In general appearance and structure it may be described as a small horse-chestnut. After shelling, the seeds are lightly roasted, by which the testa is loosened. The latter is then broken off and winnowed out, and the kernels are coarsely broken up in a wooden mortar and with a wooden pestle. Just enough water is added to form an adhesive mass. This mass is then moulded by hand into cakes, balls, or, more commonly into sausage-shaped rolls, six to ten inches in length by one or two in diameter. The drying of these is the most delicate and critical part of the operation. It is conducted by artificial heat, in specially built houses, great care being taken to avoid a disagreeable flavor from the smoke or from the subsequent development of some variety of mould through imperfect or unequal drying. Adulteration occurs only occasionally. It consists in making various additions—usually tapioca starch—to the mass before it is subjected to the drying process.

As regards the home consumption of guarana, it is the exact equivalent of tea or coffee, except that it is grated off and taken suspended in cold water. It is the staple beverage of millions of people. Its excessive habitual use brings on nervous disorders similar to those from other caffeine-containing beverages, and ending in a kind of palsy.

Description.—In subglobular or elliptical cakes or cylindrical rolls, hard and heavy; outer surface somewhat shortly nodular, smooth, slightly lustrous, deep chocolate-brown; rather brittle, the fracture uneven, often fissured in the centre, of a deep flesh color or pale reddish-brown, showing numerous coarse, angular, lustrous fragments of seeds partly invested with blackish-brown integuments; odor slight, peculiar, a little resembling that of chocolate; taste very astringent, somewhat bitter, afterward sweet, especially when chewing is followed by the taking of a swallow of water.

Composition.—Guarana stands at the head of caffeine-yielders, containing four or five per cent. A quarter of its weight is tannin, and there are starch, saponin, resin, and small amounts of fixed and volatile oil. It should not yield more than two and one-half per cent. of ash. It should be remembered that the domestic value of guarana depends largely upon its flavor. Many lots defective in this particular are exported for medicinal use and are not necessarily inferior for this purpose. At the same time, adulterated lots are undoubtedly manufactured especially for such export, but only rarely.

Action and Medicinal Use.—Because of its tannin, guarana is to be compared rather with tea than with coffee. Caffeine is elsewhere so fully treated that its action cannot be here discussed.

As the contained dose of tannin is a small one, it is, in fact, a mode of giving caffeine, and little or nothing more. Its principal clinical reputation lies in its value in nervous and sick headaches, of which there is considerable evidence. It has been the foundation of several widely known secret remedies for these afflictions.

The powdered drug can be given in gram doses or more, repeated once an hour, until the headache is relieved, or until several doses have been given. The fluid extract (*Extractum Guaranæ Fluidum*, U. S. P.) is rather neater, and of the same theoretical strength. Milk is a good vehicle for either.

Henry H. Rusby.

GUARANINE.—A name applied to *caffeine*, when derived from *guarana*.

Henry H. Rusby.

GUERNSEY AND THE CHANNEL ISLANDS.—The Channel Islands, comprising Jersey, Guernsey, Alderney, Sark, and several smaller rocky islets, are situated in the bay of St. Michael, off the coast of Normandy, and lie between the latitude of 49° 10′ and 49° 42′ North and 2° 2′ and 2° 40′ West longitude. Guernsey and Jersey are the only two islands which require consideration as health resorts, and their claim as such is based upon the mild sunshiny nature of their climate, especially in the late autumn and winter. "Recent statistics show that Jersey receives more sunshine than any other part of the United Kingdom." In these islands "camelias and rhodendrons flower in the open in February, frost is rare, and lasting snow unknown."

St. Helier's in Jersey and St. Peter's Port in Guernsey are the chief towns. The following table gives the climatic characteristics of Guernsey, which are practically the same as those for Jersey.

Climate of Guernsey and Jersey. Means for Ten Years. Height Above Mean Sea-Level, 180 Feet.

	January to March.	April to June.	July to September.	October to December.	Year.
Temperature—					
Mean average	43.7° F.	53.0° F.	60.5° F.	48.8° F.	51.5° F.
" daily range	7.6	10.8	10.9	7.6	9.2
" of warmest	47.5	58.4	66.0	52.6	56.1
" of coldest	39.9	47.6	55.1	45.0	46.9
" relative humidity	87%	83%	83%	86%	85%
Precipitations—					
Average in inches	7.53	5.82	6.96	12.22	32.53
Wind—					
Prevailing direction	....	....	....	....	W. and S. W.
Weather—					
Amount of sunshine	304 hrs.	665 hrs.	648 hrs.	247 hrs.	1864 hrs.
Mean cloud	7.1%	6.0%	6.6%	7.2%	6.6%
Rainy days	47	34	39	59	179

From this table we see that the general climate of these two islands (Jersey and Guernsey) is a mild, moist, marine one. The diurnal range of temperature is small, and there is an average of five hours of daily sunshine. Of the total rainfall one-fourth occurs in the months of October and January. March and April are considered the most trying time of the year on account of the north-easterly winds.

Of course the islands are exposed to the winds from all directions, which, coming from the ocean, are moist and salt-laden. The prevailing winds are westerly and south-westerly, especially the latter.

The following table of yearly averages of wind is given for Guernsey, for the period from 1845 to 1862, inclusive:

Northeast wind prevailed on 100 days.
Southwest wind prevailed on 104 days.
Northwest wind prevailed on 110 days.
Southeast wind prevailed on 51 days.

The drinking-water is obtained, for the most part, from wells. The drainage at St. Helier's and St. Peter's Port is by sewers into the sea.

The therapeutic effects of this climate arise from its mild sunshiny nature and its marine atmosphere. Elderly persons with low vitality and those with bronchial affections derive benefit from it. It is also of especial value for delicate scrofulous children and those of rachitic tendencies. It is unfavorable, on account of its moisture, for rheumatism, neuralgia, and renal diseases. Those with a tendency to respiratory troubles should not remain after the end of February. The Channel Islands are reached by boat from Southampton, Weymouth, or Plymouth in from six to ten hours, or from St. Malo or Granville, France, in two or three hours.

From a personal visit to Jersey the writer can testify to the delightful scenery of the island, both land and water, and the charm of the lovely drives through the winding roads, bordered by luxuriant vegetation. The air is fresh and invigorating and the sunshine most brilliant.

The writer desires to express his indebtedness in the preparation of this account of Guernsey and Jersey to "The Climates and Baths of Great Britain," by the Royal Medical and Chirurgical Society of London, 1895.

Edward O. Otis.

GUINEA WORM. See *Nematodes*.

GUINORAL (Chinoral) is an oleaginous, very bitter liquid, containing quinine and chloral. It is used as a hypnotic in doses of 0.5–1 gm. (gr. viij.–xv.), and also as an antiseptic.

W. A. Bastedo.

GUM ARABIC.—Acacia. *Gum Acacia. Gum Senegal.* "A gummy exudation from Acacia Senegal Willd. (fam. *Leguminosæ*)" (U. S. P.). In roundish tears, often an inch or more in diameter, transparent, except for the whitish fissures, of a glassy fracture, ranging from nearly colorless to a deep reddish-yellow, nearly tasteless and odorless, wholly soluble in two parts of water, to form a thick mucilage of a faintly acid reaction. The presence of starch in powdered acacia is detected by a blue color on the addition of iodine, that of dextrin by a red color. A pure solution will not be affected by neutral lead acetate.

This gum was formerly yielded by other species of acacia, notably *A. vera* Willd., and the very finest gum of commerce, now scarce and high, still proceeds from this species. It is chiefly in smaller tears, which are more brittle and broken, and less translucent and glassy, owing to the much more numerous fissures. Both species are small thorny trees of northern Africa, *A. vera* more abundant in the eastern, *A. Senegal* in the western districts. The gum is a decomposition product from cellulose and is more abundantly produced by unhealthy trees. It exudes from natural fissures and artificial incisions. Gums practically equivalent to acacia are produced by species in related genera. An excellent article is produced by species of Prosopis, growing in the southwestern United States, and known as Mesquit Gum, but the supply is too irregular to be utilized. The varieties of acacia are now little known by the locality-names formerly applied to them, the grading being done almost wholly by number, the quality depending upon whiteness and solubility. The pure gum consists wholly of compounds of arabic acid with potassium, calcium, and magnesium. Acacia has no physiological action, except that of a mechanical demulcent. Its pharmaceutical uses, as an excipient, for emulsionizing, and for suspending insoluble substances or those the acridity of which it is desired to mitigate, are very numerous and important.

Henry H. Rusby.

GUMMA. See *Syphilis*.

GUMS. See *Active Principles*.

GUNSHOT WOUNDS.—No chapter in surgery has undergone such radical changes as that pertaining to gunshot wounds in war. The changes have been coincident with the introduction of antisepsis and the new armament in hand weapons which employ armored projectiles. The changes with reference to the latter concern the military surgeon mostly. His *confrères* in civil life will continue to observe gunshot injuries, as far as their mechanical effects are concerned, as formerly. The wounds of this class that come under his care are mostly from pistol shot, the missiles of which are made of soft lead, are propelled at comparatively low rates of speed, and show a marked tendency to lodge and to deform upon impact with resistant structures.

In order to obtain a correct understanding of gunshot wounds a consideration of the implements which are concerned in their production is necessarily of much importance.

Portable Firearms.—Arms of this class are often referred to as portable band weapons. They include the firearms that are carried by hand in contradistinction to the larger guns of the artillery class. They are the pistol, shotgun, the smooth-bore muzzle-loading musket, and the rifle. A knowledge of the development of portable firearms as a whole, and of ballistics in particular, is indispensable to a correct appreciation of the subject of gunshot injuries. For all practical purposes a study of the evolution of the military rifle as it presents itself to the military surgeon will be quite sufficient to a general understanding of the subject.

Military Rifle.—A study of the guns concerned in the evolution of the small arms which culminated in the present military rifle deals with: (1) smoothbores like the flint-lock and musket; (2) the percussion-cap, muzzle loading rifle; (3) the breech-loading rifles; and (4) the breech loading magazine rifle with small calibre.

1. The smoothbores of the first class are represented by the old-time flint lock and later by the Spanish musket, whose calibre varied from .63 to .75. They fired a bullet made of soft lead weighing from 465 to 555 grains; the explosive was loose black powder in charges varying from 270 to 345 grains. The projectile was spherical in shape, with an initial velocity of from 540 to 690 foot seconds, while the maximum effective range was never more than 350 yards.

Our first three wars—the Revolutionary War, the War of 1812–14, and the Mexican War—were fought with weapons represented by this class. As implements of war they were considered very effective in their day, and yet at no time could the best type of them be loaded at greater speed than thrice per minute.

2. The percussion-cap, muzzle-loading rifles were first used in the Italian War of 1859; they were subsequently used in our Civil War, and in all European wars up to 1866. Instead of igniting the powder charge by means of a taper as in the old match-lock, or by the spark of a flint as with the flintlock, it made use of a small cap containing a detonating substance. The cap was placed over a hollow piece, the cavity of which led to the powder charge. The latter was ignited by causing the hammer to strike the cap.

In the earlier patterns of these guns there was so much escape of the powder gases through the inequalities between the ball and sides of the weapon, with consequent loss of energy, that the practice of slightly reducing the calibre of the gun as compared to that of the diameter of the ball, and grooving the interior of the former, was resorted to. This was done to insure greater accuracy in the fit of the ball. In order to allow more of the surface of the ball to come in contact with the barrel, it was elongated. The fit of the ball was so tight that it was necessary to drive it down with a ramrod and hammer, both of which formed part of the equipment of the soldier at that time. This gave greater exactness of fit between the ball and barrel and both added to the energy and extended the range by retaining the projectile a trifle longer in the barrel, while the explosive was generating a greater volume of gas. It was noticed that the elongated bullet fired from such a gun was apt to tumble or lose its balance, and this was overcome in a measure by giving the grooves in the barrel a spiral turn, at the rate, in the earlier guns, of one complete turn in about seventy-eight inches. This added much to the stability of the bullet, keeping its point foremost for a longer time in its flight, thereby adding to its range and effectiveness. This principle in ballistics should be specially remembered, aside from the development in the use of explosives, because it is really the initial point in the great strides that have been made in the effectiveness of bullets. The act of loading with the ramrod and hammer was very laborious. To overcome the difficulty Delvigne, a French army officer, hollowed out the base of the projectile next to the powder. The expanding gases pressed the sides of the cup so formed into the metal grooves in the barrel, thus causing the bullet to take the rifling. Later, in 1847, Captain Minié made a still further advance by suggesting the use of an iron disc in the cup. The harder metal being forced against the sides of the cup insured greater expansion than the gases alone, so that the accuracy of fit between the ball and the barrel was more completely secured. The so-called Minié rifle used in the Crimean War, and our own Springfield used in the Civil War, were loaded with such bullets. The following were the principal features of the Minié rifle which correspond with those of our earlier make of the Springfield rifle.

Minié-Rifle, 1851 to 1866.

Weight with bayonet	10 pounds 8¾ ounces.
Diameter of bore	.702 inches.
Number of grooves	4
Twist	1 turn in 78 inches.
Diameter of bullet	.690 inch.
Weight of bullet	680 grains.
Charge of powder	150 "
Sighted for 100 to 1,000 yards.	

The old Minié ball formed the section of a cone, so that the accuracy of fit in the barrel was confined almost entirely to the base of the bullet. The resulting inequality of its different sectional areas disturbed the balance of

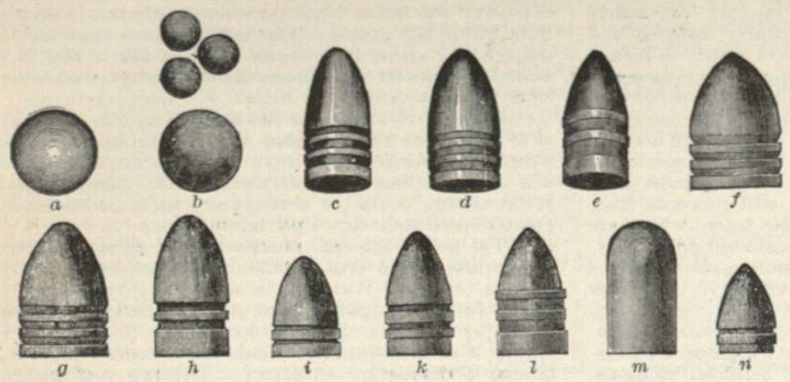


FIG. 2353.—Different Kinds of Projectiles. *a*, United States round musket ball, calibre .69, weight 387 grains; *b*, buck and ball, calibre .69, weight of ball 387 grains; *c*, Springfield rifled musket ball, calibre .58, weight 500 grains; *d*, Enfield rifled musket ball, weight 450 grains; *e*, Austrian rifle ball, weight 460 grains; *f*, elongated bullet, calibre .71, weight 675 grains; *g*, elongated bullet, calibre .69, weight 760 grains; *h*, elongated bullet, calibre .577, weight 517 grains; *i*, Burnside rifle bullet, calibre .54, weight 400 grains; *k*, Spencer rifle bullet, calibre .56, weight 434 grains; *l*, Sharp's carbine ball, calibre .52, weight 450 grains; *m*, Green's rifle ball, calibre .53; weight 575 grains; *n*, Colt's army pistol bullet, weight 207 grains.

the projectile to such an extent that its stability in flight was soon lost. Instead of rotating on its long axis, it was apt to tumble or to commence to rotate on its short axis, at right angles to its line of flight. To overcome this difficulty the body of the projectile was made cylindrical; the base was cupped, the metal stopper was replaced by a boxwood plug, and the head was made hemispherical instead of conical in shape. This was the missile used in the Enfield of the English foot troops till 1871, as well as in our old pattern Springfield rifle, which formed the armament of our infantry from 1855 to 1873. The calibre of the latter at this time was reduced to .58, its weight to 500 grains, and the charge of powder to 80 grains.

3. Breech-loaders. The great desire of military men to increase the rapidity of fire led to the introduction of breech-loaders. Although loading by the breech had been practised since the reign of Henry VIII., the mechanism of the earlier weapons was so uncertain and clumsy that they were not used by armies until about 1866, when the Germans demonstrated the superiority of their needle gun in the Austro-Prussian war.

In 1866 the United States Government modified the muzzle-loading Springfield rifle by adding the breech-block which permitted loading by the breech. It was at this time that the calibre was reduced to .50. In 1873 the calibre of this same weapon was further reduced to .45, the twist was shortened to 1 turn in 22 inches, the charge was reduced to 70 grains of black powder, while the weight of the bullet was still retained at 500 grains. These improvements increased the velocity at the muzzle to 1,301 foot seconds, and the maximum effective range to 2,000 yards. Compared to the effectiveness of a generation before the advancement was certainly very great, yet those who marvelled at these rapid strides in the manufacture of the engines of war were hardly prepared for the rapid advances that were soon to follow.

4. *Magazine Breech-loading Rifles, with Reduced Calibre.* The modern tactics in war involve rapidity in movements, and with these rapidity in fire. The latter led to the introduction of the magazine rifle, an arm that carries a reserve of ammunition in some part of its mechanism. Increased expenditure of ammunition with the new arm necessitated a greater number of rounds per man. But the soldier was already loaded to the maximum of weight, so that the number of rounds could be increased only by reducing the calibre and thereby the weight of the bullet. The calibre of military rifles has thus been reduced as far as .26, and the weight of their projectiles as low as 156 grains, thereby nearly doubling, for the same weight, the number of rounds that soldiers usually carried. This reduction in calibre of the rifle increased the difficulty incident to fouling, *i.e.*, to the lodgment of the unconsumed residue of the old black powder on the inner wall of the barrel, and eventually led to the introduction of so-called smokeless powders that leave little or no residue, and that possess the further advantage of conferring upon the projectile a greater initial velocity (owing to the fact that the gases which they emit are relatively more voluminous than those resulting from the ignition of the old black powder). This increase in velocity added quite a complication. The lead bullet instead of keeping point on, tumbled, to prevent which, a shorter twist was given to the grooves in the barrel. Instead of one complete turn in 22 inches, the twist was shortened to 1 in 10 inches. The old lead bullet became refractory under the bidding of such a sharp turn. Instead of following the new twist it was apt to strip through the barrel without properly revolving, a difficulty which was obviated by coating the lead with some harder metal.

Generally speaking, the classification of gunshot wounds is based on the character and size of the missiles that caused them.

Shotgun: The missiles from ordinary shotguns vary from fine round lead projectiles running from 2,020 to the troy ounce, to B. B. shot of .88 inch diameter running 7 to the troy ounce.

Pistol: The missiles projected from pistols or revolvers vary in size and shape, being generally round or conical, ranging from .22 to .45 in calibre, and weighing from 28 to 254 grains; they are composed usually of lead

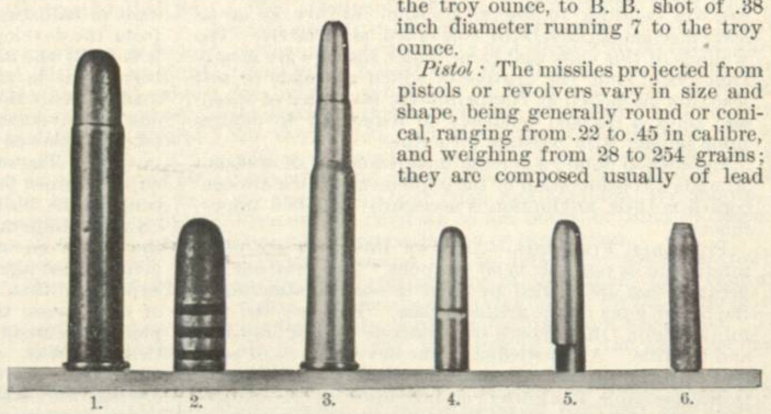


FIG. 2354.—Projectiles for Rifles. 1, Complete cartridge .45 calibre Springfield rifle; 2, projectile of cartridge .45 calibre Springfield rifle, 480 grains; 3, complete cartridge .30 calibre Krag-Jörgensen rifle; 4, steel-jacketed projectile, Krag-Jörgensen rifle, 220 grains; 5, steel-jacketed projectile, Krag-Jörgensen rifle; 6, the lead nucleus of Krag-Jörgensen projectile.

hardened with antimony in the proportion of 95 parts of the former to 5 parts of the latter. The missiles from the remainder of the hand weapons should be divided into two classes, viz., those of the smoothbore guns and

those of the rifles. Those of the latter should be further divided into the lead and jacketed projectiles.

Smoothbores.—The missiles of the smoothbore guns were round, made of soft lead, ranging from .68 to .75 in calibre, and weighing from 465 to 555 grains.

Lead projectiles for rifles were conoidal in shape and composed of lead, generally hardened with antimony; they ranged from .45 to .71 in calibre, and weighed from 387 to 675 grains.

Jacketed projectiles for rifles are made of a lead core enclosed in a mantle of harder metal, like copper, German silver, white metal, or cupro-nickel steel—generally of the latter. Their calibre is much smaller, .26 to .31, and their weight ranges from 156 to 244 grains.

range, from 300 to 500 yards, depending upon the calibre of the gun.

EXPLOSIVES.—The modern advance in conferring extended range, velocity, and penetration upon projectiles, is due to the development in the use of explosives. They are employed not only to propel missiles into space, to explode projectiles, etc., but also to explode mines, fugases, and bombs in offensive and defensive warfare; and, by evil-doers, in the destruction of life and property. A consideration of these various chemicals and the manner of their action in the creation of wounds naturally falls under the subject of gunshot wounds. Among the more familiar explosives may be mentioned: gunpowder, fulminates, and certain chemical compounds.

TABLE I.—BALLISTIC DATA OF THE NEW SMALL-CALIBRE RIFLES NOW ADOPTED BY DIFFERENT NATIONS.

Army.	Rifle.		Bullet.				Smokeless powder, grams.	Muzzle velocity, metres.	Muzzle energy in kilogram-metres.	Point-blank Range.		Rounds in magazine.
	Designation.	Calibre, mm.	Calibre, mm.	Weight, grams.	Length, mm.	Structure, core, and casing.				Infantry, metres.	Cavalry, metres.	
Argentinian	Mauser, 1891	7.65	7.89	13.7	30.7	Lead, cupro-nickel, steel	2.64	635	....	558	640	
Austrian	Mannlicher, 1888–1890	8.0	8.19	15.8	31.8	Hard lead, steel case	2.74	620	309.6	466	548	5
British and Canadian	Lee-Metford, 1893, Mark II.	7.7	7.89	13.9	31.5	Hard lead, cupro-nickel	1.97	630	320.4	503	687	8
Brazil, Chili, Mexico, Spain	Mauser, 1894–1895	7.0	7.22	11.3	30.9	Hard lead, cupro-nickel, steel	2.89	720	275.8	622	695	5
Danish	Krag-Jörgensen, 1889	8.0	8.19	15.4	30.0	Lead, cupro-nickel	2.19	620	283.2	....	....	5
French	Lebel, 1886–1893	8.0	8.19	15.0	30.0	Hard lead, cupro-nickel	2.79	630	305.4	515	608	8
German	Mauser, 1888	7.9	8.10	14.7	31.25	Hard lead, cupro-nickel, steel	2.74	640	286.1	530	594	5
Italian	Mannlicher-Carcano, 1891	6.5	....	10.5	30.5	Hard lead, cupro-nickel	1.87	700	262.2	....	....	5
Russian	Kapit-Mozin, 1891	7.62	7.79	13.68	30.2	Hard lead, cupro-nickel	1.97	620	271.6	512	580	5
Roumanian	Mannlicher, 1893	6.5	6.70	10.34	31.5	Hard lead, cupro-nickel, steel	2.44	720	272.9	....	....	5
Swiss	Schmidt-Rubin, 1889	7.5	8.10	13.7	31.7	Hard lead, steel point, paper jacket.	1.94	600	251.4	507	590	12
Turkish	Mauser, Belgian, 1890	7.65	7.89	13.8	30.8	Lead, cupro-nickel	....	652	303.4	515	608	5
United States	Krag-Jörgensen modified, 1892.	7.62	7.82	14.26	30.63	Hard lead, cupro-nickel, steel	2.09	610	275.4	515	584	5

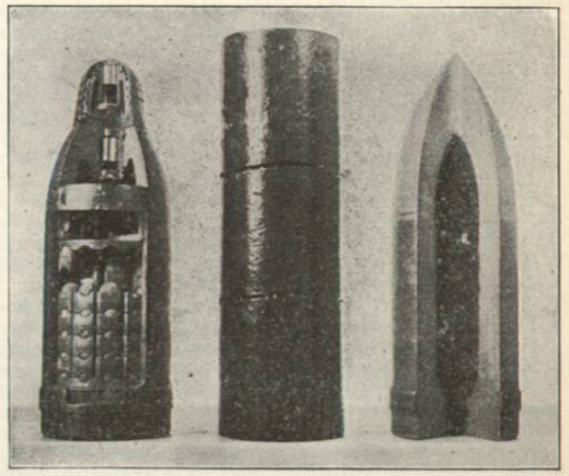
Aside from the foregoing there are other missiles and substances concerned in the production of gunshot wounds. These are principally employed in warfare, and they may be considered under the following heads:

LARGE PROJECTILES OR THEIR FRAGMENTS.—These are the large solid shot, and large hollow shells provided with a charge of some explosive used to generate expansive gases that break the projectile into fragments at or about the time of impact. The large solid shot from cannons is used to penetrate armor and to demolish fortified positions. The hollow shells are used to develop positions, and this is done by observing the distance at which bursting occurs, thereby establishing the range.

Shrapnel.—The use of shrapnel is largely restricted to the artillery arm in war, a typical example of which is found in the Frankford Arsenal Shrapnel in use by our field artillery. It is a hollow steel projectile composed of a head, body, and base. The head contains 2¼ ounces of black powder; the body holds 162 lead and antimony balls, 41 to the pound, disposed in circular layers and held by cast-iron separators. The shell and separators are deeply grooved to invite separation into corresponding fragments at the time of bursting. The head is provided with a fuse which is so timed that explosion is made to take place at any interval of 60 yards or one-sixth of a second. As many as 202 missiles have been counted after an explosion. The maximum effective range of this projectile is 7,000 yards. The flight of the fragments represents an extending cone for 400 or 500 yards, the diameter of which is 30 feet at a distance of 25 yards from the place of bursting.

Canister.—Canister, sometimes called caseshot, is a projectile not unlike the shrapnel. It is cylindrical in shape, the walls of the cylinder being composed of a thinner metal and enclosing 200 or 300 round lead balls hardened by antimony. The projectile is ruptured close to the muzzle at the moment of discharge by the force of the explosion in the gun, and not by the liberation of gases from an explosive within the shell, as occurs in the case of the shrapnel. Such a projectile is of use only at close

Gunpowder.—Gunpowder is the most ancient of all explosives. It is generally referred to as black gunpowder to distinguish it from certain chemical compounds which vary in color from brown to black and which are usually designated as smokeless powders. The composition of black gunpowder has remained almost constant for cen-



1. 2. 3.

FIG. 2355.—Larger Projectiles. Shrapnell (1), Canister (2), Shell (3), Used with 3.2 inch Breech-Loading Rifle-Filled Batteries.

turies, viz., saltpetre, charcoal, and sulphur in percentages of something like 75, 15, and 10 in the order named. In this mixture saltpetre furnishes the oxygen, carbon supplies the fuel, and sulphur promotes the rapidity of the explosion. Gunpowder explodes when heated to 700° F. The volume of the gas which it generates occupies 250 times the bulk of the charge employed. It is this resulting expansion which serves to propel the missile from a gun barrel and which confers upon it such velocity as to enable it to penetrate tissues, thereby causing gunshot injuries. The temperature of the flame which is noticed at the time of ignition has been variously estimated at 2,000° to 4,000° F., a fact which doubtless has had much to do with spreading the old-time notion of the searing and burning effects of bullets upon the tissues. The chemical results of the disintegration of gunpowder are 32 per cent. of gaseous products, and 68 per cent. solid residue. The gases generated are carbonic oxide, carbonic acid, and nitrogen, with some aqueous vapor. The pressure which the gaseous products exert on the gun barrel is said to be more than 4,000 atmospheres for 1 gm. of the powder ignited.

Fulminate Powder.—Fulminate of mercury is principally used as a detonator in exploding guncotton and other explosives, and also in charging percussion caps and primers. The volume of gas generated for the amount of substance is relatively very large. Disintegration of the substance into gases is so rapid and the pressure exerted by the sudden displacement of air is so violent in all directions that the term detonate has been employed to characterize the explosion. Thus we say that it detonates instead of saying that it explodes. The gases formed are carbonic acid, nitrogen, and vapor of mercury. As an example of the tremendous force exerted by the sudden displacement of these gases, it may be stated that in the attempt to assassinate the French Emperor in 1858, three tubes, each containing two ounces of the fulminate, were exploded, and from these explosions there were produced 511 wounds upon 51 persons.

Smokeless Powders.—So called because they emit very little smoke as compared to black gunpowder; and unlike the latter they exhibit neither flame nor burning at the time of explosion. As to their exact composition it may be stated that they are secret compounds. In a general way we know that they are composed of guncotton (cordite), dynamite, or picric acid (melinite). Some of the smokeless powders that have been analyzed show ninety-four per cent. guncotton, five per cent. nitroglycerin, one per cent. castor oil. Melinite is made up of picric acid with collodion jelly. Aside from those composed of guncotton or picric acid as a base, there is a class known by various names, such as roburite, rock-a-rock, hellofite, securite, etc., which explode only upon mixing two or more substances, as chlorinated dinitrobenzole with ammonium nitrate, chloride of potassium impregnated with liquid hydrocarbon, naphthalin, phenol, or benzin in fuming nitric acid, etc.

The causes that influence the character of gunshot wounds may be treated under the following heads:

MECHANICS OF PROJECTILES.—The character of gunshot wounds has been as much influenced by the discovery of high explosives as it has by the perfection attained in the manufacture of firearms. These two essential particulars involve a study of the motion of bullets in flight in order that the lesions inflicted on impact may be properly interpreted. It is only with such knowledge that penetration, smashing, and mutilation of tissues can be explained in a given case.

Trajectory.—The trajectory of a projectile is the curve which it describes in space from the muzzle to the first point of impact.

Velocity.—In speaking of the flight of a projectile in space we employ the term velocity, and this in turn is usually divided as follows:

1. Initial Velocity.—The initial velocity of a projectile is its rate of motion as it issues from the muzzle of the gun, that is, the number of feet it passes over in one second of time, known in mechanics as the foot-second system. For revolvers this rate is seldom more than 700 foot seconds, whereas, with the more perfect hand rifles, it is as much as 2,400 foot seconds.

2. Remaining Velocity.—The remaining velocity is the rate of speed which a bullet still possesses at any given point in its flight. Thus, for instance, the projectile that may issue from the muzzle of a given weapon at the rate of 1,800 foot seconds, is so influenced by the gravity of the earth and friction against the air that its flight is impeded in proportion as the distance from the gun increases, so that, on reaching a distance of 500 yards, the velocity, instead of being 1,800 foot seconds, will have fallen to 900 foot seconds.

Energy.—The energy of a bullet has always been of interest to surgeons, because its power to do work is measured by the energy which it possesses of overcoming resistance at the moment of impact. In olden times when the manufacture of firearms was imperfect and our knowledge of explosives was restricted to black gunpowder, we sought to increase the energy of a projectile by increasing its mass, but to-day superior knowledge in manufacture and modern advance in the use of explosives enable us to attain the same end by increasing the velocity. The latter method is more effective in this, that formerly if we chose to double the energy of a projectile we doubled its mass, whereas to-day we double the velocity and thereby increase the energy fourfold. The following table illustrates the two velocities, and the energy of our present service bullet and that of the Springfield rifle at varying ranges up to 2,000 yards.

The velocity and energy of the projectiles of the two weapons at different ranges are as follows:

TABLE II.—VELOCITY OF THE PROJECTILES OF THE TWO GUNS.

Name and calibre of weapon.	Initial velocity.	500 yards.	1,000 yards.	1,500 yards.	2,000 yards.
Springfield, calibre .45	1,301	873	676	531	429
* Experimental Springfield, calibre .30	2,000	1,103	804	627	495

ENERGY OF THE PROJECTILES (IN FOOT POUNDS).

Name and calibre of weapon.	Initial velocity, F. S.	Weight, grains.	Muzzle.	500 yards.	1,000 yards.	1,500 yards.	2,000 yards.
Springfield, calibre .45	1,301	500	1,879	846	507	313	204
* Experimental Springfield, calibre .30	2,000	220	1,954	594	315	192	120

* Which corresponds in ballistic value to the Krag-Jörgensen rifle.

Rotation of Bullets.—As a bullet issues from a gun two motions are imparted to it: one of translation and one of rotation. The former is due to the pressure of the powder gases which impel it onward into space, the latter is either accidentally or purposely given. In the first instance we have the rotation that was observed with old spherical bullets from smoothbores, in which the direction of the rotation was marked by the last point of contact of the projectile with the inside of the gun barrel. The axis of rotation was always at right angles to the line of flight, and its rapidity was always variable. In the latter instance we have the rotation that is purposely conferred by the gunmaker in grooving the inside of the barrel with from two to five or six spiral grooves, the direction of which, usually to the right, is followed by the bullet as it issues in a rotatory motion from the muzzle. This rotation is purposely conferred on elongated bullets to keep them moving point on. The axis of rotation with them is parallel to the line of flight, and not at right angles, as it is with spherical bullets. The velocity of rotation is determined by the sharpness of the twist in the barrel. In our present service rifle the twist describes one complete turn in about ten inches.

Shape and Density of Projectiles.—The character of a gunshot wound is often influenced by the shape and density of the missile that inflicts it. The tendency with the old spherical ball from smoothbore guns upon impact with resistant bone was to smash or comminute the bone at the point of impact, doing little or no damage to

the shaft above or below. As the bullet was composed of soft lead, a resistant bone usually caused it to mushroom or otherwise lose its shape, thus adding to the amount of comminution. Later, as the rifle came in vogue, the cylindro-conoidal bullets were introduced. The effect of these wedge-like missiles was to penetrate and produce splintering above and below the point of impact, thus causing displacement of larger fragments of bone beyond the foyer of fracture. The deformation of the leaden missile added to its sectional area, thereby magnifying the destructive effects. The tendency to penetrate was still further increased by the employment of jacketed projectiles. The hard envelope preserves the munition. That the trajectory of the new rifle is flatter, and that the dangerous space is consequently greater, is also apparent, since those versed in ballistics have shown us that the point-blank range of the older gun of the Springfield pattern is 300 yards, while that of the Krag-Jörgensen rifle, our present service gun, is about 570 yards.

The advantage of less recoil is perfectly apparent to any one who will shoot the two last-named weapons one after the other. The remaining advantages claimed by Hebler were not so readily determined. Greater accuracy and less deviation by wind had to be determined by comparison at target. Although the small-bore guns and

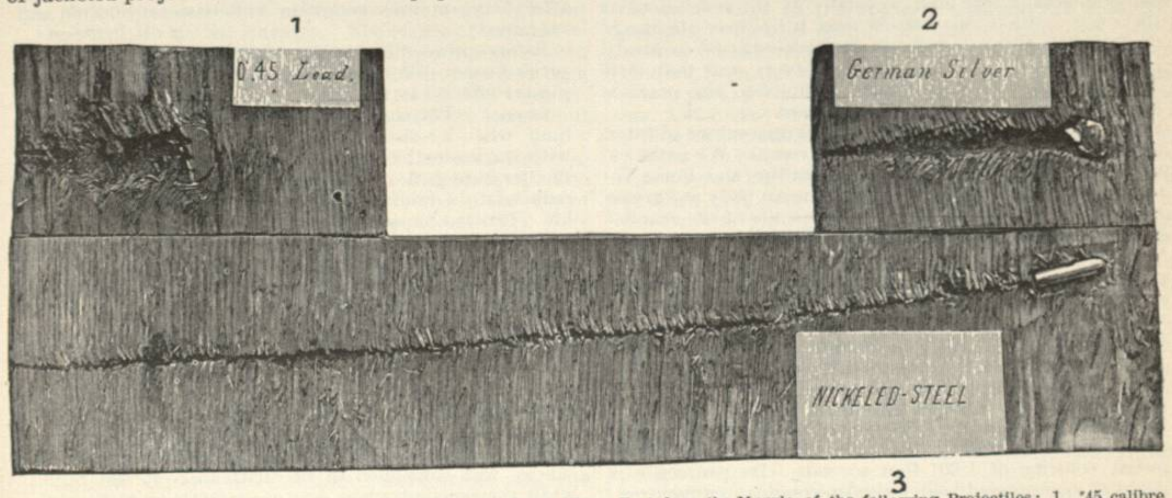


FIG. 2356.—Shows the Penetration in Hard Oak, against the Grain, Three Feet from the Muzzle, of the following Projectiles: 1, .'45 calibre leaden projectile, weight, 500 grains; I. V., 1,300 f. s., 3.'2. 2, .'30 calibre German-silver jacketed projectile, weight 220 grains; I. V., 2,000 f. s., 5.'3. 3, .'30 calibre nickel-steel jacketed projectile, weight 220 grains; I. V., 2,000 f. s., 19.'5. The latter was not deformed.

shape of the projectile, so that the additional amount of destruction consequent upon deformation, so often noticed with the old leaden bullet upon impact with resistant bone, is seldom noted. The tendency with it is to perforate and fissure bone rather than to cause extensive comminution.

The introduction of the modern rifle of reduced calibre at a time when the world was at peace rendered experimental evidence necessary to show what might be the difference in destructive effects between it and the older weapons of larger calibre and lower velocities. At no time in the history of firearms has the subject of the mechanical effects of projectiles been so thoroughly studied as it has during this so-called experimental stage. The experiments of military surgeons in the different countries of the civilized world and their studies of the injuries caused by gunshot have been conducted in such a thorough fashion, and they have entered so minutely into the mechanics of projectiles generally, that a report of what has been learned cannot fail to be of practical value to the civil as well as to the military surgeon.

Our knowledge of the rifles of reduced calibre propelling armored projectiles dates from the publication of Professor Hebler's pamphlet in 1882. In his original monograph Hebler claimed certain advantages for the reduced calibre rifle, among which were the following: (1) lighter ammunition; (2) flatter trajectory and greater dangerous space; (3) less deviation by wind; (4) less recoil; (5) greater penetration; (6) greater accuracy; (7) the wound produced, while being sufficient to disable, is much more humane.

Some of these advantages were so apparent that they could not be refuted, while the others required the proof which could be obtained only by experiments or by observation of the actual conditions in the field.

That the ammunition is lighter there is no doubt, since a soldier who carries 100 rounds of the older ammunition can carry for the same weight about 180 of the new ammunition have been perfected very much of late, it is yet a fact that, in the remote ranges, the smaller and lighter projectile is more influenced by wind than the heavier and larger leaden bullet, and that for these ranges it is not so accurate.

Greater penetration was another important advantage claimed by Hebler, and this claim was sustained by experiment. In unseasoned oak, firing across the grain three feet from the muzzle, the old leaden .45 calibre bullet from the Springfield rifle penetrates but five or six inches, while the steel-jacketed bullet of our present service rifle at the same distance will penetrate nineteen or twenty inches.

The last of the advantages claimed by Hebler, and the one of greatest interest to mankind, was that *the wound produced, though sufficient to disable, is much more humane.* This claim could be determined only by experiments on cadavers, and on the lower animals, and by observation of the actual conditions in battle. In all the leading countries of the world, from 1886 to the present time, competent men have been experimenting upon the lower animals and upon dead human bodies, for the purpose of ascertaining the character of the wounds inflicted by the different missiles employed in warfare. The Surgeon-General of the Austrian army, Johann Habart, Chauvel and Ninier, of the French army, Bruns, of Germany, and many others have furnished us important data upon the effects of the new arm. In this country the subject was first undertaken in 1893 when the change in our armament took place.*

Although there was some difference in the mechanism of the guns used by the different experimenters, the projectiles which they propelled differed but little as to calibre and destructive effects. The most of the experiments were conducted at simulated ranges. That is to say, if the work at Frankford Arsenal be taken as an example,

* Annual Report, Surgeon-General United States Army, 1893.

all of the firing was done at fifty-three feet. When it was desired to obtain the effects of a bullet at a certain range, the charge of powder was reduced in quantity enough to give the bullet the remaining velocity for that range. The results thus obtained were generally uniform, and, as far as the experimenters were concerned, sufficiently conclusive. Some critics refused to accept the results of the experimenters as final, upon the ground that the simulated velocities of the projectile, and the dead tissues fired into, did not represent the conditions that must obtain in war. It is specially gratifying to those who labored upon the problems involved to find that their deductions have been amply justified by clinical evidences in war, and especially by the revelations of the *x*-ray. When one reflects that it has been the usage of French military surgeons for generations to study gunshot wounds by firing into cadavers, and that it is done by order at Val de Grâce to this day, the practice has this claim to recommend it at least.

In order to make the results more apparent we adopted the following plan at Frankford Arsenal: We noted (1) the effects of a projectile of larger calibre and lower velocities upon different parts of the human body at various ranges; and (2) the effects of a projectile of the smaller calibre and greater velocities upon similar parts of the human body, or upon parts offering about the same resistance at similar ranges. The larger calibre weapon selected was the Springfield rifle, calibre .45, the gun which had formed the armament of our foot troops since 1873. The smaller calibre weapon employed, and to which the experiments were especially directed, is known as the Experimental Springfield rifle, calibre .30.

The following is a description of the more important ballistic properties of these weapons: "The Springfield rifle is a .45 calibre gun, the projectile of which has an initial velocity of 1,301 foot seconds. Its projectile is made of compressed lead, cylindro-conoidal, cannelured, and lubricated, weighing 500 grains, impressed by 70 grains of black rifle powder. The Experimental Springfield rifle is a .30 calibre gun, the projectile of which has an initial velocity of 2,000 foot seconds. Its projectile is made of a German silver jacket filled with a core of lead, and is not cannelured or lubricated."

It will be seen by Table II. that the initial velocity of the smaller calibre projectile is far greater than that of the larger calibre, and that the striking velocity at all the ranges is greater.

The penetration of a bullet is proportional to the square of its striking velocity; for equal velocities the penetration is proportional to the density of section. The form of the bullet and its power to resist deformation have a powerful influence. The penetration of the 220-grain bullet is greater at all ranges. This quality of penetration in projectiles is always of great interest to surgeons, and it becomes especially so in this instance, since it depends to a material extent, as far as the human body is concerned, upon the almost indestructible hardness of the projectile.

In the experimental work referred to, the penetration at the different ranges was obtained as follows: A Le Boulenge chronograph was used, the distance between first and second targets being 100 feet, and the first target being 3 feet from the muzzle. The remaining velocities of both bullets used (500 grains, .45 calibre, and 220 grains, .30 calibre) were computed for the desired ranges by the methods given in Ingall's "Exterior Ballistics." To find the penetration at a given range, say 1,000 yards, the procedure was as follows: The remaining velocity at this range computed as above, was found to be 676 foot seconds for the 500-grain bullet. The charge of powder was successively reduced until a charge was found which gave at 53 feet from the muzzle a velocity of 676 foot seconds. Cartridges were made up with this charge, and the cadaver to be fired at was placed at 53 feet from the muzzle. The striking velocity of the bullet being the same as that of a bullet fired with the full charge and striking an object at a distance of 1,000 yards the penetration would also be the same. At the ranges of 1,500 and 2,000 yards respectively, it was found necessary, in order to record the low velocities obtained, to reduce the distance between targets to 50 feet, which caused the velocity to be determined at 28 feet from the muzzle. At these ranges, therefore, the cadavers were placed 28 feet from the muzzle. A tackle was provided for traversing the cadavers and bringing a portion of the body to be fired at into proper position. Barrels filled with sawdust were placed behind the cadaver experimented with, to catch the bullets and preserve them from deformation other than that received in their passage through the body. Each bullet was marked on its base with a number or letter, for the purpose of identification, and after firing at each range the bullets were collected and examined.

Before proceeding to the observation of gunshot injuries proper, some facts were noted on impact and explosive effects, as follows:

Impact.—The shock as shown by the oscillation of the limb, when a resistant bone was hit, was always greater with the leaden bullet of .45 calibre than with that of the smaller-bore gun; on the other hand, the difference was reduced to a minimum when the soft parts alone were hit. It often happened that the occurrence of a fracture from the impact of the smaller projectile was determined only after a careful examination of the wound. This difference in shock was noted at all the ranges, but especially so after the 500-yards range.

The minimum amount of shock for the smaller projectile depends upon the superior penetration, which, as stated already, is due to its smaller calibre, greater velocity, and last, but not least, because it preserves its shape unaltered. The fact that the calibre of the Springfield was greater sufficed to explain the greater amount of shock. This was added to by deformation. Part of the energy was consumed in the flattening of the bullet, while the remainder was conveyed to the part hit in the form of shock. The difference in the amount of shock is at once suggested in Table II., already cited. It will be seen that the striking energy in foot pounds for all the ranges is greater with the projectile of the .45 calibre Springfield rifle.

Explosive Effects.—The explosive effects caused by the projectile of the Springfield rifle were noticed up to 200, and in some instances up to 250 yards, while the explosive effects of the projectile of the experimental Springfield rifle extended in some instances as far as the 350-yards range.

The term "explosive effects" is somewhat confusing, as it is apt to convey the idea that the wound was caused by an explosive bullet. It is a term that doubtless owes its origin to the similarity in the appearance of the two wounds. When we say that a wound shows explosive effects, we mean that it appears as though it had been caused by an explosive bullet. As a rule, the wound of entrance presents no special features to which attention should be called. In only a few instances is a certain amount of bone sand found in the tract leading to a fractured bone. When a resistant bone has been hit, the foyer of fracture will show great loss of substance, the bone will have been very finely comminuted, the pulverized bone will have been driven not only in the direction in which the projectile was travelling, but in all directions, and the pulpification of the soft parts will not only be limited to the track of the bullet, but utter destruction is noticed for some distance into the surrounding tissues. The wound of exit appears like a bursting forth of the skin; the track leading to the bone is conical in shape, the base of the cone corresponding to the wound of exit in the skin and the apex to the seat of fracture.

The degree of explosive effects corresponds to the velocity of the projectile at the moment of impact and the resistance offered by the part hit.

The bony structures are not alone in showing explosive effects with high velocities. Explosive effects have been noted with the projectile of the reduced calibre weapons up to 500 metres in "very vascular tissues, cavities filled with liquid or semi-liquid or viscous masses, such as the

skull, heart, liver, spleen, kidneys, stomach, intestines, and bladder, which have been attributed by some observers to hydraulic pressure."

In order to test the influence of hydraulic pressure in causing explosive effects, some interesting experiments were conducted at Frankford Arsenal.

1. Empty powder cans were fired into at various ranges. The orifices of entrance and exit were found proportional to the size of the projectiles employed. The cans were not deformed, showing no explosive effects.

2. A half-dozen or more powder cans from the same lot were filled with wet sawdust. The cans were fired into at various ranges. The orifice of entrance in each case presented no special features. The orifice of exit, however, for both projectiles was marked by a bursting forth of the tin and loss of the contents. The cans had been expanded as if by an internal force, which had been exerted in all directions. The explosive effects were about the same for both bullets.

3. Another lot of powder cans of the same size and dimensions was filled with water and fired into. The results were quite similar to those observed in the case of the wet sawdust, only more extensive, and they were about equal for the two projectiles.

The following observations upon the explosive effects of projectiles at relatively short ranges picture in a marked degree the wounds that surgeons have to treat, as a result of high velocities, and unless one is prepared to interpret their true cause he is apt to fall into very erroneous conclusions.

Notes of Gunshot Injuries on the Human Body; Experiments Conducted at Frankford Arsenal, Pennsylvania, on March 18th, 1893, with the Large and Small Calibre Projectiles, for the Purpose of Noting the Explosive Effects at Relatively short Ranges.

1. Gunshot injury, left humerus, at junction of middle and lower thirds; bullet No. 4, calibre .45; range, 17 yards. The wound of entrance is oval, .55 inch in its greatest diameter. The wound of exit is marked by a chasm on the back of the arm four inches in length, 2.36 inches in width, the edges of which are ragged. There is eversion of muscle and fat. The soft parts contain minute fragments of bone, which have been driven some distance into the tissues. The bullet struck the humerus at the junction of the middle and lower thirds. The foyer of fracture shows a loss of substance of the shaft 1.60 inches in length. There is extensive comminution. The fragments (twenty-three being readily counted) are greatly displaced, and the majority of them are free from the periosteum. The bullet is very much mushroomed, having lost about one-half in weight.

2. A gunshot injury by the .30 calibre projectile, at the same range, on the opposite arm produced a wound of entrance which is round, .35 inch in diameter. The wound of exit is 4.30 inches in length, and 2.36 inches in width. It is marked by pulpification of the muscular tissue, which contains bone sand. The missile struck the shaft of the humerus above the middle, comminuting the bone extensively, but not to the extent observed in the preceding injury with the .45 calibre leaden projectile. Fourteen principal fragments were readily counted. They are large and not so much displaced as in the injury on the left humerus. The larger fragments are retained in place by their periosteal attachment. The fissures are not so extensive in the shaft above and below the seat of injury. The projectiles were recovered, the leaden nucleus having escaped from the harder metallic mantle. The cylindrical part of the envelope is intact, the conical end having split in four pieces, one of which is entirely detached from the shell.

3. Gunshot injury of the left tibia, middle third; bullet No. 5, calibre .45; range, 17 yards. The wound of entrance is round, .45 inch in diameter; the wound of exit is marked by a longitudinal tear in the calf 3.16 inches in length and 1.18 inches in width. The bullet struck the shaft of the tibia at the junction of the middle and upper thirds, shattering the bone extensively. The seat of comminution measures 4.30 inches; the fragments, which are all detached, have been displaced backward. Large numbers of fine spicula of bone have been driven into the muscle of the calf. The soft parts are reduced to a pulp-like mass for some distance beyond the walls of the chasm-like opening. The fibula is broken at the same level. The projectile was split into two lateral halves at the conical end, one of which was lost, whilst the other remains attached to the cylindrical portion.

4. A gunshot injury by the .30 calibre projectile at the same range on the opposite tibia shows a wound of entrance which is round, .30 inch in diameter, and a wound of exit which is marked by an oblique tear extending from the lower part of the popliteal space to the lower part of the calf, measuring 6.66 inches in length and 2.36 inches in width.

The bullet collided with the tibia at its inner border 4.30 inches below the knee-joint, comminuting the shaft. Upon removing the skin the wound of entrance is seen to be filled with bone sand, the periosteum over the crest of the shaft is partly torn; on the outer side several large, sharp splinters of bone remain attached to the periosteum; the posterior wall of the shaft below the popliteal space, two inches in extent vertically, has been entirely destroyed and spicula of bone and medulla are seen in the lacerated muscle of the calf. The fibula is fractured in two places just above the level of the fracture in the tibia. The muscle of the calf has been reduced to pulp.

The projectile was very much deformed; but one fragment of the metallic mantle was recovered; it measured .79 inch in length and .39 inch in width. The leaden nucleus was mushroomed and is only half the original length.

It will be seen from the foregoing that the explosive effects at short range differ but little for the two projectiles, and that they are always enormous.

Notes on the Effects, on the Human Body, of the Projectiles of Large and Small Calibre Impressed by the Velocity Common at 350 yards; Experiments Conducted at Frankford Arsenal, Pennsylvania, January 12th, 1893.

1. Gunshot injury of the left ankle; bullet No. 2, calibre .30. The wound of entrance is 1.18 inches below the tip end of the internal malleolus; it is star-shaped, .39 inch in its greatest diameter. The projectile entered the astragalus at the lower margin and at its articulation with the os calcis. A portion of the bone belonging to the astragalus at this point, .59 inch long by .39 inch wide, is lying in the wound, attached by periosteum. The posterior portion of the trochlear surface of the os calcis, .59 inch long by .39 inch wide, is partially detached. The missile passed between the os calcis and the astragalus and emerged through the upper portion of the os calcis next to the outer margin of the articulation. There are several free fragments from the latter bone in the wound of exit. The tip of the external malleolus was crushed by the projectile. The projectile was not deformed.

2. Gunshot injury of the left ankle joint; bullet No. 3, calibre .45. The wound of entrance is round, 3.54 inches in diameter, and torn, the tears radiating from the edges of the wound. The wound of exit is irregularly quadrilateral in shape, .79 inch in its greatest diameter. The bullet entered through the internal malleolus and made a grooved fracture of the astragalus; there is complete pulverization of the inner half of the articular surface of the tibia. The missile then passed out, piercing the posterior portion of the external malleolus, the anterior portion remaining attached to the shaft. The projectile was mushroomed.

3. Gunshot injury of the right foot; bullet No. 4, calibre .30. The wound of entrance is .35 inch in diameter, 1.18 inches in front of the external malleolus. The wound

of exit was found, after several minutes of patient searching, to be located in the sole of the foot, 1.38 inches from the internal malleolus. It is marked by a slit-like opening .28 inch in length. The edges of the slit approximate each other thoroughly, hence the difficulty experienced in locating the wound. The projectile entered the os calcis near its articulation with the cuboid and below the head of the astragalus, fracturing the calcaneo-cuboid articulation, splintering the bone in three fragments, near which a small amount of pulverized bone is found. All the bones of the tarsus are intact except the os calcis. The projectile was recovered unaltered in shape.

4. Gunshot injury of the left tibia and fibula near knee-joint, bullet No. 5, calibre .30. The wound of entrance is round, .39 inch in diameter; the wound of exit is marked by a longitudinal slit, measuring .39 inch in length. The projectile entered the anterior portion of the head of the tibia, .39 inch from the joint, in the middle line, passing obliquely toward the outer side, and emerged from the posterior surface of the head of the fibula. The orifice of entrance in the bone is equivalent to the diameter of the missile; the orifice of exit is irregular, .39 inch in its greatest diameter. There is no comminution of bone. The knee-joint was not perforated, but the articular surface adjacent to the outer tuberosity shows a fissure which in the recent state was not apparent. The projectile was lost.

5. Gunshot injury of the lower shaft of the right femur; bullet No. 3, calibre .45. The wound of entrance is 1.57 inches above the outer condyle, round, and .45 inch in diameter. The wound of exit is in the upper part of the popliteal space, irregularly quadrilateral in shape, .79 inch in its greatest diameter. The bullet entered the lower shaft, 1.57 inches above the margin of the articular surface, .39 inch outside the middle line. Nine large splinters are detached, measuring from .6 inch to 3.50 inches in length. There are a number of deep vertical fissures in the upper and lower fragments; those in the lower do not invade the joint. The projectile was very much set up.

6. Gunshot injury of the right hip joint. Bullet No. 6, calibre .30. The wound of entrance is .35 inch in diameter, over the femoral vessels, 1.57 inches below Poupart's ligament; the wound of exit is in the middle of the gluteal region of the corresponding side, oval in shape, and exceeds very little the diameter of the projectile. The bullet entered the capsular ligament at its inner margin and traversed the head of the femur, .79 inch below the ligamentum teres, producing a grooved fracture. The course of the projectile was horizontal and clear-cut; a fracture, 1.57 inches in length, is noticed extending downward through the ischium. The compact bone adjacent to the track of the bullet shows fissures not apparent in the fresh state. The missile entered the acetabulum, 1.97 inches from the lower margin in the cotyloid notch. The orifice of entrance corresponds nearly to the diameter of the projectile; the orifice of exit is irregular, 1.97 inches in its two diameters. A fragment of the outer plate of bone, .39 inch in length, hangs attached by periosteum. The projectile was not in the least deformed.

7. Gunshot injury of the left hip joint; bullet No. 7, calibre .30. The wound of entrance perforated the skin on the anterior aspect of the thigh, external to the large vessels, 1.57 inches below Poupart's ligament. The wound of entrance is round, .30 inch in diameter; the wound of exit is also round, in the middle of the gluteal region, and it barely exceeds the diameter of the missile. The projectile entered the anterior convexity of the head of the femur, after passing through the capsular ligament; the acetabulum was not involved until after the bullet had passed through the head of the femur. The projectile traversed the head of the femur in a horizontal direction, .30 inch above a horizontal line drawn through the centre of the head, and emerged at its posterior surface 1.28 inches external to the ligamentum teres. A fissure is seen connecting the points of entrance and exit, and extending outward along the upper margin of the attachment of the capsular ligament; there are smaller fissures that radiate from the orifice of entrance. No splinters are detached. The outer lip of the acetabulum, however, was split, and is held in place only by the capsular ligament. The bullet at the orifice of exit penetrated the acetabulum, .59 inch from the outer margin, emerging without detaching any splinters, excepting as noted, and left clean-cut orifices upon entering and leaving the bone. The orifices of entrance and exit in the globular head of the femur are round and equal to the diameter of the projectile. The orifice of entrance in the pelvis is round, and exceeds by only a fractional part the diameter of the projectile; the orifice of exit is .59 by .39 inch in diameter, with the margins of the orifice slightly elevated. The bullet was not deformed.

8. Gunshot injury of the right elbow joint; bullet marked "E," calibre .30. The wound of entrance is on the external aspect of the arm opposite the bend of the elbow, 2.36 inches from the olecranon; it is round, and equal in diameter to that of the projectile; the wound of exit is .59 inch below the tip of the olecranon; it is star-shaped, and .30 inch in its greatest diameter. The projectile passed through the head of the radius, permitting the outer and posterior aspect of the forearm to receive the wound; the head is split in two portions, one half of which is finely comminuted, while the outer half, together with its portion of the neck and .79 inch of the shaft, remains in place without much damage to the periosteum. The pulverized bone, comprising the inner half of the head, lies free in the joint. The projectile entered the ulna .20 inch below the joint, near the posterior margin of the lesser sigmoid cavity; the olecranon is completely crushed; fissures extend through the greater sigmoid cavity, and the posterior portion of the articular surface. There are seventeen small splinters detached from the periosteum about the foyer of destruction. The projectile was slightly dented on one side in the cylindrical portion; otherwise it sustained no deformation.

9. Gunshot injury of the right shoulder joint; bullet No. 6, calibre .30. The wound of entrance is round, .30 inch in diameter; it perforated the skin well up on the anterior aspect of the shoulder, .39 inch below the acromion; the wound of exit is irregular in shape, .59 inch in its greatest diameter, on the posterior aspect of the shoulder, 4.72 inches from the wound of entrance, measuring over the shoulder. The projectile entered the bone in the bicipital groove between the two tuberosities and traversed the head of the humerus, crushing the head in passing out posteriorly. One large splinter, 1.18 inches by .98 inch, was carried through the orifice of exit in the bone and found embedded in the infraspinatus and teres minor muscles. Four other splinters comprising the globular head of the humerus lay about the seat of fracture; the central portion of the head is pulverized and discolored by lead. The bullet was not recovered.

Notes on the Destructive Effects on the Human Body, of the Projectiles of Large and Small Calibre Impressed by the Velocity Common at 1,200 Yards. Experiments Conducted at Frankford Arsenal, Pennsylvania, March 9th, 1893.

1. Gunshot injury of the lower third of the left femur; bullet marked "J," calibre .45. The wound of entrance is round, .45 inch in diameter; the wound of exit is in the upper part of the popliteal space, marked by a slit running obliquely, 1.38 inches in length. The missile struck the shaft of the left femur 2.36 inches above the articular cartilage on the inner side of the median line. The bone immediately behind the point of impact, covering an irregular space 1.5 by 2 inches in diameter, was carried away and lies finely comminuted in the track of the bullet; only a fraction of the number of the splinters of bone could be recovered. Some fragments of lead were found with the bone sand. The projectile was very slightly flattened in the cylindrical portion near the base; one-third of the conical portion of the bullet was severed

laterally and lost; the remaining two-thirds are flattened laterally.

2. Gunshot injury of the head of the right tibia; bullet marked "K," calibre .30. The wound of entrance is .30 inch in diameter, and .59 inch below the patella;

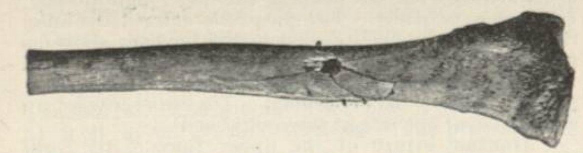


Fig. 2357.—Gunshot Injury of the Right Tibia, at the Junction of the Upper and Middle Thirds, by the .″30 Calibre German-Silver Jacketed Projectile with the Velocity Common at 1,200 Yards. The projectile penetrated the shaft six inches below the knee joint. Examination immediately after the shot was fired revealed no mobility, although upon dissection a distinct fracture was observed. The displacement of the principal fragments is very slight.

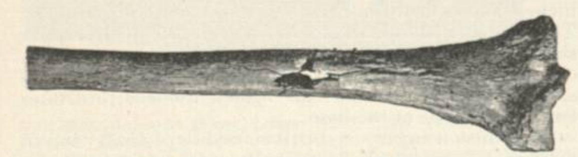


Fig. 2358.—A Posterior View of Fig. 2357.

the wound of exit is in the upper part of the calf; it is quadrilateral in shape, .30 inch in its largest diameter. The projectile perforated the head of the tibia in the middle line, .39 inch below the articular surface. The diameter of the track of the projectile corresponds to the diameter of the missile; the orifice of exit is on the posterior surface, .39 inch distant from the articular facet for the fibula. No large fragments were found in the tissues. The fibula and the articular surface of the head of the tibia are uninjured. The projectile was not deformed.

3. Gunshot injury of the lower end of the right femur; bullet marked "D," calibre .30. The wound of entrance is round, .30 inch in diameter, .79 inch above patella; the

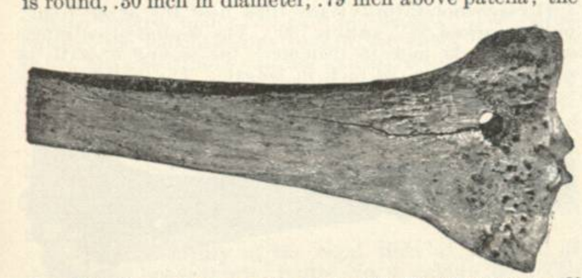


Fig. 2359.—Gunshot Injury of the Head of the Right Tibia by the .″30 Calibre German-Silver Jacketed Projectile with the Velocity Common at 1,200 Yards. The projectile perforated the head of the tibia in the middle line .″39 below the articular surface. The diameter of the track of the bullet in the bone corresponds to the diameter of the missile.

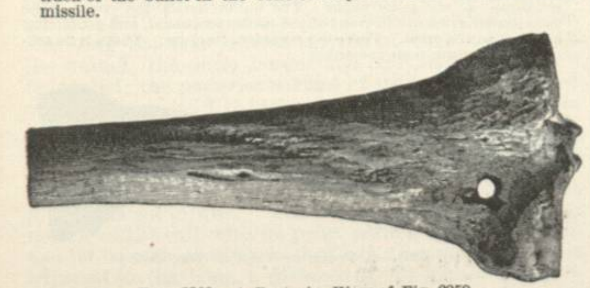


Fig. 2360.—A Posterior View of Fig. 2359.

wound of exit is in the internal and upper part of the popliteal space, marked by a quadrilateral orifice having a punched-out appearance, .79 inch in its greatest diameter. The projectile perforated the anterior face of the bone about its middle, immediately above the upper margin of the articular surface. A small quantity of finely pulverized bone was found in the wound of exit. There

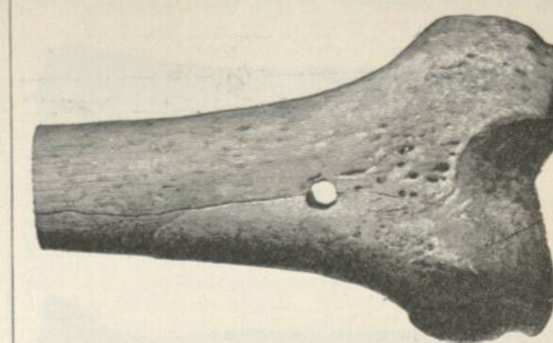


Fig. 2361.—Gunshot Injury of the Lower Third, Right Femur, by the .″30 Calibre German-Silver Jacketed Projectile with the Velocity Common at 1,200 Yards. The projectile perforated the anterior face of the bone about its middle, immediately above the upper margin of the articular surface, making a clean-cut perforation. The fissure occurred in drying; it was not present in the recent state.

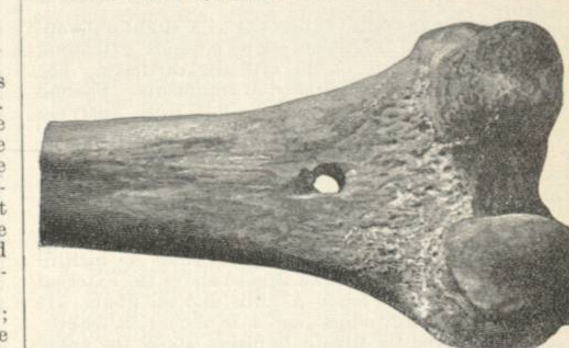


Fig. 2362.—A Posterior View of Fig. 2361.

was no fissuring, and the articular surface was uninjured. The projectile sustained a slight flattening of its tip at the conical end.

4. Gunshot injury of the left knee-joint; bullet marked "B," calibre .45. The wound of entrance is

Fig. 2363.—Gunshot Injury, Right Tibia, near the Ankle, by the .″30 Calibre German-Silver Jacketed Projectile with the Velocity Common at 1,200 Yards. The bullet perforated the tibia on the anterior aspect in the middle line 2.″17 above the ankle joint. The orifice of entrance has a punched-out appearance equal in diameter to that of the projectile. The fissure occurred in drying; it was not present in the recent state.

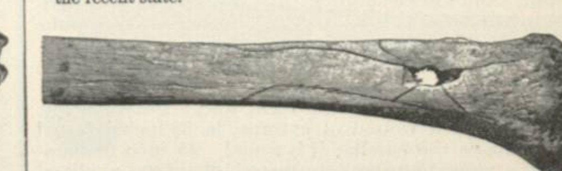


Fig. 2364.—A Posterior View of Fig. 2363. Fissures are exaggerated by drying.

round, .45 inch in diameter, a little internal to the middle of the patella; the bullet ranged downward, backward, and outward, inflicting, in the fleshy part of the