profitable, as the Japanese demonstrated in their recent war with Russia. Reconnoissance has become impossible on account of rapid long-range rifle fire, though the aeroplane fulfils that service now better than infantry or cavalry ever did. The result has been that in the Boer War and that in Manchuria, as well as in the mighty struggle now in progress in Europe, considering the number of men engaged and the time through which the conflicts last, the percentage of casualties does not now exceed those of Cold Harbor, Shiloh, or Gettysburg.

The fact that our soldiers are now carrying in Europe two different types of rifles, the Springfield proper and the Springfield-Enfield, is due to circumstances which attended our hasty entrance into the war. The 6th of April, 1917, found us in open hostilities with Germany, and in instant need of huge well-armed forces. We had the men, but not the guns with which to equip them; nor had we the factories necessary to turn out our standard service rifles promptly in the needed quantities. Our authorities were therefore compelled to cast about for other expedients. In our country were gun factories of large capacity executing contracts for the manufacture of Enfield rifles for the British Government, which contracts were about completed. As these plants could not quickly alter their equipment for the production of Springfields, our War Department decided to set them to work turning out Enfields slightly altered to permit the use of Springfield ammunition. The rifle resulting is the so-called Springfield-Enfield. In outer form, breech mechanism, and shooting power the new gun does not differ materially from our standard service rifle; so that the soldier may change from one to the other without much embarrassment. Both guns are of the bolt type, and are charged by means of clips inserted from below the lock. Using the same ammunition, of course, calibers of both guns are identical. The Springfield is one pound the lighter, the barrel of the new weapon being twenty-six inches long as compared with the Springfield's twenty-four inches. One of the variations between the two weapons is in the rifling employed, for while the Springfield is given four lands with right-hand twist, the new rifle retains the five lands and left-hand twist of the British Enfield. Just what virtue lies in the spinning of the bullet toward the left instead of the right no one has ever been able to explain satisfactorily, but it is a practice long favored in British military circles. The Springfield-Enfield, however, according to reports, is proving equal, if not superior, to either of the types from which it sprang.

CHAPTER XIII

TRAJECTORIES AND SMALL BORES

The American rifle of 1870 seemed for the time being to be such a nearly perfect weapon that many optimistic persons declared further substantial progress impossible. The brass shell created a gas-tight breechloader into which pointed bullets could easily be loaded; the percussion primer made ignition certain, while the repeating feature gave great rapidity of fire. In the light of such advantages the boast did not at first glance appear an idle one. But Hall sixty years before had made the same claim of perfection, and we have seen how far he came wide of the mark. The later prophets, too, were overbold, for with all its merits the rifle was still but mediocre for long-distance shooting.

In 1870 there was no breech-loading gun which, in spite of all its virtues, could send a missile as fast and as straight as the simple muzzle-loader of a generation before shooting the sugar-loaf bullet. The latter, with its thin form and fine lines, driven by a heavy powder charge, still led the field in long, straight shooting, furnishing, in these respects, an ideal toward which the newer and more pretentious weapons had to strive.

The trouble with the later guns was that, for reasons shortly to be stated, they had to use bullets of large diameter, driven at low speed; and these conditions were fatal to accuracy over long ranges. In the language of gunnery, such missiles were too high in trajectory. We have not used this word before, though the problem it involves has attended the gun and its projectiles of all forms from the very beginning. Discussion of this subject has seemed best withheld until this time, when we propose in this and succeeding chapters to take up the whole matter of the flight of the elongated bullet. Let us now see what is meant by *trajectory.*

If you will go to the top of a house and drop a bullet from your hand it will fall (nearly) 16 feet the first second, 48 feet the next second, 80 feet during the third, and so on in the same ratios of increased speed and distance. Using this for illustration: the total distance fallen by the bullet during the first three seconds will be 144 feet, *i.e.:* 16 ft. (1st second), 48 ft. (2d second), 80 ft. (3d second).

These distances are only approximate, for a body falling through air is somewhat retarded by it, the amount varying with different conditions. Dampness in the atmosphere slows up a bullet substantially, while its pace is faster if the air be unusually dry; cold air offers more resistance than hot, and at high altitudes the thinner air permits an easier passage than the denser medium at sea-level. Then again, since the earth is thicker at the equator than at the poles, gravity increases a little as we go southward in our hemisphere. Therefore, though we generally speak of the velocities of falling bodies, as in the preceding paragraph, the figures are subject to slight variations.

The point to be noticed especially is that the longer an object is in the air the faster it falls, and hence the greater the distances it will cover as it proceeds. The missile fired from the gun is pulled down by gravity just as when dropped at a height from the hand, so that the *time* it consumes in making its journey to the target becomes a very important matter.

For instance, if you are going to shoot at a mark 2,000 feet away, and your bullet has just enough powder behind it to make it reach there in three seconds you will have to aim 144 feet above the bull's-eye, because that is the distance gravity will pull it down in three seconds. Its course, therefore, will not be a straight line, but a curve up from the gun muzzle to a point just past the middle of the flight and then down again to the target. The curve so described is called the *curve of trajectory.*

If the supposed target be 2,000 feet away and the bullet can reach it in two seconds the aim need be only 64 feet above the bull's-eye, for that is the drop the missile will make in two seconds.

Suppose, however, that you can send your bullet fast enough to cover the desired 2,000 feet in a single second, see what a difference! The elevation necessary is only 16 feet instead of 144 or 64. That first second is, then, the important one, to be utilized to its fullest extent, for during it disturbance by gravity is comparatively slight. Making the most of the first second means a flat trajectory curve, less time for a living target to move out of reach, and greater chances in every way of hitting the mark aimed at. To impart this early speed to the bullet is the vital requisite.

In actual shooting the gun-sights are so arranged as to allow for the necessary elevation at various distances, and though the sights are to be held exactly on the mark, the muzzle is always pointed upward more or less. Of course no bullet can be driven so fast that gravity will not pull it down in some degree, for the moment it leaves the supporting gun barrel and enters the air, gravity grips it and drags it downward, the distance depending on the time the force is allowed to act. All we can ever do to offset gravity is to reduce its effect by shortening the time of its operation.

Just to prove to yourself the baneful effect of high trajectory on a marksman's bullet, set a tin can off about fifty feet and try to hit it with stones thrown upward and allowed to drop. When you have satisfied yourself of the difficulty of this feat, throw a few stones at the can, giving them speed, and note how much better will be your record of hits. As with the stones, so it is with the rifle bullet. The plunge downward from a height makes accuracy doubly hard.

In target shooting high trajectories are not so disturbing, for there the rifleman usually knows his ranges and can make the necessary adjustments of his sights for distance and wind. But consider the plight of the soldier or hunter who has to guess hastily at his distances and make the necessary allowances for over or under shooting, or for the movement of the air. If he aims a little too high the bullet comes down beyond the mark, while if he sights too low the missile falls short. For this mischief the fast bullet with low trajectory is the only cure.

In artillery the high trajectory and plunging fire are in some cases really virtues, for because of them the cannoneer can post his guns behind the battle line and throw projectiles at the enemy over the heads of his fellows. But unless the distances are accurately known such fire is of little effect, except with bursting shell or shrapnel that scatter missiles over a wide space. For the rifleman shooting single balls high trajectory is almost always a detriment.

Going back now to the problem in trajectory which gun inventors faced in the period from, say, 1870 to 1890, let us glance at some of the performances of bullets from their weapons. Take, for instance, a popular hunting cartridge then in use of .45 caliber. With its usual powder charge it emerged from the gun muzzle at a speed of 1,350 feet per second. When aimed at a target one hundred yards distant it rose only three feet above the line of sight, but so great was the air resistance it encountered in longer flights that, when fired at a target two hundred yards away, the upward curve had to be twelve and a half feet high. At a three-hundred-yard target its final velocity became so low that thirty feet of elevation had to be allowed. At three times the distance the trajectory arc was multiplied by ten.

The Springfield military rifle, with which the United States army was armed during the period in question, fired its bullet thirty-five feet above the line of sight at three hundred yards. In all the guns of which these are types the elevation necessary increased enormously as the distance shot over was even moderately lengthened, because the bullet was longer in the air and subject to the accumulated pull of gravity.

Why, then, were these high trajectories tolerated? At first glance one might say that merely adding powder to the charge would speed the bullet and so give the desired flatter curve. There were several reasons why this plan would not work, not the least of them being the increase in recoil and low efficiency of the heavier charge. The weight of the rifle had become so firmly fixed at about ten pounds that men could not be induced to go back to heavier ones. With bullet and gun remaining of the same weight, and the recoil already as great as could be borne, it is plain that additional powder was not a solution of the difficulty.

Of course greater speed can be imparted to the bullet with the same powder charge, without increasing recoil, by simply using less lead. But this expedient produces fresh troubles, even greater than high trajectory. When a bullet is left of the same diameter and made lighter by shortening it the amount of air it must displace in flight is not materially decreased, for it must still bore as big a hole through the atmosphere as ever. Lessening weight, too, lessens power, speed remaining the same.

But in order that two bullets, one weighing 400 grains, the other 200, may be made to do the same work, the lighter will have to be made travel twice as fast. Their momentum is then said to be equal. Now comes the surprising thing. When both of these bullets are traveling at a speed greater than 1,350 feet per second the air resistance which the lighter, faster one must meet is four times as great as that of the slower, assuming that the areas of their cross-sections are equal. This is because missiles of the same diameter and shape traveling beyond the speed stated meet air resistance in proportion to the square of their velocities. This immensely rapid increase of air pressure against the light, swift bullet causes it to slow up quickly, and by the time it has covered any considerable distance its energy, expended in fighting air, is so low that it cannot hit hard. Its flight is also so greatly disturbed in the aerial contest that it becomes wild and inaccurate. For these reasons the rifleman preferred to stick to his heavy bullet, slow-moving, but with great momentum stored up in it to carry it high but truly. For the missile with high trajectory, it must be remembered, is not necessarily an inaccurate one; its high curve only hampers marksmanship in requiring more allowance for wind, and greater exactness in the estimation of distance. It was therefore better to accept these disadvantages than to adopt the weak-hitting, wild-flying, light missile, no matter how much faster it could be propelled.

It will be well, perhaps, in this place to explain why in the foregoing paragraph care was taken to specify 1,350 feet per second as the minimum velocity of the supposed bullets. This was because air pressures do not increase regularly with the speed of the bullet. In velocities from one foot to 100 feet per second the air pressure increases as the square of the velocity of the missile; from 100 to 1,100 feet per second the pressure increases so fast that the figures representing the velocity must be multiplied by themselves six times to give the resistance. From 1,100 to 1,350 feet per second the resistance dwindles to about the cube of the velocity; while from 1,350 feet and higher the proportion returns again to the first ratio given, that is, the square of the velocity. These figures are, of course, not exact, for the varying pressures blend gradually from one stage to the other, there being no known rule for calculating the changes accurately. This much, however, is certain—that where weight, shape, diameter, and speed remain the same, the bullet is retarded inversely as the weight. The heavier the bullet, therefore, all the other conditions continuing the same, the less the proportionate air pressure against it and the further and straighter it will travel.

Returning now to the problem of gaining lower trajectory, we find that the only recourse remaining was to lessen air pressure by reducing the diameter of the bullet, and in that way give it the necessary long-continued speed, accompanied with accuracy if possible. But here also there were grave obstacles to be overcome. One peculiarity of spinning bodies not yet mentioned is that, as the diameter is decreased, the speed of rotation must be increased to give stability. The thinner bullet, then, would require a much faster spin than the thicker one, if it were to be made fly accurately. How true this is you may prove to yourself by taking two tops of the same material, one thick and one thin, and spinning them side by side. If the speeds given them are anywhere near the same the broader toy will stand up much more

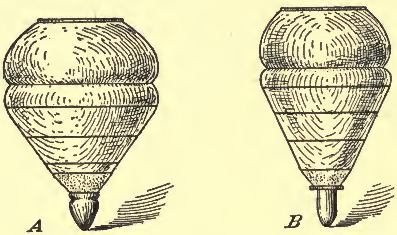


Fig. 54.—Of these two tops, *A* and *B*, the former is the thicker of the two. If both be spun at the same speed, *A* will stand up longer than *B*. Similarly the bullet with the greater diameter will remain point foremost longer than the thinner and when both are rotating at the same speed, length and material being alike.

steadily and longer than the other. This difference is due to the increase in circumference, because the greater distance traveled by the heavy outer edge in making a revolution gives greater leverage. Similarly, the bullet half an inch in diameter will keep its rotating motion and remain point foremost longer than one only a third of an inch across, when both are turning at the same speed.

For many years there was in use a type of rifle called the "express," in which a heavy charge of powder propelled a small bullet, giving it great speed and penetration. But the "express" gave accuracy only at short distances, because the projectile spun so slowly that the force of rotation held it true for but a brief portion of its full range. Many sportsmen, however, willingly accepted the shortcoming and used the weapon on account of its low trajectory.

There was no difficulty in making the rifle barrel as small as desired, nor in manufacturing projectiles thin enough to fit; the difficulty was to compel the missile to spin fast enough to stay straight in flight. To accomplish this, of course, the twist of the rifling had to be made sharper. When this was done, however, the lead refused to follow the spiral channels, simply tearing its way through the barrel, spinning little or none; when the grooves were made deeper they promptly filled up with lead from the missile's sides, leaving the gun practically a smooth-bore. The old, thin sugar-loaf bullet had been used with what was called the "accelerating twist" rifling; that is, the grooves began with a slow turn at the breech, increasing the rotation as the muzzle was approached. By this means the bullet started revolving slowly, but gained rotation rapidly as it passed down the barrel. For this type of missile such a system of grooving was admirable, and to it the sugar-loaf owed much of its merit. But it must be remembered that the sugar-loaf touched the barrel only at its extreme base and that the grooves cut into its surface were therefore quite short. When this system of rifling was tried with cylindrical bullets the results were very disappointing, for they pressed against the barrel throughout their length; and the result was much like screwing a bolt through a nut with threads of varying twist. The lead was torn, the surface of the bullet was injured, and poor shooting resulted. The idea of using the accelerating twist to gain greater spin for the thin, cylindrical bullet was, therefore, after long trial finally abandoned, and rifling uniform from breech to muzzle adhered to.

The next expedient tried to gain rotation for the bullet of smaller caliber was the hardening of the missile, to give it a firmer grip on the rifling. Tin, zinc, antimony, and other alloys mixed in small quantities with the lead, served to harden it substantially. With such bullets it was found that sharper twists in the rifling were permissible. In consequence, about 1885, rifle bores began to decrease from .50 and .45 caliber to .44,

.40, and .38. The bullet's total weight was reduced somewhat, but its length generally increased. The slender bullet hardened to make it follow the sharper rifle grooves, and therefore spinning fast from sharper-turning spirals in the barrel, gave increased range and accuracy, as well as a somewhat lower trajectory. These results were due less to the increase in the velocity with which it left the rifle barrel than to the fact that its smaller diameter displaced less air, thus enabling it to retain its forward speed for a longer period.

These alloyed bullets, however, when hardened very much proved defective because the lead, thus robbed of its semi-plastic quality, became too brittle to serve as efficient missiles. The author has seen an elk run a quarter of a mile with three direct hits behind its shoulder from such bullets, examination showing that the thin hard metal had crumbled to bits on impact, leaving wounds comparatively superficial. Experiences like this quickly warned gun makers that there were limits to their plan of making a successful thin bullet by hardening the material of which it was composed. Yet the alloyed bullet, when properly manufactured, gained much popularity in its day.

As the bullet became thinner the cartridge shell that went with it also had to undergo a change. The longer shell necessary to hold the charge when the diameter was decreased was found to have a serious drawback in that the igniting fire, being applied at the extreme base of the shell, did not cause the foremost powder grains to burn until after the bullet had left the gun. This was a demonstration of the von Dreyse theory, though it really cut very little figure in the small charges his needle gun employed. The difficulty was overcome after a while by making the rear part of the shell larger than the front, thereby keeping the powder near the primer and causing the shell to take the shape now commonly called "bottle-necked."

In the old muzzle-loading rifles shooting spherical balls it was not uncommon to have the rifling so gradual in twist as to cause the bullet to make a single turn in eight feet. In the early breech-loaders one turn in three feet was about the average, but with the coming of the smaller calibers made possible by hardening the bullets the speed of rotation increased to a turn in eighteen or twenty inches.

There must be noted here the fact that, as the diameter of the rifle bore decreases, the spirals slope more gradually; so that when we say that certain rifling makes a turn in so many inches, the expression is very indefinite. The only explicit way to specify the rapidity of rotation is to say that a turn is made in so many calibers. For

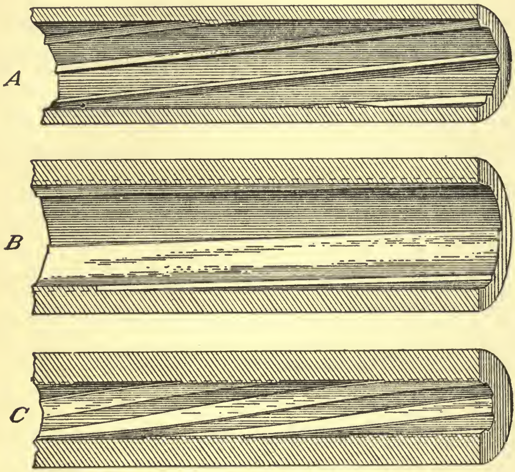


FIG. 55.—SECTIONAL VIEW OF RIFLE BARRELS
Showing different types of rifling and different slopes of twists.

instance, if the diameter of the bore is half an inch and one turn is made in thirty-six inches, our meaning is clear when we multiply thirty-six by two and say the rifling is one turn in seventy-two calibers. If the diameter of the bore were only one-third of an inch the rifling would be one turn in one hundred and eight calibers. By merely saying that one turn is made in thirty-six inches this wide distinction would pass unnoticed.

This longer slope of the rifling in small gun barrels aid greatly in causing the bullet to keep to the spiral channels, without scraping past them. While the hardening of the bullet also helped substantially to impart a rapid twist, these influences were far too limited to give spin enough for the small caliber and low trajectories which riflemen demanded and at last attained. The nearer the rifle bullet approaches the sphere in shape, the less spin is necessary to keep it on its course; and the more its form departs from that standard; that is, by being made longer, the more violent are the forces that tend to carry it astray. A certain amount of lead is always necessary to give high momentum, and as the diameter of the bullet is decreased its length must be increased. How the lengthened missile battles its way through the air from gun to target is the interesting subject of the next chapter.

CHAPTER XIV

THE PRANKS OF THE LONG-POINTED BULLET

If you were asked why the Indian of long ago put a stone tip on his arrow, your answer probably would be that the sharp stone was intended to cut a passage for the wooden stick as it struck his enemy, or the deer at which he aimed. This would be partly correct, but much less than the whole truth. The function of the arrowhead was first of all to keep the shaft point forward in its flight, and since it must be used at all, it might as well be sharp. The knife-edged steel points on the arrow used by archers today are there for the same primary purpose; that is, to place the greatest weight on the front end, and only secondarily to cut the target.

When our American Indians hunted the buffalo on horseback they used bows and arrows in preference to muzzle-loading guns, because of the difficulty of loading powder and ball while in full career. Such loading not only was hard to perform but hazardous as well; for when the bullet was not rammed down closely upon the powder the gun would bulge or burst, a very common occurrence with all muzzle-loaders. Indeed the advantages of bow and arrow were so great that our own pioneers often chose them instead of the gun for "running" buffalo, as hunting these animals on horseback was called. The bow-armed hunter would spur his horse up alongside one of the huge beasts, aim his arrow at a spot between two ribs to avoid striking a bone, and send the missile into the vitals of the victim.

Now, there was a peculiarity about these arrows intended to be shot with the point almost touching the hide of the quarry: they were not tipped with either stone or steel. The wooden point was sharp, hardened by fire; and, when no bone intervened, such an arrow has been known to pass clear through the body of a buffalo. This goes to show that the Indian knew his stone-tipped arrow to be best for long shots; while for work close up, where mere penetration was needed, the plain, lance-like shaft was best. In fact, in the days before the Indians had horses to carry them alongside the beasts, we know that they killed few buffalo except by stampeding a herd over a cliff to its own destruction, or into water, when they could be surrounded and a few drowned. The stone-tipped arrow, shot from a distance, would fly truly, but did not, on reaching its mark, have the penetrating power to pierce the bodies of such ponderous animals.

What has all this to do with the subject of rifle bullets? you may ask. Let us see. The long, thin, pointed bullet is often spoken of as arrow-like, but this is misleading, unless we refer to the untipped shaft used by the mounted Indian in his buffalo hunting. This missile and the long bullet are each thin and sharp, but, unlike the tipped arrow, are lightest in front. The Indian used his ill-balanced projectile only at the closest ranges, and never devised means to discharge it accurately to a distance. The modern rifleman, however, demands that his long, sharp bullet shall fly far and straight. The rifling in his gun barrel has in part solved the problem for him, but to understand just how this partial success has been attained, let us analyze a little more closely than we have yet done the difficulties he had to surmount.

To get at the bottom of the matter promptly and easily, make for yourself a bow and two arrows. Those of the simplest character will suffice. On the point of one arrow wrap some wire to give weight there, and then shoot it. It will fly point forward, as truly and steadily as if it were a living, intelligent thing, the point reaching the ground first, while the shaft has described a graceful curve.

After this satisfactory performance take a second arrow and wrap the weighting wire around

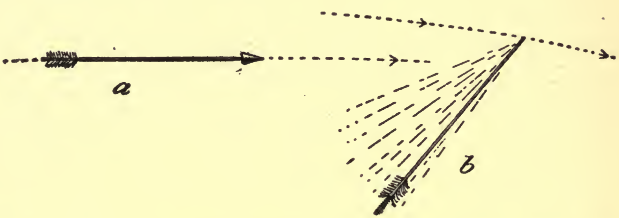


FIG. 56.—Of the two arrows here shown, *a* is weighted at the tip and flies straight to the mark, *b* is weighted at the butt and gyrates in its flight.

the butt end, first cutting a groove in the wood to contain the metal, and so give the stick a smoother surface. Then shoot this arrow and note the difference in the result. It has not gone many feet until its point has turned upward, the whole shaft has veered to one side and struck the ground butt end first, giving altogether a miserable exhibition. The light point has been supported by the air more effectually than the heavy rear; and the latter, having the greater momentum on account of its greater weight has tried to get to the front to drag the arrow on, but in so doing has turned the missile broadside to the wind and spoiled the shot. When a light body and a heavy one of equivalent size are sent forward at the same speed, through the air, the heavy one will pass the lighter one, because both meet the same air resistance, but the heavier has the more power stored up in it. So when a stick light at one end, but weighted at the other, tries to proceed sideways, the heavy end will try to take the lead. The only possible way to drive such a missile forward truly is to compel the heavy butt to remain exactly at the rear; but this is practically unattainable, because the air buoys up the light point more than the heavy butt, and the slant thus produced allows the rear to swing under and forward, with disastrous results. It is the weighted end that not only contains the greater propelling power, but is less retarded by the resisting air; hence by putting the weight at the rear we put the power in exactly the wrong place.

The long, pointed bullet is like the second arrow; it is lightest at its point, has the least power stored up there, and receives at that end the greatest support from the air. In order that we may obtain a clear understanding of this important fact—that the butt end of the bullet tends to fall faster than the point—let us use the accompanying diagram.

For our purposes here we may consider our bullet made up of two parts, the butt a cylinder and the tip a cone, the two having equal bases and equal altitudes. Let us suppose our bullet

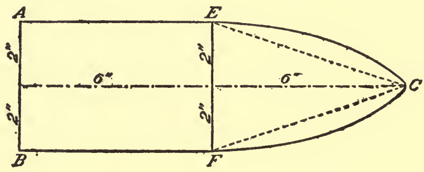


FIG. 57.—DIAGRAM OF A POINTED BULLET

cut into two lengthwise halves. The figure, then, shows the flat side of one of these halves, and is approximately made up of a rectangle and a triangle, with equal bases and equal altitudes. This flat surface measures the amount of air pressure resisting the bullet when it is falling horizontally. In order to simplify the matter let us give some simple dimensions to our projectile, calling the radius of its base 2 inches and its length 12 inches. In our diagram, then, we have a rectangle ABEF with an area of 24 square inches, which measures the amount of upward air pressure on the butt of the bullet; while the triangle EFC has an area of 12 square inches, showing that the amount of upward pressure on the tip is half that on the butt. Now, the force pulling the two parts down will be in proportion to their volumes. The volume of a cylinder is equivalent to the product of its base and its alti-

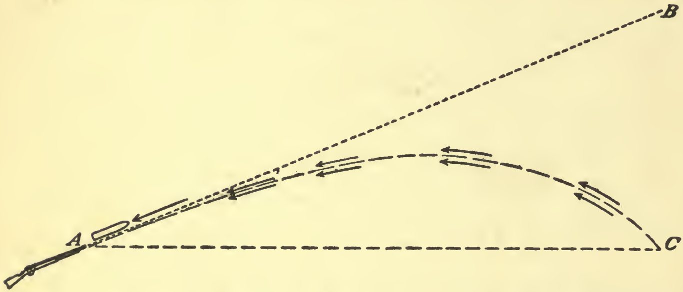


FIG. 58.—Arrows indicate the changing directions from which air pressure comes against the bullet.

tude, while the volume of a cone is only one-third of the product of its base and altitude. Hence the pull on the butt of the bullet exerted by the force of gravity is three times as great as that on the conical tip; while the amount of air pressure holding it up is only twice that on the tip. Hence the butt end of the projectile tends to fall faster than the lighter point, and as soon as it leaves the gun the bullet tries to leave its horizontal position. Herein we find one of the important demands for the supporting force of rapid rotation to keep the pointed cylinder straight.

The difference in the support which the two ends of the projectile receive from the air, however, is only one of the factors which intervene to turn the modern bullet from its course. A glance at Fig. 58 will reveal the effect of the air which lies in the missile's course as it passes forward with its point tilted upward, first, by reason of the greater buoyancy of the point, and second, because the bullet, to carry any distance, must be directed slightly upward as it leaves the muzzle.

An object once set in motion will proceed to infinity in its original direction unless obstructed or deflected. A bullet fired as in Fig. 59, therefore, would continue along the line A–B were it not for the air it must force aside, and for the pull of gravity from below. The action of these two influences, the one a yielding obstacle, the other a mere force, compels the bullet to leave the line A–B and take instead the line A–C. This line is curved, departing more and more rapidly from A–B, because gravity, as we have seen, pulls the bullet toward the earth faster and faster the longer its force is applied. The bullet, therefore, begins its flight with its point heading squarely into the air along the line A–B, but immediately leaves that line to follow the curve A–C. These two positions of the bullet are shown in the cut, which also illustrates how the air resistance constantly changes in its action against the missile. As the point receives more support from the air

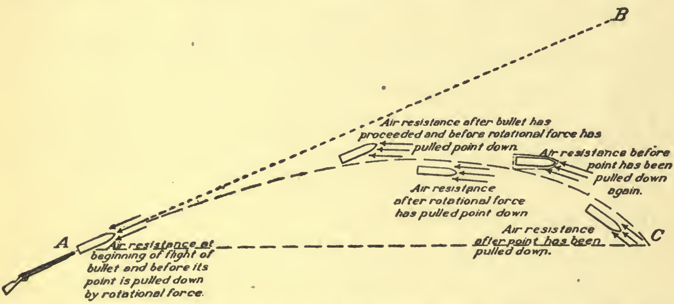


FIG. 59.—This illustration shows how the bullet starts off toward *B* with the air pressing squarely against its point; and how after some progress has been made along the curve *A-C*, the air resistance meets the bullet from below; rotational force then pulls the point down as indicated. But further along the trajectory curve the air pressure again comes from below, necessitating another rotational pull downward. This process really begins shortly after the projectile leaves the muzzle and is repeated again and again as long as the flight continues, or as long as rotational force is equal to its task.

than the butt, and is further forced upward by the air pressure against the lower side of the projectile, the whole body would promptly turn a somersault unless some force prevented. To prevent this catastrophe is the duty of the spin imparted by the rifle grooves.

Let us analyze briefly the contortions of the poor bewildered bullet in its efforts to obey the commands of these three contending masters—gravity, air resistance, and rotational force. The missile starts valiantly toward B up in the sky, but ends its flight ignominiously on the ground at C. What has happened to the unoffending bit of metal in the meantime, and how has it comported itself as it strives to obey the contradictory commands? The whole story of its tribulations cannot be told, for we still have much to learn upon the subject; some of the facts, however, are in our possession.

With air and gravity eliminated the bullet would fly truly to the target C in a straight line without requiring spin. But having these two factors to contend with, we must aim our projectile at B in order to have it reach C. No amount of spin will compel the missile to keep its point aimed directly at B during its journey to C, because the resistance of the air keeps coming more strongly from below as the different positions are reached in the trajectory curve, and the further the long body is tipped upward by this pressure, the more surface is presented to the wind and progress thereby impeded. Air resistance is least when the projectile is meeting the air exactly point on, and this is the position which the rotational force assists the missile to keep, the strong desire of this force being to bring the projectile into the line of least resistance and to keep it there. So that the more spin we impart to our bullet the more surely will its point and body stay in, or nearly in, the trajectory curve.

Our bullet is, we know, aimed upward at the beginning of a long flight; under normal conditions and within reasonable range the missile will hit its target almost exactly point first; if a screen be set up just past the middle of the flight, the bullet will pass through it in a horizontal direction. Thus we are assured of the truth of our theory that the projectile, if spinning fast, is never very far from being in line with the curve of trajectory.

In tracing the holes made by the bullet in passing through rows of screens, and in experiments with a spinning projectile so hinged as to permit free movement while a blast of air is directed against its point from below, different angles of impact of the air being used, we learn more about the queer gyrations of a secondary nature described during the journey along the main trajectory curve.

These minor antics of the projectile are produced by the contest which, during the flight, goes on among the forces of rotation, gravity, and air resistance. Let us dismiss the element of gravity now by merely calling attention to its influence in pulling the bullet bodily down from the line A–B to the curve A–C. This leaves the other two forces to fight it out between themselves. When the bullet's point is pressed upward by the air at the beginning of the flight the stabilizing force of rotation is not able to pull it down instantly, but takes a little time to do the work; the result is that the point rises slightly and is then somewhat slowly depressed; the point has not moved either straight upward or straight downward; but in obedience to the gradual yielding of one force to the other the point has moved first to the right (if the bullet is spinning to the right) and then downward. In the meantime the bullet has passed forward a considerable distance in its flight, so that its point has executed a long spiral-like movement, as viewed from the rear. During this movement, too, the left-hand side of the projectile is partly exposed to the rushing air, which causes the whole bullet to be pushed bodily to the right; then it is forced bodily downward as the point dips and the air presses against the upper side. The body of the projectile, therefore, in striving to follow directly behind its point and so shield itself from undue air resistance, also follows a spiral-like course. These are probably not complete spirals passing all the way around the curve of trajectory, however, for they seem to be interrupted midway by

FIG. 60.—When a spinning top is pushed gently on one side it will begin to wabble or "precess," the upper part describing a wide curve in the direction in which it is spinning. When the pointed bullet in following its curved course is met with changing air pressure coming from below at different angles, it also is forced to wabble or "precess" in the direction in which it spins.

still another variable element, to be considered presently.

To understand more clearly how the point of the projectile follows the curve to the right and then downward, the body of the object following in approximately the same course, let us get our top again and set it spinning. When it is in motion and standing steadily, let some one blow his breath hard against it on one side. Straightway the toy will begin to wabble, its upper end describing long curves in the direction of its spin. The air pressure during the blowing is greater upon one side than upon the other, partly overcoming the force of rotation which has been keeping the top upright on its point, and which immediately begins to pull the spinning body back into the former position. The effort so exerted acting not instantly, but requiring time, causes the spiral curve followed by the upper end.

The reason why the top stands upright when rotating rapidly, and assumes that position even though set spinning at an angle, is because of the friction upon its point as it rests upon the floor. When the top is tilted to one side this friction is increased on one side of the axis, offering more resistance there, and the toy in its gyrations gradually "feels" its way into the upright position, in which the point not only meets the least resistance, but finds that resistance evenly distributed. For the same reasons the projected bullet, spinning rapidly, "feels" for the position which produces the least and best distributed air resistance against its body. As the air resistance is constantly changing its direction against the projectile pursuing its trajectory curve, which first passes upward, then horizontally, ending in a downward direction, the secondary curves described by the missile are also necessarily changed from time to time during the flight. The projectile's point rises and passes to the right and then points downward; but as the body progresses, the air once more presses harder from below, forcing the point up; again it passes to the right and downward, as the two contending forces in turn gain control.

This alternation of these forces controlling the point of the projectile, while comparatively slow, is yet in the ordinary case too frequent to permit the point to perform a complete spiral. The result is that when the point has passed upward and to the right, then downward and perhaps partly to the left, the air pressure lifts it again rather suddenly, from which position the rotational force comes again to the rescue and by its resistance to this upward movement causes the point to veer off once more to the right.

The partial spirals so described are short and narrow in the early part of the bullet's journey, for the direction of the air resistance changes oftener on account of the great speed of the missile, the rotational force being called upon more frequently to correct the position. As the rate of rotation falls off, its force is weakened and requires a longer time to perform its work;

at the same time the bullet is slowing up in its forward progress, lessening the air resistance somewhat, but the latter is still strong enough to exert increasing superiority over the force of rotation, for we must remember the rule laid down in Chapter XIII, that the air resistance does not decrease directly in proportion to the bullet's velocity. The result, therefore, is that as the flight proceeds, air resistance comes more into control, producing curves each wider and longer than the one preceding.

The tortuous pathway thus followed by the pointed bullet is difficult to picture by lines drawn upon paper, but some idea of its appearance may be gained from an examination of Figs. 61 and 62, which give it approximately.

The longer the bullet the more surface its body will offer to the resisting air as its point veers from one position to another, and the thinner the missile the greater will be the surface thus exposed in proportion to its volume. Under these circumstances the deflection caused by the air will be greater than in the case of a bullet short and broad. In shooting against a heavy wind all projectiles will make wider curves than if the air were calm; with a following wind the air pressure is of course decreased, giving curves longer and narrower. Then again, if the missile be imperfect, either by being ill-balanced or having its surface so marred as to create air friction, these

FIG. 61.—Path described by bullet if flight is viewed from above. Exaggerated to show how point diverges to the right in repeated curves and how it comes back to trajectory through rotational force.

disturbances to its flight are increased. A bullet bruised or lopsided will sometimes describe curves of two feet or more from the trajectory within a hundred yards; while a perfect bullet of proper form, with enough spin, will not deviate more than an inch or two within the same distance

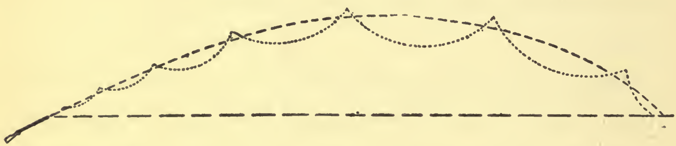


FIG. 62.—Path described by bullet if flight is viewed from one side. Exaggerated for purpose of illustrating dipping and rising action of point of projectile.

when aimed over a long course; however, all projectiles show marked inaccuracy during a long flight because of increasing width of their secondary curves.

There is still one other disturbing factor affecting the flight of the pointed projectile and that is the much discussed peculiarity called "drift," under the influence of which the bullet is carried sensibly to the right when it spins in that direction, and to the left when the rotation is reversed. The simplest explanation of drift is that the bullet in traveling to a distant mark is, in the aggregate, pressed upon by the air much more from below than from above. The effect of this is similar to what we see when a spinning top drops sideways to the floor, for the rotating motion causes the whole body to roll in the direction of the spin. The upward-pressing air is of course mild in its action as compared with the action of the floor upon the side of the top, but it is not unlikely that this conduct of air and bullet helps to produce drift.

The chief cause of drift, however, probably lies in the fact that the point of the bullet, when spun to the right, remains for a longer aggregate time to the right-hand side of the trajectory as it rises, and passes to the right at the beginning of each separate curve, seldom arriving at any point very far to the left of the trajectory. (See Fig. 61.) Given left-hand spin, the bullet's point would similarly spend most of its time on the left of the trajectory. The air sweeping past the projectile so moving forward at a slight angle would naturally push the projectile to one side or to the other, according to the nature of the angle presented; much as a ship is steered by the action of the water acting against the rudder when the

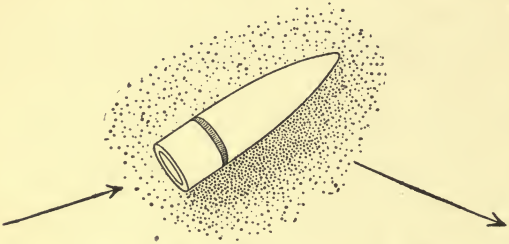


FIG. 63.—In seeking the cause of the disturbance called drift, which carries the rifle bullet to right or left, according to its rotation, some authorities assert that the air buoying the missile from below causes a rolling action, much like that which takes place when a rotating body is dropped on the floor. The picture illustrates this theory.

latter is partly turned so as to receive the impact partly against its side.

After reading this chapter it will be easy to understand how ruinous to good shooting was the attempt to change the form of the bullet by reducing its diameter and increasing its length while lacking the means with which to spin it fast. Ways in which to accomplish this much desired end of rapid rotation were finally found during the ten years between 1895 and 1905, as will be related in succeeding chapters, not the least of the means employed being the utilization of nitrocellulose as an explosive.

CHAPTER XV

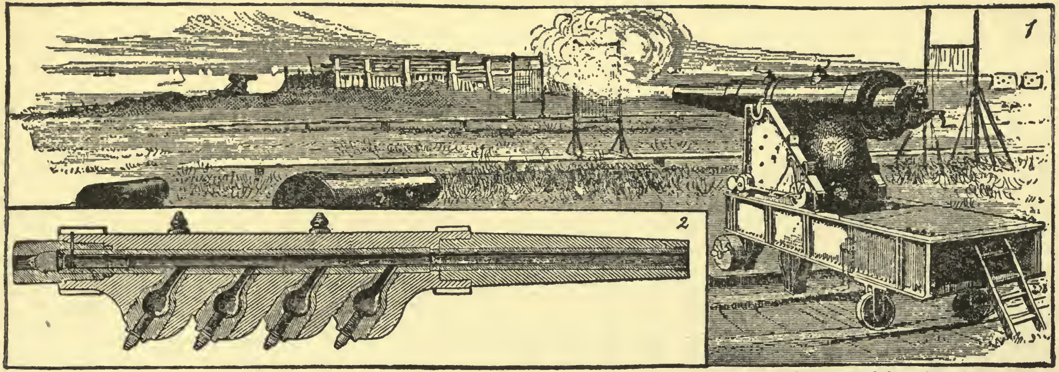
SMOKELESS POWDER

When we explode a charge of powder in a closed vessel tightly sealed and strong enough to resist the resulting gas pressure there will be no sound and no movement. The only way we can tell whether the explosive has burned or not is by the heat communicated to the walls of the container. The pressure will be there, but no work will be done, for work is the result of a force acting upon a body through a distance. Mere force without motion accomplishes nothing in gunnery.

It follows, too, that if the force acts upon the body through a distance it also acts during a period of time; for in order to move an object from one place to another, time is always required, no matter how short or how long the distance may be, or how quickly the journey is made. Therefore the time during which the force is made to act is an important element in dealing with moving bodies. Where the force used remains the same, the distance covered by the object is increased from moment to moment, until before long the speed gained is greatly multiplied. As an instance of the working of this principle, recall the actions of the bullet described in a previous chapter when dropped to the ground from a height. The pull of gravity on the missile is only moderate in strength and does not change, yet the bullet fell sixteen feet the first second, forty-eight feet the next, and eighty feet the third; it would have gone on increasing in the same proportion if the fall had continued. In the third second the speed had increased fivefold, although the power applied at any moment was never increased.

Applying these facts to the movement of a projectile from a gun, it is plain that if a long barrel be used and a steady though moderate pressure be created to act against the base of the missile during the whole journey from the breech to the muzzle, it will start slowly but gain speed rapidly during every inch of its passage through the tube. In spite of its slow start, it will issue forth at high speed, though the total pressure exerted at any one time is comparatively mild. Look, for instance, at the blowpipe, used as a weapon by some savages. Here a long tube with a smooth interior contains a dart which fits the bore loosely enough to slide readily through the bore and still tightly enough to prevent much leakage of air past its sides. When the operator blows into one end of the tube against the butt of his dart, the missile, by the mere force of the man's breath, is driven out of the tube with speed enough to kill a small animal, or even a man if the hit be in a vital spot. So, too, if we put into a gun some kind of powder that will not burn instantly, but take an appreciable time in the operation, speed can be imparted to the projectile by the more gentle but longer continued force thus created. All this seems simple enough, but nevertheless it gives rise to a large part of the science of gunnery.

In recognition of the value of the slow-starting, rapidly accelerating projectile it is interesting to note at least two of the attempts ingenious men have made to accomplish the result with the means at their hands. In 1880 the Lyman-Haskins cannon was produced, from which much was expected along these lines. It had a single tube, but with a row of several separate powder chambers branching from it below. The hope was that the projectile would be started on its way by the explosion of the charge immediately behind it, and be thrust forward with increasing speed as the other charges in the auxiliary chambers were



Courtesy of the Scientific American.

FIG. 64.—LYMAN-HASKELL MULTI-CHARGE GUN OF 1880

Here we see one of the many attempts made to impart speed to the projectile by giving it a long, slow thrust instead of the violent shock of a single explosion of gunpowder. The successive chambers under the gun exploded their charges as the projectile passed down the barrel, started by a small intial charge at the breech. The weapon proved too complicated for practical use.

set off to give a series of new impulses to the already moving body. Another and more recent attempt to solve the same problem is seen in the Zalinski dynamite gun which threw from its main tube, as a projectile, a heavy charge of dynamite. As this dangerous explosive could not be fired from the mouth of an ordinary cannon, the Zalinski gun used as its propulsive power compressed air admitted behind the missile with gradually increasing pressure. Both of the weapons mentioned were American inventions, but never came to anything, though the Zalinski gun was used in Cuba by the American forces to throw several of its charges toward the Spaniards at Santiago Bay in our war with Spain.

There is one peculiarity of gases under pressure in the gun barrel which must be noticed here, and that is the comparative slowness with which they begin to travel toward the muzzle, after the explosion. If you were to make a skyrocket of dry, loosely packed gunpowder the tube would burst and the rocket fail to rise, even though one end is open ready for easy escape of gas. This is because the powder would burn almost instantly, creating heavy pressure, and the gas prefers to burst its way out sideways, rather than travel the length of the tube to get out. So it is in the gun barrel; at the explosion of gunpowder the gas presses fiercely upon the walls of the tube, and also against the base of the bullet, forcing the missile out by the first impact; while the bulk of the gas proceeds toward the muzzle only after it has tried and failed to burst its way through at the side. By this time the projectile is out of the gun and receives no thrusting action from that portion of the gas which lagged behind. We therefore burn a lot of powder from which we get no benefit; but that is not all. The walls of the tube, to foil the attempts of the gas to burst them, must be made very thick and strong at the chamber where the explosion takes place, while the forward part of the barrel has little to do except guide the projectile. How much better it is, then, to create our propelling gases, not instantly, but more gradually, so that they will have time to get under way toward the muzzle, pushing the projectile in front of them, and not linger in the breech wasting their strength against the sides of the tube!

In a previous chapter we mentioned the practice of forming gunpowder into grains of different sizes to influence the rate of their combustion, and of making the grains hard or soft to effect the same purpose. But these expedients did not fulfil their object sufficiently to render the explosive slow enough for the best propulsion. By making the grains larger the burning becomes slower, to be sure, though not in the degree one would expect. The greater the surface of the grain the greater will be the area to be acted upon by the fire; while as the pellet is consumed, it grows smaller in size and its burning surface therefore decreases. The result is that, though the grain is long in disappearing, the greatest amount of gas is produced in the first stages of the explosion—which is just what we wish to avoid. The large-sized grain, therefore, partly defeats the very object for which it is created.

In 1860 General T. J. Rodman, of the United States army, in trying to solve the problem of slower combustion, hit upon the idea of forming the powder into cylinders the size of the bore of the gun, each perforated by holes running lengthwise through them. Afterward he built the cylinders out of small pieces fitting together and leaving holes through the mass as before. The principles involved were the same in each plan. His idea was that by igniting the cylinder from the inside, and allowing the fire to eat its way outward, the burning surface would be small at first but would increase as the holes grew larger, thus giving the greater area to the flame at the later stages of the explosion. The amount of gas produced, and therefore the pressure, would be low when the projectile began to move, increasing

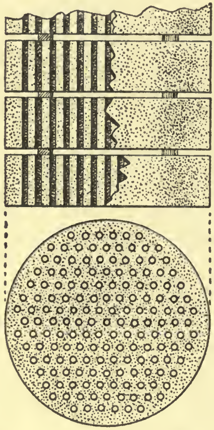


FIG. 65.—This is General Rodman's first invention for producing slow combustion at the first part of the explosion, the bulk of the powder burning later. These cylinders are compressed gunpowder made to fit the cannon bore; they are perforated with many small holes, each disk being separated from the one ahead of it by wooden blocks. The igniting fire begins to burn inside the small holes, the burning surfaces being increased as combustion progresses.

as it proceeded down the tube. That this ingenious plan was correct in fact as well as theory was proven by its prompt adoption throughout the world in artillery ammunition.

Though Rodman's discovery was a most valuable one, it did not perform the miracles expected of it. The explosion was now modified to a considerable extent, and cannon tubes were at once lengthened to take advantage of the longer thrust given to the projectile, but even the perforated cylinders could not adequately restrain the vio-

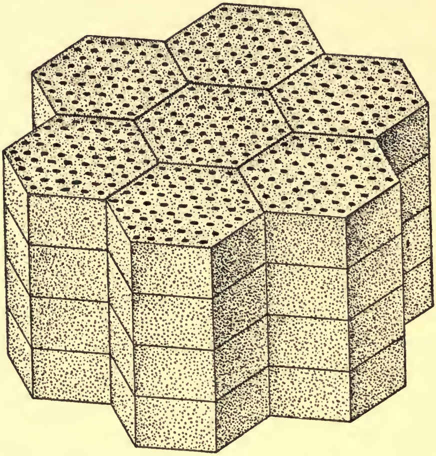


FIG. 66.—The difficulties encountered in manufacturing the powder shown in the preceding illustration, led General Rodman later to form his powder into perforated cakes as here seen. These cakes could be made of any size and pieced together to fill the gun bore. The angled spaces at the side proved to be no practical detriment in securing slower combustion.

lence of the explosive. It still burned far too fast.

A new attempt to solve the stubborn problem of leisurely combustion was made in 1880 by the United States naval officers. They produced the explosive called "cocoa" powder, a variety of gunpowder the principal features of which were a substantial decrease in the amount of sulphur it contained and the substitution of half-burned wood for charcoal. The woody ingredient gave it a brownish color, from which it derived its name. "Cocoa" powder proved to be the slowest burning of all gunpowders, giving low, long-continued pressures in the gun barrel. It had, though, two grievous defects, for it gave off an abundance of smoke and left an unusual amount of residue coating the walls of the tube, to obstruct the passage of the projectile at the next shot. Yet in spite of these drawbacks the new powder gained wide acceptance among artillerists, until its career was cut short ten years after its invention by the perfecting of guncotton as an explosive, which quickly rendered gunpowder obsolete.

While "cocoa" powder and Rodman's cylinders never had much effect upon hand firearms, being intended only for use in cannon, yet they are important steps in the progress of explosives. Knowing about them and the obstacles which they were intended to overcome will help us to appreciate the merits of the marvelous new powder which has in our day come into the world.

Guncotton was known more than fifty years before it succeeded as an explosive for guns. In

1832 Bracconnet, a French chemist, discovered that if he put vegetable starch into nitric acid and then washed it with water the material resulting would violently explode on concussion. Pelouse, his countryman, soon after found that cotton after being soaked in the same acid would give like results. One of the remarkable things about the new explosives was that they produced no smoke and left no ash; the whole of the substances was converted into gas. But, as in the case of Berthollet's fulminate, they were so extremely sensitive and sudden in their action that no gun barrel could withstand them; perfectly heedless of where the muzzle of the tube was, the gases promptly forced a passage sideways through the metal. Then chemists everywhere began to try to harness these unruly explosives, to compel them to do useful work. Cotton proved the more promising material to experiment with, because it gave a product that had less variation in the force of its explosions, so it received chief attention; though from wood fiber treated with nitric acid was produced in 1865 the excellent powder called "Schultze" powder now much used in shotguns. Wood fiber is cheaper than cotton and the shotgun does not call for a high degree of uniformity in its ammunition.

We have not the space here to set out in detail the tribulations of the scientists in their half-century search for means of retarding the explosion of guncotton. In short, their labors went on unceasingly during the whole period, to be at last crowned with success, though after many disappointments and even disastrous explosions, due to overconfidence in their imperfect products. The chief honors in the conquest are due to the Swiss, the Austrians, and the French; though the American, Hudson Maxim, had a not unimportant part in the final success.

Cotton is almost pure cellulose, the chemical formula for which is $C_6H_{10}O_5$; the letters standing respectively for carbon, hydrogen, and oxygen. When soaked in nitric acid the appearance of the cotton does not change, but in composition it has become a new and remarkable substance, called nitrocellulose. In spite of all the labors of science upon the subject, we do not yet know a great deal about the chemical composition of nitrocellulose. When the cotton is soaked in the acid for only a short time, the product can be exploded with difficulty, if at all; a little longer soaking makes explosion of it easier; while still further contact with the acid makes of the innocent-looking white fibers one of the most violent of all explosives.

Thus there seem to be a series of nitrocelluloses, but each so closely resembling the other that it is hard to say where one leaves off and the other begins.

The cotton receiving only a brief acid bath is not used for explosives, but is a valuable substance in the arts, for when dissolved in alcohol it may be transformed into celluloid, collodion, photographic films, and artificial ivory. Here we see another illustration of how the efforts to improve the gun have indirectly benefited mankind.

Nitrocellulose produced by long contact with the acid is too explosive in its nature to be yet adapted to the making of ammunition. But when the cotton is left in the acid bath long enough to carry the chemical action past the celluloid-making stage, yet removed in time to avoid becoming one of the higher explosives, we find that we can compel the resulting substance to give us excellent service in guns.

It is probable that the different grades of nitrocellulose have definite chemical formulas, if we only knew them; but we do not at present. The molecules of the more highly explosive members of the class seem to be merely multiples of the molecules of their more stable kin. This makes exact analysis very difficult. As an illustration of *about* what happens in the exposure of cotton to nitric acid, the following may be taken: $2C_6H_{10}O_5$ (cotton) + $6HNO_3$ (nitric acid) = $C_{12}H_{14}O_4(NO_3)_6$ (guncotton) + $6H_2O$ (water). As the last item, water, is detrimental to the product as an explosive, it is taken up during the process by some absorbent, usually sulphuric acid, which has a strong affinity for water and does not interfere with the chemical action.

After the cotton has been allowed to lie in the acid bath for exactly the proper time to secure the right degree of nitrating it is taken out and allowed to stand a while with the acid still upon it. Then it is washed thoroughly to remove the acid, and is called guncotton, still as fluffy and white as when the process began. It is not yet powder, for, until it is robbed of its sudden violence in explosion by the addition of slowing-up substances, it cannot be put into guns.

At this stage the chemical reaction for the explosion of the guncotton is something like this: $2C_{12}H_{14}O_4(NO_3)_6 = 18CO + 6CO_2 + 12N + 14H_2O$. In the order named the new products are carbon monoxide, a gas,—carbon dioxide, a gas,—nitrogen, a gas,—and water, a gas when heated, as in the explosion. One ounce of guncotton has produced as much gas as three ounces of gunpowder would make, but this is not all; for, unlike gunpowder, the whole of the solid substance is converted into gas, leaving no residue. Compared with this efficiency the old black powder with its fifty-seven per cent of ashy residue seems hardly worthy to be called an explosive.

It was these great merits of guncotton that induced scientists to toil so long in the effort to tame it sufficiently for use in guns. One of the most surprising discoveries made in this connection was that if the guncotton were dissolved and mixed with nitroglycerine, another violent explosive, the mixture became much more moderate and slower in exploding than either one of the substances used separately. No reason is known for this strange result, unless it is that the guncotton contained too little oxygen for a well-balanced compound, while the nitroglycerine contained too much. The guncotton, you will see by its reaction, gives eighteen molecules of carbon monoxide, which is incompletely burned carbon, carbon dioxide being the natural molecule. But as there is not enough oxygen to give two atoms of oxygen to each atom of carbon, some of them have to be content with a half-portion. This condition, existing in the guncotton at the start, probably makes it so sensitive and violent; while the extra oxygen which the nitroglycerine brings into the mixture satisfies the desire of all the carbon atoms. How true this explanation may be, or just how the odd result is brought we do not now know. Perhaps time will tell.

The first cotton powder successfully used in guns was that containing a portion of nitroglycerine. To further soften the shock of the explosion other deterrents were also added, the principal substances so used being graphite and heavy oils like vaseline. This result was still further aided by first forming the mixture into a paste and then converting it into hard grains or rods, which burned more slowly, as in the case of gunpowder. It was not long, though, before it was found that the nitroglycerine, when used in large quantities, seriously injured the tubes of guns, by forming upon them a rust-like scale, which made repeated firing quickly wear them out. This did not cause the abandonment of guncotton ammunition, for its advantages were too great to permit that. By decreasing the amount of the offending ingredient used its harmful effects were lessened, while the other foreign substances were increased to offset the loss. Of guncotton powders there are scores today, all differing slightly, nearly all containing some nitroglycerine, though the tendency is to reduce the amount used and to do away with it entirely where possible, relying upon the less objectionable deterrents.

Guncotton powder burns quietly when lighted in the open, seeming to be in no hurry at all. It cannot be exploded by a blow unless first made hot. In the gun barrel it takes a strong primer to set it off, for the explosion seems to result partly from heat and partly from shock. Just how its gradual decomposition takes place in the gun we do not wholly understand, but the most reasonable theory now held is that, when the flame from the primer strikes the base of the charge, it burns the outer layers of the rearmost grains, making gas, and doing this so suddenly that a shock is communicated to that part of the charge, exploding it. The gas thus formed heats and shocks into explosion the grains next to it; and so on, heating and shocking, until the grains in front are reached and the whole charge turned into gas. During this rather complicated and comparatively slow process, the gases first formed begin to push both charge and projectile down the barrel. the composition of the powder and the quantity used being just right to have the burning completed when the bullet reaches the muzzle.

Whether the reasons thus given are correct or not, we at least know that guncotton powder keeps up its decomposing process during the whole journey of the projectile from breech to muzzle. In this its action differs greatly from that of gunpowder, for with the latter the explosion takes place principally at the extreme breech. From the new powder we therefore gain the advantage of the long mild push, the value of which was illustrated by comparison with the pull of gravity and the missile from the blowpipe at the beginning of this chapter.

CHAPTER XVI

THE MODERN RIFLE

Having learned in the last chapter how, by the aid of the new, slow-burning powder, we can impart great velocity to our projectile by means of low pressure applied through longer time and distance, we are now ready to go on and note the striking changes this development has wrought in the gunner's art. Especially are we to see how the coveted flat trajectory was thereby secured.

Though guncotton gives, weight for weight, about three times the amount of gas produced by the older explosive, yet when the retarding adulterants have been added to make it smokeless powder, the difference between the two in the amount of gas is much decreased. In general, however, it may be said that the smokeless powder gives about twice the propulsive effect of gunpowder, which means, of course, that only half the quantity is required to give the same velocity to the bullet. But this is only the starting-point in the enumeration of the virtues of the new explosive.

There was an early limit to the velocity that could be given to a projectile by gunpowder with its sudden explosion. Where very large charges were used, as we have seen, the main body of gas spent an appreciable time in fighting the walls of the gun barrel before acknowledging defeat and taking the longer journey to liberty through the muzzle. The bullet, meanwhile, having been moved forward by the gas nearest it, was far down the barrel, or clear of it entirely, before the strongest outrush of gas began. Therefore an excessive powder charge created great pressure on the gun, and unduly increased the shock of recoil, without adding much to the speed of the projectile. By experiment the later gun makers determined the correct amount of powder that could be burned behind their bullet to give it the greatest velocity with least waste and with an explosion moderate enough not to strain the gun, or create undue recoil. The quantity of powder so fixed was called an "ordinary charge" for that particular kind of gun.

In the days of black powder it was estimated that if the length of the gun barrel were twenty times the diameter of its bore the bullet would then gain practically all the speed which an "ordinary charge" could impart to it. Thus if the bore were half an inch, the barrel need be only ten inches long to allow the bullet to receive the full propulsive effect of the explosion. If the bore were only a third of an inch the barrel thus prescribed would be but six and two-thirds inches in length. Any additional extension only created greater friction to retard the bullet. With the coming of smokeless powder this formula has been greatly changed, so that the rule now is that the length of the barrel must be at least fifty times the diameter of the bore, in order to give the bullet the full propulsive effect. This change reveals to us how much greater is the distance through which the new powder applies its force. The push administered to the base of the projectile is continued two and a half times as long as formerly. Of course the barrels of hand guns have always been longer than is called for by formulas, but the point to be noted here is that under the old conditions only a short section of the barrel near the breech sustained the pressure of the explosive, while now the work is distributed over a much greater section of the tube.

The result is that, instead of an immense strain at the immediate breech, we now have a more moderate pressure extending further forward than before. Therefore a well-made gun barrel in these days requires a longer section of medium strength, rather than one extremely thick at the very breech and becoming thin again within a few inches.

In the case of the rifle a long barrel is regarded necessary to give the bullet a longer passage through the grooves, insuring proper spin. In all guns, however, the extra weight at the outer end is a benefit in preventing the violent upward throw from recoil, such as we see in the short revolver when fired. The long tube, too, allowed greater distance between the sights, which is of much assistance in straight aiming; then again, there was in times past a firm though illogical belief that great length of barrel guided the ball more truly. It was in pursuance of all these ends that the old Spanish musket boasted a tube of six or more feet in length, while the New England colonists ordered their match-locks "4 foote in the barril." The modern rifle, likewise, bears a longer barrel than is demanded by propulsive requirements; for, according to the rule, since the bore is one-third of an inch in diameter, the length of the barrel need be only sixteen and two-thirds inches to insure proper combustion of its charge; in fact, however, it is usually twenty-four inches or more.

The barrel of the hand gun, therefore, being intended for purposes other than propulsion alone, does not readily show in its outward form the changes in construction introduced by smokeless powder. In artillery, where weight and length have always been reduced as far as possible, the visible changes wrought are startling, as the two following pictures will show.

The first cannon shown was made in 1880 and is one of the best of its time. Its caliber is twelve and one-half inches and its tube sixteen and one-half feet long; which length was carefully calculated to allow the projectile to receive all the force the black powder explosion would transmit to it. The second picture shows a twelve-inch modern naval gun which is forty-five and one-half feet long. In this weapon the strong gas pressure follows the projectile the whole length of the tube and is yet strong enough at the muzzle to give it a slight added impetus after it clears the bore. The great contrast in the shapes of the two pieces reveals clearly the difference in the nature of the explosions produced by the two kinds of powder.

Above the picture of each gun is a curve which indicates the pressure in tons per square inch exerted against the walls of the tube at various points when an "ordinary charge" is exploded in it. The weights of the projectiles and their velocities differ too greatly for ready comparison (for the long slender gun is immensely more

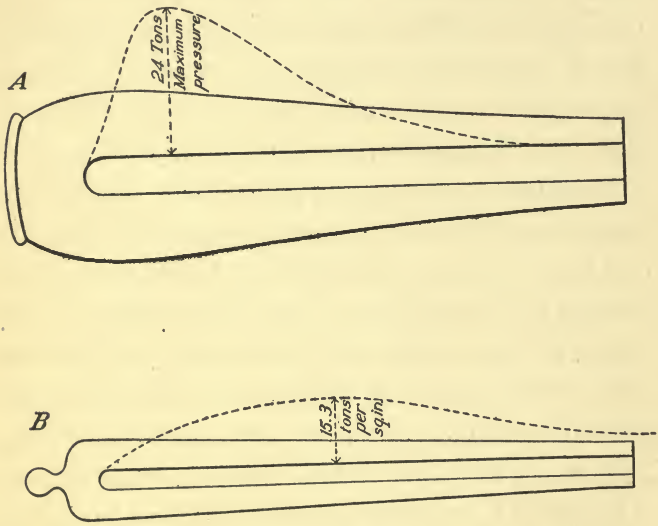


FIG. 67.—Illustrating the pressure of powder explosion in different types of cannon. *A*, Rodman Gun; *B*, Modern Naval Gun.

powerful than the short, bulky one); but the differences in pressure are very interesting. The old gun used one hundred and thirty pounds of black powder and, as its curve shows, this comparatively puny charge created a high pressure of nearly twenty-four tons, confined to a short section near the breech. Such a force in so large a bore is dangerous in any gun, however carefully constructed, for even steel has its limitations in strength. It is a curious fact that piling steel upon steel does not increase the strength of the tube in proportion to its thickness, so that the big gun of 1880 represents about the maximum power possible in artillery using gunpowder as an explosive. The new gun, on the other hand, shows a maximum pressure of only fifteen and three-tenths tons per square inch, though its charge produces three hundred and sixty-five and one-half times as much gas as the black powder charge in the old gun. This great difference in maximum pressures arises from the peculiarities of the two explosives. The one creates its smaller amount of gas suddenly and at the extreme breech; while the other, burning slowly, distributes its pressure gradually from breech to muzzle; the total thrust given the projectile, however, being five times that imparted by the smaller, quick-burning charge. In the one case great strength is required of the gun around the powder chamber itself, though the pressure dwindles rapidly from there forward; in the other case moderate strength is required of the tube throughout its length. The total weight of the tube built for smokeless powder will be less than half that of the one built to withstand an equivalent charge of black powder. The revolutionary effect of smokeless powder upon artillery is thus apparent.

Now, after using the cannon to illustrate the great virtues of smokeless powder as a propellant, let us note the effects of the new explosive upon hand guns. In Chapter XIV we left the gun inventor struggling to lower the trajectory of his bullet by making the missile thinner and longer, but finding his efforts thwarted by inability to make it spin fast enough to remain point forward in flight. He had succeeded to some extent in the endeavor by using alloys to harden the lead, thereby giving it a firmer grip on the rifling, though the reduction in diameter thus gained was still much less than he desired. He could send his over-broad bullet out of the muzzle of his gun at good speed, but the great air resistance it met quickly slowed it down, resulting in high trajectory and consequently poor marksmanship. His hopes were now to be realized, however, and in greater measure than he even foresaw.

When about 1890 smokeless powder was perfected sufficiently to permit its being used in hand guns, the many virtues it possessed recommended it highly for that purpose. The absence of smoke alone promised great things for the soldier. With the new powder he could shoot from cover, without the telltale blue vapor to reveal his hiding-place; while the battle line could fire repeatedly without having its view shut off by clouds of obscuring smoke, such as was emitted by the old powder. The avoidance of residue in the gun barrel after firing, too, was a great relief, for with the new explosive cleaning was necessary only after fifty shots, instead of ten as before. Another advantage of the cellulose powder, even more important than any of these, was the effect on recoil. It was found that the gradual burning process started the bullet very slowly, giving it speed by degrees, and thus greatly decreased the shock against the shoulder of the firer, and lessened the upward throw of the barrel. This quality alone would have given smokeless powder preeminence, for it meant that more gases could be created in the gun barrel and more speed given the bullet, without increasing the kick. The chief part played, however, by smokeless powder in lowering trajectory yet remains to be stated.

When the bullet starts very slowly down the tube, receiving its impetus in easy stages, the rifle grooves cause it to revolve gently at first, the speed of rotation gaining as the forward motion quickens. Now this is exactly what the so-called "accelerating twist" did to the old sugar-loaf bullet. In the latter case the rifling turned slowly near the breech, increasing the rotation toward the muzzle. Smokeless powder achieved the same result by actually allowing the bullet to lag along at first, progressing slowly and revolving slowly, giving the rifle grooves a chance to get the rotating motion under way by degrees, instead of almost instantly, as with the more sudden explosion of black powder. The effect of this was, of course, to allow faster spin to be imparted to the projectile, without the danger of its rushing through the tube in partial or entire disregard of the spirals.

In spite of these manifold advantages of the new powder, however, it developed a very serious drawback in the early attempts to use it in hand guns. Smokeless powders, and especially those varieties containing much nitroglycerine, as most of them did at first, produce great heat in exploding, even up to 4,500 degrees. Then, too, it is a peculiar fact that when two metals are blended together in an alloy the mixture melts at a lower temperature than either of the metals would in its pure state. Therefore when the lead bullet, hardened by admixture of tin or some other metal, was fired by means of a charge of smokeless powder the butt end of the missile melted under the high heat created by the explosion. The molten metal remaining in the gun barrel then choked the rifling, while the deformed bullet sped forth a cripple, unbalanced and unsteady in flight. This difficulty was fatal to the use of the new explosive for a short time, until the invention of a means of avoiding it. This invention, too, did more than merely prevent fusing of the bullet, for by its aid practically the whole remaining question of rapid rotation was solved.

Instead of trying to increase the melting-point of the bullet, some one not now known to history, but entitled to high credit for his ingenuity, hit upon the idea of encasing the leaden missile in a thin envelope of steel or other hard metal. This device not only protected the soft lead from the heat of the explosion, but at the same time gave the bullet a more secure hold on the rifle grooves than had ever before been deemed possible. By its use, and with the aid of smokeless powder, practically any speed of rotation could be imparted to the missile, without its "jumping" the grooves. Of course the wear upon the inner surface of the gun barrel was intensified by the hard-surfaced projectile, but material damage has been successfully avoided by making the walls of the tube also extremely hard. It is now estimated that at least fifteen thousand shots can be fired from a well-made gun using such bullets before signs of wear will appear. The missile with the hard envelope, which is usually made of alloyed copper and nickel, we call the "metal-patched" bullet, and its use has become well-nigh universal with smokeless powder.

The slow start of the bullet down the barrel allowed by smokeless powder, combined with the superior gripping powers of the new bullet, had the immediate effect of reducing the diameter of rifle barrels. From .45, .44, and .38 caliber, the standard bore became three-tenths of an inch, or .30 caliber. This was practically the old .32, which had previously been considered as little more than a toy. The metal-patched bullet did not require so deep a "bite" as the one with the softer surface, so that rifle grooves became much more shallow than before, changing from two to four one-hundredths of an inch in depth, to the same number of thousandths. The grooves now imparted a spin of one turn in from six to ten inches, which expressed in calibers would be one turn in 20 calibers for the six-inch twist, and one in 33⅓ calibers in the ten-inch spiral.

In comparison with the old rifles, which gave a turn in seventy-five or a hundred calibers, the modern bullet spins at a terrific rate, advancing from hundreds of revolutions per second to thousands. With this remarkable decrease in calibers and increase in spin to keep the bullet straight upon its course, the thin, sharp missile could not only be sent off at a higher speed, but owing to the low air resistance met on its journey, that speed was maintained through a long distance. Thus the two requirements of lower trajectory were supplied in good measure.

But the whole story of trajectory is not yet told. The mildness of recoil from smokeless powder, permitting a much more powerful explosion in the gun barrel, without serious disturbance from the shock, allowed an increase in the amount of explosive which could be used. When this was done, still higher velocities resulted. From fifteen tons to the square inch, which was about the limit which recoil permitted in black-powder guns, the pressures were increased to twenty and twenty-five tons per square inch. Improvements in steel making not only furnished barrels capable of bearing these tremendous strains, but the ability of the gun barrel to resist the high pressure was also aided by the reduction in the size of the tube itself. This latter principle was what permitted the use of the ancient corned powder in hand guns when prohibited in artillery; for, as we recall, the small-bored tube, having fewer square inches of surface than one of larger bore, will bear the greater pressures, though the materials and thicknesses of the two be identical. From these heavy pressures the new projectiles received velocities of two to three thousand feet per second; whereas, in the old guns, fifteen hundred feet per second was about the highest speed attainable, on account of the greater weights of their bullets, their excessive recoil, and the low efficiency of large powder charges.

One other important reason for the low recoil experienced under the new high pressures lay in the decreased weight of the bullets used. The old bullets, lacking high velocity, had to have weight to enable them to hit hard. The .45 caliber, therefore, contained from three to four hundred grains of lead. The new bullets, on the other hand, are only about half these weights, ranging from one hundred and fifty to two hundred grains. As we have already learned, a heavy bullet shot slowly produces as much recoil as a lighter one sent off fast. Thanks to its great speed, the smaller missile strikes a powerful blow, for our rule is that the energy of the projectile increases as the square of its velocity. The smaller body going fast does as much execution as the heavier one going more slowly. The chief advantage of the small one is that its narrow body meets less air resistance, which allows it to fly further, faster, and closer to the ground. These qualities are just what the earlier gun makers tried to attain in their "express" rifle, but of which they, with their limited facilities, fell far short.

Encased in its hard metal envelope the new bullet, however, revealed one defect so serious that both soldier and hunter hesitated to adopt it whole-heartedly. Being so thin and sharp, the projectile fired at a man or an animal would, unless it struck a bone, slip through the flesh, making a wound so slight that little damage was done. The hunter found that his deer would run off almost unconcernedly with one or more of these small punctures through his body. British soldiers, in skirmishes with natives in Africa, had to hit a warrior several times before he would cease his half-frantic rush forward. To overcome this defect it became customary to form the envelope so as to leave the soft lead exposed at the point, thus making what are known as "dum-

dum'' bullets, which spread on entering even soft flesh. On account of the frightful wounds inflicted by such bullets, civilized nations agreed not to use them in warfare with one another (a compact flagrantly ignored, however, by a certain nation now fighting in Europe). But since the purpose of the hunter is to kill his quarry as quickly as possible, and to avoid the wounding of animals only to have them escape and die in slow misery, he has adopted the soft-pointed bullet. By its aid, the small-bored, high-velocity gun has become available for sportsmen, who before its introduction stuck to their old big bores and heavy projectiles, simply because of their superior killing power.

Let us now compare the areas of the cross-sections of some of the old bullets with that of the .30 caliber. As air resistance, generally speaking, increases directly in proportion to the area of missiles traveling at like speed, the wonderful reduction of air pressures accomplished by the use of the thin bullet will be made clear from the following pictures.

The difference between the old and new trajectories is also very interesting. We give below diagrams of a few of the former, for comparison with that of the Springfield rifle now used by the

United States army, one of the best of modern military guns.

The low trajectory curve followed by the

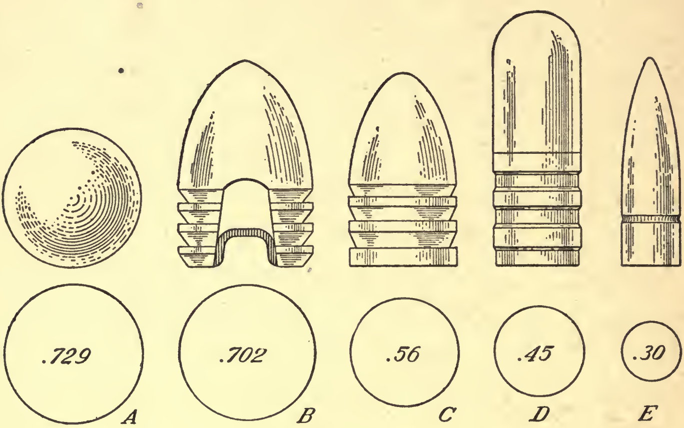


Fig. 68.—That the reader may adequately realize the great changes which have come in the sizes and shapes of bullets, five well-known types are here given for comparison. They are, respectively: *A*, the spherical musket bullet of ancient memory; *B*, the Minié bullet used prior to 1865; *C*, the Spencer repeating rifle bullet introduced during our Civil War; *D*, the hugh projectile used in our army Springfield rifle from 1870 down to the war with Spain; *E*, our present service bullet, sometimes called the Spitzer, after a German army officer, but which is merely a refinement of our old sugar-loaf form. As air resistance decreases with decrease in area of cross-section it is easy to see why the .30-caliber missile will carry over three miles.

The channels around the bodies of the bullets are to contain grease or wax which lubricates the passage down the barrel.

Springfield bullet thus permits a soldier to lie upon the ground and shoot his bullet 636 yards before it comes to earth, the missile at no time

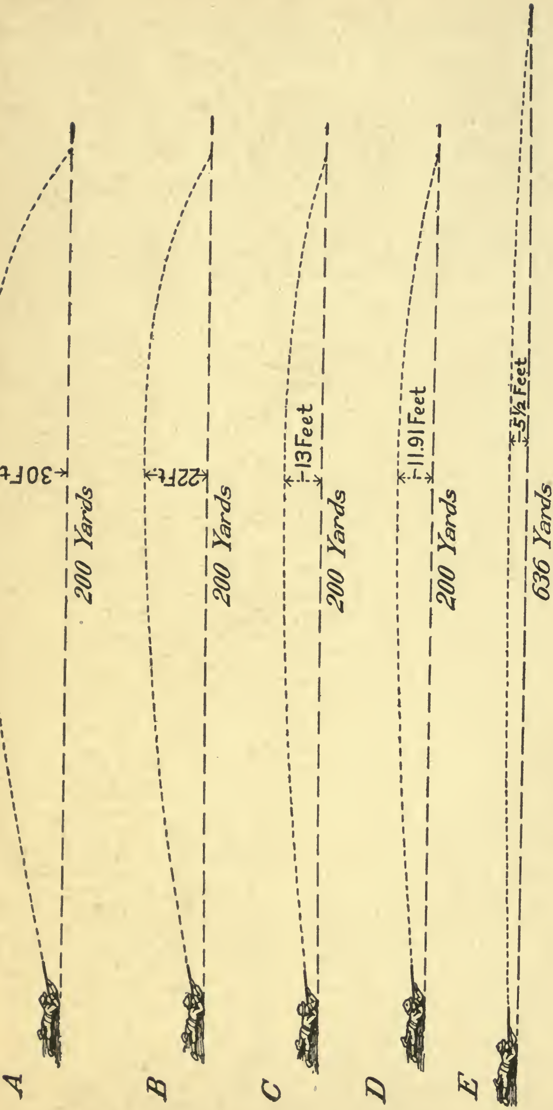


FIG. 69

A, Trajectory of 18th century musket (estimated). *B*, Spencer .56 caliber, 1860. *C*, Government Springfield .45-.70, 1870-1880. *D*, Winchester .45-.90, still in use. *E*, U. S. Government Springfield, 1906 Model.

rising above five and one-half feet, the average height of a man. If a human target be anywhere in front of the bullet within that distance he will be hit in some portion of his body. How greatly such low trajectories aid the soldier and hunter will be apparent when we recall that in field shooting with black-powder guns it was estimated that errors in judging distance caused four missed shots for each miss due to variations of the bullet to right or left of the target. The modern rifle, therefore, sends a low-flying missile over a course so long that the human eye is taxed to aim the piece truly at full range, which fact suggests that the next great advance in gunnery will be some practical apparatus to aid the rifleman's vision.

In rapidity of fire the rifle now in use cannot be said to have reached the end of its development, though breech mechanisms seem to be as efficient as is permitted when the firer's hand is employed to eject the empty shell and recharge the gun for each shot. But speeding up the rate of fire in hand guns is a problem now almost attained, as will appear when we come to the subject of the automatic rifle—offspring of the machine gun.

CHAPTER XVII

FROM MACHINE GUN TO AUTOMATIC RIFLE

In reading what has, in times past, been written about the origin of the gun, one does not go far before coming across the name Berthold Schwartz, that half-mythical German who was born in Freiburg about the year 1300. To him many German historians have credited the invention of cannon and hand gun. And not content with that they have gone the further length of allotting to this superman the honor of being the *Erfinder* of gunpowder itself. To make his fame secure in their memories his fellow-townsmen have erected to him a statue at the base of which is set forth these three great achievements.

That Schwartz lived and made cannon in the fourteenth century is true enough; but the total lack of evidence to support the preposterous claims made in his behalf makes their assertion a piece of mere national self-flattery.

A somewhat similar charge is likely to be made by one not familiar with the facts when he reads the story of firearms as set down by an American covering the growth of the gun during the last two hundred years. The constant recurrence of American names and inventions in the record actually grows so monotonous that the casual reader might easily decide that we indulge in considerable "Schwartzing" on our own account. Such a critic, however, is advised to go to the original facts for verification of the vital part men of the United States have commanded in the weapon's modern progress.

In examining the development of the important weapon now called the machine gun leading, as it has done, to the automatic rifle, American names force their way to the front even more persistently than before. Indeed it is conceded by the world that America has practically monopolized the invention and improvement of rapid-fire guns.

Beginning with the Gatling gun, invented by Dr. Gatling of Chicago, Illinois, during the Civil War, down through the list of Maxim, Hotchkiss, Nordenfeldt, and Gardner guns, each revealing advantages over their successors, we come in more recent days to the weapons invented by Browning and Lewis, which seem destined for a time at least to have the field to themselves. The machine guns now used by European armies are chiefly variations of American types.

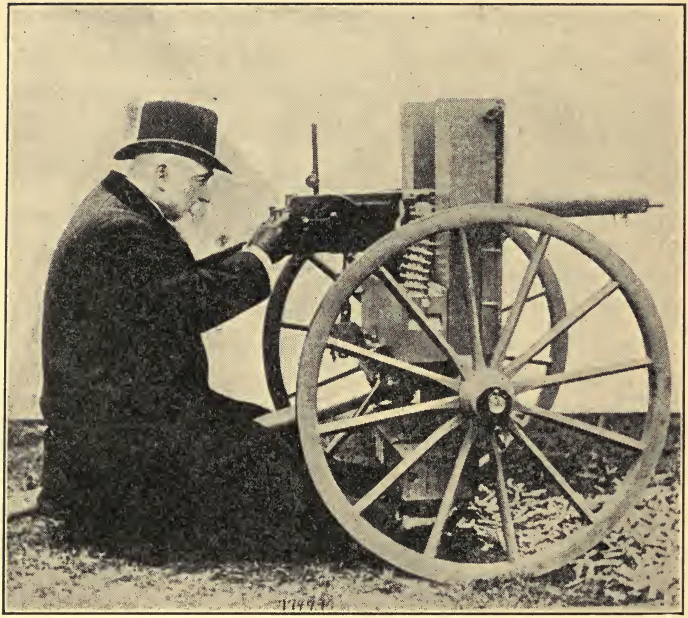
Shortly after 1830 Samuel Colt worked upon a rapid-fire gun which had a number of barrels arranged in a circle parallel with each other, so as to rotate upon a spindle when the firing hammer was drawn back. It was, of course, a muzzle-loader, using percussion ignition. Colt did not succeed in making his new weapon workable, but in 1836 adapted the principle to his rifle and revolver, changing them in the important respect that the revolving part contained the powder and ball, while a single barrel was used for the passage of the successive bullets. As we have seen, the idea was not new, but it is the first appearance of the principle in America.

During our Civil War the demand for faster-firing small arms was so insistent that many inventors turned their attention to the production of such weapons, among the number Dr. Richard J. Gatling. He produced the Gatling gun, which was used occasionally in minor combats in the later days of the great struggle. Our military men, however, thought so little of Gatling's invention that the inventor was obliged to hire his own men to go with the machines and operate them. As a prophet is not without honor save in his own country, Dr. Gatling's gun gained attention first in Europe, among the French.

Gatling's gun was a breechloader, using prepared ammunition with metallic rim-fire shells. It had ten barrels arranged parallel with each other around a circle, the whole group turning together upon a spindle, as in Colt's previous model. An attendant at the rear of the gun turned a crank which caused the barrels to pass the breech mechanism successively, the top one being fired while the others were having their empty shells ejected and new cartridges inserted. Though so heavy that it had to be rolled about upon a carriage, it could fire several hundred shots per minute, and, when improved sufficiently to become reliable in operation, became a truly famous gun.

Shortly before 1870, Napoleon III, anticipating a war with Germany, seized the ideas of Gatling and secretly equipped his armies with similar guns, which the French called "Mitrailleuse." In the subsequent contest with the Germans these guns were used with considerable effect at times; but the enemy soon learned their weaknesses and succeeded in keeping infantry out of range until artillery could be brought up to destroy them at a distance. Against cannon the mitrailleuse could not stand on account of the difference in range, and especially when the Germans, using breech-loading field pieces, could remain behind their guns to load and fire them, using the gun and carriage as shield against small-arm missiles. On the whole, the new weapon proved a severe disappointment to the French, though chiefly because they used it as a substitute for artillery, which function it was never intended to perform.

To Hiram Maxim, American born but later of British citizenship, goes the credit for making the first successful automatic rapid-firing gun. His ideas were revolutionary, for he not only employed a single barrel in place of many, but he made his gun load and fire itself without more human intervention than the touch of a finger at the trigger to set it going. The Maxim gun, invented in 1883, was six years later officially adopted by the British army, that Government at the same time conferring knighthood upon the inventor as a partial reward for his achievement. A verbal description of the Maxim quick-firer is not necessary here, as the manner of its working may easily be made out by an examination of the accompanying illustration. For motive power in its operation the force of recoil is used, by means of which the gun, when the trigger is once pulled for the first shot, ejects the empty shell, inserts a loaded one into the firing chamber, and fires again. A belt contains the ammunition and feeds

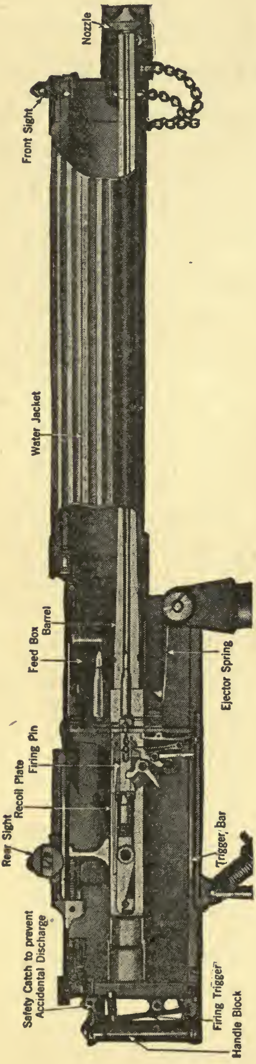


Photograph from Kadel & Herbert, New York.

FIG. 70.—FIRST AUTOMATIC MACHINE GUN, WITH HIRAM MAXIM, ITS INVENTOR

Hiram Maxim is here shown testing out the first model of his invention. It was while testing this machine gun that Mr. Maxim became deaf.

it to the gun by sliding transversely at the breech. It was originally so heavy that it was mounted on wheels, to be pushed about by its operators; but the models now in use are light enough to



Courtesy of the Scientific American.

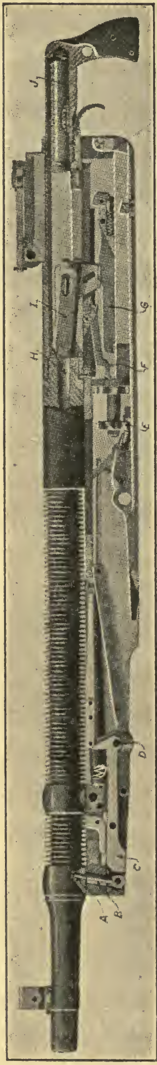
FIG. 71.—MAXIM GUN OPERATED BY ENERGY OF RECOIL

This gun, operated by the force of recoil, was the first automatic firearm. Its ammunition is fed to it by a transverse belt sliding across its breech. It is water-cooled.

be carried by two men. The weapon fires three to five hundred shots per minute, or faster than a man can count, and is even today a gun highly valued in European armies.

Maxim's idea for using recoil as the actuating force for a machine gun originated in his mind when a boy by having his shoulder bruised by the impact of a large-bore gun while shooting. Here was energy not only going to waste, but doing harm to the gunner and to his shot. "Could not that power be put to work operating the gun, thus relieving the firer's shoulder from shock, his arms from labor, and at the same time speeding up the delivery of bullets from the muzzle?" Such was the problem which kept presenting itself in the mind of the youthful Maxim for many years after, until at last his hands gave form to the thought, the wonderful gun resulting. Thus great oaks from little acorns grow.

After the pronounced success of the Maxim gun had been revealed many other automatics came into existence both in this country and abroad, but none showing any basic difference until 1898, when the American, Browning, came forward with a rapid-fire weapon, using a new principle for its operation. In Browning's opinion a machine gun lighter than the Maxim could be made by utilizing,



Courtesy of the Scientific American.

FIG. 72.—COLT MACHINE GUN PARTLY BROKEN AWAY TO SHOW THE OPERATING MECHANISM

Gas from port *A* pushes down piston B, rocking lever *C*, which compresses coil-spring *D*. The cartridge, fed into the gun by wheel *E*, is extracted by *F*, raised by *G* to breech *H*, and rammed in by bolt *I*. *J*, piston firing-hammer. John M. Browning of Utah invented this gun the first of the type operated by gas from the barrel. A belt crossing its breech supplies it with cartridges, while the corrugations along the barrel help to keep it cool.

not recoil, but the expansive force of the gases in the gun barrel to operate the mechanism. With a proper arrangement of cylinder and piston much the same as those in the ordinary gasoline engine, using powder gas instead of that from burning petroleum, the thing, he was convinced, could be done. The result of his experiments was the machine gun, afterward named the Colt's, from the manufacturer.

Remembering the tremendous gas pressure created in the gun tube during a shot, we may readily believe Browning when he says that his problem was not the getting of enough power to operate the little engine he proposed to attach to his gun barrel, but rather in keeping the actuating force within reasonable limits. He therefore drilled a hole almost microscopic in size through the gun barrel near its muzzle, which allowed the escape of a slight portion of powder gas into his auxiliary cylinder. There it pressed down a piston which in turn tilted a lever and the mechanism at the breech thus set in motion ejected the empty shell, inserted the new cartridge from the belt, and fired it, somewhat as in the Maxim gun. With this information the detailed picture of the workings of the Colt gun can be made out more easily than by a description in words.

One of the chief problems in devising quick-firing guns with a single barrel is to find ways and means of carrying off the tremendous heat generated by the burning powder. When a gun barrel grows very hot the tube expands so much that the bullet no longer fits, thus allowing gas leakage around the sides of the missile and at the same time making useless the rifling spirals. The gun must, therefore, be kept reasonably cool, or it will be worthless. In obedience to this requirement, Maxim fixed around the barrel of his gun a water jacket holding nearly a gallon, which when filled with water kept the gun cool enough for operation under all ordinary conditions.

This water-cooling feature of the Maxim gun is one of its great handicaps. With each thousand successive shots after the gun is hot, about a pint and a half of the fluid is evaporated, thus requiring the soldier to carry not only the extra weight of the water in the gun, but a supply to keep up with the loss, if any, in action. Browning succeeded in avoiding the use of the water cooler by placing around the barrel of his gun a number of flanges, which, by increasing the surface of the outside of the barrel, allow more air to come in contact with the metal to absorb its heat.

Though air cooling is not as efficient as cooling by the use of water, yet in the opinion of many military experts the other advantages gained in the Browning system more than offset that objection. Of course, in ordinary use, even in the heat of battle, the gun is seldom called upon to deliver shots by the thousand in a steady stream, but to provide for such a crisis the Colt gun is supplied with an extra barrel which can be attached in a few seconds.

As we are tracing only the development of new principles in gunnery we will not stop to describe the Gardner, Hotchkiss, and Benet-Mercier quick-firers (the latter a French production), which have been and are now being used under those and other names. They differ from the Maxim and Colt guns in minor details alone. But the recently invented Lewis gun gives us something new in this field which deserves attention.

Like the Browning gun, that invented by Colonel I. H. Lewis of the United States army, and which bears his name, is operated by gas taken from the barrel through an orifice, in the usual manner of weapons of that type. The operating parts are shown in the accompanying diagram. One of its distinctive features is the method by which the ammunition is fed to it, for instead of the usual transverse belt the cartridges are placed in compartments in the top of a flat, circular, plate-like magazine holding forty-seven rounds in two layers. In this respect the Lewis gun is really an adaptation of that of

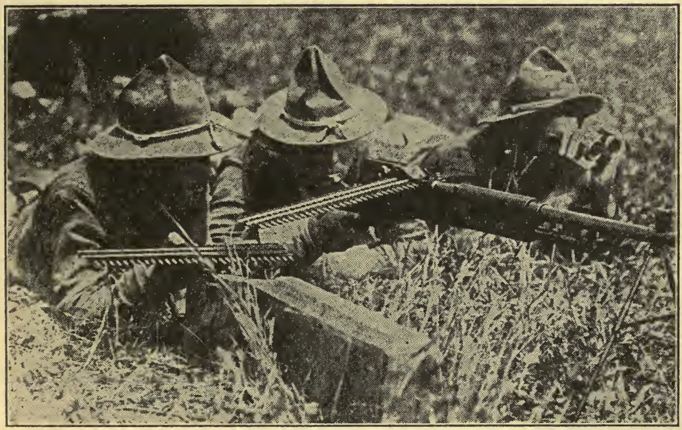
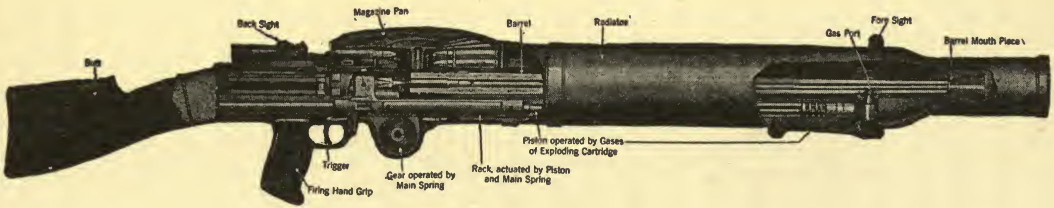


FIG. 73.—BENET-MERCIER MACHINE GUN
This gun uses long metal clips instead of belts with which to feed cartridges to the mechanism.

Colt with its revolving cylinder. The magazine, when set on a spindle at the breech of the gun, revolves as the gun is fired, bringing fresh ammunition to the firing chamber. Only about two seconds are required to remove the emptied magazine and replace it with a full one. Though the whole weapon weighs but twenty-seven pounds, it is capable of firing as high as seven hundred and fifty rounds per minute. The Lewis gun is being used in all of the Allied armies now in France, and has been found especially adapted, by reason of its low weight and reliability, to use by soldiers flying and fighting in aeroplanes. (See *Frontispiece.*)

The Lewis gun is of especial interest, however, by reason of the cooling device it carries. Browning, as we have seen, caused his gun to stay cool by means of corrugations encircling its barrel, thereby exposing much heated surface to the surrounding air. Colonel Lewis added similar increased surface to his gun barrel by running thin plates of metal lengthwise along the tube. But to bring still more air in contact with the barrel, he devised an apparatus whereby the powder gases rushing out at the muzzle would produce a strong draft of air upon the barrel. This device appears in the picture, consisting of a large hollow jacket around the forward part of the gun, tapering in size in front of the muzzle. To the mouth of the barrel is fixed a nozzle through which missile and burned gases pass in firing, of course at great speed. The propulsive gases the instant they emerge from the muzzle widen out, increasing their volume, but still proceeding rapidly for-



Courtesy of the Scientific American.

FIG. 74.—LEWIS MACHINE GUN, OPERATED BY GAS

On top of the gun is shown its plate-like magazine partly cut away. The powder gases expanding at the muzzle cause a strong current of air to be sucked through the big tubular jacket, thus keeping the gun barrel cool.

ward. This action creates a partial vacuum inside the air jacket at the rear of the gun muzzle, causing a current of air, coming from behind, to sweep along the barrel and so carry off its heat. The draft thus created reaches a velocity of seventy miles an hour when the weapon is operated at full capacity, and serves to maintain the desired low temperature, except under the most extraordinary conditions of rapid fire.

Those familiar with the ancient "water-blast" apparatus used in early iron furnaces will readily understand how the Lewis gun cooler works, and where its inventor got his idea. In order to melt iron ore in quantity great heat is required, this calling for forced draft to bring the necessary oxygen into the furnace fire. Engines and fans were, of course, unknown in olden times, so the ingenious iron maker produced the air blast he needed in the following manner: the furnace was located near a plentiful source of water, and below it, so that the fluid could be brought to the furnace in pipes and under pressure; then by admitting confined water from a small pipe into a larger one, the resulting jets and sprays of the liberated stream occupied the space inside the big pipe, and falling, drove the air ahead of it, producing a partial vacuum above. This upper space in the big pipe was connected with the furnace, and as the stream of water continued to flow, a steady draft of air was drawn through the fire,

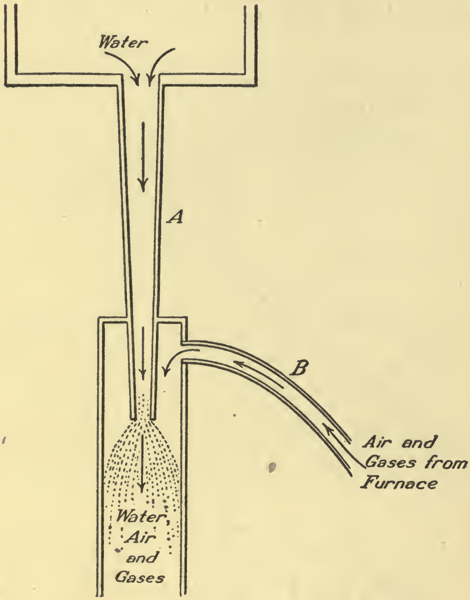


FIG. 75.—The water blast, formerly used in smelting furnaces, utilized falling water to produce air suction. In the type shown the water coming through the pipe *A* under compression sprays out of the nozzle; the falling drops, each driving air ahead of it, produce a draft through the furnace fire passing in through the pipe, *B*. Observation of the strong air currents existing at the foot of all high waterfalls probably suggested this ancient invention.

producing the high heat desired. Examination of the drawing of the water blast and comparison of its parts with those of Colonel Lewis's gun cooler will make the similarity clear at a glance, the one using water under pressure to accomplish the purpose, and the other gas at high velocity. While it is hardly true that there is no new thing

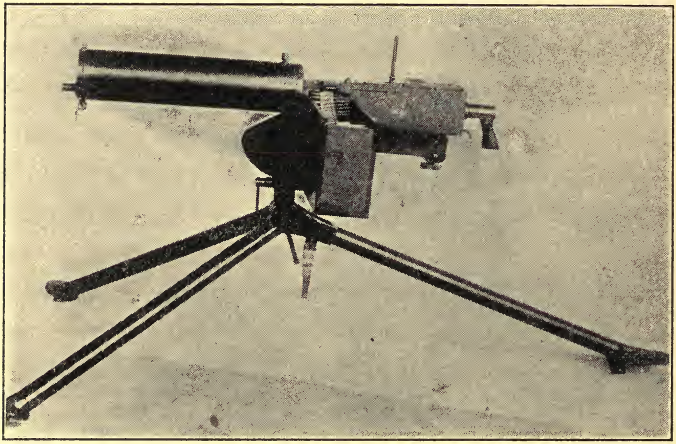


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FIG. 76.—BROWNING HEAVY MACHINE GUN

This gun is fed from a belt of 250 rounds of cartridges. It weighs 34½ pounds with water jacket filled and is operated from a tripod. This model has fired 20,000 shots in forty-eight minutes. While this is called the heavy Browning gun, it must not be confused with heavy guns of other types, some of which now in use in Europe weigh 250 pounds and are carried about upon an automobile or a horse.

under the sun, such adaptations of old ideas to new uses show that there are fewer real novelties than we sometimes suspect.

Much like its predecessors is the new Browning machine gun which has appeared within a year and which is now being manufactured in large quantities for use by our soldiers in France. It is of the water-cooled type, using recoil as its motive power, and weighs twenty-two and one-half pounds, to which must be added ten pounds of water, or a little over a gallon, when the cooling chamber is filled. Its ammunition is also fed to it by a belt which is peculiar to the new gun, in that it is made wholly of cotton, instead of the metal or part metal hitherto employed for that purpose. The chief merits of the new gun, however, lie in its simplicity and reliability, for it has fewer main parts than have ever been used before in a like weapon. Thus it is easily manufactured, has great endurance, and is less likely to get out of order during the stress of battle. Six hundred shots per minute are possible from the gun; while in the Government test it fired twenty thousand shots in succession with a loss of only four and one-half seconds for stoppages, part of this delay being due, too, to defective cartridges. While we are permitted to present a picture of the exterior of this remarkable gun, a more detailed description is rightly forbidden at this time by our authorities, to the end that our national enemies may not profit by the information.

If the reader is by now asking himself why, in a book devoted primarily to the hand gun, so much space is being given to machine guns, the answer is at once forthcoming. It will be remembered from a preceding chapter how the Spanish musketeers after the sixteenth century advanced upon the battle-field with two men carrying a single gun of the weight of forty pounds or more, and how our present light hard-shooting rifle is descended directly from this cumbersome ancestor. It has been pointed out, too, that the standard hand gun of a few years hence promises to be the automatic rifle. The connection between these two facts is that just as our modern arm came into being through refinements added to the clumsy musket, so the machine gun by one improvement after another is coming close to the point where both soldier and sportsman will adopt the automatic weapon for his ordinary purposes. The truth of this statement will be borne out by a casual glance at the revolutionary character of the weapon next to be mentioned—the Browning automatic rifle.

But let us pause for a moment in our examination of machine guns to say a word about this man Browning, whose name appears so often in connection with the firearms of the last twenty-five years. His Christian name, John M., was given him in Ogden, Utah, where he was born sixty-two years ago of Mormon parents. Young Browning began inventing useful improvements in guns at the early age of fourteen years, by whittling out of wood the breech-operating mechanism afterward adopted for, and now used in the famous Winchester repeating rifle; from that time down to the present day this Western genius has continued to produce one device after another for the improvement of the gun until there is hardly a modern rifle, shotgun, pistol, or machine gun that does not embody one or more of his ideas. Growing up as he did in the remote frontier, Browning's youthful environment was saturated with guns and the talk of guns, for firearms were almost as necessary to him and his people as the very clothes they wore. But as further stimulus in the study of gunnery, Browning had the advantage of being assistant to his father in the little gun shop and store by which the family gained its livelihood for many years after reaching the village at the head of the Great Salt Lake. The familiarity with firearms and the knowledge of the metals, tools, and processes used in their making, which Browning in this situation acquired, gave such fostering opportunities to his exceptional natural talents, that it is a moderate statement to say that no one man has ever contributed more to the development of the hand gun than John M. Browning.

Browning's culminating achievement seems at

FIG. 77.—BROWNING AUTOMATIC RIFLE

As used in the shoulder position. Three hundred and fifty shots may be fired, with magazine pauses of 2½ seconds between bursts of forty, before the gun becomes too hot to operate. Weight, 15 pounds. Our men are also being taught to fire this gun with deadly precision "from the hip"—that is, while being held at the side, the aiming being done by marking the course of the bullets as they strike the ground ahead. By this method the firer can deliver shots with surprising accuracy while walking or running forward.

present to be the automatic rifle he has just produced and turned over to his country, for her use in preserving her rights and liberties now so treacherously assailed by the Prussian Aristocracy. And surely the gun has never set out on a more righteous mission than that of this new weapon, which promises such aid in restoring justice to the world. As with Browning's machine gun, we are not allowed to present the details of his automatic rifle, but a picture of its outward appearance is permissible, as well as the telling of a few of its leading merits.

In the first place the new arm weighs but fifteen pounds, thus enabling the soldier to carry it and aim it from his shoulder almost as easily as the ordinary service rifle, much of its lightness being due to the fact that it is of the air-cooled, gas-operated type. The bearer can with it fire a single shot, or more as he wishes, by pulling the trigger for each shot; or if he desires, he may let the automatic mechanism operate the gun, giving a firing speed of twenty shots in two and one-half seconds. The cartridges are fed to the breech in clips of twenty, the empty shells being thrown to one side, the .30-caliber ammunition of the service rifle being used. But besides its light weight, the chief merit of the gun is its unusual simplicity, which permits of its use in the field by the non-expert, and adds to its reliability, as well as to the low cost of manufacture. Only one small wrench is needed for use in taking apart or reassembling the gun; and these features, coupled with the weapon's ability to go on shooting after being subjected to immersion in dust and sand, seem to indicate that at last we have a true hand gun of the automatic type, light and sturdy enough for use by the common soldier—a weapon that has been long sought.

In reading and hearing of the battles and aeroplane duels now going on in Europe, how monotonous becomes the expression: "Then the machine gun jammed and went out of commission," the sequel frequently being a tale of death and disaster. It is only when we realize the seriousness of this distressing fault of the old-style machine gun that we can appreciate the virtues of the new weapon with which Browning has presented us. The theory he followed in its construction was that a high degree of exactness in framing the parts was undesirable, for this meant that with undue heating the precisely fitting members would refuse to act together; or if the weapon should receive a bump, or if bits of foreign matter like dirt should enter the mechanism, the gun would become hampered in operation, if not forced to quit working entirely. And not alone is great precision a detriment to the gun itself under trying conditions in the field, but a weapon so made is immensely more difficult to produce. With these two important facts in mind, Browning has made his weapons, both the machine gun and the automatic rifle, with parts loosely engaged wherever possible, confining accurate workmanship only to those members and parts where precision is imperative, and which, as he has proven, are surprisingly few in number. Hence the American soldier is enabled to enter the war with quick-firing weapons not only so light in weight as to be easily portable, but so trustworthy in operation that his courage is buttressed by the knowledge that his gun will stand by him unfalteringly through thick and through thin.

In 1914, in the city of Serajevo, in Austria, an Archduke was struck down by a pistol bullet, and this assassination furnished the Kaiser his pretext for beginning the war which has deluged Europe and Asia with blood. That fateful bullet was fired from the pistol invented by John M. Browning. When the curtain falls upon the harrowing scenes of this world disaster we hope to see the Prussian tyrants overwhelmed, their misguided people repentant, and the rights of the little man and the little nation restored so securely that peace with liberty will be founded as upon a rock. If this cherished end comes about, as we have reason to believe it will, not a little of the credit will be due to the superior implements of war devised by the distinguished Mormon inventor who created the weapon which set in motion the whole train of sorrows.

CHAPTER XVIII

HOW THE NEW WEAPONS HAVE AFFECTED THE ART OF WAR

Though the science of projecting missiles from guns has greatly advanced, the changes which the new weapons have wrought in the art of war are less than we sometimes suppose. Remembering that strategy is, roughly speaking, the planning of the battle before it begins, while tactics deals chiefly with the methods of carrying out those plans when the armies have been brought face to face, a survey of the present European campaigns reveals the fact that it is the latter branch of military art that has been most affected by the introduction of better guns.

From time immemorial the main object of opposing generals, as has been already pointed out, is not so much to kill the soldiers of their adversaries as to disorganize them, crumple them up into mobs, and so capture men, weapons, and supplies. Mere killing takes too much time and is a game at which two can play, while reducing an army to a confused rabble robs it almost entirely of its fighting power. Cold-blooded trading of man for man is the resort only of stupid generals or of dire necessity.

When two armies are about to confront each other for hostilities there have always been two general methods by which one of them can, without excessive losses, throw the other into confusion; one of these methods being the frontal attack, the other the flanking movement. In the parlance of our American football game these maneuvers are known as "bucking the line" in one instance, and "running around the end" in the other. In the frontal attack the enemy is engaged with especial vigor at one or more points in his line, in the hope of breaking through and so being able to assail the foe from side and rear where he is exceedingly vulnerable. In the flank movement the object of the attacker is to bring a force suddenly against or around the end of the enemy's line and in this manner gain a vantage point at his side or rear. Napoleon employed both of the theories of attack with consummate skill, and in our Civil War each plan was used time and again by the opposing forces. In the Battle of Gettysburg Lee battered a section of the Union line with artillery, and then launched Pickett's Brigade against the front so weakened. More successful was Jackson's secret march around the end of the Federal line at the Battle of Chancellorsville, which stands as a classic example of the flank attack.

Why, then, do we see in Europe no "end runs," but only the plunging of huge forces headlong into the enemy's lines in frontal attacks? The answer lies not in the fact that weapons of increased deadliness are being employed, but rather in the enormous size of the armies now in the field.

Look back at the Battle of New Orleans, for instance, where the defenders lay behind earthworks while the attackers advanced in front and in the open. Packenham probably was not aware of the efficiency of the American rifle and rifleman, but even if he had been, there was no choice of strategy for him because on each side Jackson's army was protected by waters deep and wide. The Americans, though outmatched in both numbers and military skill, were still sufficiently numerous to permit their line to reach entirely across the neck of land the British had to pass in order to reach New Orleans, their objective, thus compelling the invader to attack in front or not at all.

On a small scale the Battle of New Orleans is a counterpart of the situation existing in the principal campaigns being waged in Europe. In Russia, France, and Italy, owing to the number of men engaged, the battle lines have been so extended as to permit the flanks to be protected by some natural obstacle such as deep waters, high mountains, or bottomless swamps; or, in place thereof, the forbidden boundaries of some neutral nation. Under such circumstances the European general finds himself in the same predicament to which Packenham was reduced at New Orleans; that is, he is confined to the frontal attack in order to make any advance.

During the invasion of France, the German, von Kluck, in trying to outflank Joffre's army, was himself outflanked by a separate French force advancing from Paris. The Germans thereupon retreated, but slowly enough to permit the digging at their rear of a line of trenches, which was ultimately extended from Switzerland to the sea. To these trenches they withdrew, followed closely by their French and British adversaries. The latter, being unable to turn either German flank, though General French tried manfully to do so on the west with his small British army, could assail the Germans only by advancing upon their line from the front. This they tried again and again, unsuccessfully and with terrific losses. The Germans were well supplied with machine guns, and one of these operated by a single man, well protected or well concealed, is deemed to be equal to a hundred men armed with ordinary rifles, advancing in the open. This means that one hundred German machine gunners firing from their trenches were equivalent to ten thousand attacking French and British—a superiority which the latter forces could not overcome. The Allies thereupon dug themselves into the ground confronting the Germans to gain protection, to be the better able to resist a renewed attack, and last but not least, to gain time in which to consider what next was to be done. They were face to face with the enigma of how to make a successful advance in frontal attack against the machine gun, a problem not yet wholly solved after four years of fighting.

The only recent example of war on a large scale to which the puzzled generals of the Allies could turn for the lessons of experience was the Russo-Japanese conflict in Manchuria; but not much of value was to be learned there because the little brown man had overthrown the bearded Slav chiefly by means of successful flank movements. The German line being in much the same situation as a city to be besieged when encircled by fortifications, it was early seen that artillery and explosive shells were likely to prove the sole means of driving the Germans from their strongholds and force them to fight in the open, and therefore on more equal terms. This conclusion inaugurated the tremendous blasting operations we have since witnessed, in which cannon in number and effectiveness unheard of before have been employed in preparing the way for advances by infantry. In principle, however, the methods thus employed do not differ from those of Lee at Gettysburg.

Preparation by artillery for infantry advances, however, turned out to be less simple than at first supposed. While the huge projectiles which the Allied armies poured lavishly upon the German trenches smashed the earthworks and drove their occupants into their deep caves, still enough machine guns and gunners always survived the storm to enable the defenders, when the fire lifted, to emerge from their dens and inflict severe punishment upon the unprotected soldiers advancing. To make the difficulty of such attacks all the greater, the wily German invented the "machine gun nest," a concrete shelter apart from the trenches, so hidden as to be unseen by aeroplane observers and vulnerable only to direct hit by a large projectile. Some of these nests are even made with small conning towers which rise out of the ground at the critical moment the opposing infantry appears, when the machine guns inside spit out deadly missiles by the thousands. To meet this new German invention the British produced their tanks, those crawling armored vehicles which carry guns of considerable size, but which are proof against impact of machine-gun bullets.

So dangerous are machine guns, protected and concealed, that before an infantry attack neither side hesitates to send shells by the hundred into a spot of ground where the existence of one is suspected. But until recently the machine gun has been useful in defense alone, being too heavy to be readily carried and used by the soldier while making an advance. The French and Germans, however, are now using light automatic guns weighing a little over twenty pounds, which soldiers are taught to carry and shoot in charging trenches of the enemy; while the British are using the Lewis gun for the same purpose. All of these guns are giving good results, though they are not so efficient as when fixed to the tripods or bases which they are really meant to use in action. But for the soldier walking or running the new Browning automatic rifle promises to give a firing power far beyond that of any such weapon now in use.

The advance of infantry upon the modern battle-field is conducted substantially as follows: the artillery, light and heavy, pour projectiles upon the opposing trenches for hours, sometimes for days, before the attack is started, destroying machine-gun emplacements, tearing up trenches, and spreading heavy, noxious gases over the enemy's zone. Then at a set moment the infantry in concert emerge from their own trenches and start forward at a pace carefully calculated beforehand. As the attackers approach the enemy's line where the explosive shells are dropping, the artillerymen at the rear slightly elevate the muzzles of their pieces, thus placing their projectiles a little farther forward, covering the trenches there and interfering with oncoming reinforcements. This is the moment when the survivors in the assailed trenches and machine-gun nests come to the top as best they can and commence to pour bullets into the oncoming ranks.

Though the survivors of the preliminary bombardment may be few, such is the strength of the shelters in which they hide during the shelling that seldom are all wiped out, no matter how fierce the artillery fire may have been. If tanks are being employed in the attack they now come into action, wandering over the battle-field looking for machine guns and turning upon them, when discovered, the artillery with which those steel monsters are armed. The attacking infantry, of course, are firing at every spot before them that shows signs of hostile men, using their ordinary rifles, automatic rifles, and portable machine guns. Part of such infantry, however, carry no guns, but are armed with a kind of weapon resurrected from the distant past—the grenade, thrown from the hand and bursting, either by means of a timer or upon contact with the ground. A twelve-pound grenade can only be thrown about one hundred and thirty feet, so that the rifle bullets must keep the enemy below ground, if possible, to enable the grenadiers to get within throwing distance; but once close enough to hurl their destructive missiles into the machine-gun emplacement, the latter must succumb. The barrage fire advances yet again, with the infantry following, until trench after trench is thus taken, the advance being limited, however, to the zone of fire possible to the supporting artillery. Then, experience has shown that if losses are to be considered, infantry must stop and wait for cannon to be moved up and preparations completed for a new battle.

The crucial moment in an infantry attack against machine guns is that elapsing after the barrage fire has lifted, and before tanks and grenadiers can fall upon the defenders with their cannon and high explosives. So great is this defect in the offensive that even aeroplanes are used to swoop down, braving the projectiles of their own side as well as those of the enemy, to shoot the emerging machine gunners and force them back into their caves, during the few seconds which the infantry line requires to reach the hostile trenches. When the charging infantry are able to protect themselves against the machine gun during these few precious moments by a strong counter-fire, the question of successful offensive fighting will be to a large extent solved; and this vital need seems to be now supplied in the coming of the Browning automatic rifle already mentioned. If our army and those of the Allies ever succeed in pushing their way through the German line and so bring the war to the enemy in his home, we believe that the remarkable new American arm will play a large part in the achievement.

CHAPTER XIX

SHOTGUNS

After a survey of the wonderful attainments of musket and rifle in shooting their single missiles, the companion arm, the shotgun, seems a laggard in the path of progress. In ignition, in breech-loading, and in repeating systems it has been a follower rather than a leader, taking the benefit of such ideas as could be adapted to its uses, but contributing little to the science of gunnery. With one single exception, the discovery of the principle of choke-boring, it has experienced no such revolutionary advancements as those witnessed in the other classes of firearms.

The shotgun is the direct descendant of the old blunderbuss, the office of which was to scatter a handful or so of nondescript missiles over a wide area, at a range of about a hundred feet. Its shooting distance is not much greater even now. The only superiority it can boast is the ability to deliver its pellets in a closer group than the ancient weapon did, together with less weight and greater strength, due to good workmanship and material. Quick shots at short range, without accurate aiming, are now, as they have always been, its distinctive qualities.

It is believed that the shotgun has possibilities much greater than have ever been achieved by it, for in artillery the shrapnel shell has shown how small missiles in large number may be thrown to a distance and made to scatter when and where desired. But no inventor has come forward with any similar plan to increase the range of the shotgun. This suggests that if it had held promise of usefulness in warfare its progress might have been much more marked. The rich financial prizes for improvements in guns have almost invariably gone to inventors working upon military weapons. Thus, Minié, the Frenchman, received a hundred thousand dollars from the British Government for the right to use the rifle ball which took his name; while other nations also paid well for the same privilege. There are many other examples of the same sort today, where governments are paying millions in royalties to men who have furnished ideas for the betterment of military arms. In all this the shotgun has had no share, though what it might have been today under such stimulus no one can say.

As early as 1580 guns seem to have been made for the purpose of shooting at flying birds, for in that year the sport is mentioned in Italian records. In 1626 we have already seen that the New England colonists were supplied with "ffowlinge peeces, 6 foote longe," delivered with a lot of muskets. The weapon therefore is not an infant. In the United States it has been put to more uses than the killing of birds and rabbits, for even now there are hunters who load it with buckshot and pursue deer or bear in brushy country where short ranges and quick shots are the ruling conditions. On the frontier, too, for many years the guards on stage coaches habitually carried "sawed-off" shotguns to repel bandits. These had short double barrels about eighteen inches long, which permitted easy handling, and when loaded with heavy shot were weapons to which even the hardy road-agent showed respect. The writer has vivid recollections of sheriffs and their posses armed with these ugly-looking dwarf guns going about after outlaws and other criminals in the early days of the Northwest; while even today we hear that our American soldiers in France are using sawed-off shotguns to repel trench raids and that with good effect. But the chief use of the shotgun has always been that to which it is put today, the killing of small game in motion, at short ranges.

The principal part of the fowling piece is its barrel, which is large in bore, long, and thin. As it scatters its missiles so widely it must throw a comparatively heavy charge of lead in order to succeed in hitting a small target; the bore must therefore be ample to receive and eject it. To prevent the shot from scattering too much the barrel is made long; but so short are the ranges intended that severe pressures are not required, hence the tube may be made quite thin as compared with the barrel of the rifle. The shotgun is never expected to develop more than from four to six tons of pressure per square inch, whereas the rifle must bear four or five times that much. A shotgun with a good barrel is nearly always a good gun.

Upon the making of these barrels has been lavished the genius of many generations of skilled gun makers. The large-bored tube was, of course, very heavy unless made thin, and the thinner a given piece of metal is the weaker it is and the more easily damaged. As thickness decreases, furthermore, the more serious become any slight defects the material may contain. Then, too, the larger the tube the greater the number of square inches of its inner surface exposed to the powder pressure, thereby adding to the danger of rupture. So that the production of a tube large, light, and still strong enough for its work, requires exceptional skill and pains.

The severest strain upon a gun barrel is always at right angles to the bore. Expanding gas presses equally hard in all directions, but as the missile moves forward under the first impact of the explosion the pressure in front is quickly relieved; the walls of the tube, however, must stand firm. Therefore the tendency of the barrel is to burst at the side, instead of being pulled apart endwise. This is almost invariably the manner in which gun barrels give way. This peculiarity has given rise to interesting methods in the making of the thin shotgun barrel.

A well-worked iron or steel rod has fibers running lengthwise through it, something like the strands of a rope. When such a rod is pulled upon in the direction of the fibers it will bear a great load before breaking, while a strain across its grain will tear it apart much more readily. Taking advantage of this difference in strength, shotgun makers in the last century began forming barrels for these guns by winding strips of iron into a spiral-like tube, and then welding the edges together to make the whole a solid unit. By this means the powder pressure inside the barrel was resisted by the lengthwise strength of

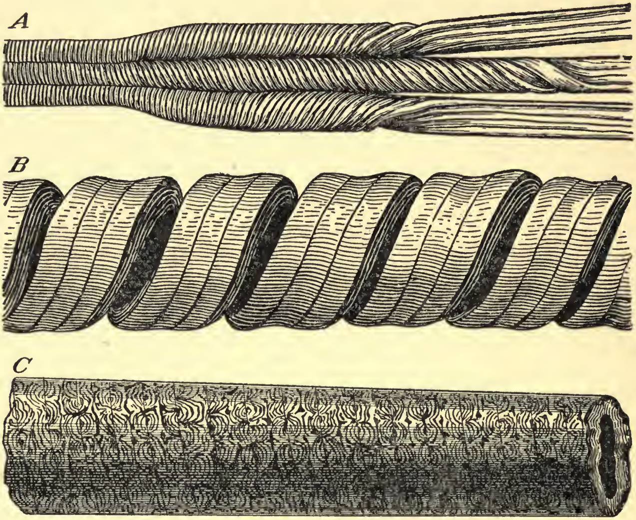

FIG. 78.—Showing the methods by which shotgun barrels are made of coiled rods of steel and iron, and how such barrels, after being subjected to an acid bath, appear as if beautifully engraved.

the fiber. Thus a much stronger tube was produced than those formed by simply boring a hole in a long solid rod of iron. The same principle is used in the construction of big artillery, where unusual transverse strength is obtained by layers of wire wrapped around the inner tube. It is this spiral method of manufacture that gives us the shotgun with the "twisted" barrel, very common a few years ago and even seen today in the more costly weapons.

The beautiful figures appearing on the outer surface of twisted barrels are the result of the discovery that alternate strips of iron and steel coiled into a tube and welded together gave better results than either steel or iron used alone. The iron gave elasticity and toughness, while the steel added more strength than mere iron could supply. When these barrels of combined materials are dipped in weak acids the iron corrodes more rapidly than the steel, and thus is produced upon the surface of such tubes the beautiful scroll-like lines so much admired. The more complicated figures are the result of twisting the strips around each other, before they are coiled to make the tube itself. These fancy barrels, pleasing as they are to the eye, are easily damaged by rough usage and are giving way to sturdier, though no heavier ones, of special steel, molded and compressed by modern processes until great resistance is obtained.

Early in the nineteenth century this success in making tubes strong yet light led to the production of the double-barreled gun. This plan not only gave the hunter a second shot when he needed it, but the extra weight was a distinct advantage in overcoming recoil; for we must not forget that a gun too light is worse than one too heavy. The loads which the shotgun is required to shoot have never been decreased, as in the rifle, so that a very light shotgun has always been out of the question. Therefore except in repeaters, which have the added weight of their increased mechanism, the double-barreled shotgun remains the standard type to this day.

After breech-loading principles became well established in rifles, shotguns also were made to load at the breech. There have been many plans tried for making the gun open easily for charging and closing it securely again for firing, but the method that has finally won out is that seen in the old breechloader of Philip V, in which the gun breaks on a hinge at the lock, the muzzle descending, exposing the rear of the barrels. The levers by which this operation is performed have been variously placed at the bottom, top, and side; the top device having in the long run proved best. The real difficulty has always been in fastening the barrel to the stock and frame when in position for firing. Even in this respect improvement has been made only in recent years, though the problems involved have been of the simplest kind. The early breech-loading shotguns had their sole fastenings below the barrel, close to

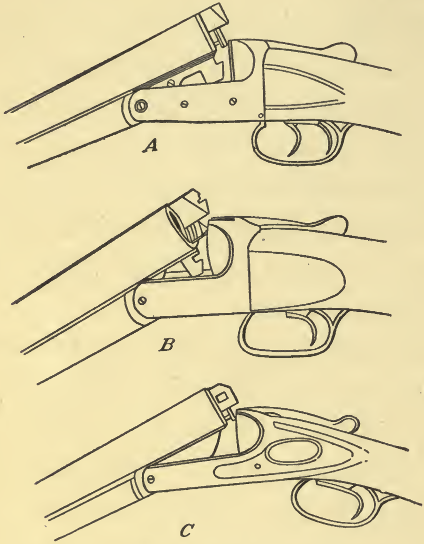

FIG. 79.—TYPES OF SHOTGUN BOLTS

When the drop-down principle became generally adopted for the breech-loading shotgun, we were long without a satisfactory method of securing the hinged barrel to the stock. *A* and *B* show the lug under the barrel into which a wedge operated by a lever fitted to hold the barrel in place for firing. *B* has in addition a wedge extending back from the top of the breech, called a "doll's-head," which helped some; but all these fastenings were insecure. The method now used is to place a wing below the barrel to check side strains and then bolt the barrel to the stock by means of a perforated pin extending backward into the stock at the top of the barrel, as shown in figure *C*.

the hinge, which of course put such great strain on them that with use the barrel became so loose that it would rattle when shaken. The first breech-loading shotgun the writer owned, a rather expensive gun, too, began to rattle before it was three months old. In the modern gun, however, this defect has been remedied by placing the fastening at the extreme breech and on top, the position in which it belongs, and where the Smith & Wesson revolver used it long ago. Just how crude the old guns were and how simple the cure was, can best be judged by a view of the principal types of breech fastenings which have been used at various times.

For two reasons the range of the shotgun is necessarily very short. When the group of tiny missiles is sent out of the barrel the pellets always spread more or less, each fighting its own way through the air. According to the principle that the small object exposes more surface in proportion to its contents than a larger one of the same shape, the resistance each pellet has to overcome is great, compared with its weight. Therefore, no matter how fast shot are sent out from the barrel, their speed is quickly cut down. Large-sized pellets carry further and have greater penetrative power, but of course the number used in a charge must then be lessened, which results in broad spaces between the shot; and, if the target be small, misses will be frequent. Then, too, it is found that if the muzzle velocity exceeds ten to twelve hundred feet per second, the pellets scatter too much for effective shooting. Hence, in the present state of knowledge, the weapon has about reached its limit of efficiency. It is a good gun that will in continued shooting deliver seventy per cent of its shot within a thirty-inch circle at forty yards. Nor was even this moderate result attainable until the principle of choke-boring was discovered.

Some time before the middle of the last century a practice grew up in the United States of slightly decreasing the bore of the barrel at the muzzle, with the result that the shot scattered less than when fired from the true cylinder. Who first conceived the idea and put it into practice we do not know, but who ever did it is entitled to the credit of making the single important discovery peculiar to this type of weapon. It seems to be generally conceded that the invention originated in America, and though a man named Roper secured a patent for a similar gun barrel in this country, in 1866, the idea was in use long before that. It took a good many years to test out the full limits of the choke-boring principle, the final result of the experiments proving that in a ten-gauge gun, if the final two or three inches of the bore at the muzzle be made four one-hundredths of an inch narrower than the rest of the barrel, the shot will be best held together. As the size of the gun decreases the constriction must also be lessened; so that in a twenty-gauge gun, for instance, the amount allowable is only half that of the ten-gauge.

We do not know exactly the reason why choke-boring should cause the pellets to remain closer together, but modern photography and the use of powder without smoke have given us a tolerably clear idea of the operation. By shooting the charge against a wire which electrically operates the camera shutter, we have been given pictures of the charges as they emerge from both plain and choke-bored barrels. From these pictures it seems that in the plain barrel when the gases push the charge from the rear, with the air pressing against it in front, the effect is to squeeze the center pellets out sideways at the instant they leave the tube, thus causing them to fly off at angles, and so arrive at their target widely spread. The peculiar effect of choke-boring in sending the pellets off in a closer group seems to depend chiefly upon the action of the wad behind the shot charge when it reaches the constriction. This wad, being strong and tight-fitting, appears

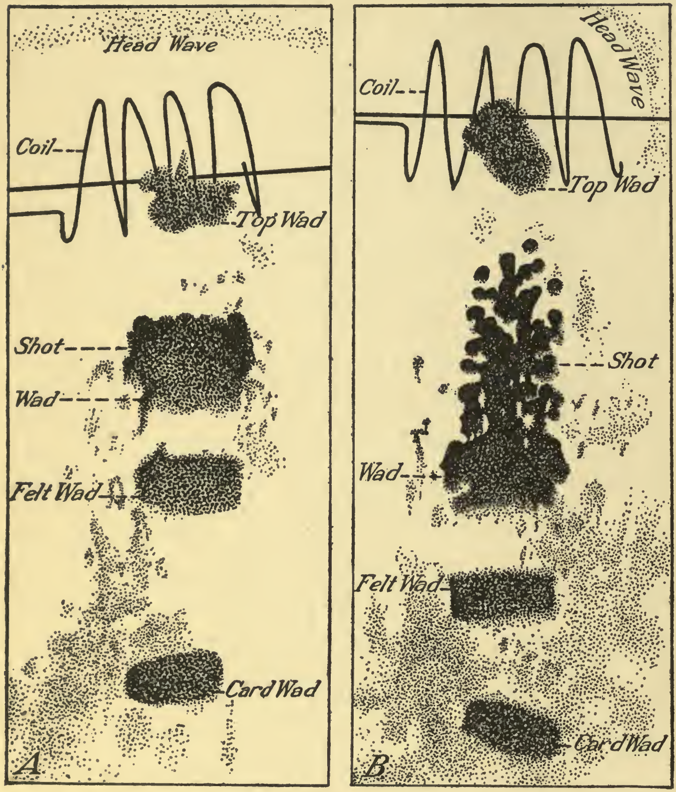

FIG. 80.—Photographs of shotgun charges leaving the muzzle, the camera being snapped by contact of the forward wad against the wire. *A* shows the shot leaving an ordinary barrel in a compact body, while *B* reveals the shot from the choke-bored barrel stringing out for the reasons explained in the text.

to have its progress checked momentarily by the slight obstruction; in turn the oncoming gases are similarly retarded. This happens just as the charge is leaving the muzzle. Thus the pressure being relieved at the rear, the squeezing effect produced in the plain barrel is avoided, and the units of the charge pass on straighter to their mark. While this explanation is not entirely satisfactory, it is the best of the many ingenious ones offered. All agree that we have still something to learn about how the choke-bored barrel produces its results.

It might naturally be expected that the choke-bored barrel, keeping the pellets close together, as it does, would have caused a reduction in the number of missiles necessary to a charge. This has not been the case, though, because of the substantial percentage of them practically destroyed at the muzzle. The slight shoulder against which the missiles are forced so suddenly flattens about thirty per cent of those on the outside of the mass, and these deformed ones fly wildly because of unequal air pressures on their surfaces; many of them, too, while going fairly straight, arrive at the journey's end too late to be of service against a moving target. On account of this waste the aggregate charge is, therefore, not much less than before choke-boring was introduced. Better workmanship and more careful loading, however, are giving adequate results with smaller-sized guns, and there is in consequence a distinct tendency toward the adoption of guns as low as sixteen and even twenty gauge.

The repeating principle has been applied to shotguns with excellent success, though most sportsmen find that the double-barreled weapon giving its two shots supplies all ordinary needs in hunting small game. In America the repeating shotgun, like the repeating rifle, is more popular than in Europe, and its use here seems to be growing. There are a number of good weapons of this kind to be had, but as they do not differ in principle from the types already shown in rifles, none calls for special mention here, except perhaps that invented by Browning, which operates by means of a slide under the barrel, whereby the firer is permitted to reload with his left hand while the gun remains in firing position. Americans are now beginning to take up the automatic loader, which promises in time to displace all other types. When these attain greater simplicity and become less expensive the existing shotguns will surely be laid aside. The mechanisms of these new weapons are not dissimilar to those of the self-loading pistol, which we shall consider in detail in the next chapter.

CHAPTER XX

THE PISTOL

Of all the forms which firearms have taken none has become so closely intertwined with the lives of modern men as the pistol. Cheap, light, and handy, powerful at short ranges, and requiring little skill in ordinary use, it has proved to be the ideal weapon for personal defense. The result is that the number of pistols in existence and use is probably greater than that of all other weapons combined. Yet only within the last century has this prominence come about. Before that time it was the sword that men, even in private life, generally carried or kept in the home as a convenient and reliable weapon for self-defense. On the backs of some of their coats men wear buttons even down to this day, the original purpose of which was to support the sword belt of the wearer. It was the revolving pistol produced by Samuel Colt in 1836 that sent the non-military sword to the garret as a relic, and at the same time made the ancient art of swordsmanship obsolete.

The early pistol was designed to be held in and fired from a single hand, and was especially intended for the use of cavalry. It was really the only weapon that could be used to advantage by the horseman, for this weapon could be aimed and fired by the right hand, while the left was free to hold the reins and guide the horse. The musket proper, as we have seen, was too long and heavy and too hard to load to be of much use to the mounted man. The lighter weight of the short arm permitted the addition of an extra barrel, and this became common, for though making the weapon somewhat more unwieldly, the firing power of the bearer was thereby doubled. From the early part of the sixteenth century on the pistol in some form has usually been a part of the cavalryman's equipment.

For several centuries the mounted soldier was taught to charge the enemy, fire his pistol at short range, and then throw it as a missile, a purpose for which the old, heavy instrument was quite well fitted. After thus relieving himself of the firearm, the charging horseman drew his sword and began the real fighting. In 1544 we read of a combat between Germans and French, in which the cavalry of the former fought with pistols alone, riding forward one after another, firing, and retreating to reload. This maneuver became much used after that, being called "caracole," a term still employed to describe the wheeling of cavalry ranks into lines or files. But the pistol

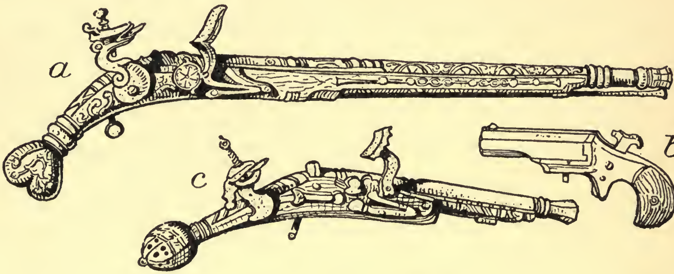

Fig. 81.—Old Pistols
a, Highland pistol for horseman, 17th century;
b, Derringer;
c, Highland pistol for the belt, 16th century.

never took a leading part in warfare, and has always been regarded by the soldier as a minor weapon.

Down to the time of Colt's invention the pistol commonly used did not, except in length and the shape of its stock, depart far from the type of the muskets used alongside of it. The various advances in ignition were transferred to it, as they came forward from time to time; while the rifling of the barrel to spin the projectile was also adopted for the pistol as soon as the greased patch made loading easier. Until 1836 the pistol was in fact only a musket or rifle of smaller size.

Colt's invention, made when he was only twenty-one, was not new, as has been explained, except in the method of making the cylinder revolve, and holding it fast while being fired. One other attachment which he added to the arm, and which tended to quicken the loading of it, was the ingenious ramrod under the barrel. This was a lever which, when pulled downward, operated a plunger in and out of the chamber of the cylinder; by its help the powder and lead could be rammed into the chambers tightly and quite rapidly considering that the operation was restricted to one charge at a time. The ratchet which turned the cylinder, the stop which held it in place, and the manner of working the jointed ramrod are shown in the illustrations.

The Colt revolver proved to be such a meritorious weapon that within a few years after its introduction its use had spread throughout the civilized world. No contribution to firearms of any sort has ever achieved such quick and general recognition; which fact not only emphasizes the virtues of the invention itself, but reveals also the universal need which existed for such an arm. In measuring Colt's success it must at the same time be remembered that without the percussion principle, with which even his earliest productions were fitted, the usefulness of his revolver would have been doubtful. Therefore to Forsyth

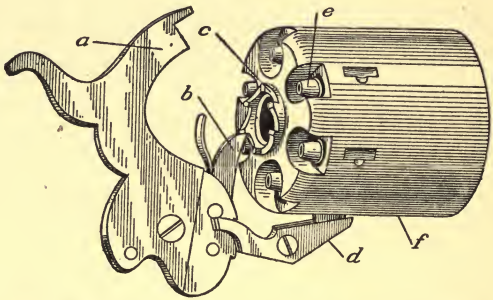

FIG. 82.—MECHANISM OF THE ORIGINAL COLT REVOLVER

The above diagram shows the ingenious invention of Samuel Colt, which formed the basis of the successful revolvers. In such weapons used heretofore the cylinder was turned by hand, with the result that the firing chamber did not always come opposite the barrel, which made them dangerous. In Colt's weapon mere cocking of the hammer moved the cylinder exactly into place and locked it there. (See Figs. 48, 49, 50, Chapter XII. *a*, hammer; *b*, hand; *c*, ratchet; *d*, bolt; *e*, nipple; *f*, cylinder.

the Scotchman and Shaw the American are due a substantial share in the triumph.

During the life of Colt's patent his invention enjoyed practically a monopoly of the field in pistols. With the coming of the metallic cartridge shell and the resulting success in breech-loading, the cylinders of the revolver were altered to use that kind of ammunition, thereby increasing its rapidity of fire substantially, and making it a better weapon than before. The self-cocking action added in later years also permitted quicker operation. Upon the expiration of the patent a large variety of revolvers came upon the market, nearly all using Colt's ideas, and differing chiefly in modes of loading cartridges and discharging the empty shells. None of these new arms used any novel principle of sufficient importance to receive mention here; and then, too, most of us are already familiar with the parts and workings of the best of them.

The revolver has never been a perfect weapon, for, though the later models loaded at the breech of the cylinder, the gap remained at the junction between cylinder and barrel. No matter how skilfully made, there must always be play enough at that point to allow the cylinder to revolve easily, the effect of which is to permit substantial escape of gas and consequent loss of power. The man who can devise a plan to close that joint without obstructing the cylinder in its motion may ask and receive practically his own price for the invention; for thereby will be cured the one great drawback from which the revolver has suffered from the beginning. So far no successful method to accomplish this has been evolved, though hundreds of men have worked valiantly at the task. But in spite of this great fault the revolver has for seventy years continued to hold its important place among firearms.

Though it happened to him as a boy many years ago, the author distinctly remembers the day when he first had forced upon his attention the quantity of gas wasted by the revolver at the junction of its cylinder and barrel. It was in the sagebrush near the Yellowstone River when, as he rode along, a coyote jumped up from his covert and ran ahead. The author drew his revolver, a .44 Colt, and spurred forward in chase. After missing a shot or two, the reins were dropped while the weapon was grasped with the left hand to steady it in the effort to make a sure hit. The shot was delivered, but whether or not the bullet took effect the young hunter never knew, for his attention was instantly arrested by an unexpected occurrence. At the explosion, the fingers of the supporting left hand were thrust violently apart, while a dart of pain in the members made their owner wince. A glance at the fingers showed them seared and blackened. His first thought was that the weapon had burst, but examination proved it still intact, whereupon the truth dawned upon the mind of the startled youngster. The burned fingers had been placed around the rear of the barrel and the side-way blast of gas at the explosion had been powerful enough to forcibly disengage them and burn the hand severely. The lesson then learned by the author he now passes along to other novices in revolver shooting, which is that if extra support is to be given the weapon in making a shot, the left hand, or better, the arm, should be placed under the frame of the weapon and not in proximity to the upper chamber of the cylinder where danger lurks.

The ascendency of the revolver is now upon the wane, however, for a rival has appeared against which it probably cannot long contend.

This new weapon, the self-loading pistol, is rapidly gaining the place of honor, not only among private citizens but in armies as well. Nearly all the nations have adopted it as the official weapon for officers in army and navy; while the United States infantry is equipped with it in France, where it is relied upon as an adjunct to the bayonet in fighting at close quarters. The type of automatic pistol that has received practically unanimous favor both in America and Europe is that invented by Browning. As it is the official weapon of our military forces and a good example of the whole class of firearms which use the force of recoil to effect the loading operation, a careful inspection of the Browning pistol, or, as it is called after the manufacturer, the Colt Automatic Pistol, will be instructive.

FIG. 83.—COLT AUTOMATIC PISTOL, GOVERNMENT MODEL

This pistol, .45 caliber, has been adopted by most of the armies and navies of the world, including our own. This production of Browning promises to displace entirely Colt's invention, which has reigned supreme in its field for 80 years.

The magazine is within the stock and holds seven cartridges, inserted from below; a spring pushes them up, keeping one always near the breech of the barrel. After loading, the slide is drawn back once by the hand, which operation places the cartridge in the firing chamber, and locks the weapon. When the trigger is pulled the recoil thrusts the barrel and slide backward together, during which journey the bullet escapes from the barrel. By the time this takes place the barrel drops downward on its toggle joints and stops, while the slide continues to the rear,

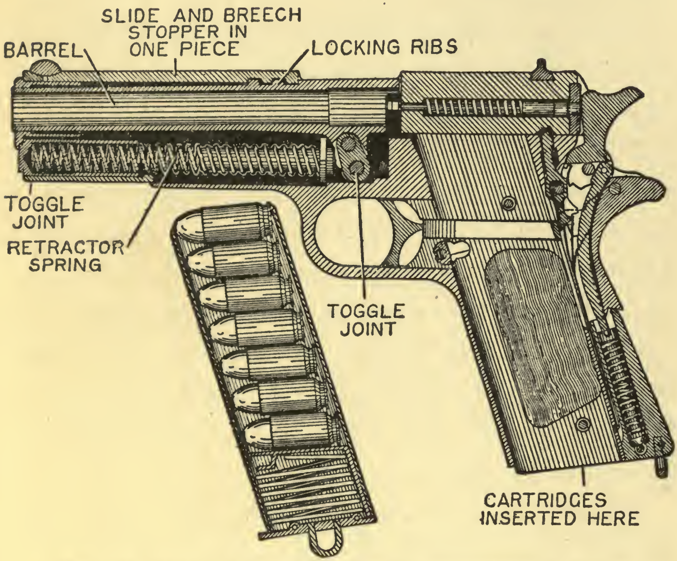

FIG. 84.—COLT AUTOMATIC PISTOL, GOVERNMENT MODEL (Browning Pistol)
Sectional view, showing mechanism.

cocking the hammer, and opening a space underneath into which the magazine spring thrusts a cartridge. The retractor spring then pulls the slide forward, which inserts the cartridge in the barrel; after which both barrel and slide return to their former positions, the toggle joints raising the barrel again so that the locking ribs engage the slots in the slide, and the weapon may be fired again when the trigger is pulled. This operation is repeated as long as a cartridge remains in the magazine.

Thus this type of pistol is not only a repeater, but avoids the gap which exists in the revolver between cylinder and barrel, for the cartridge is exploded in the barrel itself. Not the least of the advantages of the new weapon is the decreasing of the shock of recoil, which was a serious drawback to the revolver of large size. Instead of disturbing the shot, this force is now largely taken up in the operation of the mechanism, the result being that a .45-caliber pistol of this kind gives no more recoil than a revolver of .38 caliber of the same weight.

Why is it, one may well ask, that while rifle calibers have so steadily decreased, our military authorities have adopted the huge .45 caliber for their service pistol? At first glance this seems to be a turning backward of the clock of progress; yet the answer is quite satisfying. The pistol is essentially a weapon for moderate ranges. With its short barrel bringing the sights too close together for distance work and intended, as the pistol is, to be supported and fired from a single hand, fifty to seventy-five yards are about the limit within which hits from it may be expected. Recoil being largely taken up by the reloading mechanism, heavy powder charges are permissible, giving a surplus of power which the arm should in some way be made to utilize. The modern pistol firer then finds himself in much the same situation as did the musketeer mentioned in Chapter VII; he can send a small missile far but not accurately, hence he may as well use a big, hard-hitting bullet with low velocity, which will inflict the maximum damage to the human enemy for which it is intended. The small metal-patched bullet will frequently pass through a man without checking his advance, and the soft-nosed variety, which spreads on contact, has been, as we have seen, barred from use in warfare by consent of nations. There has, however, been no limit placed upon the size of the missiles which the soldier may employ. Therefore our .45-caliber pistol is a legal man-killer—the irony of it—which, upon entering the body of a German in the present war is expected promptly to cause him to lose interest in his mission of spreading "kultur" by force.

There are already on the market a number of sporting shotguns and rifles which utilize recoil in loading and cocking themselves, as in the Browning pistol, but a study of the latter will give a fair understanding of the merits and principles of the whole class.

CHAPTER XXI

THE GUN OF THE FUTURE

In the writings of past centuries about guns one is struck by the cocksure beliefs constantly expressed that the particular kinds of firearms which the authors saw about them, in their various times, were the best that could ever by any possibility be produced. And we of these later days, even with all the former false predictions before us, are also inclined to take the same attitude toward our own weapons. A few sober second thoughts upon this subject will, therefore, not be amiss, for there still remain some very serious drawbacks in the gun, some of which, at least, in the light of experience, we may reasonably expect to see in the near future successfully overcome.

In the shotgun, for instance, there is reason to believe that some change will be made or some device originated, whereby its range will be increased from forty yards to a hundred or perhaps several hundred yards. It is not more than half a century since the cannon was used as a huge shotgun, to throw scattering charges of grapeshot a few hundred yards from the muzzle, while the shrapnel shell now permits the cluster of missiles to be carried as a mass for several miles, and then to be opened up and, with great accuracy, strewn over the space selected. If the pellets can be held in a compact body they will meet comparatively little air resistance during their long journey forward, and arrive near their target traveling at high speed, only needing to be released at the proper moment to scatter and do their work. This kind of projectile can be easily adapted to use in the shotgun if some one will come forward with a plan to make the shell cheaply enough for the ordinary sportsman's use. The specific device lacking is an inexpensive timing apparatus, by which the charge can be liberated at the right instant. When this invention arrives, as it very probably will, shotgun shooting will be the most fascinating and scientific of all sports.

One of the chief drawbacks to all our firearms is the high cost of ammunition. No weapon for general use can be called a success when its operation is so expensive as to prevent the average man from using it freely. The scarcity of powder and the costliness of iron did much in the earlier days to keep the gun in the background, as it was for so long, and a similar reason now keeps the gun of standard sizes out of the hands of the majority of men. The weapon itself is quite low in price—lower in America than anywhere in the world, considering quality—but as long as each shot costs the gunner from two to five cents, rifle and shotgun shooting are bound to remain the pastime of the well-to-do, to the exclusion of the masses.

There is no sufficient reason why a brass, or brass and paper, shell, made of costly material and by intricate processes, should be discarded after a single shot. This part of the cartridge is its most costly item; and though it can be reloaded, there are few persons who possess the skill to make a modern cartridge with the necessary accuracy, even when given the shell ready to their hands. Experience has taught most gunners the futility of trying to get good results from ammunition of their own creation. It not only shoots poorly, as a rule, but the mechanism of the gun is so exact that the slightest variation in dimensions of the cartridge interferes seriously with quick and easy operation, to say nothing of the very real danger from premature explosions which exists in the loading and firing of home-made ammunition. The modern gun demands cheaper ammunition, and the inventor who can produce it will accomplish a great contribution to gunnery.

One cannot help believing, too, that our system of ignition falls far short of what is possible in that respect. The making of the primer, the forming of the shell to receive it, and the mechanism the gun requires to set it off, all add greatly to the cost of shooting. But it is not in cost that the chief detriment lies, for the most archaic part of the gun is the present means of discharging it, the trigger and hammer. No one doubts that at least half of the errors in shooting are the result, directly or indirectly, of faulty work in releasing the trigger. For safety's sake a pull of several pounds is generally provided for, and the exertion of so much force on a particular portion of the weapon, at the most crucial instant, cannot help introducing serious disturbances where mere hairbreadths on the sights count in yards at the target. In time some genius will give us an ignition system which will be cheap, and will permit firing by a mere touch, yet with safety. Electrical devices for this purpose are in existence today, but have been found too faulty for good service. They also require a primer to start the explosion, for we know of no means today to ignite smokeless powder by electric current without a cap of some sort. With this want supplied the cumbersome and costly ignition method now in use will promptly disappear, perhaps leaving us in wonderment at our having so long borne with its crudities.

The military rifle of the future, it is confidently predicted, will be practically a machine gun, firing with great rapidity, by means of self-loading and igniting devices, as are the heavier weapons of that name now in use. The present objection to their general adoption for the infantryman is the difficulty in supplying ammunition in larger quantities than is now possible. With the standard rifle already in use the trooper can in five minutes' time fire his full burden of cartridges, fifty to one hundred, so that faster shooting under present conditions of supply is of little importance, for the soldier without cartridges is left to his bayonet alone for offense and protection. The automatic rifle when used in France today is usually accompanied by two extra men who serve as ammunition bearers; thus three men are exposed to the fire of the enemy while only one of them is delivering fire in return. The amount of ammunition carried per man could be doubled if the brass shell could be abolished, for it constitutes nearly half the weight of each cartridge. The cartridge used in the United States Springfield, for instance, weighs 395½ grains; 200 grains being due to the charges of powder and lead, leaving 195½ grains for the shell alone. To give the soldier two cartridges where he now has only one would not usher in the automatic weapon in

FIG. 85.—MAXIM SILENCER

The loud noise made by the explosion in the gun is due to the vibrations of the air caused by the violent outrush of powder gases. The silencer permits the bullet to pass through a hole in its center, the gases being caught by the curling fins and made to whirl around inside the silencer; thus their forward velocity is decreased and their final escape made more gradual.

place of the common rifle, but the advantage conferred would be a great one, nevertheless.

Then there is the noise of the gun, once considered one of its chief virtues, but now counted a great defect in shooting. The soldier firing from cover reveals his position by the loud report, while on the battle-field the uproar of myriads of explosions cuts him off from spoken orders from his officers. The hunter, too, would find in the noiseless gun a weapon well suited to his purposes, for, should he then fire and miss, another shot would be possible before his quarry fled in alarm. The best silencer yet produced is the Maxim, which arrests the gases at the muzzle, and by causing them to follow a winding path to the outer air, and so to issue slowly, muffles the explosion very substantially. In rifles of high power, however, the sound is not deadened enough to warrant general acceptance of the device.

Aside from the report of the explosion, there is another detrimental sound produced in firing the modern rifle, which arises from the action of the air while being pierced by a very fast bullet. When the speed of a missile is much over 1,300 feet per second it produces a snapping sound in its passage, which at higher velocities becomes a sharp report to one standing near its path. In the days of black powder and low velocities this effect was practically unknown, though with our present arms, sending off bullets at the rate of two and three thousand feet per second, it has come to be a serious drawback, especially to the hunter. Where an animal is fired at and missed, the report of the gun at a distance is bad enough, but to have this secondary crack take place about its ears makes it flee in instant alarm. No method has yet been suggested whereby the bullet as used at present can be prevented from making its noisy passage through the air, though it is possible to make a missile of such form that it will not only dispose of this sound, but bring in with it other almost revolutionary advantages.

We have seen that the modern bullet is grievously defective, in that it travels light end foremost. But combined with that is another fault which, when both are considered, would almost justify the statement that we have been forced to adopt the worst possible form which a projectile could take. In order to apply the force of the explosion to the bullet we make its rear end flat; though nature has shown us in its swift birds and fish that, for efficient locomotion through air or water, both ends should be pointed, the longest taper being at the rear. In building boats and torpedoes we have copied the forms of these creatures successfully; but boats and torpedoes carry their own propulsive power with them, while the projectile must receive its total impetus from the gases in the gun barrel. If we could send our bullet off efficiently when formed in a general way like a trout, that is, with a pointed nose, the thickest part well forward, and a long tapering tail, there would be need for only spin enough to overcome the disturbing influences of slight defects in its construction and material; for with the principal weight toward the front there would no longer be the tendency to tip over and fly rear end first, as in the broad-based bullet. Nor would the cracking sound the present missile makes in its passage be heard, for that is caused by the air snapping together after the flat-ended bullet has pierced it. The long-tailed projectile would fill up the hollow behind it, allowing the air to come together again slowly. A missile so shaped would not only slip silently through the air, and require less spin, but would actually retain its speed much longer than the clumsy object we use at present.

The form of bullet we now use wastes power, as the snapping together of the air behind it clearly proves. A boat that tosses water about wildly when underway is badly built and uses up excessive energy, for experience proves that to get the most speed from a ton of coal the vessel must glide through the water, making the least commotion possible. The water pushed aside by the forward part of the hull of a well-built boat is allowed by the sloping rear lines to come together gradually, and by its returning weight and motion helps to urge the vessel forward. A simple illustration of the principle occurs when a boy "shoots" a wet melon seed by squeezing it between his finger and thumb. The bullet with pointed prow and long tapering tail would act upon the air, and be acted upon by the air, in this identical manner. The vacuum which the broad-based bullet causes would be filled up with lead, and the missile thus could be longer without increasing the total air resistance; furthermore, the action of the inrushing air at the rear striking against the sloping sides would help to thrust the missile forward. With all these benefits to be derived from the double-pointed projectile, why do we not adopt it at once? The answer lies in the difficulty of projecting such an object from the gun barrel.

The idea of the fish-shaped projectile is not new, for the great merits it possesses in many respects have been recognized for at least two hundred years. Its use has been so far forbidden us, because we cannot project it from a gun barrel with any degree of success, partly on account of its tendency to lean to one side or the other in the tube, and thus pass out unbalanced, and partly owing to the peculiar effect of the powder gases acting upon its sloping sides. When the gases are impeded by having their direction suddenly changed the bursting of the barrel is a likely result, for easy escape is thereby prevented, while their velocity thus checked cannot impart much speed to the projectile itself. The flat base, then,

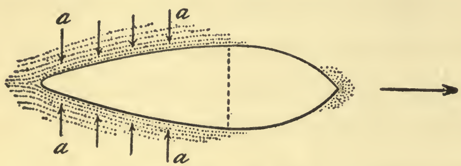

FIG. 86.—BEST FORM FOR BULLET
a, a, Air pressure.

is the only form in which we can use bullets in our present state of knowledge, though perhaps at some future time the seemingly impossible dif-

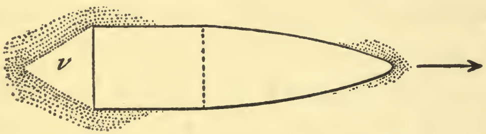

FIG. 87.—BULLET WITH FLAT END
v, Vacuum behind flat-end bullet in flight.

ficulties surrounding the use of the double-pointed missile will be overcome.

Of course ingenious men have already tried placing a separate piece with a flat base at the rear of an oval bullet, thus giving the powder gases a vertical surface to act upon, while the bullet once out of the barrel would speed on its way alone. In shots thus made, the separate base is a projectile itself and a wild flying, dangerous one at that, while no such auxiliary has yet been produced which will maintain the long-tailed bullet in its true position. Some better plan yet remains to be devised.

The subject of the gun of the future must not be dismissed without calling attention to another point, probably the most important of all. This is the matter of sighting. The modern rifle will shoot, and with a low trajectory, as far as the average man can see to aim it, and is therefore about up to the limits of human vision in range and accuracy. The next step in advance should be in means of reinforcing the eye of the gunner, for there is no use in improving the gun further if it is to fail on account of the firer's limitations. There are instruments to be had today to aid the rifleman's vision, but they are costly and delicate, and their errors, however slight, tend to multiply the original mistakes in sighting. The crying need of the rifleman at present is a cheap, simple, and substantial device by which a distant target will quickly be made plain to the eye, and which will help, and not hinder the operation of the gun by its size, weight, and flimsiness. Fame and fortune await the inventor of such an instrument.

Efficient as our guns are, therefore, they are still open to a number of very serious objections. The improvements suggested in this chapter all seem to be within the bounds of possibility, for none of them appears to offer obstacles more insuperable than those which have already been overcome. We have today scientific knowledge concerning the causes of the shortcomings of our guns better than ever before, and greater mechanical skill with which to put our ideas into working form than that of any of our predecessors. Hence it is not unreasonable to hope that the gun of the very near future will far surpass even the weapon of which we now rightfully boast.

CHAPTER XXII

THE PRINCIPLES OF SHOOTING

At the Battle of Bunker Hill, in 1776, the American troops were told: "Don't fire until you see the whites of their eyes." Thirty-nine years later Jackson's men at New Orleans opened fire at four hundred yards, doing considerable execution even at that distance. In the first case the order was intended to eliminate almost entirely the act of aiming, while in the later fight marksmanship of a high order was called for. In these two incidents we see the striking difference between the musket, which was chiefly used at Bunker Hill, and the rifle with which most of the Americans were armed in the Southern contest. Marksmanship can be fairly said to have begun with the introduction of the rifle, which in America, of course, was at least a century before 1815.

The ancient musketeer, or even the rifleman of a century ago, would be amazed at seeing his modern successor coming onto the shooting range armed not only with his gun, but with thermometer, barometer, and wind gauge as well. Yet these additional instruments are today all ordinary parts of the equipment of the long-distance marksman. The colder the air the denser it is, and the less easily the bullet can make its way through; therefore a slight fall in temperature requires an elevation of the gun barrel to allow for the extra drop the slowed-up missile will make in its long journey. A rising thermometer, on the other hand, calls for a lowering of the rear sight; for air, like iron, grows softer the hotter it becomes, and is thereby more easily penetrated. The presence of moisture in the air makes it heavier, and the bullet is retarded or quickened in its flight as the barometer changes. Following winds decrease the air's resistance, while against head winds the missile meets increased opposition. Cross winds, too, tend to sweep the missile to right or left as it speeds along. The wind-gauge must, therefore, not only reveal the direction of the wind, but its velocity as well. Making allowances for all these conditions, changing as they do from minute to minute, tends to make rifle shooting as complicated as a game of chess.

The missiles of revolver and shotgun, intended as they are for use over comparatively short ranges, are less affected by changing air conditions than the far-flying rifle bullet, but each weapon has its peculiarities, strict attention to which is necessary to get out of the instrument the best there is in it. Full discussion of this entire subject is worthy of a whole book instead of a mere chapter; but there are certain principles of marksmanship applicable to all firearms which can be briefly told, and without knowledge of which even moderate success in shooting is impossible.

For instance, it is absolutely necessary, in aiming any of the three weapons, to hold it squarely, so that it does not tip to one side or the other. As the leaden charge begins to fall toward the earth the moment it issues from the gun barrel and begins to slow up the instant the air resistance in front exceeds the force of the powder gas at the rear, some elevation of the tube is always required, and all hand guns are built and sighted to allow for this drop. With this fact in mind, note from the following drawing the result of firing a gun which is allowed to tip to one side.

It will thus be seen that when the weapon is canted even slightly its missile will not rise as the arrangement of the sights intends. The effect is, on the contrary, to rob it of this benefit, and at the same time to send it wide of the mark. Without the most careful attention to this important matter all other efforts at marksmanship are futile.

The proper operation of the trigger when the sights are on the mark is also a vital part of good shooting with any firearm. The trigger must not be *pulled*. Its release should be effected

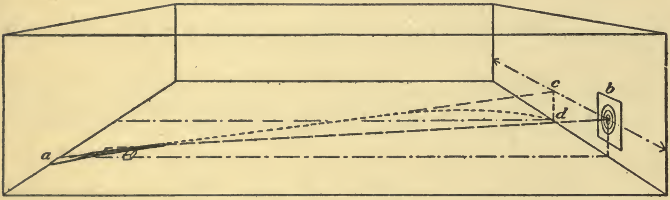

FIG. 88.—Gun on its side at *a*, sighted for target at *b*. Direction of bullet is from *a* to *c*, falling at *d*.

by a squeezing action, in which the whole right hand closes gently but firmly against both trigger and stock; at the same time, especially in using a light gun, the left hand should tighten its grip slightly in its forward position, under the barrel. By manipulating the trigger in this manner, the weapon will remain steady at the explosion, without the twitch which inevitably results when the trigger is pulled. In aiming, the important moment is that at which the explosion takes place, and if any disturbance in pointing the piece is allowed then the whole shot is spoiled.

As no two triggers pull off exactly alike, only earnest practice with any particular gun will teach the shooter just when the pressure exerted by the right hand is sufficient to allow the hammer to fall and fire the shot. This practice can best be had with the gun empty, but aimed and snapped as carefully as if actually being fired. No one can hold the sights of revolver or rifle

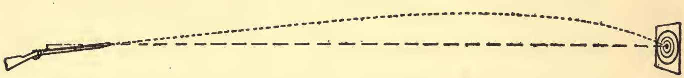

FIG. 89.—Showing arrangement of sights whereby the eye in aiming looks at the target, while the bullet is projected upward, gravity later on pulling it down to the bull's-eye.

steadily upon a small target in offhand shooting. In practice the sights wander over and around the bull's-eye, the trick in marksmanship being to explode the charge at one of the moments when the sights are exactly on the mark. This is really the main thing in accurate shooting, and in the operation the proper releasing of the trigger is of prime importance. Only the most delicate co-operation of hand, eye, and brain can bring off hit after hit, and while some seem to possess naturally the faculty for it, most of us can acquire the knack only by persistent practice.

In using the eye for sighting, especially at a distant mark, there is one cardinal principle to be heeded, applying equally to the shooting of all the three hand guns; that is, the vision must be on the target first and the sights brought into line afterward. The necessity for this is plain when we remember the peculiar action of the eye in adapting itself to far and near sight. When a distant object is looked at the pupil of the eye dilates, admitting the increase of light necessary for a clear image. When a nearby object is focused upon, the opposite process takes place and the shutters are narrowed, excluding unnecessary light. This change of adjustment requires time, as we realize when we go from a well-lighted room to a dark one. How important, then, it is for the marksman not to handicap his eye by compelling it to show him the nearby sights, and immediately after call upon it for a clear view of the target, dim and wavering perhaps in the distance! The human machine, as well as the metal one, must be humored, if hits are to be obtained.

One of the worst evils in all shooting is the habit of flinching when the gun goes off. All beginners are afflicted by this trait, while many experienced gunners have been unable to shake it off entirely. It probably spoils as many shots as any other single cause, for its victims are seldom conscious of the act. Flinching is not the result of fear, for the most courageous of men are sometimes guilty of it; nor is it wholly nervousness, because many good marksmen are persons of high-strung nerves. Whatever the real cause may be, we know that the only cure lies in cultivating familiarity with firearms, and constant practice in shooting of them, giving attention to the habit and striving to overcome it.

In shooting in the field, where the ranges to be shot over are not accurately known, the judging of distance is a very essential part of marksmanship. After our study of trajectories this fact will be apparent, for though the modern rifle bullet does not fall much within ordinary shooting ranges, the variation is still to some extent present; and even in shotgun and revolver shooting the element of distance is decidedly important. The persistent marksman, however, will not wait until he is out with his gun to practice his mind in judging quickly the space intervening between himself and objects within his view. It is surprising how vague are the guesses on distance the beginner at this pastime will make, and equally surprising how a little practice will sharpen the wits in this respect. One ambitious as a hunter or target shooter should learn the length of his average pace, and while walking along street or road pick out various objects in his path, make an estimate of the distance intervening, and then count his steps to verify or disprove his judgment. Such a habit even occasionally indulged in will go far to make the judgment of distance not only accurate but rapid.

In shotgun shooting the target is usually a moving one, and here enters into the problem, not only the distance to the object, but its rate of speed as well, for the charge must then be aimed, not at the spot where the target is when the gun goes off, but at the place where it will be when the lead reaches it. Suppose the target is a wild duck flying across the line of fire, at forty miles an hour, it being one hundred and twenty feet from the muzzle of the gun. The shot pellets will travel on an average of nine hundred feet per second, which is about sixteen times as fast as the fowl, so that for each foot the latter flies the charge will move toward it sixteen feet. The gun must then be pointed seven and one-half feet ahead of the creature, to allow the center of the charge to reach it. As the angle of the duck's flight changes, the estimation of speed and distance must likewise change, and this frequently at an instant's notice. Shooting at clay targets requires similar calculations, though in less degree, for distances and speeds are more uniform. The accurate judging of speed, as well as of distance, can be gained by practice, though actual shooting at moving targets is the only method by which the shooter can learn how far to hold his shotgun ahead of the object to make successive hits.

In aiming the gaze should be fixed on the target itself, and not upon the sights. The practice of keeping both eyes open, now the common method in shotgun shooting, is gaining favor with users of the rifle and revolver as well. A good clear view of the target is essential; and this is aided both by raising the gun to the mark and by using two eyes instead of one. It is the right eye, of course, that does the aiming, but the use of both gives the stronger, more definite vision. With the shotgun, in pointing ahead of the moving target, the sight cannot well be used, for the object would thereby be at least partly obscured by the muzzle and the time allowed is only an instant; so that with this weapon the aiming is done by pointing it as one would his finger, with arm extended. The use of both eyes in this work is, therefore, a great advantage.

Upon the difficult question of what kind of rifle sights to use, no advice can be offered except that all forms be tried out at the various kinds of work for which they are intended, and then a choice be made. Tastes and opinions differ so greatly in this matter that the experience of one person is seldom of any value to another. The front sight, if too dark in color, will be hard to see when the light is dim, while, if too bright, will give false direction when the sun shines upon one side of it. The latest cure devised for these evils besetting the front sight is make it bright and then place over it a hood to exclude excessive illumination. Such is the equipment used upon our present army rifle. In target shooting over long ranges the micrometer adjusters on rear sights are the necessary and important consideration. For short-range practice the rifleman may indulge his own fancy. The needs of the hunter, however, are somewhat different from those of the target shooter, for his game may be moving or half concealed, making it necessary for him to get the clearest view possible of the creature. A rear sight with a deep narrow slot will conceal his whole view, except for the small space immediately in front. That rear sight is the best which obscures the least; therefore the straight, transverse bar with a nick in it serves the hunter well.

The best rear sight ever invented for permitting an unobstructed view and giving a quick, accurate line on a distant object is that invented in 1870 by William Lyman of Middlefield, Connecticut. It is the peep sight, which does away

FIG. 90.—LYMAN COMBINATION REAR SIGHT

with the nick to be looked through, providing a small circular hole in the line of fire. Except for the upstanding front sight, there is no interference with the view so obtained. The value of the Lyman sight for general use has been disputed ever since its appearance, but for long-distance shots it has been adopted by the best marksmen the world over. With the coming of the high-powered, far-shooting rifle the supremacy of this sight is now generally acknowledged, not only by sportsmen but by military experts as well. Hence we see it today in a modified form, affixed to the service rifle as well as in common use by the sharpshooters of the Europeans.

One of the most important conditions necessary to good shooting is a healthy state of mind. No one can shoot well when tired or worried or ill; for of all sports none requires more concentration of mind and control of muscles than shooting. Harmonious action of the brain and limb are absolutely necessary to success. The real marksman plans the details of the shot he is about to make before he brings his gun into position, this preparation being done perhaps deliberately, or in the twinkling of an eye, as occasion requires. Hence if the brain be dull the planning will be faulty, and if the muscles do not respond promptly their failure will bring disaster. Shooting, therefore, not only requires a serene mind and great self-control, but the admirable thing about the sport is that it teaches and encourages these most valuable traits.

Correct form in shooting lies chiefly in finding a comfortable position for each style of shot and then sticking to it. The beginner should study carefully the booklets issued these days by ammunition concerns, and to be had for the asking, which contain excellent illustrations of the various postures approved by skilled marksmen. Each person, however, has peculiarities of his own and may safely depart in small details from generally accepted rules. After practice has disclosed the best positions there should be no variations from these, since a change in one particular upsets the whole arrangement, and interferes with that uniformity which is so necessary for consistent shooting. Above all, the position should be free and easy; otherwise strain and lack of balance will result, whereby progress in the art will be temporarily, if not permanently hindered.

A besetting sin of all beginners in shooting, is the tendency to delay the shot after the gun is in position, in the hope that a better alignment will be later obtained. This practice is a grievous weakness. While the motions needed to bring the sights upon the target need not be hurried, the piece should be discharged when sights and target *first* come into line. There must be no dallying. It requires resolution of mind at first thus to fire promptly, especially when something is at stake on the shot, but the habit once acquired will prove invaluable. At target shooting it is possible to be deliberate in action, but deliberation and caution must not be confused with hesitation. One may act slowly, yet with decision. The target range, however, should be used only as the preparing ground for more manful deeds with firearms. It frequently happens that he who makes the best scores in practice is the last of a hunting party to bring game to camp. Only the experienced hunter knows how often the quarry leaves but an instant in which to plan and execute a successful shot. The onset of a wounded bear does not allow the hunter much time for deliberation; and the dawdling soldier will fare hard when face to face with an enemy, where not only a straight shot but a quick one is required to save himself and overcome his foe. The great merit in trap-shooting with the shotgun lies in the necessity for there observing this vital element of time. Given but a second in which to hit the flying target to best advantage, the trapshooter must fire then or risk wasting his shot. It is for this reason that many fathers, in teaching their sons to shoot, take them to the traps for practice before permitting use of the rifle. Let the novice, then, take as his watchwords, not: "Straight shooting," but instead the better formula: "Straight shots promptly delivered."

Again, there is a class, composed not only of beginners, but occasionally of veterans also, who in firing grip the gun with grim determination as if they expected it to fly from their grasp when it goes off. Others handle the weapon as if it were a crowbar, requiring a strong heave. Nothing could be more subversive of good shooting than this unnecessary straining of muscles, the unconscious but underlying idea of which seems to be that these exertions of the firer are necessary to keep possession of the gun, or to aid the bullet on its way. In watching a skilful gunner making hits the onlooker is impressed with the apparent ease with which the weapon is manipulated, unhurried, unstrained, but prompt and decisive in each step of the performance. Such marksmen have learned well the adage which should be kept constantly in mind: *"Let the gun do the work";* all it ever asks for is the unhampered opportunity.

Up to twenty years ago the American gunners habitually carried off the world's chief trophies for marksmanship. Then for a while a lull in interest crept into the sport, during which we either failed to compete or had to be content with minor honors. This period of apathy has now happily passed, and the principal championships with all arms are ours again. But we should not rest content with the training of a few men of special skill, and sending them to win or defend trophies and championships. Honors thus brought to us are of small importance compared with what should be our real aspiration—to be a nation of skilled riflemen. It was not unthinkingly that the Fathers wrote into our constitution the declaration that the right of the people to keep and carry arms should never be infringed. Let each one of us, therefore, train himself in the use of the gun, not only for the health-giving sport afforded, but that we may one and all be better able to go to the aid of our country when she needs us for her defense, whether the enemy assailing her be from within or without.

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Not a rambling, hap-hazard collection but a vade-mecum for youth from the ages of six or seven to sixteen or seventeen. It opens with Nursery Rhymes and lullabies, progresses through child rhymes and jingles to more mature nonsense verse; then come fairy verses and Christmas poems; then nature verse and favorite rhymed stories; then through the trumpet and drum period (where an attempt is made to teach true patriotism) to the final appeal of "Life Lessons" and "A Garland of Gold" (the great poems for all ages).

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