THE SPORTING RIFLE

AND ITS PROJECTILES.

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BY

LIEUT. JAMES FORSYTH,

BENGAL STAFF CORPS.

"Our object in these inquiries must be the discovery of Truth alone. We must hold ourselves in readiness not only to abandon an old principle, but to relinquish a new one upon reason shown. We must go backwards as well as forwards, if needs be. No previous conviction or apparent settlement ought to weigh with us against the latest and most absolute evidence."—*Times*.

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PREFACE TO SECOND EDITION.

THE progress of gunnery since the publication of the first edition has necessitated many additions to the present work. Most of it has been re-written, and the plates are almost entirely new.

I find, from the flood of queries that was poured on me from all quarters soon after the first edition appeared, that I had taken for granted the possession of more knowledge of the elementary principles of gunnery than is generally the case. I have, therefore, in the present edition endeavoured to "begin at the beginning;" and must bespeak the patience of those of my readers who "knew it all before."

I trust the work will now be found to be a complete guide to the young sportsman in all matters connected with the SPORTING RIFLE.

J. F.

Camp, 1866.

PREFACE TO FIRST EDITION.

THE inquiry, of which this little book contains the matured results, was originally undertaken in order to determine to my own satisfaction on what principle the SPORTING RIFLE may be best constructed; but my own skill—and, consequently, pleasure—in the use of the rifle *in the field* has been so much enhanced by the conclusions arrived at, that I cannot refrain, even at the risk of being deemed presumptuous, from thus presenting to my brother sportsmen the fruits of my labours; confident that such of them as may make trial of my advice will not regret having done so.

THE AUTHOR.

Central India, September, 1862.

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CHAPTER I.

THE OBJECTS AND CONDITIONS OF MILITARY AND SPORTING RIFLES.

1. It will be admitted on all hands, that the objects proposed to be attained by a military rifle are essentially distinct from those sought for in a sporting rifle. Whether they are also incompatible; that is, whether a rifle can, or cannot, be the best military, and, at the same time, the best sporting rifle, will be afterwards considered. Meanwhile, let us see *what* is the object to be attained in each case.

2. The military weapon, then, is, by the conditions of modern warfare, required to be capable of *disabling* an enemy at the longest possible range. This will be almost equally well effected whether that enemy be killed outright, or merely wounded; for a man hit is,

in most cases, also a man *hors de combat*, and the effect on the fortunes of the day is the same as if he had been shot dead; or perhaps greater, as a wounded man has to be assisted from the field, while dead men need no tending; and also, as the Texan captain said when advising his Rangers to fire low at the "yaller-bellies," because they groan, and "demoralize" the others! Consequently, the rifle that will throw *any* projectile to the greatest distance with accuracy is, other things equal, the best military weapon. Easy loading under all circumstances is a *sine qua non* in the military rifle; volley and file firing would be inefficient without it. Neither must the military rifle be too heavy to carry through a day's marching; and its recoil must not be so great as to destroy steadiness in firing. The conditions of a military rifle may be set down in the order of their importance, thus:—

i. Moderate weight.

ii. Moderate recoil.

iii. Easy and rapid loading.

iv. The longest possible accurate range.

v. Sufficient penetration at the longest range to lodge a projectile in the body of an enemy.

vi. The lowest possible trajectory, *particularly at long ranges.*

vii. General simplicity of construction.

In almost all our modern rifles, these conditions are found to be more or less combined, and perhaps in none better, on the whole, than in the present arms of our troops. This, however, does not come within the scope of my subject.

3. On the other hand, what is required from the

sporting rifle? Sporting rifles may be divided into two classes:—

1st. Those for general use; to be invariably carried by the sportsman himself; to be always in his hand ready for whatever game may appear; accurate enough to strike a deer fairly in the shoulder at a sporting distance; and, at the same time, powerful enough to afford a good chance of disabling the largest animals of the forest. Such a rifle must not be too heavy for the sportsman's strength, or he will inevitably give it to some one to carry for him, and it will be absent just when most wanted.

2nd. A more powerful description of rifle, for use on special occasions, to be carried, as a rule, not by the sportsman himself, but either by a gunbearer or in the howdah, according to the sport in hand. At the same time, it must also be within the sportsman's power, to some extent; that is, he must be able, on occasion, to shoulder it himself; but moderate weight is not, in this class, so prime an object as in the other. Were sportsmen in India to admit no rifles into their battery not completely within their own power to carry throughout a long day's walking, much advantage in the use of heavy projectiles and large charges must be foregone by a vast majority of them.

With this difference, all the conditions requisite apply equally to both classes. The second class is evidently only suited for use in a country like India, where gigantic or ferocious animals have to be encountered; the first includes the sporting rifles of every land where anything larger than an antelope is to be found.

4. The prime object of a shot fired at any animal of chase, be it of the bashful sort that fly *from* you, or of the audacious sort that fly *at* you, is, if possible, to kill or disable that animal on the spot. In the former case, this is desirable in order to make sure of bagging, to avoid a long stern chase and the expenditure of more shots, and to kill with as little unnecessary cruelty as possible; and in the latter case, it is essential in order to save your life. By the word "disable," used above, I mean the infliction of such a wound as will prevent the animal from leaving the spot where he was first struck. A wound, unless by its physical effects it disables or stops an animal, is useless, for it can have no *moral* effect as in the case of man. In fine, to "disable" an animal, the ball must either reach the vitals and kill him at once; break some large bone essential to his locomotion; or by the general shock to the system so "take it out of him," that he has neither power nor wish to do aught but lie down and die peaceably.

5. The effect of wounds on animals appears to depend, in some measure, on the amount of nervous force directed at the time to the part struck. It has been observed that, when an animal is feeding, a shot in the stomach affects him more than at other times; and that, when running, leg wounds produce a greater shock in the system than when at rest. Still more curious are the phenomena observed in firing at animals which have been previously wounded: all sportsmen remark that subsequent shots seem to have much less effect than they have on unwounded animals; and, indeed, it sometimes appears as if a wound acted as a sort of charm against wounds in other places. Is it

that, in such cases, the nervous energy of the system is so completely directed to the locality of the first wound, that the subsequent shots fall as it were on dead flesh, and affect but little the great centres of life? Who does not remember the wounded grouse, that, almost bare of feathers, led him that terrible chase along the hillside, receiving with indifference doses of No. 5 that would have cut an unwounded bird to ribbons; or the spotted buck, wounded to the death, that no ball would stop, and that finally staggered into impenetrable jungle completely riddled, and on *one* leg?

In olden days, when the niceties of sport were better attended to than now, "clean killing" was considered the first qualification of a ranger. Was not Halbert Glendinning offered the post of huntsman to the jolly abbot who loved his venison clean killed, simply on account of his reputation for killing with a single shot? Besides, what can be more shocking to a man with any pretensions to feeling, than having to follow up a wounded deer, and kill it limb by limb by repeated shots, as is too frequently the case in jungle shooting? Sport, in such cases, degenerates into brutality. If we are to kill at all, then our object ought to be, if possible, *to kill outright* with the first shot! Now what species of rifle and projectile is best calculated to effect this desirable end—*i.e.*, that of killing or disabling by one shot?

6. It is evident that, of two wounds of equal depth, that which has the larger area will have most effect on the internal economy of the animal. It will rupture more blood-vessels and nerves in proportion as it is larger than the other, and so produce more sudden blood-

letting and shock to the system. It may, moreover, include a bone or a vital organ, such as heart or brain, in its path, which would not be included in the narrower wound, and in practice this will frequently be found to be the case. *Penetration, therefore, being equal, or sufficient, in both cases, that projectile which has the largest striking surface is the best for our purpose.* Therefore the largest gauge * of rifle, consistent with the weight in each class, should be used. It is found in practice that for killing the ordinary beasts of chase, such as deer of all sorts, no ball of less diameter than about 16 gauge is to be depended on. A great deal of game may, without doubt, be killed with much smaller sizes than this; but a certain percentage of animals fairly hit with the small bore will escape, which would have been bagged with a ball having a larger striking surface. I have had this fact most strikingly brought to my notice throughout my Indian sporting career. When very young in the country I was fortunate enough to form one of a shooting party in the Terai jungles. The quantity of game in these jungles, consisting of spotted and hog deer, bara-singah, neilgae, pigs, leopards, and tigers, is so enormous that, in the course of a day's sport with a good force of elephants, each man in the party may perhaps have as many as a hundred shots at four-footed game. In this description of sport thick jungle is almost always close at hand, and a merely wounded animal very generally gets away. I was then

* "Gauge," in reference to sporting rifles, means the number of spherical leaden bullets, fitting the barrel, that go to the pound. Thus the Enfield rifle is, in sporting parlance, described as 24-gauge, because 24 round bullets fitting it would weigh one pound.

armed with a beautiful little 36-bore double rifle, carrying a conical ball of about 19 to the pound, a double smooth bore No. 14, another No. 8, and a two-grooved double rifle No. 12,—forming a somewhat disorderly battery, I confess. The experience of some five months of this forest-shooting convinced me that, while the 36 bore was utterly useless, and never stopped an animal unless it was struck in the brain, spine, or heart, the 14 bore was large enough for most of the above animals; and that the stopping power of my guns increased just in proportion to their largeness of gauge. Since then, during a somewhat lengthened service in the forest department in Central India, I have had considerable experience with all sorts and sizes of guns, at every description of game; and, as I never omit to make a note of any remarkable point connected with my hobby, I have now a quite sufficient array of facts from which to form a reliable induction. As above stated, my experience is that a 14 or 16 gauge is large enough for any of the deer tribe. Smaller game, such as antelopes, wolves, hyænas, &c., can be equally well disposed of by a smaller ball, 18 to 24. Bears and tigers are sometimes very tenacious of life, and I think perhaps the best size for them is 12, although they may be killed almost as well with 14. It is when we come to the more ponderous brutes that large gauges begin to tell. Less than 12 should never be used for bison or buffaloes, and any increase of size that the sportsman can manage will well repay him in such sport. These remarks refer, of course, to solid bullets only: the question of shells will be treated further on.

7. Ample *penetration* must also be secured; other-

wise, however large the ball is, the effect will be trifling; but observe, if the penetration be sufficient, more is not desirable; that is, if the bullets of two rifles were each found to have sufficient penetration, the question of their respective merits for sporting purposes would have to be tried on other grounds than this, even were it found that the total penetration of one was much greater than that of the other: for our purpose, they are in this respect equal. As a rule, a rifle should be able to drive its ball through and through the animal fired at.

8. The third point to attend to is, that the sporting rifle must have *sufficient accuracy at sporting distances.* What are sporting distances? Mr. Baker, author of *The Rifle and the Hound in Ceylon*, answers the question as follows:—

> "I consider a sporting range to be limited to a distance at which the shoulder of a deer may be fairly struck under ordinary circumstances—say 150 yards; shots beyond this range are bright moments, which, though not unfrequent, are not the rule. Thus, 200 yards may, I think, be accepted as the range required for a sporting rifle, beyond which I think extra sights useless."—*The Field*, March 23, 1861.

Most practical sportsmen will allow this to be a pretty correct definition, rather over than under the mark as far as my experience goes: 200 yards may be taken as the very outside limit at which it is ever advisable to fire at ordinary game; not because the rifle may not be accurate enough to ensure frequent *hitting* at much greater distances, but because the probability of *killing* at such ranges is very small indeed; and humanity, not to say sportsmanlike feeling, demands that we shall not knowingly run so strong a chance of wounding, and consigning to a miserable and lingering death, the animals over which we have dominion, to use but not to abuse. Moreover, most men who have shot much in the forests of India will agree that it is only on the open plain that such long shots even as this will be *likely to present themselves. In the jungle, at least one-half are under 50 yards, three-fourths under 75,* and all, with scarcely an exception, under 100; that is to say, these are the distances at which animals are usually killed in jungle shooting, and I imagine that the case is very much the same in other forest countries. If any one thinks that the general run of his *successful* shots are at longer distances than these, let him put them to the crucial test of measuring; and, if still unconvinced, all I can say is that his experience differs from my own and that of most shots of my acquaintance. One hundred and fifty yards, then, may be taken as the distance up to which *great* accuracy of shooting is to be sought for in the sporting rifle; consequently, if any two rifles are found each to be sufficiently accurate for our purpose up to that distance, the question of their respective merits for game-shooting must be decided on other grounds.

9. The fourth point to attend to in the sporting rifle is, that it shall require *the least possible amount of elevation* to carry its ball up to *sporting ranges, i.e.* up to 150 or 200 yards; or, in other words, that its trajectory, or path of flight of its projectile, up to that distance, shall be as flat a curve as may be obtainable. It is in this respect that the old style of rifle, and too many modern ones also, are so wofully deficient. It is a point of the very utmost importance, and cannot be sufficiently insisted on. It

is, in fact, the life and soul of accurate rifle shooting at game, particularly when in motion. A miss is generally caused by wrong elevation—misjudging distance, or not allowing for something or other. If the sportsman is a moderately good shot, the ball seldom goes to the right or left, but "just a little too high, or too low." This is generally the fault of the rifle in requiring so much elevation that allowance has to be made even at the shortest ranges. The objects aimed at by military rifles, or the bodies of men, and those at which the sporting weapon is generally directed, or the bodies of animals, offer marks of very different shape. The former are tall and thin, and thus present considerable margin for an error in elevation; while the latter, though often long enough horizontally, yet generally offer a very small vertical margin indeed for errors of this description. It is, therefore, of double importance that the elevation should be as little as possible in the sporting rifle. It will be seen afterwards, that the point-blank range of a sporting rifle is defined to be the distance up to which a shot may be taken without considering elevation at all, that is, covering exactly the object intended to be hit; and beyond which distance artificial elevation either by sights or by allowance must be given. It is evident that the longer this point-blank range can be made, the better will the rifle be for sporting purposes. The point-blank of a bad rifle may end at five paces from the muzzle, while that of a good one may extend to 100 yards or more; and this, if the other points necessary to be attended to are present, forms a very good criterion of the merit of a sporting rifle. The far-famed American backwoods' rifle was pre-eminently distinguished in this respect; and hence the fame acquired by the men who used it for splendid shooting at short distances, that is, within the point-blank range. Any one with practice can learn to hit a stationary object the distance of which is known,—the sight of the rifle being regulated accordingly; the difficulty lies in judging the distance. But with the Yankee rifles no judging was required; at anything under 100 yards the aim was taken point-blank with the same sight, and consequently it made no difference whether the squirrel squatting on a branch, or the wild turkey's head over a tree-top, was 20, or 50, or 90 yards away; only cover it truly, and down it went! The nearer, therefore, we can make our sporting rifle resemble the Kentucky weapon *in this respect*, attending also to the other essential elements, the better will it be.

10. As will afterwards be shown, it by no means follows that, because a rifle requires comparatively little elevation at the extreme length of its range, it is also necessarily the best in this respect at sporting distances. Some rifles start their projectiles at a low velocity, and require considerable elevation at short distances; yet, on account of their offering a small surface for the atmosphere to act on in proportion to their weight, they retain this velocity but slightly impaired up to the extremity of a long flight, and require comparatively slight elevation at long ranges. Others again start with a very high velocity, and so require but little elevation at short distances; but from their presenting a large surface to the air in proportion to their weight, are unable to retain a sufficient portion of their initial velocity for any time, and require great elevation at

long distances. Now it will be evident that, of these two, while the former will, in the matter of elevation, be the better military weapon, the latter is the one we should select as a sporting weapon—sacrificing what is of no use to us, a low trajectory at long ranges, in order to get in greater perfection what we want, the lowest possible trajectory at sporting distances. This lowness of trajectory is only to be secured (as will be afterwards explained) by giving the ball the highest possible velocity of flight. By so doing we gain a further advantage in shooting at running game; for the faster the ball "goes up," the less allowance will have to be made when animals present crossing shots at speed.

11. The fifth point for attention is, that the anterior or striking surface of a sporting projectile must not be of too acute a shape. It is found, that with any form more pointed than a hemisphere, the shock given to an animal is much less, although the actual diameter, and consequently the striking area, of the ball be the same. Almost all practical sportsmen agree on this point. The author and sportsman above quoted says,—

"Having expressed my opinion respecting the bore of the rifle, I will now touch upon the shape of the bullets. As I before stated, I do not approve of the sharp-pointed cone; it does not produce sufficient concussion, but enters the animal more like the thrust of a sword than the blow of a bullet; there is not sufficient shock; there is as much difference between the blow of a hammer and the thrust of a dagger, as in the shock of the blunt bullet and the perforation of the sharp cone. Thus, should the sharp point strike in the wrong place, it produces no immediate effect—it is scarcely felt; but the stunning blow of the blunt bullet, even when wrongly placed, will generally disable the animal."

12. It is, moreover, found that the slightest obstruction of bone or sinew, or even muscle, meeting obliquely a pointed cone passing through an animal, is apt to turn it from its course, and frustrate the aim of the sportsman. The bones escape unbroken, and the ball merely makes an eccentric flesh wound, harmless at the time, although it may eventually cause the death of the animal. It was from observing constant instances of such wounds that I first began to doubt the advantages of the pointed form for sporting projectiles; I have seen such a ball strike a tiger between the eyes, and cut a groove over the top of his head, making its exit at the nape of the neck, with no other effect but that of temporarily stunning him. I have seen another glance from the ribs of a "neilgae," pass over his chest, and lodge in the opposite side of his body. Indeed, there is no end to the instances I might give, from the experience of myself and my friends. The published experience of many sportsmen confirms my own in this point; and, shortly after the Crimean war, a surgeon in charge of a large number of wounded men reported that he—

> "Also observed that these bullets (the Minié) made holes as if they had been drilled, and that they travelled over or through the body in the most eccentric directions. . . . . The conclusion drawn is that, after all, conical balls produce less dangerous gunshot wounds than the ordinary spherical ones, since, whenever they first meet an obstacle, unless they strike with the apex, they deviate from their course instead of smashing the bone, and make their way through the fleshy part of the body."

13. In addition to the above five points to be at-

tended to in the construction of the sporting rifle, it is necessary that its *weight*, if for general purposes, be *within the power of the sportsman to carry.* This will, of course, depend much on the natural strength of the user, and also on his state of training; for, by practice, a man may bring himself to bear with ease what at first was far beyond his powers. The military authorities have fixed the weight of the short Enfield rifle at about 8¼ lbs. exclusive of ammunition; and in India, particularly in the hot weather, I think 9 lbs. will be found as much as an average man can manage, even when in practice. Of course, if any one finds that he can bear a pound or two more, so much the better, for he will be able to use a more powerful weapon than his neighbours. But I think 9 lbs. may be taken as the standard for the average of men. In the second class of rifles again, any weight may be allowed, so long as the weapon remains manageable.

14. The recoil of the sporting rifle must not be so severe as to be unpleasant, or to occasion that shrinking from the explosion, which is the cause of so much bad shooting. In the second class, a little more latitude may be allowed in this respect, as comparatively few shots would be fired with such a rifle at any one time; still there is a certain limit, which must not be transgressed even in them. Here, too, practice will be found to improve the sportsman's power of standing up to large charges in heavy rifles; and, moreover, it must be remembered that, in the excitement of firing at game, the effect of the recoil is much less felt than in target shooting. I have used a very powerful 8-gauge rifle with eight drachms of powder, and although three

shots at a target made my shoulder ache for days, I never felt the recoil when firing at game, whether at the time or afterwards. The reason must be, that the rifle is held tighter to the shoulder in the latter, than in the former, case. Apropos of this, I must be allowed to quote the following description, from Mr. Baker's Nile book, of a sweet thing in rifles :—

"Among other weapons I had an extraordinary rifle that carried a half-pound percussion shell. This instrument of torture to the hunter was not sufficiently heavy for the weight of the projectile; it only weighed 20 lbs.: thus with a charge of 10 drs. of powder, behind a *half-pound* shell, the recoil was so terrific that I was spun round like a weathercock in a hurricane. I really dreaded my own rifle, although I had been accustomed to heavy charges of powder and severe recoil for many years. None of my men could fire it, and it was looked upon with a species of awe, and was named 'Jenna el Mootfa" (child of a cannon) by the Arabs, which being far too long a name for practice, I christened it the 'Baby;' and the scream of this 'Baby,' loaded with a half-pound shell, was always fatal."

15. Another point to attend to is, that the barrels of the sporting rifle *be of a moderate length*, particularly for forest shooting. This also will, in some measure, depend on the stature and strength of the user; but, for quick shooting, a rifle should never exceed 28 inches; and many, including myself, consider 26, or even 24, quite as long as should be used. Now, all the different systems of rifling and of projectiles will not be equally suitable to barrels of these lengths. Some are quite incompatible with them, while others are more adapted for such barrels than for longer ones. If, then, any

two systems were equal in other respects, but one of them more suitable to short barrels than the other, it would be the better of the two for a sporting rifle. The very contrary, it may be observed, is the case with military arms; in which, to ensure safety, and give efficiency to the bayonet, considerable length of barrel is requisite.

16. Let us now set down, in the order of their importance, the conditions of the sporting rifle, as was done in the case of the military weapon:—

i. Weight, if for general purposes, not more than 9 lbs.; in second class, manageable.

ii. Moderate recoil.

iii. Sufficient accuracy at sporting ranges.

iv. Sufficient penetration at sporting ranges.

v. The least degree of elevation *at sporting distances.*

vi. The largest possible striking surface (or gauge) in the projectile.

vii. Projectile of a shape not more acute than a hemisphere.

viii. Easy and rapid loading.

ix. Moderately short barrels.

x. General handiness and simplicity.

Under this last head are included many minor points, which, collectively, may vastly increase or diminish the usefulness of the sporting rifle, and which will hereafter be mentioned in detail. It is, for instance, sometimes necessary to increase the regular charge of powder for the ponderous beasts of chase. For it would be absurd to use constantly, for all game, such excessive charges as are found necessary for such sports as elephant or bison shooting, for example. Now, some rifles will bear this increase of charge without having their accuracy of shooting impaired; while others, if over-charged, or if by accident two charges be used instead of one, are immediately rendered most inaccurate at the shortest ranges. The former would be decidedly more "handy" than the latter for a sporting weapon. Again, a rifle which fouls very rapidly is likely to be less useful throughout a long day's sport than another which does not foul so fast. It is also of great importance that a rifle should be as free as possible from all chance of accidental derangement. Simplicity in all its parts is, therefore, most desirable.

17. I shall now proceed to inquire what system of rifles best fulfils the majority of these conditions—bearing in mind that, although a rifle may be pre-eminently good in one or more of these points, yet, if it fails in others that stand higher in the list, and are suppsed to be of greater importance, its excellence in the point of lower value will weigh comparatively little towards its merit as a sporting rifle. Before, however, entering on this inquiry, I must claim the indulgence of such of my readers as have made gunnery a study, and briefly explain some of its theoretical principles, without which I might not, by some, be thoroughly understood. I shall, however, omit all matters that may be supposed familiar to all, and touch on nothing but what is absolutely necessary to my purpose. Those of my readers who feel a disinclination to purely theoretical argument are recommended to "skip" it, and proceed at once to Chapter III., where the practical application of the principles deduced is made.

CHAPTER II.

SOME PRINCIPLES OF MODERN GUNNERY.

18. The influences which determine the path traversed by projectiles in their flight through the air are chiefly, *the force of impulse, the force of gravity,* and the *resistance offered by the atmosphere.* Were the first to act alone, the projectile would evidently proceed to an infinite distance in the direction in which it was originally projected. This is, however, modified by the action of the other two, which cause it to describe a curve, and eventually bring it to a state of rest.

19. Gravity tends to draw the projectile down from its line of projection towards the earth, and *in equal time has an equal effect on all balls of whatever shape and weight;* that is, an ounce ball and a two-ounce one will each be drawn the same distance towards the ground by this force during the 1st second of their flight, an equal (although greater) distance during the 2nd second, and so on. The horizontal distance traversed during any period of time does not affect the truth of this; thus, the 1 oz. ball may traverse 400 yards, and the 2 oz. 600, during the first second of their respective flights, yet it will be found that each has fallen the same distance from the line of projection,

and this distance is just the same as that they would have fallen through in the same time if dropped from a state of rest. The action of gravity begins to operate on the projectile as soon as it ceases to receive artificial support from the barrel by leaving the muzzle of the gun.

Axiom A. *A uniform accelerating force is one which adds equal velocities in equal times.*

Axiom B. *With uniform accelerating forces, the space described from the beginning of the motion is as the square of the time.*

Now gravity is a uniform accelerating force, and therefore *adds* equal velocities to a body under its influence in equal times; and, also, the whole space described by the body increases according to the *square* of the time it has been under its influence. Thus, if a ball falls 4 inches in any short period of time, in two similar periods it will fall, not 8, but 16 inches.

20. The resistance of the atmosphere is a force tending to obstruct the passage of the projectile through it; and, unlike gravity, varies according to the shape and weight of the projectile, the velocity with which it is travelling, and some other minor conditions which it is unnecessary to refer to here.

21. This resistance is somewhat modified by the form of the anterior portion of the projectile, a bluntly pointed one receiving more resistance in the direction opposite to its line of motion than a more tapering one, although each displaces exactly the same volume of air.

22. The effect of this resistance, then, is more or less to retard the flight of the projectile, and lessen its rate of velocity more and more as it gets farther from

the rifle. If the whole distance traversed be divided into equal portions, it will be found that it takes a longer *time* to accomplish each successive portion of the *distance;* that is, it will take a longer time to traverse the second hundred yards of its flight than to do the first hundred, and a still longer time to do the third hundred than the second, and so on.

23. But the action of gravity depends on the *time of flight,* not on the *distance traversed;* it will, therefore, on this account also, have a greater effect on the ball during the second hundred yards of its flight than it had in the first hundred yards, and a still greater in the third hundred yards than in the second. Supposing, then, that a projectile took any certain period of time to travel the first hundred yards, and, owing to the resistance of the air, takes two similar periods to travel the second hundred yards, the distance it would be drawn towards the earth by gravity during the first period would be to the total distance it falls in the three periods, as 1 to 9. For example, if it fell 4 inches during the first period, or hundred yards, it would have fallen, at the end of the 200 yards, 36 inches altogether.

24. From all this it results that a projectile fired in a horizontal direction begins at once to describe a path curving downwards towards the earth, increasing in sharpness the further the bullet flies. Fig. 1, Plate I., shows the imaginary curved paths of three different projectiles, each supposed to have been originally projected in the horizontal direction. A. B. This diagram is necessarily much distorted, the vertical falls being shown on a much larger scale than the horizontal ranges; it suffices, however, to illustrate the theory.

25. It is evident, then, that if we point a gun directly at any object we can never hit it, owing to the ball having been subject to the action of gravity during the time it took to reach it, and so having been drawn downwards from its original direction. To remedy this, we must direct the gun at a point as much above the point we wish to hit, as the ball will fall during its flight. This is the principle of giving *artificial elevation*, and in the rifle is effected by the well-known device of *raised sights.* By fixing a high sight on the breech end (*a*, Fig. 2), and using it in taking aim, we elevate the axis of the barrel more or less according to the height of the sight, and so are enabled, while continuing to *look* straight at an object, to in fact direct the weapon at a point a certain distance above it. Thus (Fig. 1, Plate I.), if we wish to hit a mark *a*, placed at 400 yards, we must direct the axis of the barrel, not at *a*, but a certain distance *a b*, *a c*, or *a d*, *above* it, according to the projectile's natural path being higher or lower at that range. By using an elevated sight-piece we effect this tilting-up of the barrel, while our aim still follows the horizontal line A *a*.

26. Some persons cannot divest themselves of the erroneous notion that there is some force tending to make a bullet "rise" from the direction in which it is projected. This is owing to their confounding the *line of fire* with the *line of sight*, or aim. A reference to Fig 2, Plate I., will, I trust, assist such persons in coming to a right understanding on this point. In order to hit the target D, we project the ball in the line A B: this is the *line of fire.* We maintain our aim on the target by looking over the sight-piece *a*, in the

line C D: this is the *line of aim.* The curved path of the bullet, it will be observed, *rises* relatively to the line of aim, but *falls* relatively to the line of fire.

27. The following axioms are true of all projectiles in motion through the air:—

AXIOM C. *The larger the area presented to the action of the air in proportion to the mass or weight of the projectile, the more it will be resisted.*

Thus, a leaden sphere weighing 1 oz. will present a much greater surface for the air to act upon than a cone of the same weight, and will therefore be more resisted in proportion to its weight.

AXIOM D. *The resistance of the air to projectiles which present to it similar surfaces varies nearly as the squares of their velocities.*

Thus, if two similar projectiles are travelling with different velocities, say, with the velocities 2 and 3 respectively, the resistances each will receive from the air will be as 4 to 9.

28. By Axiom C, a sphere will be more retarded in its flight by the atmosphere than any elongated projectile of equal weight; and the longer the latter is made in proportion to its greatest width, the less will it be retarded; for the area of its greatest circle (which is the surface resisted by the air) will be less and less in proportion to its weight, the longer and narrower it is made. Suppose, then, two elongated projectiles of lead, A and B, of equal diameter, but varying in length, so that B contains a greater weight than A, in the proportion of two to one; the surface presented to the air will be the same in each, but B being twice as heavy as A, will be only half as much resisted, and will therefore

lose its initial velocity in a much less degree. Suppose now that both these are started together with such an initial velocity as would cause them to travel, if unresisted, at the rate of 100 yards per second:—Suppose, also, that B, owing to the resistance of the air, loses 10 yards of this velocity in the 1st second:—then, A being twice as much resisted, will lose 20 yards; or, in other words, while B goes 90 yards in the 1st second, A will only go 80 in the same time. But gravity acts equally on both in the same time; therefore A will have been drawn the same distance towards the ground in 80 yards, as B in 90. Again, B starts on its second period of flight with a velocity of 90 yards per second, while A starts with a velocity of 80 yards per second. This time the proportion of resistances will not be so great as two to one; for B is now travelling faster than A, and by axiom D, the resistances are as the squares of the velocities. The resistances experienced by A and B respectively will now be nearly as 14 to 9. Suppose, now, that during this second period of flight, B loses 18 yards of velocity from atmospherical resistance; it will then, starting at 90 yards per second, go 72 yards in this 2nd second of its flight; while A, resisted as 14 to 9, and starting at 80 yards per second, will lose 28 yards, and go only 52 yards in this 2nd second. A will therefore be drawn down by gravity as much more in 52 yards as B will be in 72; or, adding both periods together, while B will have fallen from its line of projection a certain distance in the first 162 yards of its flight, A will have fallen the same distance in 132 yards, and so on; A losing ground more and more the farther the flight of both extends. Applying in these two cases the principle of giving artificial elevation by raised sights (para. 25), the shorter bullet, A, will evidently require to be given a greater elevation to make it range the same distance as the longer B, *when both start with the same initial velocity.*

29. Again, let us suppose that these two elongated bullets start with unequal velocities. Let that of A be to that of B as 2 to 1; or, while the heavy bullet B, starts as before at 100 yards per second, let the lighter, A, start at 200 yards per second. The ratio of resistances on account of difference in weight will still remain the same as before, and B will be resisted in proportion to A as 1 to 2; but (by axiom D) B will also be resisted in proportion to A as 1 to 4. The total ratio of resistances will therefore be as 1 to 8. B being started under the same conditions as before, will travel 90 yards in the 1st second, losing as before 10 by resistance, while A will lose 8 times as much, or 80 yards, and will, therefore, travel 200−80=120 yards in the 1st second. In this case, therefore, the lighter ball has the advantage of the heavier during the 1st second, and will be drawn by gravity a certain distance towards the ground in the first 120 yards, while B is drawn down the same distance after traversing only 90 yards. A will now start on its second period of flight with a velocity of 120 yards per second, and B at 90 yards per second, and the resistances experienced by them will be as 2 to 1 on account of weight, and as 16 to 9 on account of velocity (by Axiom D), or altogether, as 32 to 9. Suppose now, as before, that B loses 18 yards of velocity during the 2nd second, it will as before go 72 yards in that time; while A, starting at 120 yards per second, will

lose 64 yards, and, therefore, travel only 56 yards in the 2nd period of their flight. In the two seconds together, therefore, A has gone 176 yards while B has gone 172. Although B, then, started originally with only half the velocity of A, and was far behind it at the end of the first period, yet it is seen that by virtue of its greater *overcoming power* (as it is termed), it has travelled nearly the same distance as A during the first two seconds together; and it is evident that, during the third second, the heavier projectile B must pass the lighter A, and the farther they fly gain more and more upon it. Applying, as in the former case, the principle of artificial elevation, it is evident that the lighter ball A will require less elevation, and will have a lower trajectory than the heavier B during the first period of their flight. The elevations and trajectories at the end of the second period will be nearly equal in height, and during future periods the longer and heavier ball will have a lower trajectory, and require less elevation than the shorter and lighter; and this superiority will become more and more decided as the ranges get longer.*

30. From the above it will be understood how it is that *of two rifles the one may be superior in the matter of elevation at short distances, but inferior at long, to the other,* and *vice versâ. This law has hitherto been ignored in the construction of the sporting rifle,* and it has been assumed that, because a particular rifle takes the least elevation at long ranges, it must also have the lowest

* It will be at once perceived that the calculations here made are not intended to represent the actual paths of any known projectiles, but are merely selected as convenient for illustrating the theories advanced.

trajectory at sporting distances; whereas the very contrary is the fact. When we come to consider the merits of the different systems of rifles, I shall have more to say on this point; at present, my only object is to explain the theory as I believe it to stand, of what has been found in practice to be a fact. I am bound to say, however, that since the first publication of this work the subject is much better appreciated.

31. In order to elucidate this theory still farther, I have drawn out the accompanying chart of the trajectories of three different projectiles of the same gauge, but varying in length and weight (Fig. 1, Plate I.); the one coloured black being the plain sphere, the red an elongated projectile of two diameters in length, and the blue a still longer one of three diameters. Their respective trajectories are also drawn in these colours to assist the eye. All three are supposed to start from A in the direction A B, but with different initial velocities—the sphere having the greatest, the short cone next, and the long cone least of all. It will be seen that in the matter of elevation the sphere will be the best up to 200 yards, the red cone will be the best if the ranges are extended to 500, red and blue equal at 600, and at farther distances the blue the best. It will be seen that to economize space the diagram is very much distorted, and consequently the trajectory curves seem much higher than they should be. It must also be understood that, in this instance, as in the last, no actual existing projectiles are here referred to: they and their trajectories are alike imaginary, and only made use of to illustrate the law above laid down.

32. This effect of atmospherical resistance on pro-

jectiles, namely, that of obstructing their flight, is a constant one, *so long as the same surface is presented to the air,* and may be reckoned on as having the same effect on any number of similar projectiles discharged under similar circumstances. It is, therefore, under our control, and by regulating the arrangement of the sights, it has no effect on accuracy of shooting; but we have now to consider another effect of atmospherical resistance, of such a nature as, if we had not discovered a method of altogether preventing it, would be fatal to all accuracy of flight. In treating of the inaccuracy of flight of all projectiles fired from plain barrels, I shall divide my remarks into three heads, viz., THE CAUSE, THE EFFECT, and THE CURE. And first:—

THE CAUSE.

33. In order to understand this, a few more definitions will be necessary:—

AXIOM E. *If the directions of any number of forces acting on a body are parallel to each other, their resultant is a force parallel to them, and equal in amount to their sum.*

AXIOM F. *If the direction of a force acting on a free body pass through its centre of gravity, it will communicate to the body a motion in the direction of the force, which is called a motion of* TRANSLATION; *but if it pass on one side of the centre of gravity, it will communicate to it, in addition to the motion of translation, a motion of* ROTATION *round its centre of gravity.*

AXIOM G. *The* MOMENT *of rotation round the centre of gravity is equal to the strength of the force causing it, multiplied by the perpendicular distance of its direction from the centre of gravity.*

34. Let us now apply these principles to the motions of projectiles; first, with reference to the impulsive force of the charge; and, secondly, to the obstructive force of the atmosphere. The force of the gunpowder gases is just so many parallel pressures on the hinder end of the projectile, the resultant of which may or may not pass through the centre of gravity. With elongated projectiles having a considerable bearing on the barrel, it is evident that it is of no consequence whether the resultant pass through the centre of gravity or not; for no motion of rotation can be established within the barrel; but it is otherwise with spheres which merely touch the barrel in their peripheries. If a sphere be mathematically true in form, and perfectly homogeneous (that is, having its centre of gravity coincident with the mathematical centre of its figure), then it is evident that the resultant of the pressures of the gases must pass through its centre of gravity, and in this case also a motion of *translation* only will be the result. But if, through a flaw in its structure, its centre of gravity be on one side of the centre of its figure, then it is clear that the resultant of the pressures cannot pass through its centre of gravity, but on one side of it, and it will, therefore, by Axiom F, receive a motion of rotation about its centre of gravity, with which it will leave the muzzle.

35. With reference, again, to the resistance of the air; the whole resistance experienced by the projectile is evidently made up of an infinite number of parallel resistances or forces, which have a resultant acting in the same direction, and equal in strength to the sum of the whole. This resultant may or may not pass through the centre of gravity of the projectile. If it does, the

only force will be one of *translation* (which is the retarding force treated of in the beginning of this chapter), but if it passes on one side of the centre of gravity, it will, in addition to the force of translation, produce a motion of rotation round the centre of gravity. Now, the only circumstances under which the resultant *can* pass through the centre of gravity, is when the plane passing through the centre of gravity, at right angles to the direction of the resultant (called the *plane of resistance*), is symmetrical on opposite sides of the centre of gravity; or, in other words, is divided into equal areas by all other planes which pass through the centre of gravity.

36. If a sphere be mathematically true in sphericity and homogeneousness, it will constantly answer to these conditions, for in all positions the plane of resistance will be a circle, and symmetrical round the centre of gravity. Likewise, all accurately constructed elongated projectiles answer the conditions, *so long as they keep their longest axes perpendicular to the plane of resistance.* But since they travel through the air in a curved, not a straight line, they cannot do this for any length of time after leaving the muzzle, for the direction of the resistances is constantly altering, while that of the longest axis remains the same.* As soon as the plane of resistance ceases to be at right angles to the longest axis, it is evident that it can no longer be a circle or symmetrical round the centre of gravity; consequently the resultant of the resistances will no longer pass through the centre of gravity of the projectile, but on one side of it, and by Axiom F will produce a rotatory

* I speak here of unrifled projectiles.

motion round the centre of gravity. This tendency to assume a rotatory motion will be more or less powerful according to circumstances. The farther the projectile flies, the more oblique will its axis become to the plane of resistance, and the more unsymmetrical, therefore, will that plane of resistance be; consequently the perpendicular distance from the centre of gravity to the direction of the resultant of resistances will become greater, and by Axiom G, the *moment* of rotation will become greater in proportion. Also, the more the centre of gravity fails to coincide with the centre of figure in any projectile, the greater will the perpendicular distance from the centre of gravity to the direction of resistance be, and by axiom G, the greater the moment of rotation. The longer, therefore, a projectile is in proportion to its width or greatest diameter, the more tendency will it have to assume a motion of rotation, for its centre of gravity will be farther from its centre of figure. The result of this non-coincidence will vary according to the position of the centre of gravity. If it be posterior to the centre of figure, the *moment* of the force may be so great as to establish a motion of *rotation* round the centre of gravity; or it may be only sufficient to force the front of the projectile to the rear, and establish a motion of *oscillation* round the centre of gravity, in which the revolutions are not complete (as they are in rotatory motion). But if the centre of gravity be anterior to the centre of figure, a motion of *oscillation* only can be established, and this will be more violent the greater the distance between the centre of gravity and the centre of figure.

37. It is, therefore, evident that the only projectile containing *in itself* the conditions necessary for a true

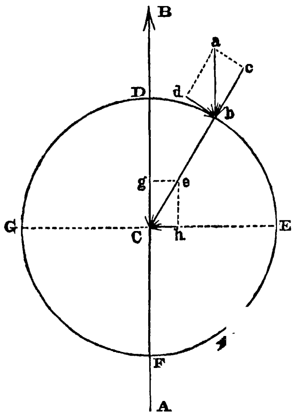
and regular flight, is the perfect sphere—the "ideal" sphere, we may call it—perfect in sphericity and homogeneousness, and starting without any rotatory motion. But such projectiles are unobtainable in practice—they cannot be constructed by human skill, so that their centre of gravity and centre of figure shall invariably coincide. *All known projectiles,* therefore, *when discharged from a plain barrel, are more or less liable to receive an irregular rotatory or oscillating motion, the direction and amount of which cannot be ascertained by previous calculation,* as it varies at every shot. This is the Cause; let us now see what is—

THE EFFECT.

38. If the motion be one of *oscillation* merely, it will cause the projectile to present to the air an ever-varying area of surface; and the amount of air displaced, and resistance experienced, by the projectile, will be constantly altering at different points of its flight, which *will cause it to range a greater or less distance with the same elevation at different shots.* Here is one source of inaccuracy;—also, the oscillating end will act like a helm on the projectile, and render the direction of its flight most uncertain. Neither the *elevation* nor the *direction* of its flight can, therefore, *be calculated on;* and its flight being quite beyond our control cannot be rendered useful for any purpose.

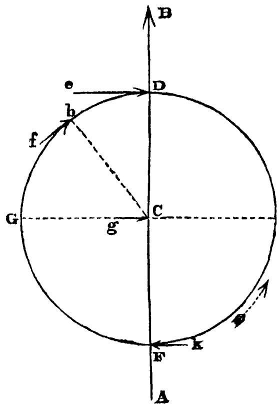
39. If a motion of *rotation,* however, be established, in addition to these causes of divergence are others. The accompanying figures illustrate these. If the projectile of which D E F G is a section be moving in the direction A B, and have also a motion of rotation in

the direction of the dotted sagitta, let its velocity in the direction A B be V, and the velocity of its rotation be V′. Then it is evident that relatively to the surrounding air, the hemisphere D E F will be going with a velocity V + V′, and the hemisphere D G F with a velocity V − V′, that is, with a less velocity than hemisphere D E F; therefore, by axiom D, the *pressure* of the air on the quadrant D E will be greater than that on the quadrant D G, in proportion to the difference of the squares of their velocities. It is evident then that the force resultant from the whole of the pressure on the hemisphere G D E, must be represented by a line the



direction of which passes, not through the centre of gravity C, but on the side of it on which there is a greater pressure. Let this force be represented by the line *a b*, meeting the surface at *b*. This force may be resolved into two others, *d b* and *c b*, the former tangential to the surface, and acting only in retarding the rotation of the projectile, and the latter *c b* acting at right angles to the surface, that is, on the centre of gravity C. This latter force may therefore be represented by the line *e* C, of similar length and direction. This force again may be resolved into two, *g* C and *h* C, the former representing the retardative force of the air to the ball's forward motion in the direction A B, and the latter, a force tending to divert the ball in the direction *h* C, that is, *in the direction of the rotation of the front of the ball.*

Again, suppose the projectile as before moving in the direction A B, and rotating in the direction of the dotted sagitta, then the air in front of it will be more condensed than that in rear of it, and consequently the *friction* of the air against the surface E D G, will be greater than that on the hemisphere E F G. Let *b* be a point on the hemisphere E D G. The force of friction on this point may be represented by the tangential sagitta *f b*, and, by the theorem of couples, this force may be represented as acting at D, instead of *b*, in the line *e* D. In the same manner, the force of friction at any point of the hemisphere E D G, may be transferred to the point D, and the line *e* D may be made to represent the total force of friction on the hemisphere E D G. Also, in the same way, the total friction on the hemisphere E F G, may be represented by a line *k* F, acting at F, and this force will, for the reason above stated, be less than the force *e* D. The total force of the friction then tending to retard the rotation of the projectile is



e D + k F. But, by Axiom F, there will be another force equal to e D $-k$ F, tending to give the projectile a motion of translation in the direction e D; this force may be represented by the sagitta g C, acting *in the direction opposite to that of the rotation of the front of the projectile.*

Here, then, we have two causes of divergence acting in exactly opposite directions; one from the *pressure* of the air tending to divert the projectile in the direction in which the front of the projectile revolves, and the other from the *friction* of the air tending to divert it in a direction directly opposite. If these two tendencies in any case exactly balance each other, no divergence would occur. When, however, one is greater than the other, a divergence must occur. It remains to apply these principles to actual cases. If we suppose D E F G in the first figure to be the section of a sphere, it is evident that when the rotation of the front takes place from right to left, the sphere tends to diverge to the left, and *vice versâ;* when from above downwards, the projectile must fall, and so the range be lessened at any elevation; and when from below upwards, it would tend to rise, and the range at a given elevation be increased. The force of friction, acting as exemplified in the second figure, would of course tend in all these cases to counteract these divergencies; but the effective *friction* on a sphere is, in proportion to the effective *pressure* of the atmosphere, comparatively small, and we should expect to find that *spheres* deviate *in the direction of the rotation* of their front parts. Now, careful experiments in the English, Belgian, and Prussian artillery services have demonstrated that this actually occurs in a very marked degree, and attempts have been made to increase the range of smooth-bored ordnance by giving the shot a rotation from below upwards. Greatly increased ranges have thus been obtained in leisurely experimental practice, but mechanical difficulties have hitherto stood in the way of any practical advantage being gained. Again, let the first and second figures represent sections of an elongated projectile flying side foremost, then it is clear that, when its fore part rotates from right to left, the *pressure* of the air will tend to drive it to the left of its course, and when rotating from left to right, to the right of its course, as shown in the first figure. But the *friction* of the air will in each case tend to counteract these effects; and as the effective friction on such a projectile is very great (particularly when its surface is roughened by grooves), and as the eccentricity of the resultant of the pressure of the air will be comparatively small, we should expect that such a projectile would deviate in a direction opposite to that of the rotation of its front. Now, it has been constantly found in practice that elongated projectiles fired with a right-handed rotation, when they are so shaped as not to keep their long axes invariably tangential to the trajectory, deviate to the right, and *vice versâ.* These two cases have been selected from all possible ones as illustrations of the theories propounded, because they explain satisfactorily what has not hitherto been well understood, namely, why elongated projectiles have a drift or "derivation" to the right when fired with a right-handed rotation, while spheres with a similar rotation deviate in the opposite direction. At the same time, these instances will serve to illustrate the nature of the forces which constantly tend to cause rotating bodies to diverge in some direction or other, and all such divergences must come under one or other, or both these heads. Perhaps more familiar examples may tend to make these principles clear to those who do not care to follow the foregoing arguments, and we have two such ready to our hand in the action of the paddles in steam-ships and the sails of a sailing vessel. The action of a side wind on a sailing vessel illustrates the case of resolution of forces supposed, in the first figure; *a b*, being the direction and force of the wind, striking at an angle on the sail at *b*, is resolved into two forces; one, *d b*, parallel to the sail, causing friction only, and the other, *c b*, acting at right angles to the sail. This force transferred to C, the centre of gravity of the vessel, resolves itself into two forces, *g* C, tending to drive the ship to leeward, and *h* C, giving the vessel a motion in the direction of its course, E G. Again, in the second figure, if D G F E be supposed to be the paddle-wheel of a steamer, the lower half of which, E D G, revolves in water, a denser medium than the air in which the upper half, G F E, revolves, the friction on the lower half will be greater than that on the upper half; that is, *e* D will be greater than *k* F, and *e* D – *k* F, that is, *g* C, will represent the force which, acting at C, the centre of gravity of the steamer, gives it a motion in the direction of its course, G E. These are not perfect examples of the forces created by the revolution of projectiles, but they will serve to illustrate the subject to those who are unable to apprehend it from the more correct demonstration previously given. To resume, then:—It has been shown that a projectile revolving in air is liable to diverge in some direction, which, could its exact rotation be ascertained, might be calculated and allowed for in aiming; but (para. 37) it has been seen that the direction and amount of this rotation cannot be ascertained by previous calculation in the case of projectiles fired from a plain barrel; and it therefore follows that the direction and amount of the divergence is uncertain also.

The Cure.

40. This uncertainty of flight inherent in all projectiles, it will be observed, arises from the direction and amount of the rotatory or oscillating motion being *uncertain.* A projectile launched into space is like an abandoned ship at sea, with no one to set the sails, and the helm veering round in all directions. Set but the sails and the helm at a certain angle, and the ship will hold a straight and settled course. Just so, if we communicate to a projectile a certain determinate motion of rotation, constant in amount and direction; we thereby prevent its assuming any other rotatory motion, and *give it a fixed tendency to diverge in a certain known direction, and at a certain known rate.* We can then, by previous calculation, determine its path of flight, and by altering our aim according to the known divergence, make it available for useful purposes. This rotatory motion might be communicated *in any direction,* but *its rate must vary according to the inherent tendency of the bullet to assume other rotatory motions;*—that is, the *moment* of the normal or regular rotation which we designedly give the projectile, must be greater than the *moment* of any other abnormal rotation, or oscillation, which the projectile would otherwise naturally assume.

41. I have said that the *direction* of the rotation we impart may be any we please, for any determinate rotation *may* be rendered useful: there is, however, one particular direction of rotation which possesses advantages over all others, and which is, therefore, adopted for the purpose, viz., *that round the axis which is perpendicular to the plane of resistance.* Its advantages over others are :—

i. It has no tendency to make the projectile diverge from difference of density in the air behind and before, or creates no "derivation," as the French call it.

ii. It is more easily communicated to the projectile than any other by means of the *rifled barrel.**

These are the only advantages over others it possesses when spherical balls are used; but in addition, when elongated projectiles are employed, is this other :—

iii. It keeps the same area of surface (in an elongated projectile) always presented to the air; and this being the smallest area, there is less resistance experienced from the air, and what there is, is regular.

42. From the above principles (para. 36) it is evident that very much elongated conical balls will require a greater amount of twist to be given to the grooves than shorter ones; and that the greater the distance between the centre of gravity and the centre of figure in any projectile, the greater degree of rifling will be required in the barrel with which it is used. This distance is liable to be increased by accidents in casting, &c.; the *moment*

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* It is believed to be unnecessary to explain here what rifling a barrel is; for this and other points not touched on, I must refer the reader to some elementary work on gunnery, such as the *Regulation Manual of Musketry Instruction.*

of the rotation given by the rifling will, therefore, require to be considerably greater than the *moment* of any rotation that *might* be produced in the projectile by such accidents, if stability of flight is desired.

43. It has been seen, then, that all irregularities of flight to which projectiles are subject, are owing to irregular and uncertain rotatory or oscillating motions communicated either by the action of the powder-gases in the barrel, or by that of the atmosphere during flight; that these irregular motions may be prevented by giving the projectile a determinate rotatory motion which produces regular effects, and is, therefore, under our control; that the power, or moment, of this known rotatory motion must be greater than that of the possible irregular motions which the projectile might otherwise naturally assume; and that the known motion can be communicated most conveniently by means of the rifled barrel. What actual velocity of rotation it will be necessary to give a projectile of a certain shape can only be determined by experiment. As in all gunnery problems, we require here to have a standard, determined by accurate experiment. This standard, however, once obtained, we can to some extent obviate the necessity for constant fresh experiments, by studying the ascertained laws which bear upon the subject, and determining therefrom the relative changes due to certain variations in the size or material of the projectile or in the method of projection. Let us see what changes in the degree of rotation will be required when we—

1st. Use a projectile of larger diameter.

2nd. Give a higher velocity of projection.

3rd. Project the ball at a higher elevation.

44. It must be remembered, in this inquiry, in what manner the resistance of the air acts in causing divergence. If at any point of the bullet's flight the force of the air's resistance, tending to cause abnormal motion, becomes greater than the moment of the normal rotation, the axis of the projectile at once becomes unsteady, and divergence begins. What we have to contend against, therefore, is the *greatest* resistance at any point during the flight; not (as some have stated) the total resistance throughout the flight. If the rotation is sufficient to secure steadiness at the point of greatest resistance, no accumulation of inferior resistances can endanger it. It is, therefore, the *momentum* of the rotation, and not its *vis viva,* on which the stability of the projectile will depend; and if we give a momentum of rotation so great that the greatest resistance of the air fails to upset it, we are safe afterwards, for the force of resistance must diminish more rapidly than the velocity of rotation. Now, the momentum of the rotation of any body is measured by its weight, multiplied by its radius of gyration, and by the velocity with which the extreme point of its radius of gyration travels. But the radius of gyration bears a constant proportion to the diameter. Let A and B be two spheres of lead, with diameters a and b respectively, and let the angular velocity of their rotation be V and V′. Let also M be the moment of rotation of A, and M′ that of B. Then, as their weights will be proportional to the cubes of their diameters, we have—

$$M : M' :: a \times a^3 V : b \times b^3 V,$$

$$\text{or as } a^4 V : b^4 V'.$$

But the resistance of the atmosphere on A will be to that on B as a^2 to b^2; and it is, therefore, only necessary that M should be to M′ as a^2 to b^2, in order to secure the same stability of flight. Now M will be to M′ as a^2 to b^2, when

$$V : V' : : b^2 : a^2.$$

From this we deduce the rule, that in order to secure the same available *moment* of rotation in projectiles of different diameters, the angular *velocity* of rotation we give them should be in the inverse proportion of the squares of their diameters.

45. This rule, it appears, will hold good regarding all spheres of similar material; but with spheres of different specific gravities, the angular velocities will vary in a ratio compounded of the inverse ratio of the squares of their diameters, and of the inverse ratio of their specific gravities.

46. Again, if the projectiles are cones or cylinders, this formula will be incorrect; for the weights of such bodies do not increase in the ratio of the cubes of their diameters, but nearly in the compound ratio of the squares of their diameters and of their heights. This is in general a higher ratio than the cubes of their diameters, and consequently, with large elongated projectiles, the velocity of rotation may be reduced, as compared with small ones, in a greater degree than in the case of spheres.

47. For example: by the above rule, if the diameter of a spherical projectile, A, is 1 in., and that of another, B, 2 in., and A requires to turn on its axis once in every 8 ft., B will require to turn only once in 32 ft.

But if both were elongated projectiles, and a turn in 8 ft. were sufficient for A, a turn in 40 ft. might perhaps suffice for B.

48. These theoretical principles have been found to hold good in practice, as far as any accurate experiments have been made, and it is probable that they are correct.*

49. Secondly, what change in the angular velocity will be required if we increase the velocity of projection? By so doing, the extreme power of the air's resistance to cause upsetting is increased in proportion to the squares of the velocities; but the angular velocity is increased only in the same proportion as the increase in the velocity of projection; we ought, therefore, to increase the sharpness of the rifling just in the same

* If these principles of regulating the pitch of rifling according to the size of the bore are even approximately correct, it is clear that our artillerists have hitherto been proceeding on erroneous ideas in their attempts at the construction of an efficient rifled great gun; and that, until a true conception of the rates of spiral required by very large projectiles, is attained, all their mechanical ingenuity must fail to produce the desired effect. I cannot perceive the difficulty of constructing a 9 or 10 inch gun to throw a rifled spherical projectile to an immense distance with perfect accuracy, provided the pitch of the rifling be no greater than is necessary for such a projectile. It seems to me that, as in the case of the sporting rifle, the efforts of inventors of great guns have hitherto been all in the wrong direction. In very large guns the advantages of elongated projectiles over spherical ones in *range*, are very much less than in small arms; and the advantages of the spherical form in the low pitch of rifling it requires, its high initial velocity, and the reduction of strain on the gun, are very great. If, as has been found to be the case, even the unrifled smooth-bore cannon with its spherical ball can hold its ground in destructive properties against other forms of projectile up to the farthest ranges at which its comparative inaccuracy allows it to compete, it is surely worth while at least to try what it can do when the advantage of suitable rifling is conferred on it.

degree as we give increased velocity of projection. Thus, if we give A a velocity of 1,000 ft. per second, and B of 1,500 ft. per second; if A requires to turn on its axis once in 9 ft., B will require to turn once in 6 ft.

50. Again, an increase in the rotatory velocity will be required when the ball is projected at a higher elevation; for then the direction of the air's resistance acts at an angle, increasing with the elevation, to the direction of the motion of translation, and its upsetting power will be proportionately increased. In addition to this, in the case of an elongated projectile, there will be a larger surface for the air to act on, and, therefore, a greater resistance. The angular velocity must, therefore, be greater, as the angle of projection increases, and rifles intended for long ranges require a sharper twist than such as are to be used only for more horizontal firing. The circumstances vary so much, and so little has been done in the way of accurate experiment, that it would be futile to attempt to lay down any rules on this point at present; and, moreover, it is a question, like the effect of the curvature and diurnal rotation of the earth, which may be safely omitted in calculations respecting *sporting* projectiles, as these are all discharged at such low elevations that it can make no perceptible difference.

51. It has been shown above that the conditions of perfection, in a short-range rifle, are very different from those of a weapon in which range is a main object; that, for short ranges, the main thing required is extreme velocity of projection, irrespective of the form of projectile, while for long ranges we require, first of all,

to shape the projectile so that it shall meet with the least possible resistance throughout its flight, giving it, at the same time, as high a velocity of projection as we can. I now propose to inquire what mechanical construction in the rifle is most suitable for attaining each of these objects. In order that this may be understood, it is necessary to discuss the forces that act in the interior of the barrel.

52. The present state of our knowledge of the action of fired gunpowder is most unsatisfactory. From the nature of the subject, we can only guess at the facts from observed results; and thus many different theories have, from time to time, been started, which agree, more or less, with what is observed in practice. All attempts to express the actual force of fired gunpowder in figures have hitherto failed, owing to the infinite variety of circumstances attending its conversion into gas in different cases.

53. It appears clear that a charge of powder fired in a gun barrel is converted into gas in a more or less minute space of time. Its force of expansion, when the gas occupies the same space as the powder did—that is, before the ball has begun to move—has been variously estimated. Robins calculated it as equal to 1,000 atmospheres; Hutton at 2,000; and more recent writers at upwards of 40,000!

54. Be this as it may, being an elastic fluid, it will follow Marriotte's law, that its force of expansion will decrease just in proportion as the space it occupies increases. It will also, like all such fluids, possess the greatest force of expansion when its temperature is highest. It follows that the force of the gas is greatest

when first fired; for it then occupies the smallest space, and is subjected to the most intense heat. It will become less and less powerful as the bullet passes up the barrel, for the space occupied increases while the temperature becomes lower.

55. The period of time required for complete ignition will vary somewhat according to the quantity of powder in the charge, and also according to the size of the bore, the granulation of the powder, &c.

56. In order to deduce accurate theoretical principles, therefore, we would require to know—

i. The initial force of inflamed gunpowder, under all circumstances.

ii. The diminution of temperature due to any increment of space, or of time.

iii. The diminution of force due to any decrease of temperature.

And no satisfactory knowledge has yet been attained of any one of the three!

57. Without, therefore, venturing on any exact calculations, we must endeavour to deal with the subject, as far as ascertained facts will carry us, in examining the action of the charge on the projectile and on the rifle.

58. A charge of gunpowder exploded in the chamber of any barrel exerts an equal force in all directions; on the sides or walls of the barrel, tending to burst it, if of insufficient strength; on the projectile in front; and on the gun backwards, tending to cause recoil. A certain charge of gunpowder is capable of being converted by ignition into a certain quantity of expansive gas, or, in other words, can furnish a certain amount of effective force. Now, any portion of this force absorbed or

"used up" in one direction, is just so much deducted from the total force available in other directions. But the sides of the barrel can absorb none of this force unless they burst, for no force can be absorbed without producing or destroying motion; the whole effective power of the gas produced is, therefore, expended on the projectile and on the breech.

59. AXIOM H. *Equal forces, acting, under similar circumstances, on two bodies whose weights are different, will communicate to them velocities inversely proportionate to their weights.*

60. By the above axiom, the velocity communicated to the projectile would be to the velocity of recoil communicated to the gun in inverse proportion to their weights. Thus, if we desired to give a velocity of 1,600 ft. per second to a 1 oz. ball in a rifle weighing 10 lbs., we would have to be prepared for a recoil at the rate of 10 ft. per second—for

160 oz. : 1 oz. : : 1,600 ft. per sec. : 10 ft. per sec.

But if we used an 8 lb. rifle with similar charge and ball, the recoil would be increased to $12\frac{1}{2}$ ft. per second —for

$$128 : 1 :: 1{,}600 : 12\tfrac{1}{2}.$$

61. In reality, however, the above proportion between recoil and velocity is liable to a correction—and it is well for us that it is—on account of the force of the explosion not acting on the projectile and on the barrel *under similar circumstances.* Were either of them immovably fixed, the other would receive the full force of the explosion, and the result on that which was free to move would be as above; that is, if when

the gun is fixed immovably, the velocity communicated by any charge of powder to the ball were 1,600 ft. per second, on the other hand, if, by any means, the ball could be fixed and the rifle left free to move, the velocity it would receive from a similar charge would be 12½ or 10 ft. per second, according as it weighed 8 or 10 lbs. But this is not the case, for both the gun and the projectile give way, although in different degrees. The effect of this yielding in one direction must be to lessen the force acting in the opposite direction; just as a person, wishing to push with all his strength, gets his back, if possible, against a wall or other support, but if this support gives way his effective power becomes at once comparatively small. Now, while the breech of the rifle against which the gas *has got its back*, when trying to move the ball, gives way but little, and offers a comparatively solid basis against which to act, on the other hand the projectile, which in turn takes the place of the wall when the gas is acting on the breech, is a very treacherous support indeed, and gives way at once. The consequence is that, in the former case, the gas acts with almost its full power, and, in the latter, with that power very much curtailed.

62. This may be explained otherwise, thus:—The law of impact of perfectly elastic bodies is that the velocity of restitution is equal to that of impact, minus the velocity communicated to the object struck. Now, the gunpowder gas may be considered as possessing perfect elasticity, and as the velocity it communicates to the rifle is very much less than that communicated to the ball, it is evident that the remaining velocity of that portion of the gas which reacts from the breech on

the ball, must be higher than that of the portion which reacts from the ball on the breech. From this, it appears that the proportion between the velocity of projection and that of recoil, will not be exactly in the inverse ratio of the weight of the rifle and the projectile, but in a ratio somewhat lower.

63. In order to calculate exactly the amount of correction due on this account, we should require to know the actual velocity of the expansion of fired gunpowder, and here again we are pulled up by the total absence of any certain knowledge on the point! This is, however, of little consequence, as the correction must be a constant quantity, and leaves untouched the fact that the velocity of projection, and that of recoil, depend on the relative weights of the ball and the rifle; *that the heavier the rifle in proportion to the ball, the less will be the recoil, and the greater the velocity*, and *vice versâ*—the charge, of course, being the same.

64. Again, by Axiom H, when we use projectiles of different weights, with the same rifle and charge of powder, the velocities communicated to them should be in the inverse ratio of their weights; that is, a 1 oz. ball should receive four times the velocity of a 4 oz. one. But this is not found in practice to be the case; in point of fact, the velocities communicated to the two balls would be more nearly as two to one, that is, in the inverse ratio of the square roots of their weights. This, again, seems to be because the force does not act in the two projectiles *under similar circumstances.* The heavier ball will possess a greater *vis inertiæ*, and will not give way at first so rapidly before the expanding gas; the gas will therefore, from being longer confined, be raised

to a higher temperature, and become more highly elastic, and (as we are supposing the barrel to remain of the same dimensions) will expand up to the muzzle at a higher average velocity. The total pressure on the heavier ball will, therefore, have been greater than on the lighter, and the initial velocity will be *comparatively* greater.

65. This relative gain of velocity with heavier projectiles must, however, be purchased by a corresponding increase of the ratio of recoil; that is, in the above supposed case of a 1 oz. or a 4 oz. projectile being fired out of the same barrel with the same charge, had the 4 oz. received only one-fourth the velocity of the 1 oz., its recoil would have been only four times as great, but the increase of pressure required to give double the velocity must also double the recoil, and raise it to eight times that of the 1 oz. ball.

66. After all, then, we gain little or nothing by this property, by which a greater weight to lift seems *per se* to increase the power of the charge; for as the recoil is also increased, we must reduce the charge till the recoil again diminishes, and of course the velocity decreases along with it; so, as the saying is, "it is just about as long as it is broad."

67. In the above remarks, we have assumed the initial pressure of the charge to remain the same, or in other words, that we have been using one charge of powder, fired in exactly the same way; but great differences in these points exist in practice; we must, therefore, consider the effect of using different charges, fired in various ways.

68. By increasing the charge, we increase the

quantity of gas which will be produced on ignition just in the same proportion. The total pressure on the projectile, however, is not increased in the same degree, for the space occupied at first by the increased volume of gas is larger just in proportion to the increase of charge, and consequently the initial tension of the gas is no greater in the one case than in the other.

69. It is certain, however, that the total force of an increased charge of powder must be still more enhanced by the greater degree of heat developed; as before explained, however, no accurate information has been acquired on this point, and we can only guess at the truth. It is probable that the specific heat of fired gunpowder is the same without reference to the size of the charge, when it occupies a larger proportionate space; and also that the heat of inflamed gases varies in intensity somewhat in proportion to the space it occupies. Should this be the case, the calculation of the increase of force from this cause would be similar to that in para. 68, regarding the tensions of varying charges, and a ratio compounded of the two ratios of tension by space, and tension by heat, would result in this that the velocities communicated by different charges of powder would be nearly as the square roots of the charges—which, with ordinary charges (up to eight drachms, or so) has been ascertained to be the case.

70. Again, if we ignite the charge of powder in barrels of different bores, some variation of effect must be looked for. In a smaller gauged barrel a very large charge, from a large portion of it being at a distance from the point of ignition, will probably take a longer time to ignite than it would in a wider barrel. The

projectile may, therefore, have been moved from its seat before complete ignition takes place, and the tension of the gas will be less powerful at first starting: but owing to the inflammation of the rest of the powder afterwards, and the cubical contents of the barrel being less for a given length, the pressure in the later stages of the ball's passage up the barrel will be considerably higher.

71. It would follow from this that in narrow gauges, the action of the charge is more useful towards the muzzle end than in wide gauges; and, therefore, that small-bored rifles require longer barrels in proportion to their bore, than large bored rifles do, in order that the fullest effect may be obtained from a certain charge of powder. This is found to be to a great extent the case in practice. For example, if a charge of three drachms be used with a small-bored Henry or Whitworth rifle, it continues to give considerably increased velocity up to about 36 inches of barrel length; but the same charge in a smooth-bored ball gun of 12 bore, ceases to add any considerable degree of velocity at about 26 inches; while, therefore, it is advantageous to have such long barrels with the former description of weapon, they are practically useless with large bores, *unless the charge be proportionably increased.* The granulation of gunpowder, however, to some extent, modifies these deductions, which will be considered further on.

72. The manner in which the *column of air in the barrel* affects the velocity of projection is a somewhat intricate subject to deal with. Its amount and variations for different gauges and lengths of barrel have not been determined with any accuracy. Like all

atmospherical resistance, it will be greater in proportion as the effort at displacement is more violent; that is, as the velocity with which the ball attempts to pass up the barrel is greater. It is probable that, owing to the inertia of the particles of air—that is, to the fact that they require a certain time to move out of the way of the ball—the whole of the column becomes compressed into a small space at the muzzle, as the ball rushes up the barrel. But I am of opinion that the resistance offered from this cause has been very much overrated. Suppose, as an extreme case, that the whole of the column gets compressed into the space of 1 in. before any of it leaves the muzzle; then, of course, in a barrel twice as long as another, the air will be twice as much compressed, and will offer twice as much resistance. In a barrel of Enfield bore (·577 in.), 27 in. long, allowing 2 in. to be occupied by the charge, there will remain 25 in. of air to be compressed into the space of 1 in.; the resistance offered, when this is effected, will be that of twenty-five atmospheres; and allowing that one atmosphere presses with a force of 15 lbs. on the square inch, and that the area of the Enfield barrel is ·261 square inch, the total resistance at 1 inch from the muzzle experienced by the ball will be about 98 lbs. Now the computations of ROBINS make the force of exploded gunpowder, when confined to the space originally occupied, equal to 1,000 atmospheres. HUTTON afterwards doubles this; and more modern researches show that even he estimated it far short of the real amount. Allowing it to be only = 2,000, however, and suppose, as before, that 1 inch is occupied by the powder, when the gas created by the explosion has expanded so as to fill 25 in. of the barrel (leaving 1 in. for ball and 1 in. for condensed air, as before), it will press on the ball with a force of $\frac{2000}{25}$ atmospheres to the square inch, which, on the area of the Enfield rifle, is equal to a pressure of 313 lbs. The pressure in front of the ball, therefore, at 1 in. from the muzzle, is 98 lbs., and in rear of it, 313 lbs. It must be remembered, however, that this is the point of maximum pressure in front and minimum in rear; the powder is then weakest, and the condensed air strongest; at any other point of the barrel the preponderance in favour of the propelling force would be infinitely greater. By similar calculations to the above, counting the pressures at each inch along the barrel, it will be found that the total sum of the pressures in front is equal to ninety-six atmospheres, or, in the Enfield barrel, 375 lbs.; while the sum of the pressures in rear has, during the same time, been 7,538 atmospheres, or 21,505 lbs.! At the highest computation, therefore, the velocity of the ball in a barrel of this length is diminished by the resistance of the air in the barrel *less than 2 per cent.* It is evident, however, that with every increase in the length of barrel the percentage will be increased in a greatly enhanced ratio; and from this cause it is that every inch in the length of barrels becomes rapidly more and more useless as its distance from the breech increases, and long barrels are not found to shoot better than short ones in proportion to their lengths.

73. Fine-grained powder will produce a greater amount of resistance of this sort than coarse; for it will drive the ball with greater velocity up the barrel at first,

and will give the column less time to escape at the muzzle; but in no case can it be supposed that the resistance can be greater than in the above supposed case, viz., the whole column being compressed into one inch at the muzzle. In all probability this only occurs with the finest electric gunpowder, and with the ordinary rifle powder the compression does not take place to any such extent. I see no reason to suppose that the calibre of the barrel should affect the amount of this resistance, provided the pressure of the powder to the square inch remains the same.

74. From the considerations mentioned in paragraphs 71 and 73, it is evident that for a certain calibre a great length of barrel will require larger-grained slower-burning powder than a shorter barrel. I see no reason to suppose, however, that a larger calibre should require larger-grained powder, unless the increase of gauge be accompanied by a corresponding increase of length.

75. *Friction.* — The facility with which the ball passes up the barrel will be affected to a considerable extent by the amount of friction between it and the sides of the barrel. Friction depends on the roughness and extent of the surfaces in contact, and on the force with which they are pressed together. Hence the necessity for the most perfect polish in the interior of gun-barrels. An elongated projectile which has a large surface in contact with the barrel will suffer more from friction than a sphere, which touches only in its periphery; also, an expanding conical ball, which is pressed forcibly by expansion against the barrel throughout, will be very much more retarded by friction than

a sphere, or than a hard mechanically fitted bolt, which cannot expand. Lubrication by oily substances lessens friction very greatly.

76. *The Rifle Twist.*—It has been seen that different projectiles require different degrees of rotatory motion to keep them point foremost (par. 42). This entails a change in the angle at which the rifle grooves, by means of which the rotation is communicated, are cut.

77. The way in which different degrees of spiral in the grooving affect the above laid down principles of velocity and recoil is best explained by reference to the accompanying diagram (Fig. 3, Plate I). It represents a barrel cut open along its length and rolled out flat, when of course the angle of inclination in the grooves would remain the same. Two different degrees of spiral are here represented. The length of the barrel A D being 26 in., we have in one case the groove A B making a quarter turn in that length, which is equal to a whole turn in 8 ft. 8 in.; while the groove A C makes a whole turn in the length of barrel, or in 2 ft. 2 in. It is evident that these are nothing more or less than two inclined planes, up which the ball has to be driven by the charge, instead of moving along the level A D, as it would do were the barrel a smooth bore. Now the force required to drive a given weight of ball at a given velocity up the lesser gradient A B, will evidently be much less than that required for the same purpose when the gradient is four times as steep; and if the same force be available in both cases, the rate at which it will move the ball up A B will be greater than the rate it will accomplish on A C. Rolling up our dissected barrel into a cylinder again, let us see how this

affects our principle of velocity and recoil. It is precisely the same as if we added something to the weight of the ball, or deducted it from that of the rifle; it alters the ratio of work to be done forwards and backwards by the charge; and thus it is that any increased sharpness of twist in the grooves lessens the velocity of projection and adds to the recoil.

78. Various other results arise from this increased sharpness in the rifling of barrels, which, however, will find a more suitable place farther on.

CHAPTER III.

SPORTING WEAPONS.—SELECTION OF A RIFLE.

79. In the last chapter the theoretical principles of gunnery, as applicable to our subject, have been set forth; we now proceed to apply these principles to the examination of the various systems of fire-arms now before the world, with a view to determining their several advantages and disadvantages for sporting purposes.

80. The Smooth Bore is the simplest and oldest form of gun now remaining in use. It consists simply of a cylindrical tube, closed at one end, and loaded with a plain spherical ball. In this weapon, if it be truly bored, and scientifically constructed, as regards length, weight, &c., friction is at a minimum, the velocity of the projectile is the highest, and the recoil is least of all possible guns of similar dimensions.

81. In considering the effect of modifying this simple arm, it is necessary to adopt some standard of reference with which all may be compared; this must be that of weight, which is the only element in the sporting rifle that may be considered constant and unalterable for any particular person. Let us suppose a person capable of carrying—or, in sporting phrase, " up to "—

9 lbs., then that must be the extreme weight of his rifle; and the question is, how to make the best use of this weight, by getting the most useful and powerful weapon consistent with the weight allowed. The recoil is the test. Any rifle whose recoil is not excessive, and weight not exceeding 9 lbs., may be used; there are multitudes of such—which shall we use? Of course, that with which we can shoot best, and which has most effect on game. We must take some particular gun, charge, and projectile as a standard, whose recoil at 9 lbs. weight is not excessive. This will vary somewhat according to the shooter, for some men by their position in shooting counteract the recoil more than others, and feel it less. Theory, however, is inadequate for this purpose, and we must consult experience. It is well known that a 12 gauge smooth-bore, with 3 drs. powder and 1¼ oz. of shot, should not recoil excessively at 7¼ lbs. weight; and by repeated experiments, firing many shots a day, I have found that a smooth cylindrically bored gun, 2 ft. 6 in. in the barrel, 14 gauge, 9 lbs. weight, loaded with a No. 15 spherical ball and patch, and 4 drachms of Hall's No. 2 rifle powder, has a sufficiently moderate recoil for all practical purposes.

82. The smooth bore is still universally used by all uncivilized nations who are acquainted with the use of fire-arms, such as the native hunters of India who use the smooth-bored matchlock. Their weapon is generally very long in the barrel, and therefore suited to the coarse-grained, slow-burning powder which they use. It is a most extraordinary fact, that these people generally kill whatever they fire at with a single shot; while European sportsmen, using the best modern rifles, very

seldom indeed succeed in doing so with any of the large kinds of game. One reason for this may be the calm and catlike nature of the native, who waits till his game approaches within certain distance; but the chief cause I take to be the vastly *superior* penetrating power of their weapons, owing to the enormous velocity generated in such long barrels with a heavy charge of suitable powder. The gauge is, generally, from 12 to 16, and the charge from *six to nine drachms:* the recoil is violent, but it is not altogether received on the shoulder, as the stock is made to slip off beneath the arm on firing. These people admit the vastly superior *accuracy* of our rifles, but scorn their miserable game-killing power. Many European sportsmen still prefer for shooting dangerous game the plain smooth-bored gun; nay, I think I am justified in saying that the vast majority of sportsmen in India have, at this very moment, in the year of grace 1866, a pet old double gun which they would prefer to any rifle they ever fired for a close-quarter shot—say under 30 yards! They say they can't *hit* with the rifle so well as with the smooth-bore, although most of them admit the superior accuracy of the rifle. Few, however, comprehend *why* it is that they can hit better with the one than with the other, and this I will endeavour to explain. Few sportsmen ever think of using any weapon of less gauge than 16 against dangerous game. Now an ounce spherical ball admits of being put into a higher velocity in a plain barrel of this gauge than any elongated projectile whatever in a rifled barrel does; and consequently, so long as its velocity remains superior, it will, as before explained, require a less amount of elevation than the rifle. The 14 smooth bore, for instance, mentioned above, will describe during the first hundred yards of its flight a curve, of which the greatest height above the line of aim would be about 3 inches, and its trajectory up to 60 yards would not rise above 1 inch. The sportsman, therefore, with such a weapon, has positively no allowance whatever to make at any distance under 70 or 75 yards; for an inch one way or other to make any difference, the shooting must be very fine indeed. He would, therefore, hit everything he fairly covered up to that distance, so far as elevation is concerned. Not so with the *rifle of similar gauge* as generally made. An Enfield-shaped ball, for instance, with such a charge as could be used with it, would rise fully 6 inches in its 60 yards trajectory; and this rise would take place at about 30 yards from the muzzle. To hit, then, the brain of an animal at that distance, the sportsman would require to aim 6 inches *below* it; with the smooth-bore he would aim *at* it, but if he did so with the rifle he would miss it altogether.

83. So also in the allowance to be made when firing at running animals—the smooth-bore bullet, moving at a great velocity, requires to be directed but little ahead of the part to be hit, while the slow-going rifle ball requires a large allowance. For example, suppose an antelope crossing at 100 yards, at a speed of 18 miles an hour (nothing uncommon), the smooth-bore with a velocity of 2,000 ft. per second would require an allowance of 3½ ft., or one length, to be made; whereas such a rifle as that supposed would require an allowance of 9 ft., or nearly three lengths, at least. This may account to many sportsmen for some "unac-

countable misses" they have perpetrated when using such rifles.

84. Although the smooth-bore has this great advantage over the elongated-ball rifle, it is universally admitted, and cannot be denied, that, at anything beyond the very shortest distances, accuracy of shooting cannot be got out of it. I do not think that even the best smooth-bore can be depended on for *accurate* shooting further than about 40 yards, or *perhaps* 50, if bored a true cylinder, as very few shot-guns are.* The elevation given to ordinary smooth-bores, being calculated for the droop of the *shot charge* at 40 yards, is, invariably, too great for the ball with large charge at that distance. A gun purposely made for ball shooting would require far less elevation to be given to the rib, sufficient only in fact to carry the ball up to 50 or 60 yards with a large charge; but this again would not be sufficient for the shot, which is another proof that *no gun can be made equally perfect for any two methods of loading.* Ball guns, smooth in the bore, are still, as I said above, in general use all over India. They are found to carry nearly far enough for practical purposes in jungle shooting, and they certainly kill, if they hit, much better than the generality of rifles. This is simply owing to the carelessness or prejudice that has hitherto prevailed amongst the makers of sporting rifles

* This statement is liable to a correction in the case of breech-loaders. In a cylindrically-bored breech-loader the accurate range is much more than 50 yards, owing, I believe, to the accuracy of fit secured. I have lately made some wonderful shooting with a "lockfast" breech-loading smooth-bore, killing, in one case, two tigers, right and left, in motion, at 80 and 170 yards. The gun was made only for ball shooting.

in England. If a rifle were offered to the many good sportsmen who now prefer the smooth-bore, combining with the largeness of gauge and low trajectory of the smooth-bore, the accuracy of the rifle principle up to sporting distances, many, if not all, of them would doubtless take to it at once; but such a thing is *not to be had* from an English maker. If large enough in the bore, it is certain to take enormous elevation at short distances (just where we want to use it), and so baulk the sportsman in his shooting; and if right in the matter of elevation, it will to a certainty be so small in the gauge as to be hardly big enough to "pot cats with." * My chief object in writing these pages is to point out to the sportsman how he may get such a rifle, if he has courage enough to disabuse his mind of all prejudice.

85. Spherical Ball Rifles.—The first alteration effected on the smooth-bore was the application of the rifle principle to it, which, as we may fancy, was not done in the most scientific manner at first. If any one who possesses a set of the *Indian Sporting Review* will turn to vol. xv. No. 29, he will there find an article entitled (in the hybrid language which writers on Indian sports think so attractive), "The Philosophy of Shikar," and signed "Jack Furlough," in which the writer propounds the science of gunnery applied to sporting rifles, as understood by himself; and as, with the exception of one self-evidently absurd statement, his positions remained uncontested, we are bound to believe that, in those days, such was the universal state

* I have left this passage as it stood in the first edition; but I must say that many gunmakers now know very well what is required in the Sporting Rifle.

of ignorance on such subjects among Anglo-Indian sportsmen, who were certainly not behind the rest of the world in that sort of knowledge. The article will, doubtless, furnish a vast fund of amusement when read by the light of modern science; for, although Jack was in the main right as regards his *facts* about the rifles of the day, his *reasons* for the same, and the deductions he draws from them, are truly most absurd and unaccountable even in that age of Cimmerian darkness.

86. Of a verity, the rifles of a former race of sportsmen *were* the most unscientific machines it is possible to conceive in an enlightened age (except, perhaps, some *modern* ones which are as bad, or worse). Every accumulation of obstructions it was possible to throw in the way of their doing their work properly was heaped upon them by their makers; and in the blindfold attempts made at improvement, gunmakers and sportsmen only succeeded in plunging deeper and deeper into the mist. Let us see what they were.—First, there was the polygroove rifle, that is, a rifle having any number of grooves more than two, used with a spherical ball several sizes too large to enter the muzzle, which, with the addition of a patch, was hammered in by a mallet and driven home by heavy blows of a rod:—what its shape must have been when it came out again may be imagined better than described. But owing to the sharp rate of spiral given to the rifling, this tight fitting was absolutely necessary in order to avoid "stripping." The twist varied from a turn in 3 ft. to a turn in 4½ ft. of barrel, and, as may be imagined, the charge it would admit of,

retaining its accuracy as a rifle, was ridiculously disproportionate to the weight of the ball. It cannot be denied that considerable accuracy of flight was attainable by this rifle, *with small charges and great elevation,* and at standing shots of course considerable execution might be done by a *perfect judge of distance,* when time was allowed for the necessary calculations; but the effect of the ball, *so used,* was very insignificant on the large and powerful beasts of chase. If a large charge of powder was employed to give greater power, "stripping" was the result, followed of course by great inaccuracy of flight—reducing the rifle, in fact, to an imperfect smooth-bore. Well, to remedy this, some long-headed individual introduced the two-grooved rifle with a belted ball, and ultimately four grooves with a double belt were adopted. A greater hold on the grooves was thus obtained, and a larger charge of powder could be employed, retaining the advantage of the rifle principle; but, instead of leaving the rate of spiral in the grooves as it was, in which case some small advantage might have been obtained, it was increased till it ran as high as a whole turn in 2 ft. of barrel! — creating thus an enormous amount of additional friction in the passage of the "ragged" bullet both through the barrel and through the air, and cancelling altogether the advantage of the increased propelling power. The result was, that the new rifle was found to possess very little, if any, advantage over the polygroove; and their respective merits remained a bone of contention till the inventions of Minié and Jacob turned every one's attention in a new direction, and all attempts to improve the old weapons were abandoned.

87. But it may be said, that the sportsmen of that day killed a vast deal of large game of all descriptions with these weapons, and, in fact, made bags seldom equalled, and never surpassed by more modern Nimrods. True, and why? Because they soon discovered the inefficiency of their rifles if loaded with the regulated small charge, and systematically overloaded them when shooting heavy game; preferring thus to sacrifice accuracy to force, and reducing the rifle, as I said before, to the state of an imperfect smooth-bore—that is, if they did not abandon the rifle altogether, and adopt the smooth-bore as being the best weapon, in their battery, which was certainly, under the circumstances, the wise thing to do. By this system, they also secured a flatter trajectory at short distances, got close to their game, held straight, and bagged by the pure driving force of the ball at such short distances that the violence done to the rifle principle had not time to affect much the accuracy of flight.

88. Now, *why* were all these disadvantages found to attend the use of the rifle with the plain spherical ball? Simply because a rate of spiral was adopted utterly inconsistent with its use, and necessitating deep grooves, tight bullets, and much hammering to get them home. A less turn than 1 in 4 ft. was hardly ever given to rifles in those days, and the miserable smallness of the charge was in proportion. A Purdey rifle I once possessed, 13 bore, with a turn in 3 ft. 6 in., invariably stripped if I gave it the least thing more than 1¾ drachms:—with *that* charge, it shot splendidly, but the elevation was excessive, the rise in its 100 yards trajectory being about 11 inches, rendering it utterly useless

and absurd for sporting purposes, that is, for *shooting game in the field.*

89. How strikingly these sharp spirals absorb the force of large charges of powder, I had an excellent opportunity of noting in the field some time ago, when shooting buffaloes with a friend in the Sumbhulpore country. He used a powerful-looking 8-gauge 4-grooved rifle; a savage bull charged us, and when within a few paces of my friend, he fired this pocket cannon loaded with a double-belted ball and 5 drachms of powder in his face, and the next moment was sent flying by the bull! We found afterwards that the ball had struck him below the eye, and stuck there within about a couple of inches of the skin,—and all because the gun was rifled at the preposterous rate, for a rifle of that sort, of 1 turn in 20 inches!

90. About the year 1841, I think, Mr. Kennedy, gunmaker, Kilmarnock, made an improvement in spherical ball rifles, by reducing the spiral from the established rates to 1 turn in 10 or 11 ft., which he found to be perfectly sufficient for sporting distances. He was patronized by a good many sportsmen, particularly in India; but he was unable to grasp the whole advantages resulting from this reduction of the spiral, and failed to facilitate the loading by shallowing the grooves and giving the ball an easier fit, or to secure a flat trajectory and great penetration, by using heavy charges. In these respects his rifles were almost as defective as any others, and on this account could not hold their own when the invention of the easy loading expansive bullet took place; they never, therefore, came into any very general use, and were, in the wild

impulse of the new invention, consigned with everything "spherical" to oblivion.

91. The idea of thus reducing the spiral of spherical ball rifles is a very old one, as the following passage from Johnson's *Sportsman's Cyclopædia*, published in 1831, will show:—

"It has always been considered that three-quarters or a whole turn in the angle of a rifle in a barrel 3 ft. in length, was the best for throwing a ball to a certainty. This mode of rifling is practised by the Germans, French, Americans, and all the foreign rifles that I have ever yet seen, are rifled according to that principle; and several English gunmakers are firmly of opinion that one turn in 4 ft. is the best angle possible. With these angles of rifle I never could fire at a long range to any degree of certainty. If I apportioned the powder to make it range at 300 yards, I found the ball go very random, and from this I judged that the balls tripped over the top of the rifle, which caused it to fire as random as a common musket. In order to find out the cause of this evil, I rifled a barrel one turn in 4 ft.; and on trial found that the nearer I came to the straight line, the more true and further I could range. I then cut it to 1 ft. ¼ turn, and found I could fire more true at a shorter distance than I could when more angle in the rifle. From this conviction I made a barrel 2 ft. 6 in., and rifled in ¼ turn. The experiments succeeded to my most sanguine expectation. I was perfectly satisfied that I could range further, and more true, than in any previous trial, and with less elevation."*

92. About this time also, or a little later, the riflemen of the English and some of the Continental armies, were armed with spherical ball rifles, rifled at the rate

* Our writer seems rather illogical here, and his conclusion somewhat of a *non sequitur*, but perhaps he only expresses his meaning badly.

of a turn in 10 or 12 feet; but, as might be expected, they were not found to answer for military purposes, where an accurate *long* range is looked for. Although found to be equal in accuracy at short distances, they were surpassed in that respect by rifles with a sharper twist at longer distances. In fact no *small* sphere can be projected with accuracy to very long distances; for it must either have a sharp spiral, and then the velocity is insufficient, or it must have a slow twist, which will be insufficient to keep its axis steady at long ranges, and high elevations.

93. I have found that a 14 gauge barrel rifled at the rate of one turn in 8 ft. 8 in., if correctly made, will throw a plain spherical ball with sufficient accuracy for all practical purposes up to 200 or 250 yards. A rifle on this principle requires the grooves to be cut very shallow and broad, and the lands very narrow, almost knife-edged; the ball should just touch the lands, and no more, and the hold on the grooves is given by a very substantial patch; the loading, if the ball is properly fitted, is most easy, and no rifle that I am acquainted with fouls so little. The ball will *never strip*, whatever charge you use, with so little twist in the grooves; and balls of any degree of hardness may be used. Referring this rifle to the standard above adopted, if of the same dimensions and weight of ball, the velocity ought to be a little reduced, and the recoil increased on account of the rifling, but this occurs in so slight a degree as to be almost inappreciable. The elevations for 60 and 100 yards are nearly the same as in the smooth-bore, with the same charge; perhaps the ball rises about ½ inch more in the hundred yards' trajectory. That the accu-

racy of such a rifle is ample at sporting distances, the following fact will show:—I am in the habit of determining the trajectories of my rifles by placing screens of fine paper just above the line of aim, and accurately levelled (the method of doing this will be afterwards explained); and on several successive occasions, the bullets of such a rifle, when firing at 100 yards, passed through the same holes in the three successive screens. The heights of its trajectory (a 14-gauge) were at 25 yards, 1 in.; at 50 yards, $2\frac{5}{8}$ in.; at 75 yards, $2\frac{3}{8}$ in., and on the line at 100. The point blank of this rifle with 3 drachms is about 60 yards; with 4 drachms, about 85 yards; with 5 drachms, 100 yards. The only effect of increasing the charge was to lessen the elevation, and make the rifle hit harder; the recoil, of course, increased in proportion. It is of great importance that the sporting rifle should admit of varying charges without affecting its accuracy to any serious extent. This is the case with the spherical ball rifle as properly constructed, but with no other that I am acquainted with. The only effect increase of charge has on this rifle is to make the point-blank range somewhat longer, and to make the rifle hit harder; the accuracy remains unimpaired. If it be a double barrel, and it shoot true with the ordinary charge, an increase will have a slight effect on the shooting of the barrels, making each diverge slightly to its own side. As such animals are always shot at short distances, this will hardly be perceptible; but some error of this description is unavoidable with double rifles used with varying charges.

94. I have said that this system of spherical ball rifles never obtained much ground previously to the intro-

duction of the new and wonderful conical ball systems, and that it was lost sight of on their invention; let us see what these are, and how they have affected the SPORTING RIFLE.

95. The gradual development of scientific knowledge, and the utter unsuitableness of the spherical ball rifle, as then made, for military purposes, sharpened the wits of inventors, and at last they stumbled on the truth that accurate long range is only to be got by using elongated projectiles. These could, of course, be used only in a *rifle* of some sort, as any but the spherical ball in a smooth bore must fly with the utmost irregularity. For a long time after their introduction, conical balls continued to be used in barrels of equally large gauge as the spherical ball. The Minié rifle, as first used in our army, was nothing but a regulation musket rifled. Had things remained at this stage, but little improvement would have been gained; but gradually it was found that in order to obtain a sufficient initial velocity the gauge must be reduced as the ball becomes elongated, so as to keep the *weight* of the mass to be projected the same.

96. I have stated that a smooth-bore, 9 lbs. weight, with 30-inch barrels, 14 gauge, loaded with a spherical No. 15 ball, and 4 drachms of powder, gives a moderate recoil. If now we reduce the gauge, retaining the weight of ball in a conical shape, and apply the necessary rifling, we have the same weight to be lifted; but in addition we have extra friction of the ball against the barrel (75), and we have to lift the weight up an inclined plane instead of on level ground, on account of the rifling (77); but, using the same charge of powder, the

effective power is the same, and it will therefore give less velocity and more recoil in the smaller gauge than in the No. 14.

97. Again, retaining the gauge, and using a heavier ball than the sphere, which must, therefore, be an elongated one, we have a greater weight to be lifted, greater friction (75), and the resistance due to the rifling (77) to be overcome; the velocity will therefore be much reduced when the same charge is used, and the recoil will be increased in proportion (64).

98. It has been shown above (42) that the longer the projectile is the greater will be the degree of rotation required to keep it point foremost to its true line of flight without upsetting or vibration. This necessitates that a greater degree of spiral be given to the rifling of the barrel; and on the *effects* of this I have a few words to say.

99. On a line of railway, a sharp curve is more liable to cause a train in motion to fly off the rails than a curve of greater radius, and this has to be counteracted somehow or other. It may be done in one of two ways, or by combining the two—either by lessening the speed of the train in proportion as the curve is sharper, or by giving the wheels a greater hold on the rail, by depressing the inner or raising the outer rail, so as to counteract the centrifugal tendency of the train. Just so in a rifle barrel; the sharper the rate of spiral the greater the tendency of the ball to fly from the grooves and go straight, instead of following the curve. When it does so it is technically called "stripping," and is, of course, fatal to all accuracy of flight. This tendency, like that of the train, can also be counteracted

in the same two ways, namely, by reducing the velocity, or by giving the ball a greater hold on the grooves; or by a combination of both. Any of these methods may be adopted as may suit any particular case. In modern small-bored rifles, where a greatly elongated projectile is used, our inventors obviate the danger of its stripping from the sharp curve of the grooves, partly by starting it with only a moderate velocity, and partly by increasing the hold between the ball and the barrel, by giving a large bearing surface to resist displacement.

100. In truth, the whole of the wonderful success attained in modern long-range rifle making is due to the recognition of these three great principles, which have been above, I hope, intelligibly set forth. Let me here recapitulate them in their order of consequence:—

i. Of two projectiles, equal in weight and started with equal velocities, that which is the more elongated (or of smaller gauge) will range the farther.

ii. But the more elongated of the two will require to rotate faster than the other, and will, therefore, have to be fired from a rifle with a greater degree of spiral in the grooving. This renders it more liable to "strip."

iii. Therefore, the longer of the two projectiles will require to have a greater hold on the grooves than the other.

101. These are the three great principles, each depending on the preceding one, that have been so slowly developed, step by step, until it almost seems as if perfection were attained in long-range rifles. But here I must pause to "render unto Cæsar the things that are Cæsar's." Whose was the mind that first grasped in their entirety these great principles, and, at

great expense of time, trouble, and cash, developed them and gave them a local habitation and a name in the rifle, which, although overlooked in favour of the more finished productions of recent inventors (?), yet bears his name? None but our own General Jacob, to whom be all the honour—but an empty recompence for such a discovery; for, while others are now reaping fortunes from patented copies of the general's model, and Government but recently paid some 20,000*l.* for the re-invention of the principles established by him years before, and freely offered to the nation at the time, I believe the inventor was never repaid a farthing of the large sums expended in his gunnery experiments. There can be no doubt, that the science of gunnery received more advancement from his experiments and publications than from the efforts of any other individual in modern times; for it is patent to all who carefully examine the subject, that his rifle contains every principle of the best weapons of the present day—the chief difference between them being mechanical, in the details of construction, or in the extension of the principles then established.

102. It is to the manner of carrying out the third great principle above laid down (effecting a greater hold on the grooves), without creating more additional friction and other inconveniences than may be absolutely unavoidable, that our inventors are now chiefly directing their efforts; and doubtless some improvement yet remains to be effected in this particular. It is doubtful, however, whether the two former principles have not been stretched to their very utmost limits in the Whitworth, the Henry, and other small-bored rifles. It

must be remembered that every reduction of gauge and the necessary consequences give rise to many disadvantages, some of which, such as increased friction and recoil, have been explained in the last chapter. The following is another:—

103. In order to give the projectile an equal initial velocity, its weight being the same, an equal (or greater) charge of powder must be used in the reduced bore. This charge will give rise to a certain amount of residuum or deposit on the interior of the barrel; but in the smaller bore there is a much smaller surface available for the reception of this deposit; it will, therefore, lie thicker, after a certain number of shots, in the smaller than in the larger bore; or, in other words, the smaller bore will *foul quicker* than the larger. In addition to this, the grooves of the former being deeper or more angular than those of the latter, are less susceptible of "wiping out," or of lubrication being applied with the bullet in loading, and the ratio of increased fouling is greater on this account.

104. The small gauge barrel, with its sharp twist, is also far more subject to "leading," that is, to having the grooves choked up by particles of lead cut from the projectile; any one who has used our modern "small-bores" will know the inconveniences of this. From this arises the necessity of enveloping the projectiles used with them in a coating of waxed parchment.

105. There is a very common, but mistaken, notion prevalent amongst sportsmen, and held even by some gunmakers who should know better; namely, that by reducing the gauge of a rifle, retaining the same *weight* of ball and charge, the *weight* of the rifle may also be

reduced. True, if *safety* only is considered, it may, for a much lighter barrel of 50 gauge will be equal to the same pressure as one of 25; but if *safety* only be considered, the weight of *all* rifles might be greatly reduced, for all are made much heavier, in order to counteract recoil, than is necessary on that score. Whether the bore preferred be 12 or 24, or 50, so long as the same *weight* of ball and charge is retained, the rifle must be of at least equal weight in all three cases. I say "at least," because owing to the additional causes of recoil mentioned above (para. 96) as attending any reduction of gauge, in practice a *greater* weight of metal is found necessary in the small than in the large gauge, in order to secure the same freedom from recoil,and pleasantness of shooting.

106. There is nothing more common than to see a sporting rifle fitted up with several different bullet moulds for projectiles of different shapes and weights—say a spherical, a hollow based cone of two diameters, and a solid cone of three. It is needless to repeat that the rifling, if perfectly suited to any one of these, must be quite unfitted for the use of either of the others. True science in gunnery consists in adapting the barrel, the charge, and the projectile to each other, and the whole to the work to be done; and nothing causes more mystification and bad shooting among sportsmen, than the practice of ignorant gunmakers sending out their rifles fitted with a number of bullet-moulds of all shapes and sizes; no intimation being generally given as to which the rifle is made and sighted to shoot. I am bound to confess, however, that this is very often the sportsman's own fault, who insists on having a rifle to shoot all sorts

of balls, and gets a mongrel weapon that does shoot them all, but none of them well.

107. Conical-ball Rifles may be divided into two great classes—the *expansive*, and the *mechanically-fitted;* meaning thereby those in which the rifling is effected by the expansion of the lead into the grooves on firing, and those in which the ball is fitted into the grooves previous to firing. All conical balls, if long enough and of pure lead, expand more or less on firing, owing to the resistance of the posterior atoms of lead being overcome before that of the anterior, whereby the projectile is shortened up in the direction of its length and expanded in that of its breadth, that is, into the grooves; but, in the first class, the bullet *depends* on this expansion for its hold on the grooves, and in the second it does not. The purest lead is necessary in all rifles of the first class, as well as the utmost regularity of outward form and homogeneousness of material. It is on this account, that bullets formed by compression are found so superior to those cast in the ordinary way; and the least admixture of any other metal, irregularity of surface, or flaw in the casting, is fatal to their accuracy. It was thought, on the first introduction of this principle, that a very loose fit might be given to the bullet without any sacrifice of accuracy. This was subsequently found to be a mistake on the following account:—If the bullet fit so loosely that its longest axis be not perfectly coincident with the axis of the piece—and a very slight amount of windage may cause this—the expansion does not take place equally on all sides of the axis of the ball, and the greatest inaccuracy of flight is the result. Even expansive bullets, therefore, require to be most accurately

fitted to the bore; and hence, in such rifles, either extreme accuracy, or the boasted facility of loading, must be to some extent sacrificed. It is now universally admitted, that bullets which have to depend entirely on expansion for their hold on the grooves, if of so loose a fit as is essential to quick loading, have little to boast of in the matter of accuracy. How small an amount of windage is allowable, the following passage, extracted from a leader in *The Field*, on the results of the second great Wimbledon meeting, will suffice to show:—

"Either there must be (as decided on by two Government commissioners) a difference of 27-thousandths of an inch between the barrel and the ball, or loading becomes impossible after a few rounds. But if there is this difference, the accuracy of shooting is sacrificed, as was exemplified both in the Whitworths and the Enfields used at Wimbledon, and the makers of the muzzle-loading rifle for military purposes are therefore between the two horns of a serious dilemma."

108. Expansive bullets may, or may not, have a cup or hollow at the base. The theory of the expansion being effected by dilatation of the cup is long ago exploded; although, owing to the sides of the posterior part of the bullet being thereby weakened in the direction of its length, a bullet so hollowed will doubtless expand with a less charge of powder than a solid based one.

109. Another equally antiquated theory, by which the expansion of projectiles used to be accounted for, is that it is effected by the air in front, and the powder in rear, crushing up the bullet between them; now it has been shown before (72), that the compression of the air in front can never give rise to any such resistance as is

here supposed, unless indeed it be held that the expansion does not take place until the bullet is near the muzzle. But this idea cannot be entertained, for independently of the difficulty the grooves would have in laying hold of the bullet in full career, it is a fact that short barrelled pistols on this system act as well as the long Enfield. The real cause of this crushing up, or expansion, must be that for the moment its *vis inertiæ* is greater than the tenacity of its material, and the latter gives way before the projectile has time to move; and I hold that the expansion takes place at or near the place where the ball lies in the barrel. That this is the true theory, is shown by the fact that by increasing the length of a ball, and therefore its *vis inertiæ* indefinitely, metal of any degree of hardness may be used, and yet expansion be effected.

110. Another idea, now given up in most quarters, is, that the force of the gunpowder is greater on expansive bullets than on those which do not expand, owing to the destruction of windage. Such would be the case were the latter so loose as to admit of any escape by windage, but this should never be. No one will doubt, that Whitworth's hardened bolts, which are mechanically fitted to the grooves and cannot expand, receive an impulse from the charge equal to that communicated to any expansive projectile; and so it is, or ought to be, with all bullets, in all barrels. If the ball with its patch, or other covering, completely fill the bore and the grooves, what more can expansion effect? Expanding bullets, whether mechanically fitted or not, create enormous additional friction against the sides of the barrel. A spherical bullet, which does not expand,

or any hardened bullet, such as Whitworth's bolt, has merely the friction due to the original fit—that is, the same it experienced in going down the barrel—to contend with in coming out again; but any bullet that expands before the powder, presses with greatly increased force against the sides of the barrel, and experiences increased friction in proportion to such pressure, all the way from the breech to the muzzle.

111. All expansive bullets have one charge of one kind of powder, with which they are found to act best. No one who has not extensively experimented with such bullets, can imagine the wonderful irregularity of shooting that takes place on slightly increasing or diminishing the charge.

112. It is well known that large-grained powder and long barrels are found to give the best results with expansive bullets. The remarks made in Chapter II. on the action of gunpowder will furnish the "reason why;" fine-grained powder acts too instantaneously, and forces the bullet forward with such extreme velocity, that, although expansion takes place, it has not time to settle properly into the grooves, and total or partial "stripping" is the result. Coarse-grained powder, again, expands the bullet as effectually, but permits it to settle into the grooves *at the breech* before extreme velocity is created. In the former case, the bullet will be found marked all over with the grooves, but in no place *regularly*, so as to show that it had at any time succeeded in laying hold.

113. The type of the expansive system of rifles is the Enfield. It is made of all gauges for sporting purposes, the bullet being slightly modified as the taste of

the maker dictates. If we refer this to our standard, the smooth-bored gun, we may have bullets of very different weights, all such as *may* be fired from a 9-lb. rifle. If we retain the weight of lead, we must reduce the gauge to about 25 instead of 14, and thus sacrifice striking surface. This is the gauge adopted by Government, and the Enfield rifle is now so well known that it would be superfluous to enter into any description. I shall, therefore, only examine a few of its points as a sporting rifle. The largest charge that can be used is 2½ drachms of Government powder, and about 2 drachms of ordinary rifle powder will be found to give as much recoil in a 9-lb. sporting rifle as is pleasant. The initial velocity of the ball is, therefore, very much inferior to that of the No. 14 smooth bore, or spherical ball rifle; so low, in fact, that the bullet falls 15 in. in the first 100 yards of its flight!

114. Its trajectory at sporting distances is proportionately high. I give it below for 100 yards:—

Distance from the muzzle	50	75	100 yards.
Height of the trajectory, in inches.....	9	6¾	0

Comparing this with the 100 yards' trajectory of the spherical ball rifle (paragraph 93), it will be seen that, for sporting purposes, the latter is vastly superior in this respect; indeed, owing to the immense friction of the Enfield bullet, its trajectory in the early stages of its flight is almost the highest of any rifle known. Of course, at longer ranges, the momentum of the Enfield will tell, and at about 400 yards its elevation will be about equal to the other. But as we do not shoot deer, &c., at 400 yards, this cannot be allowed to tell.

115. Again, an Enfield bullet in a 14 *gauge* will

weigh about 2 oz. To shoot this ball with its proportionate charge of powder, we would require a rifle of at least 15 lbs. weight; but having only 9 lbs. at our command, let us see what we can do. We must reduce the charge, and we shall find that 1½ drachms will give such a recoil as few would like to stand very often. We must also increase the hollow to insure expansion. And now we have got a very perfect rifle, have we not? "Eight to the pound will kill anything." Yes, if you put plenty of driving power behind it; otherwise, it is worse than half the weight of lead with a proper charge. Such a rifle possesses the most contemptible penetration possible at sporting distances. It will shoot true enough, doubtless, as a mortar shoots, by pitching its shot to a certain distance, leaving all the intermediate ground in perfect safety. The elevation required by such a rifle may be conjectured from the trajectory above laid down for the 25 gauge. The height of the 100 yards' trajectory will be about 2 ft. or more above the line of sight, and there will be literally no point blank at all!

116. A great deal of execution on game may be done with a 25-gauge Enfield rifle, and, for deer-shooting, there is little objection to its use by those who are perfect judges of distance. The greatest care must be taken to have the ammunition always the same; also in loading that the bullet is quite straight in the barrel, for no bullet "jams" so readily as a tight-fitting Enfield. The gauge 25 will be found, however, too small to give sufficient shock even to deer of large size; it will not "kill dead," as the equivalent weight of lead will do in a spherical shape. Accurate shooting cannot be expected at uncertain distances with such a rifle, as, having a low

velocity and next to no point-blank range, calculation and allowance for the rise and fall of the bullet will have to be made even at close quarters, as well as a large allowance in aiming ahead of running animals.

117. The severity in the rifling of an expansive rifle must vary according to the length of the ball, as also the amount of rifle twist. The spiral adopted for a 25 gauge is one turn in 6 ft. 6 in., though it is very doubtful if this is sufficient; but when the gauge is reduced to 50, retaining the weight of ball, one in 18 in. is found to be requisite. The grooves may be cut shallow, with the slight twist of one in 6 ft. 6 in., but they require to be deepened, or the hold otherwise increased, as the twist increases in rapidity. They may be any number from two upwards, but three or five have been found to answer best.

118. On striking the large bones of an animal, or anything that arrests their progress, expansive bullets with hollow bases flatten out into a larger surface than any others in proportion to their weight, excepting hollowed projectiles, such as empty shells. This is a serious inconvenience in shooting large game, for it reduces the penetration very much; neither can it be corrected by hardening, for alloy is inadmissible with such bullets; but it may be an advantage where shock more than penetration is wanted. A steel point may be used, but steel points are by no means so effective as hardened balls, as they do not prevent the back of the bullet from flattening out around them.

119. Lancaster's elliptic rifle is an expansive one, but as it possesses no advantage over the Enfield at sporting distances, it is not necessary to discuss it here. It requires even more attention than the latter in the matter of nicely

fitting ammunition, without which it is exceedingly liable to strip. Whitworth's, Henry's, and other "small bore" rifles, when used with expanding ammunition, may be included amongst expansive weapons. They have no advantage at sporting distances over the Enfield, except in penetration. Their trajectories are almost equally high at such ranges, although very much lower at longer distances, and the tendency to fouling and "jamming" is much greater. The largest gauge that could be used in a 9-lb. rifle would be about 50, and a ball of such small diameter must be at once set aside as useless for killing large game. It is difficult for a man without experience to bring himself to believe that bullets which give such astonishing *accuracy* and *penetration* as these should be inefficient for any purpose; but it is, nevertheless, a *practical fact*, testified to by every one who has used them at anything larger than an antelope. As bullets of such extreme length in proportion to the gauge are incapable of being used in barrels of large enough bore for shooting game, I think I may at once dismiss them from these pages; for my readers may rely upon it that their use will only entail disappointment and an empty bag. When used with empty shells, however, and a large enough charge to flatten the projectile well on striking and give a low trajectory, they make very good weapons for deer-shooting.

120. A serious drawback to the use of loosely fitting expansive bullets, is the tendency to rise in the barrel, and leave a space between them and the powder. I have several times found, after jolting about for some hours in the howdah, that the bullets of such a rifle had risen half way up the barrel! The extreme danger of firing a rifle in that state needs no comment.

121. Mechanically fitted conical balls may be used in almost any muzzle-loading rifle, and, in fact, almost every gunmaker has a separate "make" of his own for such rifles. Some use two grooves, some three, some four; some of the grooves are semicircular, some oblong, some "ratchet-wheeled." There is no end to the varieties of ball and rifling that have been mechanically fitted together; but they are all simply the mechanical means of effecting the requisite hold between ball and barrel; and I believe that, if this is of a severe enough description in proportion to the rate of spiral in the grooves (which, again, depends on the length of the ball), it matters not a pin what system of grooving be adopted, so long as unnecessary friction be avoided. Jacob's four-grooved, and Purdey's two-grooved, rifles may be taken as examples of the mechanically-fitted class; in the former, a ball of 2½ diameters, and in the latter, one of about 1¾ diameters in length being used. In each case the projectile is accurately fitted to the grooves, and expansion is not looked to for the rifling. They differ, of course, in the rate of spiral required; for while Jacob adopted one turn in 2½ ft. as necessary for his lengthened picket, the shorter projectile used by Purdey is found to fly true enough, at sporting distances, with a turn in 6 ft. of barrel. The latter will, therefore, have much less friction, and will be put into a higher velocity with the same charge. The largest gauge that either will admit of in a 9-lb. rifle will be about 40, and the charge in the former case will be about 2½ drachms, and in the latter, 3¼ drachms. In a 14 gauge, a ball of Jacob's dimensions will weigh 2½ oz., and of Purdey's about 2 oz., and if the proportionate charge of powder be used, the rifle to project the former will be 19 lbs. in weight, and

the latter about 15 lbs.! The trajectory of Jacob's bullet at sporting distances has little advantage over the Enfield; but Purdey's of 40 bore is very much superior, and comes nearer the spherical ball rifle than any other. For the first 100 yards, I believe the latter to be superior, as it admits of a larger charge of powder in proportion to the weight of the ball. At 150 yards they are about equal; and beyond that distance, Purdey's ball of equal *weight* has the advantage. In any sport, therefore, at which longer ranges than 150 yards may be sought for (such as wild antelope and bustard shooting in the plains of India, or ibex and other hill shooting), and in which the smallness of gauge (40) may not be objected to, I consider a rifle on Purdey's principle perhaps the best of any.

122. This rifle has obtained a great reputation amongst deer-stalkers at home, and very justly; for it is indeed an excellent weapon for their particular sport. But it must be remembered, that, at home, almost every red deer wounded is bagged by the assistance of deer-hounds; to wound, therefore, is the object nearly as much as to kill, and this rifle does *this* perhaps better than any other. It is a very different thing in India and other countries where such assistants are not at hand; where tracking is frequently impossible, and an impenetrable jungle is almost always close by. Then we must *kill*, not *wound* merely, if we wish to *bag;* and Purdey's little ball, unless placed in exactly the right spot, is inefficient for the purpose. If made, again, of large enough gauge for *work*, its good qualities, low trajectory, and penetration, immediately disappear; for in a 9-lb. rifle we cannot give a fourteen or sixteen gauge Purdey anything like its proportionate

charge of powder, and it will, therefore, lose velocity and lowness of trajectory. Jacob's bullet possesses these disadvantages in an enhanced degree in proportion to its greater elongation and more rapid twist, and is not to be thought of for sporting ranges, except in relation to the explosive shells which will be treated of further on. Almost any gunmaker can make a small-bore rifle on the mechanically fitting principle quite as well as Purdey, and probably at a much lower figure. Among others I may mention Messrs Henry, of Edinburgh, and Rigby, of Dublin, as makers who make excellent weapons on this principle.

123. It may be, and often is, said that by using these elongated balls in large gauges, we do not, after all, lose in momentum; for, although we can only afford to start them with diminished velocity, yet their greater weight makes up for this. This is true to a certain extent; but I will explain :—Suppose in any barrel we may use any one of two balls—a sphere, say, 1 oz., and a projectile of 2 oz.—and suppose we can afford to give the former a velocity of 2,000 ft. per second, and the latter only 1,000 ft. per second; then, momentum being made up of the weight multiplied by the velocity, each would have precisely the same momentum; but, as before explained, the effect of a projectile, or "work" of which it is capable, is measured by its *vis viva*, that is its weight multiplied by the *square* of its velocity. It is, therefore, of great importance to have this last element of the momentum as great as possible, as we thus lessen the elevation, increase the facility of hitting running game, and improve the penetration.

124. A high velocity and consequent low trajectory at short distances are the life and soul of good shooting

at game. Take an instance:—We stalk an antelope on a grassy plain; we are an hour about it, and have then got to what we think a fair 100 yards; our weapon is a fourteen-gauge with Enfield bullet, and if it hits, is safe to make an "immortal smash" of his carcass. We have put in 2 drachms, and rather funk the kick; but we put up the 100 yards sight, and rest the barrels on the banks of our concealing nullah. The meeting of the white and black, the fatal spot behind the shoulder, is plainly exposed, and we have covered it with the fine front sight, accurately sunk into the notch of the hind one. He is cropping the young shoots of a green bush, and, as he raises his head to snuff the gale—bang! He's down! no, off! By Jove, I believe it's a miss! Hang this rifle, I believe I should have hit him with my old double partridge-popper. Let's pace the distance, though, and see whether it is the rifle or not:—50, 60, 80, 100, and not come to the green bush yet!—120, 140—5—6—7—one hundred and forty-seven paces, equal to about 130 yards. Of course, I knew it was a mistake in my calculation, and the rifle isn't to blame after all. But I, Ego Auctor, say the rifle *is* to blame. Had it been a properly constructed rifle, we should only have missed the fatal spot by about 2½ in. or so, and probably bagged our buck; whereas, as it is, we must have missed by 5 in. at least—which such a rifle as I have supposed us to be using is perfectly capable of doing, let me tell you.

125. In the foregoing remarks on rifles, I have referred them all to a certain standard, viz., such as may be used at a weight of 9 lbs.; but it is evident that the same reasoning applies to any other weight that

may be selected. Thus, suppose you could use a rifle heavy enough to throw a 2 oz. spherical ball with a large charge of powder (7 or 8 drachms); then, if you prefer the conical form, you must either, retaining the weight of ball, 2 oz., reduce your gauge accordingly, and so lose striking surface; or, retaining the bore and surface, adopt a much heavier ball, with a much lower initial velocity, in which case you will lose in lowness of trajectory at short distances.

126. I append a table of various rifles typical of the different systems available for sporting purposes, from which the sportsman may determine at a glance what size of bore he may have, and what advantages he may expect from any system he may select. They are all referred to the same standard—namely, such as may be used in a 9 lb. rifle without excessive recoil. It must be observed that this table is only an approximation to absolute accuracy, for the reason, that rifles on the same system will vary when made by different makers, to a considerable extent.

TABLE OF PROJECTILES available for use in a 9-lb. RIFLE

Description of Projectiles.	Gauge number of rifle.	Rate of spiral, 1 turn in	Charge of powder.	Point blank range.	Extreme accurate range.
		ft. in.	drs.	Yards.	Yards.
Whitworth, Henry, and other small-bore bolts	about 50	1 8 to 2 6	2½ to 3	30 to 40	1,200
Jacob's picket	40	2 6	2½	35	1,000
Purdey's 2-groove winged ball	40	6 0	3¼	70	350
Enfield shape, hollow cone	24	6 6	2½	40	500
Plain sphere	14	8 8	4	85	250

127. It will now have been perceived to which of the many principles now employed in rifle making the writer's preference inclines. It was long before I could acknowledge to myself the plain *fact*, that, better than all the magnificent modern inventions, better, that is, for general *game-killing* purposes, is the plain polygrooved rifle, used with the old-fashioned globular ball; not, however, as our forefathers used it, but as modern science has enabled us to produce it, with its manifold defects corrected. I need not here detail the long course of experiments by which I have been irresistibly led to this conclusion; the spare time of the last ten years has been greatly occupied in conducting them, and, I fear, rather more than the *spare* cash of the same period in procuring the necessary material. I have now completely satisfied myself (and many others) that, for ordinary sporting purposes at sporting ranges, given the weight of a rifle, that weight will be most beneficially applied in projecting the largest spherical ball, with the largest charge of powder that can be managed without too great a recoil.

128. How unorthodox this opinion is considered by the gunmaking trade, a not altogether imaginary instance will best explain. A young gentleman, an ardent sportsman, but somewhat inexperienced in guns and gunnery, received an appointment to India. Amongst the items of a liberal outfit was included, of course, the invariable double rifle "in case complete." He went to a well-known maker (and therein did wisely), and told him his wants. He was shown a few ready made, but being a long-necked, long-armed personage, none would fit.

"We shall have to make you one, I see, sir," said the salesman; "what sort would you prefer?"

"Well, really," replies our "Griff," "I don't know;" and naturally added, "What would you recommend?"

As naturally the maker to him replied, "I don't think you will find anything to beat our eccentric three-groove principle; all our customers prefer it to any other."

"All right, make it on the what-d'ye-call-it principle; but I should like a heavy ball, you know; they say the beasts out there require a good dose of lead."

"Certainly, sir; we are in the habit of making rifles for India, and quite understand what is wanted; you may rely on us for a perfect weapon." Exit "Griff."

The weapon was finished, packed in tin, paid for, and despatched round the Cape to Calcutta, and there seen and admired for the first time by the delighted purchaser. It was a lovely weapon to look at; short and handy, about 32 bore, with the cuts of the what-d'ye-call-it principle showing fine and clear against the new metal of the muzzles; beautifully finished (as it ought to be, for the bill bore an alarmingly big figure before the cypher in the sum total); and the locks clicked with the music of a first-rate. Altogether it was just such a weapon as the soul of the inexperienced gunner loveth. "By Jove!" he thought, as he put up the 500 yards sight and squinted through it at the coolie pulling his punkah, "I only hope to get a bang at a bison or a tiger before long, and I rather think this will prove a smasher for him." It would be cruel to follow our friend through the scenes of heart-rending disappointment by which he discovered the utter inefficiency of such a weapon for much smaller game even than the bison or the tiger. Suffice it to say, that ere the second year, it was sold by auction at a price that would have driven its aristocratic maker into fits.

129. In this case the gunmaker had caught a customer exactly to his mind. Suppose now our hero, after a few years' experience in the jungles, and having become a convert to the opinions herein laid down, were to pay a second visit to the same maker and order another double rifle:

"I want you to make me another rifle, Mr. ——."

"Very good, sir, many thanks; like the last, sir? hope it gave you satisfaction? We have improved on our principle since then—a little smaller bore and sharper twist—find it shoots farther."

"Not at all," replies his enlightened customer; "I want it 12-gauge."

"12-gauge, sir! ball will be very heavy, 2½ oz. at least, sir; must be a very heavy gun to stand it."

"Yes, 12-gauge, Mr. ——, and with a round ball."

"A round ball, sir! we never make such things now, sir, except for shot guns; no use whatever, I assure you."

"And only a quarter turn of rifling in the barrel," continues the incorrigible heretic.

"A quarter turn, sir? why, you'd better have sights put on a fowling-piece and call it a rifle: shoot just as well, believe me."

"Well, never mind; the question is, will you make me such a rifle, or must I go elsewhere for it?"

"I'm afraid you must, sir; really we have a character to lose, and can't afford to put our name on such an affair; very sorry, can't understand how you can be so mistaken. Ah! I see how it is, you must have been standard as before, weight of rifle and absence of recoil being still the constant elements :—

I. *Weight, if for general purposes, not more than 9 lbs.; in 2nd class manageable.*

II. *Moderate recoil.*

By the conditions, all are equal in these points.

III. *Sufficient accuracy at sporting distances.*

14-GAUGE SPHERE.	14-GAUGE CONICAL.	14 to LB. CONICAL.
Sufficient.	Sufficient.	At any range beyond 150 yards, superior.

IV. *Penetration at sporting distances.*

Amply sufficient.	May be equal to sphere.	Superior in total penetration.

V. *The least degree of elevation at sporting distances.*

Superior to both.	Very much inferior to both.	May be equal to sphere, but is generally inferior.

VI. *The largest possible striking surface.*

None can be superior to the sphere.	The same as the sphere.	Greatly inferior to both.

VII. *Striking surface of a shape not more acute than a hemisphere.*

As obtuse as can be conveniently given to any projectile.	May be the same as the sphere.	Cannot be made so obtuse as the others without inaccuracy.

VIII. *Easy and rapid loading.*

14-GAUGE SPHERE.	14-GAUGE CONICAL.	14 TO LB. CONICAL.
If properly constructed, loads as easily as any muzzle-loader, and when all are fouled it is perhaps the best.	If tight-fitting enough for accuracy, is about the same as the sphere, but when both are foul it is inferior, particularly with mechanically-fitted bullets.	The same as the 14-gauge conical, except that it fouls more rapidly, and gets difficult to load after a less number of shots.

NOTE.—If breech-loading be adopted, of course all are placed on an equality.

IX. *Moderately short barrels.*

None superior to the sphere, which, in fact, requires a short barrel.	If on the expansive system, must be longer than the spherical ball rifle.	The same as the 14-gauge conical.

X. *General handiness and simplicity.*

In this, none can surpass the sphere. A mistake in charging has no bad effect; double charges may be used without diminishing accuracy; hardened balls may be used. May be used in smooth bores of the same gauge, which is a very great advantage in foreign sports. Ball goes in any way, no chance of a mistake; and the results are always the same, and may be depended on, being less liable to accidents than any other.	If hollow-based, must be most accurately charged; easily jams if care is not taken in loading; will not admit of different charges; cannot be used in smooth bores; a greater weight of lead has to be carried without corresponding momentum, as equal velocity cannot be given; less to be depended on than the sphere, being more liable to accidents in firing, such as "stripping," "jamming," &c.	The same as the 14-gauge conical, but with the addition of fouling much more rapidly.

132. It will be seen from the above that, for all ordinary purposes, the preponderance of advantages is very greatly in favour of the sphere. The only point in which its opponent, the small-bored cone, is superior, is that of extreme penetration. But why do small-bored cones penetrate deeper than spheres of equal weight? Because they are less resisted in proportion to their weight. But this is just what we do not want; we want a sporting projectile to be resisted by all the bones, nerves, and blood-vessels we can possibly oppose to its

passage; and we want it, by crashing through these, to shock the system of the animal, instead of shirking them, as is so frequently done by the *acuter* picket. That the penetration of even a simple leaden ball in a 14-bore spherical rifle of 9 lbs. weight is ample for all ordinary game, I have quite convinced myself. With 4 drachms it goes through and through any animal likely to be met with in the forests. Mr. Baker has stated that 4½ drachms will drive a ball of that size through both sides of an elephant's head, and 4½ or even 5 drachms may be used in such a rifle without any unpleasant recoil, and *without any bad effect on the accuracy of the shooting.* The penetration may also be increased to almost any extent in such a rifle by simply adding a little tin or mercury to the composition of the ball. I have thus even driven a 2 oz. ball through a full-grown wild buffalo *longways*, which I have never seen accomplished with a conical ball. This does not injure the grooves of the rifle in the least, as they ought not to indent the metal of the bullet at all, the spiral motion being given by the patch alone. It may be doubted whether such spiral motion can be given by the patch; I say *try* in a rifle of that degree of twist. Mark the posterior end of the ball, and you will find in every case that the *other* end has struck first and been flattened.

133. It must, however, be clearly understood that none of the advantages I have attributed to the use of the spherical ball are obtainable without using it in a rifle made on purpose for it, and on the principles laid down. In general, spherical balls, when used, have not a fair chance given them of displaying their merits. Rifles are generally made and sighted for some descrip-

tion of *conical* ball, and a spherical mould is "thrown in," the ball of which has, perhaps, never even been fitted to the barrel. To any one desirous of giving the spherical ball a fair trial, I say, disabuse your mind of all prejudice, and order a rifle to be made and sighted for the spherical ball, as herein recommended, and make up your mind never to fire a "sky shot" with it at anything whatever; try its accuracy at a target at the distances you usually kill game, and try it at game in the field, but never beyond proper sporting ranges. Do this, and I will venture to say you will, after six months, allow that you never had a rifle in your hands so pleasant to shoot with, that you could hit game better with, or that more certainly *killed* when you did hit.

134. The contrast between this system and that formerly applied to spherical balls in rifles will at once explain the superior results attained. *Formerly*, the twist, friction, and tendency to "stripping" were enormous; this necessitated deep grooves, indenting the zone of the bullet, and causing atmospherical resistances of a most irregular description, which again, working in a circle, necessitated great spiral in the rifle *for such balls*. *Now*, the twist, friction, and tendency to strip are at the minimum: this permits an easy loading bullet, which leaves the muzzle a perfect sphere, and has very little tendency to irregular flight; which, again, permits the slight rate of spiral in the barrel that gives rise to these advantages. In the one case, everything is *forced*, and, in the other, *humoured*.

135. The two-grooved rifle, with belted spherical ball, is sometimes used by sportsmen still, but only because the principles that should regulate spherical ball

rifles are not understood. With the old rate of spiral, it held the ball better than the polygrooves; but when the spiral is reduced to a turn in 8, 10, or 12 ft., it is merely extra holding power thrown away, and creates enormous additional friction both in the barrel and in the atmosphere. Moreover, such rates of spiral as I advocate cannot be used with a belted ball; for the belt causes a tendency to irregular flight, which must be counteracted by additional spiral in the barrel, again showing how the principles of the rifle work in a circle. The extra spiral causes the adoption of the belted ball, and the belt gives rise to the necessity for extra rotation and rifle twist.

136. I shall finish this argument by quoting the published opinions of various sportsmen and authors on this point; as, although I think I have advanced sufficiently strong reasons why the spherical form should be preferred for sporting purposes, yet, as many consider that "in a multitude of counsellors there is wisdom," perhaps my position will be strengthened by their support. They are all, it will be observed, favourable to my views, and, lest it be supposed that I suppress those adverse to them, I may state that I am not aware of any, entitled, by experience in the field, combined with an adequate knowledge of gunnery, to have weight attached to their opinions, who pronounce a contrary judgment. It is somewhat curious that none of these make any reference to what I consider the greatest practical advantage of the sphere for sporting purposes; namely, its comparatively low trajectory at short distances, retaining the necessary striking surface. This is probably owing to their using the sphere with the old

rate of spiral; and if so, and they *then* found it preferable with even an equally high trajectory, what must its superiority be when it is improved in this respect at least 100 per cent.?

137. In *Gunnery in* 1858, page 404, Mr. Greener says:—

"For other purposes than war, rifles will continue to be constructed on the polygroove principle, and with spherical bullets. The perfect destruction of various animals is dependent generally on two causes—the penetration into the body, and the shock to the system during that act of penetration. No doubt exists that a spherical bullet would combine these two qualities best. The 25 bore, the 32 and 50 hexagonal bore would be, practically speaking, useless for the killing of elephants, tigers, &c. The effectual and instant killing of seals on ice is an illustration; failing to kill a seal dead, he will, to a certainty, reach his hole in the ice, and disappear, to the shooter's serious disappointment. Small-bore elongated bullets were very rapidly adopted, and as rapidly abandoned. 'They did not kill dead;' the spherical bullet did this better. It would be wise to pause and consider whether a good military rifle is a good game-shooting rifle or not: whether the hole in the beast be wide enough. I am inclined to think the reduction to a bore of 25 too small for this purpose."

This is the opinion of a practical English gunmaker —almost the only one who has given us any writings on subjects connected with his profession. It is also to be remarked that he, of all others, is the stanchest advocate of expansive bullets for military rifles. This opinion, therefore, as devoid of all prejudice, is most valuable.

138. Major Shakespear, the author of *Wild Sports in India*, says:—

"I have Minié bullet-moulds for my rifles; but so long as the spherical bullets go through and through large game, I do not see the use of running the risk of shaking the stock of the gun, and of extra recoil, by using the heavier balls."

139. Mr. S. W. Baker, author of *The Rifle and the Hound in Ceylon,* unsurpassed in experience with very heavy game, writes as follows in the *Field* of March 23rd. 1861:—

"I strongly vote against conical balls for dangerous game; they make too neat a wound, and are very apt to glance on striking a bone. The larger the surface struck the greater will be the benumbing effect of the blow. . . . In giving an opinion against conical balls for dangerous game, I do so from practical proofs of their inferiority. I had at one time a two-groove single rifle, 21 lbs., carrying a 3 oz. belted ball, with a charge of 12 drachms powder. This was a kind of 'devil-stopper,' and never failed in flooring a charging elephant, although if not struck in the brain he might recover his legs. I had a conical mould made for this rifle, the ball of which weighed 4 oz.; but instead of rendering it more invincible, it entirely destroyed its efficiency, and brought me into such scrapes that I at length gave up the conical ball as useless."

If largeness of scale, as has been contended, enhances the value of an experiment, surely the results arrived at with such artillery as this should be conclusive!

CHAPTER IV.

SHELL RIFLES.

140. The almost universal adoption by Indian sportsmen of rifles on the spherical ball principle which has followed the publication of the first edition of this work, and the constantly expressed opinions of satisfaction from their use which I have received privately, and observed in the public prints, are the best proofs of the correctness of the views brought forward.

141. Although, however, the rifles that have been made on the principles described in previous chapters have proved themselves the simplest, best, and most trustworthy for all *ordinary* sporting purposes, yet no one who has had any opportunity of observing the astonishing tenacity of life displayed by the larger carnivora can avoid the conviction that the best of our modern sporting arms, as hitherto constructed, are insufficient to secure even a moderate amount of safety to the sportsman who makes a practice of encountering them alone and on foot. Some years ago, convinced of this, I turned my attention to the various explosive shells then before the world.

142. I first tried thoroughly the shells invented by the late General Jacob. These, as most people know,

consist of a tapering copper tube, filled with gunpowder, and primed with a little detonating powder. A conical ball is cast with a hole in its apex corresponding to the tube, which is then inserted, and fastened with a little lac cement. There is thus nothing to protect the percussion powder from explosion by a blow but the thin copper of the tube, and the consequence is that these shells are extremely dangerous to carry and to load with. Serious accidents have thus happened to several sportsmen in India. I soon gave these shells up as worse than useless for sporting purposes. I have fired one through a tiger, at two yards distance, without any explosion; and, on the other hand, I have seen another burst on the skin, and fly back without penetrating an inch. Even when they do burst in an animal, the effect is less than that of a similar solid ball; for the shell does not fly to pieces, but merely opens out at the tip, while, of course, its penetration is checked, and the killing effect of a through-and-through wound lost. The subjoined extracts from letters I have received from sporting friends will show, if necessary, that I am not solitary in my opinion of Jacob's shells:—

1. "I am more than ever convinced that your shells are the only safe things to use for shooting tigers on foot. On the 13th inst. I fired (on foot) at a tiger with a Jacob shell, distant about six paces; it passed through his shoulder and lungs, and going diagonally through his intestines, lodged in the flank. Notwithstanding this, the confounded thing never burst (it was an English-made copper shell), but forced the copper tube out of its berth, and was cut out of the beast's body smashed like any ordinary conical ball."

2. "You remember I used to be an advocate for Jacob's shells, but my faith in them was considerably shaken by one

which I fired into a tigress, charging me at a distance of only some ten feet, having failed to burst or to stop the animal; and subsequently by the failure of another, with which I hit a tiger not half-a-dozen yards from me, on the vertebra of the neck, or perhaps I should say the backbone, but which, exploding on the surface, merely blew off a patch of the skin, without penetrating at all. The tiger I allude to was subsequently shot; and, as you were present on that memorable occasion, you must remember the very superficial appearance of the wound."

143. Finding, then, that Jacob's shells were so inefficient and uncertain, I turned my attention to Norton's invention. There were several varieties of these—the main principle of all being, however, to cast the lead round a rigid hollow chamber of hard metal, which was afterwards charged either entirely with a detonating mixture, or with gunpowder and primed with a percussion cap. In one the cap was sunk below the surface of the lead, to prevent its being exploded by the blow of the ramrod in loading. This identical idea has recently been revived by other parties, and, I believe, patented. The whole of Captain Norton's ingenious devices in gunnery are to be found described and figured in a pamphlet published by him. I found on trial that this shell was little superior to Jacob's, for sporting purposes. It burst better when loaded with detonating powder only; but the presence of a rigid chamber, the position of which in the ball could not be regulated with perfect exactness, rendered its effect extremely uncertain.

144. I then tried Metford's shell, which is simply a ball with a hole cast in its apex, which is filled with percussion powder, and stopped up with wax. The

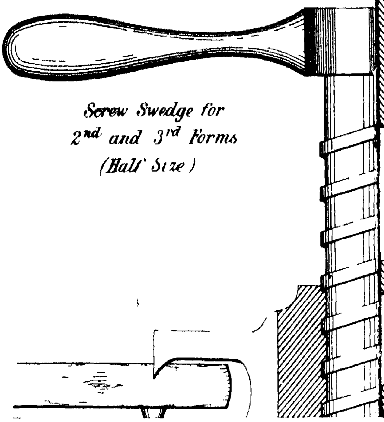
explosion of this merely opened up the point like Jacob's; and, although safer, it was in effect not the least degree better than it.

145. I therefore determined to endeavour to *invent* a shell for sporting purposes. I saw that any rigid metal was inadmissible; and the difficulty, therefore, arose how to cast a shell with a hollow chamber larger in its internal dimensions than at its orifice. It was the old problem of "how to get the egg into the bottle." If a rigid chamber, to be left in the shells, could not be used, a core of some kind must be employed—and the point was how to get this core out again.

146. The most natural method is, of course, to cast on a clay core, and pick it out in small pieces afterwards. This is the usual plan employed in the arts for hollow castings; and I found it had already been tried by a sporting friend, now dead, Captain B., of the Bombay Engineers. We used these with tolerable success for some time, but the great objection to them was the trouble of making them. Each core had to be separately prepared beforehand, and was useless after one casting.

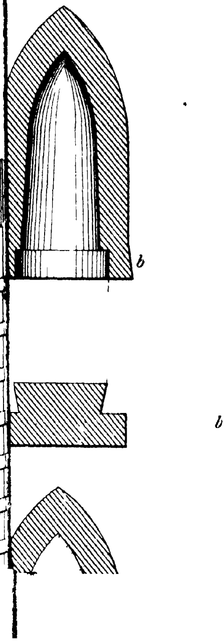
147. I tried an infinity of plans, under all the difficulties of bad workmen, &c., natural to up-country stations in India, and at last hit on the idea of casting the shell in two pieces, and afterwards "swedging" them into one by compression in a steel matrix. In Plate II., figs. 1, 2, and 3 show several forms of the shells thus made. It will be observed that the principle consists in forming a "dovetail" joint between the parts, a tenon being cast on one part, and a slot on the other; the tenon is then inserted into the slot, and

Fig 5.



Screw Swedge for 2nd and 3rd Forms (Half Size)

Fig 2.



the shell passed through a swedge, in which a steel matrix of the exact size of the shell is cut. The portion of the lead on the slot piece, which in casting had been left beyond the true form of the perfect shell (*b b*, figs. 1, 2, and 3), is thus compressed round the neck of the tenon, and a perfect waterproof "dovetail" joint is the result. So perfect is this joint, that, when the shell is exploded, fragments of both parts sometimes fly off together, the joint between them remaining unopened.

148. In the former edition of this book I figured, for the benefit of sportsmen abroad, the rude implements for making these shells which I had been able to get made by native workmen. I now present them with figures of the beautiful apparatus made by English skill for the same purpose (figs. 5 and 6, Plate II.). The moulds I thought it needless to figure, as they consist simply of the ordinary conical bullet moulds, with special "plungers" of the shape of the hollows in each part, fitted to them. These can be made by any decent workman. The screw swedge (Plate II., fig. 5) can also be made in many parts of India; Boput, of Nagpore, in Central India, for instance, turning them out in a style almost equal to English work. Any English gunmaker can furnish them, and I may mention Messrs. W. W. Greener, Henry, Reilly, and Dougall, as being well acquainted with the requirements of this projectile, who have made them of every description for me, and thoroughly understand the principle.

149. These shells may be loaded in a variety of ways. At first I loaded them with gunpowder, with a priming only of detonating powder. I shortly found,

however, that the effect was much greater when the whole shell was loaded with detonating powder. A hole may be left in the point of the shell, through which to load after swedging, and closed with a plug of wood or wax. This is the best method of loading the first form. Or, on the other hand, the explosive mixture may be first inserted, and the swedging done afterwards in the screw swedge (fig. 5) with perfect safety. These shells are absolutely safe to make, carry, and load with; indeed, I have not heard of a single accident, except when a man fixed a loaded shell in a vice, and proceeded to saw it open!

150. The detonating powder I use is by no means a very sensitive compound, and, in fact, can hardly be exploded, except by firing it in a shell from a gun. It consists of sulphuret of antimony and chlorate of potass pounded and mixed in equal parts by weight. There is no danger in mixing, if done dry with a bone knife on a wooden or china plate. Pound each separately as fine as possible, and then mix. If mixed in solution, the compound is much more sensitive, and is dangerous to use. The materials for this mixture are procurable from any chemist, and the cost is a mere trifle, less, in fact, than that of gunpowder itself. The powder should be made in quantities, as required, and not kept ready mixed. This compound is the least sensitive of all detonating mixtures, and is, therefore, peculiarly adapted for sporting shells. A sporting shell should explode only when it gets completely crushed up, as bullets do after traversing a solid piece of flesh. A bullet glancing from a bone, or fired through a board, only gets its point somewhat flattened, and is very little crushed up;

but if fired against flesh, clay, or any similar substance, its tendency is to get quite "squashed" in the act of penetration. We take advantage of this property to make our shell on a principle that requires this "squashing up" to occur before it explodes, and so avoid all chance of accidental bursting against twigs or the ribs of an animal. For this reason a considerable thickness of lead must be left between the point and the chamber.

151. Game beasts, when considered as objects on which to operate with shells, may be divided into two great classes—the soft-bodied and the iron-plated. The former includes tigers, lions, bears, deer of all sorts, &c.; and the latter buffaloes, bison, elephants, rhinoceros, alligators, *et id genus omne.* Now, it is evident that no shell can be equally well suited to both classes; and a shell which may act perfectly on tigers, &c., will not have penetration enough for the iron-plated monsters. But this shell admits of its penetration before explosion being regulated to suit either class. This is done by altering the thickness of the walls, and using a more or less hard alloy as the material—a little tin should be used even for the soft-bodied animals, as it makes the shell splinter more in bursting; and by increasing the proportion of tin, and along with it the charge of powder, any amount of penetration may be ensured.

152. After much experiment, the form and dimensions shown in fig. 1, Plate II., were adopted as the best for all ordinary game.* The shell represented is a

* This form of the shell is represented in the plate as made with the joint on the shoulder, to swedge in the lever swedge. It may, however, be made with the joint in any part of the cylindrical portion (fig. 3), and to swedge in the screw swedge (fig. 5).

12-gauge, and holds about 1½ drachms of detonating powder. It is cast in an alloy composed of $\frac{15}{16}$ lead and $\frac{1}{16}$ tin. The effect of this shell on tigers, bears, &c., is really tremendous. It penetrates nearly through the body of a tiger before it bursts, and generally flies into three or four large, ragged pieces, which tear through the animal in every direction. If the explosion occurs in the vicinity of the spine, it becomes at once paralyzed; and if it takes place any where in the body, death ensues either instantaneously or in a few seconds. I have never known an animal, hit forwards in the body with one of these shells, to leave the place afterwards. Even when hit in the most unlikely places, such as the haunch, if the shell gets into the cavity of the body before it bursts, fragments of it are almost certain to reach some of the vitals. I have never known one of these shells to explode by accident on twigs or branches, and never hesitate to fire through thick bushes, if need be. I have killed a tiger dead through a mass of jungle so thick that I could barely distinguish something red on the other side: nor have I in any case seen the skin in any way injured. The shell makes a clean round hole on entering, and does not burst till deep below the skin. Of course, if shells intended for large animals are used on small deer, &c., they may burst near the skin on the other side, and damage it somewhat. I have myself shot many animals with these shells, and have the most perfect confidence in them. I have dropped tigers over and over again when shot in the most unlikely places—places where a wound from a common ball would have had little or no effect; and I have received numerous letters from sportsmen who have used them with the same success. Perhaps the best testimony to their usefulness I can offer, however, will be the following extract of a letter that appeared lately in *The Field*, from a writer whom I have not the pleasure of knowing:—

"From my own experience I pronounce the shell to be a valuable invention. I have killed many animals with it, bears and one tiger amongst the number, and in no instance did I find a second shot necessary. Although of less specific gravity than a solid ball, it is not less true in its flight; and its penetrating power is sufficient to carry it well into the body of the animal it is fired at before it explodes, whilst the explosion produces such a shock to the beast as to render it harmless.

"Certainly its power of 'doubling up' an animal is astonishing. With a good, big-bored, double rifle, loaded with this shell, carefully primed, and with central fire-caps to insure the ignition of the powder, I am of opinion that any 'cool hand' and good shot would run but small risk in stalking or shooting a tiger or any dangerous brute, in the same way as one would stalk and shoot a deer. Were this shell generally used for shooting large game, I feel sure that those deplorable accidents to sportsmen which are of such common occurrence in this country—the result in all cases of following up a wounded animal—would become rare. One runs but small danger even in tiger-shooting until the beast is wounded; and from my experience, to wound with this shell is to kill, so in using it, the great danger of 'following up' is avoided."

The gentleman referred to in the beginning of the present chapter as having come to such grief with Jacob's shells, wrote me lately to say that he had taken to my system, and had just killed a tiger with a shell that struck him on the thigh!

153. The question then arises, how far the sportsman may venture to rely on shells, and thus be tempted to expose himself to dangers which he would otherwise avoid. Now I do not mean to assert that these shells are quite infallible, that they will invariably kill stone dead every tiger, bear, &c., that they hit. There is always a large margin to be left for accidents and exceptional occurrences; and I know a few instances where animals, fairly hit on the shoulder with large shells, have retained life long enough to do damage. Still, I do not think that many persons will be induced to run any extra risks by their having shells instead of bullets in their rifles; and all I expect from the common use of shells is that people, who would have run the risks whether or no, will now cope with their antagonists on somewhat more equal terms. The use of large shells for the first shot will, without the least doubt, render tiger-shooting on foot a less fearfully dangerous pursuit than it is. There is in general very little danger in firing a first shot at a tiger, if the precaution is taken of pulling when he is turned away from you. If not then killed or disabled, he will almost invariably dash straight ahead through the jungle for one or two hundred yards. Then comes the dangerous part of the work. You have to follow him by his blood, and pass, step by step, through rank grass and vegetation. Perhaps you find him dead, but more often he has lain down to lick his wounds, and either dashes away when you approach, or, watching his opportunity, treacherously charges in flank or rear. No shooting, nothing

will then save you, but luck; and it is generally under these circumstances that accidents happen. Now the advantage of shells is in having far fewer wounded tigers to follow up. They almost always either drop them on the spot, or cut them up so terribly that they cannot get out of view before the hæmorrhage completely pulls them up.

154. The second form of the shell may be used for ordinary shooting if preferred. The great difference between it and the first form is that it blows out more behind than at the sides. All these forms of shell expand most perfectly into the grooves of a rifle, and they may therefore be used in any rifle which shoots well a conical solid ball of similar form.

155. The "pachyderms," however, require a shell possessing greater penetration than these; and for this purpose the third form is the best. The front part may be made of metal of any degree of hardness, the swedge being mechanically fitted so as to allow the wings cast on the forepart of the shell to pass through. This shell is made longer, so as to weigh the same when made of hard alloy, and admit a larger bursting charge.

156. The charge of powder required for soft shells for ordinary animals is from 3 to 3½ drachms. For the "iron-clads," from 4 to 6 drachms. The spiral in a 12-bore rifle should be one turn in four feet or so of barrel for forms one and two, and one in three feet for form three. The weight of the rifle will of course be proportionate to the gauge and charge of powder. What system of rifling is adopted for shell rifles I do not think matters much, so long as it is severe enough

to hold the shell to the sharp twist of the grooves. Jacob's 4-groove, Rigby's "ratchet-wheel," Whitworth's, Henry's, and in fact any rifling which admits of the shells being mechanically fitted, will do almost equally well. If shells of the forms shown in the plate are used, the weight of rifle required for different gauges and charges will be somewhat as follows :—

Gauge and Weight of Rifle.	Charge 3 drs.	Charge 4 drs.	Charge 5 drs.	Charge 6 drs.	Charge 7 drs.	Charge 8 drs.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
12 gauge, weight	10	11	12	13	14	15
10 " "	11	12	13	14	15	16
8 " "	12	13	14	15	16	17
6 " "	13	14	15	16	17	18

This table will enable selection to be made of a size of bore, and weight of rifle suitable for any object. Less than 12 bore should not be used, and the larger the gauge the greater the effect; I prefer 8 gauge myself. Of course the smaller the bore that is selected the better will be the point-blank range. A good point-blank cannot be expected from large-bored shell rifles, which, however, as such rifles are generally used at close quarters, does not so much matter. An ordinary cupped ramrod is all that is necessary in loading. The shells should go down easily with a thin greased patch, and a thick felt wad should be used behind them.

157. Any gunmaker will be able to make a shell rifle on this principle from this description. As I said before, any system of grooving which admits of mechani-

cally-fitted projectiles, will do. It may happen, however, that you have had shell-moulds made for your rifle, or borrowed them from a friend, but when you try them you cannot get them to fly point foremost. This may occur from two causes, the first being because the shell has not expanded properly, and filled the grooves, in which case it will strip. If the marks of the rifling on the shell (after being fired, unloaded, or filled with charcoal, and sand into clay) are not perfectly distinct, or like a cast of the interior of the barrel, this must have been the case. This may happen from the shell being cast in too hard metal, or you will perhaps find that the shell fits too loosely, and the use of a thicker patch may effect a cure; but generally this occurs from the charge of powder being too small, and it should be increased. The second cause of the shell not flying accurately is that while the rifling may be perfect and the shell fitting it, yet the rate of spiral in the barrel is too slight to keep its point foremost; it does not give it a sufficient "moment of rotation" for a ball of that shape. But for reasons before explained, a rotation which is insufficient for a certain velocity, may be sufficient for a lower velocity. You must, therefore, in this case, try the effect of reducing the charge of powder, taking care not to reduce it so much as to create the other fault of imperfect expansion. If a cure cannot thus be effected, there is nothing for it but to reduce the length of the shell by altering the moulds, and try again.

158. Of course any alteration in the size of the shell, or in the charge of powder, will alter its effect on animals; and if it exploded correctly at first, it may not

do so after the alteration. This is one of the cases constantly arising where a knowledge of mechanics and gunnery is of such use to the sportsman. I have known many excellent rifles parted with by their owners in disgust simply from their not knowing how to cure trifling or accidental faults. In using shells more particularly, slight alterations will often convert a useless projectile into a most deadly and reliable missile.

159. Should you find, for instance, that your shell bursts too soon on animals, you may conclude, either that the metal at the point is too thin, or the metal is not hard enough for the velocity, or that the latter is too small for the sort of animal fired at. In the first case the plunger of the mould must be filed down, in the second, harder metal must be used, and in the third, a larger charge must be adopted.

160. If, on the other hand, the shell penetrates too far without bursting, the point may be too thick, the metal too hard for the velocity, or the charge too great for the size of animal. The cure in each of these cases will be obvious.

161. Shells may be used in a breech-loading rifle, if desired; but I prefer a muzzle-loader, chiefly for the reason that you cannot use the deadly hard mechanically-fitted shell in a breech-loader, and also because I think all elongated projectiles, as mentioned in the chapter on breech-loaders, more or less unsuited to that weapon. I may mention again that there is positively *no* danger in using my shells in muzzle-loaders, if they are properly made and fitted; whereas it should be recollected that there is always the chance of the shell getting compressed in passing from the chamber into

the grooved part of the breech-loader, though I am bound to say that I have not known this accident to occur.

162. Among numerous queries which the publication of the first edition of this book has brought on me from sportsmen in all parts of the world, the most common is, "How can I get a rifle to shoot both balls and shells well?" Hitherto there has been a difficulty in using common balls with rifles made expressly for shell shooting. A shell rifle requires a pretty sharp twist in the grooves in order to give the shell such stability of flight as to enable it to overcome all accidental causes of deviation from the point-foremost position. A shell rotating slowly, even if it would under ordinary circumstances keep point foremost, yet when fired through grass or bushes, as must often be done, will inevitably be turned more or less, and so fail to strike so exactly on its point as it ought.* By the principles formerly established, then, all spherical balls and short cones are excluded from use, except as a makeshift, in a good shell rifle. Again, a rifle made for shell shooting may be much lighter and more handy than one made to shoot solid balls of the same size and shape, with a proper charge to give low trajectory. If a long solid ball is used, then, in a shell rifle, it will give poor results, from the smallness of the charge that can be used with it.

163. Empty shells make a good projectile in such a case. I have, however, lately been trying *tubular*

* Statements differing from this have been made in print, but I have satisfied myself by many experiments that long shells cannot be used effectively with slow-pitched rifling.

projectiles, and I am satisfied that they meet all the requirements of a sporting projectile. Their trajectory is remarkably low, and accuracy quite equal to that of a solid ball. The resistance they receive from the air is quite insignificant, which accounts for their very high mean velocity. It would be easy to show that the *moment of rotation* in this form of projectile is the highest of any; it will, therefore, shoot accurately with less twist than a solid ball of similar length. The weight of a tubular projectile, with the hollow equal to half the diameter, and two diameters long, is scarcely greater than that of a spherical leaden ball of the same gauge; the extra friction in the grooves is amply balanced by the absence of resistance in the air, and thus you have a projectile with a very low trajectory, large striking surface, and extreme accuracy, which may be used with a light shell rifle. Tubular balls of pure lead (or even with a considerable admixture of tin) expand beautifully into the grooves, but they are too weak for use against animals. I have succeeded in getting splendid shooting with expansive tubular balls out of Henry's rifle, at long ranges; and perhaps this may be the principle on which the hollow bullets used by Metford and Whitworth have succeeded so well. You gain vastly, however, by carrying the hollow right through, as the resistance of the air is thereby much diminished. Tubular balls for use against large game must be cast in hard alloy (20 per cent. of tin or zinc), and made to fit the grooves mechanically. Fig. 4, Plate II., represents such a projectile, suited for use in a shell rifle, in place of the shell shown in fig. 3. It will be seen to be hollow from end to end; a thin sheet copper wad *a*, and a thick felt wad *b*, are placed behind it to receive the force of the powder, and drop behind as soon as it is out of the rifle. These projectiles may be cast in the same mould as the fore part of the shell (fig. 3), by having an extra plunger to cast them fitted to the mould. I strongly recommend any one getting a shell rifle to have this inexpensive addition made to his moulds. Besides the plunger, all that is wanted is a wad punch to cut the discs out of sheet copper, which is procurable everywhere. It would be a good thing if gunmakers could furnish cheaply hollow steel cores, on which to cast tubular projectiles of soft lead, for use in breech-loaders.

164. Since the invention of swedged shells, many devices for rifle shells have been brought forward. These are, without exception, either plagiarisms of my invention, or old plans which had been long before consigned to the limbo of failures No form of the dovetailed joint formed by swedging can be anything but a plagiarism; and I therefore claim as mine, for the benefit of the public, all shells so formed. Having no interest whatever in the manufacture of any shells, I may say this without any risk of being misunderstood; but at the same time I have no idea of standing still while my invention, which has solved the problem of shells for small arms, is calmly appropriated and "tabooed" by a patent. This has been attempted more than once.

165. The "resurrectionist" plans, as they may be called, are chiefly that of casting on a clay core, and that of casting on a rigid copper chamber. The former has the advantage of being cheap; but it is also, as is

proverbially the case, rather "nasty." No one who has experienced the facility of making shells by swedging, and the certain results attained by that process, will be content with the tedious and uncertain plan of casting on prepared clay cores. As regards the copper chamber plan, invented by Norton, and again more recently revived, its only claim to attention is its *apparent* cheapness; for the shells so formed are more troublesome to make, and much inferior in effect. Its cheapness is, however, only apparent; for, in the long run, the swedged shells are really the cheapest, as will be seen from the following estimate of the cost of 1,000 shells on each system :—

Cost of 1,000 Shells on the Swedging Principle.

Shell Apparatus	£5	0	0
6 lbs Detonating Mixture	3	0	0
Total	£8	0	0

Cost of 1,000 Shells on the Copper Tube Principle.

Shell Mould	£1	8	0
1,000 Copper Chambers, at 12*s* 6*d* per hundred	6	5	0
6 lbs. Detonating Mixture	3	0	0
Total	£9	5	6

The price of lead, being the same in both cases, has not been entered. If greater quantities are made, the gain in favour of swedged shells will be 6*l.* 5*s.* per 1,000. I take these figures from bills paid, and estimate given me by the makers.

166. The inventors of the "copper-bottle" system have also contrasted their plan with the swedging system, to the disadvantage of the latter, in the matters

of weight and bulk of apparatus, and of handiness in manufacture. With reference to these points, I say that you would only carry about the swedge in cases where you would, on the other plan, require a large supply of copper chambers; and that the weight and bulk of 1,000 of them exceed considerably that of the screw wedge (which will make any form of shell with the joint on the cylindrical part). As regards quickness, I will back myself to turn out fifteen swedged shells for every ten on the other plan, beginning at the first operation.

CHAPTER V.

BREECH-LOADERS.

168. HAVING now determined the principles on which the interior of the barrel should be constructed, the great question of BREECH OR MUZZLE LOADING remains to be considered. In the first edition of this work, I remarked that, although not then quite convinced of the complete applicability to foreign sports of any of the breech-loading systems then before the world, I was open to conviction. Since then I confess to having been completely won over to the side of the breech-loaders.

169. Many of the first introduced systems of breech-loading are unsuited to foreign field sports on account of the necessity of using only cartridges made in England with them. It has been found that gunpowder does not keep well in small quantities; and for this reason loaded cartridges invariably deteriorate with keeping. The following opinion, expressed in *The Field*, by the Hon. Grantly Berkeley, after a trial of some cartridges he had brought back with him from the American prairies, is very much to the point—

"It is very evident to me, in the practice I have had with these rifles, that cartridges, unless perfectly fresh, cannot be depended on in trials of rifle against rifle at a mark. The muzzle-loading rifle, charged from its powder-horn, is always the same; whereas, I find cartridges that have been carried and shaken about, shrink from their effective quantity of powder, either by some grains escaping, or from being over dry, or from some sort of evaporation, or other cause, and that the cartridges do not all maintain a similar fulness or size. This is remarkably the fact with the cartridges made for Prince's carbine."

Of course this does not apply to ready-made empty cartridge *cases*, but only to such as must necessarily be purchased loaded and ready for use.

170. Still a greater number of the systems are excluded from not being applicable to double-barrelled rifles. Two barrels are essential in the sporting rifle, whether for a right and left at deer, &c., or in order to have a second barrel ready to stop a charge elicited by the application of the first. Forest deer almost invariably stand still for some seconds when startled by a sudden shot; and then is the time to pick out the leader of the herd for your second barrel. Again, you never have the same confidence in closing with dangerous game, unless you can keep one barrel in reserve for emergencies. Altogether, single rifles, except for antelope and such like, are a great mistake. The weight requires to be equal to that of a double barrel on the same principle, and nothing is gained in accuracy at sporting ranges (if the double be correctly made).

171. For these reasons, as well as their liability to get out of order, none of the many breech-loading systems made any progress for sporting purposes, until

the introduction from the Continent of the Lefaucheaux system.

172. The peculiarity of this system lies in the use of a cartridge case formed of stiff pasteboard, with a thin copper or brass capsule on its end, which, when inserted, forms as it were a separate breech, renewed after every shot. The force of the elastic gases on firing expands this cartridge-case so as to completely seal up the joints of the breech-loading "action." It is doubtful whether any breech-loader can be made gas-tight for any time without an arrangement of this sort.

173. Fowling-pieces on various modifications of the original French plan are now in universal use, to the almost total exclusion of the old muzzle-loader. They are found to shoot with almost, if not quite, equal strength; and the facility of loading and unloading them, and of cleaning and keeping them in order, has gained for them a place, in the estimation of real sportsmen, that is daily becoming higher.

174. The success of this principle, when applied to smooth-bored guns, soon led to its adaptation to rifles; and now many rifles of all gauges are sent by the best makers to all parts of the world. The simple "Lefaucheaux" plan, in which the breech end of the barrels merely abuts against the false breech, is still used, as well as many modifications of it introduced by different makers.

175. One of the most ingenious of these is the "lock-fast," invented by Mr. Dougall, gunmaker, St. James's Street, London, and Glasgow, which has been selected for illustration. A reference to the figures in Plate III.

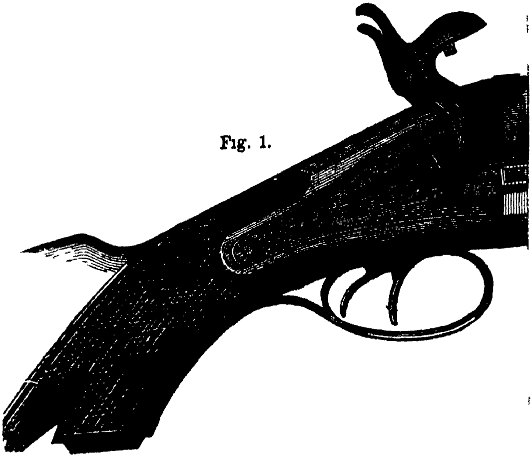


Fig. 1.

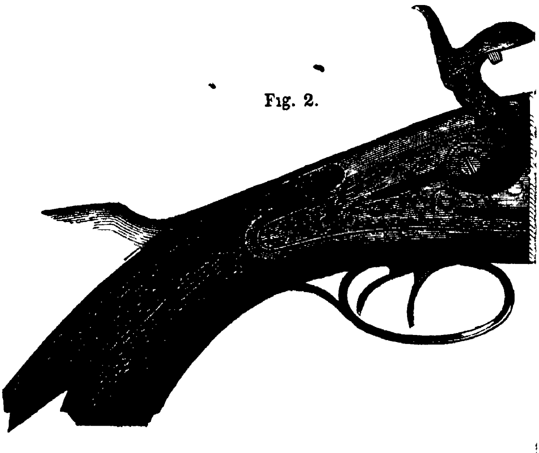


Fig. 2.

will at once explain the extremely simple and ingenious contrivance by which the inventor has secured the solidity of the breech.

176. In Plate III., fig. 1 shows the "lockfast" when opened for insertion of the cartridges, which are usually the ordinary "pin" ones of the old Lefaucheaux.* The lever A being brought up to the position shown in fig. 3, the gun is closed.

177. In the Lefaucheaux, the hinge on which the barrels turn is a simple pin; and, when closed, the barrels merely abut against the false breech, being held in their place by a bolt that shoots into the lump of metal B (fig. 1). In the "lockfast," this hinge is converted into an eccentric rod (fig. 4), which gives the barrels, in addition to the old falling motion, a retractile movement horizontally on the stock. Mr. Dougall takes advantage of this retractile motion to secure the breech by the insertion of two projecting discs on the false breech (C, figs. 1 and 2), and a pin (D, figs. 1 and 2), into the breech end of the barrels. The interlocking is most complete, and the force with which the eccentric binds the parts together, is estimated by the inventor at about 1,200 lbs. By this means also, all drooping of the barrels from the true line on firing, which was most perceptible in the old Lefaucheaux, is completely prevented.

178. The pin-cartridge case is so well known now as hardly to require description. Its cost is 50*s.* per 1,000; but, as each contains a percussion cap, 9*s.* per 1,000 caps must be deducted in order to form an esti-

* This gun is also made to take "central-fire" cartridges, but I have not used it with them.

mate of the increased cost of ammunition if the breech-loader be adopted. Whatever this cost might be considered in using the shot-gun when large numbers of shots are fired, it cannot be deemed very heavy in rifle shooting at game—not quite a halfpenny a shot!

179. Let us now compare the breech and muzzle-loading rifles under the headings given in the first chapter (para. 16).

i. Weight.—In this point there is no difference whatever.

ii. Moderate recoil.—My experience of breech-loaders is, that with equal charges, they recoil less than the old gun. I think this is accounted for by the soft paper and copper of the cartridge case acting as a sort of buffer in breaking the force of the gases backwards.

iii. Accuracy at sporting ranges.—Equal to the muzzle-loader, if not superior.

iv. Penetration.—I have been unable to discover any difference in this point between them.

v. Elevation.—The same.

vi. Largeness of gauge.—May be the same.

vii. Shape of projectile.—May be the same.

viii. Easy loading.—Here the breech-loader is beyond comparison superior. With properly fitting cartridges, at least half-a-dozen shots could be fired for every one with the quickest muzzle-loader out. In the howdah, or on horseback, facility in loading is of very great importance. In the excitement of a tiger scrimmage in thick jungle, it is most awkward to load the old gun in the howdah; bullets drop, powder gets spilt, ramrods are always in the way, you put all the powder in one barrel, and all the balls in the other, jamb your fingers, lose your temper, and shoot execrably in consequence; of course, there is nothing of this sort with the new gun. On horseback it is next to impossible to reload a muzzle-loader at the gallop, particularly if you have to dodge the charges of a savage old buffalo or anything of that sort.

ix. Short barrels.—This of course is not affected by the new system.

x. General handiness and simplicity. Under this head I think the advantages are decidedly on the side of the breech-loader. Among the advantages of the breech-loader, are, facility of cleaning, and keeping the inside of the barrel in order; the power of withdrawing the charge at the close of the day's work without firing it off, and of rapidly changing one description of charge for another (most useful in smooth bores), of recharging in case of a missfire, and of withdrawing the charge during rain, &c.; the certainty of loading always with one and the same charge, and, last, not least, the perfect safety insured. I have never found the cartridges stick after firing, and during upwards of three years' shooting have never experienced the slightest interruption to the smooth and regular action of the gun. Its disadvantages are—the necessity of using prepared cartridge cases only; this is almost an imaginary difficulty, except, perhaps, for purposes of exploration in Central Africa, and such places. The cases are now to be got at any gunmaker's shop throughout the world, and before long will, I anticipate, form part of the regular stock-in-trade of "Parsee" shops in every station in India. Very few rifle shots are fired in a season's shooting at game, and there ought to be no difficulty in keeping oneself always well supplied. Secondly, the possibility of the surface of the eccentric hinge, or other breech action, getting worn down, so as to necessitate being replaced. I see no signs of this as yet in a rifle which I have used for two seasons, and I do not believe it would occur before ten or twelve years of use, and even then a new "action" would make it as good as ever. This greater tendency to wear in one part in the breech-loader as compared with the old gun, is, I consider, amply compensated by the power we possess of keeping the inside of the former in perfect preservation, and its freedom from injury to the grooves by the ramrod in loading. If in the breech-loader we may require a new pin after twelve years' use, it is not less true that an ordinary shallow-grooved muzzle-loading rifle is, after twelve years' hard work, a *rifle* in little more than its name—the constant rusting and scouring out, together with the effect of the ramrod on the lands, having nearly obliterated the grooving.

180. I consider the spherical ball system, as advocated in these pages, peculiarly suited to breech-loading rifles. The application of a breech-loading "action" removes the one point on which objection might be taken to the sphere. It is found that when conical projectiles are used in these rifles, they must lie for at least half their length in the grooved part of the barrel before firing. This necessitates a very short chamber, and the unvarying use of one particular charge; and the use of the same cartridges for both rifles and smooth-bores is impossible. If a spherical ball is used, how-

over, the bored-out chamber may be made the full length of the ordinary cartridge case, and the same cartridges will do for guns and rifles of the same bore. Conical projectiles *may* be used with the full length of cartridge by filling it up behind the ball with several thick wads; but it is a clumsy contrivance. The use of mechanically fitted projectiles in breech-loaders has not been accomplished as yet. At present, the only way to fire hard projectiles of elongated form is to coat them with a jacket of soft lead.

181. My experience of the "lockfast" and other breech-loaders has now extended over about three years of hard jungle work, and I have no hesitation in saying that, *when carefully made, and with due regard to the needful strength in the "action" when using large charges,* a spherical ball rifle, on the "lockfast" principle, is not to be surpassed for general sporting purposes. In the howdah, in the saddle, or on foot, it is infinitely preferable in every way to the muzzle-loader; and I am satisfied that in a very few years a muzzle-loading gun or rifle will be as rare as a flint lock is now-a-days. Whether improvements will not still be made, is of course hard to say; but I doubt it much for *sporting* purposes. I consider that a 12-gauge rifle, which I used last season, is as nearly as could be *perfect.* For howdah shooting, nothing could be better. Its balls never remain in the largest tiger, even when hit end on. Of seven tigers I fired at with this rifle during last season, five dropped in their tracks, one went a short distance only, and the seventh escaped at a long distance. Almost all these were long shots for tiger shooting, that is to say, over 100 yards; and the only

ball I ever found was one which had struck a tigress on the rump, and after traversing her from end to end, lodged under the skin on the top of her head. Its weight, 11 lbs., made it a little heavy to drag about after deer or bison; and I had no opportunity of trying it at the latter. Every sort of deer, however, went down before it in a most satisfactory manner.

182. Some persons prefer "central-fire" breech-loaders, as they are called. The great apostle of this system is Mr. Daw, the well-known gunmaker of Threadneedle Street. In his cartridge a small detonating cap is placed on an anvil, and inserted in a small chamber at the back of the case. It is exploded by a blow from a small needle, struck by the hammer. This is the only peculiarity of Daw's system of breech-loading. In all other respects his gun is the old Lefaucheaux, and has no more locking power than it. The supposed advantages of the central-fire system are that the cartridge, having no projecting pin, can be inserted any way, whereas, with the pin cartridge, care must be taken to have the pin opposite the slot cut in the barrel to receive it. This is, no doubt, some advantage, but I have never found that delay was caused by the pin of the ordinary cartridge. The next advantage claimed for it is its superior safety in carrying, having no projection to receive accidental blows. I have used pin-cartridges now for three years, constantly carrying them loose in my pocket, and knocking about in every sort of way, and I have never seen nor heard of one exploding by accident. Such things have occurred, however; but it was found that the explosion of one did not affect others among which it was carried. There

is then, practically, nothing to be gained in safety by using the central-fire cartridges. On the other hand, a very serious disadvantage in using central-fire cartridges is found in the fact that with them you never know whether your gun is loaded or not, as no part of the cartridge shows outside. Another objection to them is, that having no projection to lay hold of, it is impossible to extract them from the gun after firing, without the use of a mechanical extractor attached to the gun. Mr. Daw has, therefore, invented an ingenious piece of mechanism for this purpose, which, as long as it is in order, answers its purpose perfectly; but, in my opinion, the addition of extra mechanical actions to a breech-loader is objectionable, as it greatly increases the complication and liability to get out of order. I consider that, having got the power of opening and closing the breech, we should reduce the mechanical action to the utmost point of simplicity. A gun which requires a mechanical extractor is just twice as liable to get out of order as one in which this action is performed by the shooter's fingers. On the whole, then, I cannot recommend the central-fire system for sporting purposes.

183. Several devices for rendering breech-loaders self-cocking have been invented. One of the best of these "actions" is Greener's,* in which the barrels are held down by a piece running into the breech end, above the chambers. Any system in which the barrels are thus held (as the lockfast and Greener's) is preferable to those which are held merely by bolts shooting in *below* the barrels. This is particularly the case in

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* W. M. Greener, St. Mary's Works, Birmingham.

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rifles; indeed, I have tried some of the Lefaucheaux systems, in which no amount of artificial elevation appeared to make them shoot high enough, owing to the drooping of the barrels thus imperfectly held underneath. I have received an excellent rifle on this system from Mr. Greener, weighing only 8½ lbs., and which shot pleasantly, and with great accuracy and force, a 16-gauge spherical ball, with 4 drs. of powder. The best test of a breech-loader for rough jungle shooting is to set up a circular target, 2 feet in diameter, at 80 yards, and see how many shots you can put into it in a given space of time, say, three minutes. A trial of the lock-fast and Greener self-half-cocking rifles, the other day, gave this result, in three minutes,—

Lockfast fired 17, put in 16.
Greener fired 18, put in 17.

But the lockfast was a heavy 12-gauge, while the Greener was the light 16. The latter would probably have done better, but that it was working somewhat stiff; but I do not see much advantage in the self-half-cocking arrangement, for you have only to bring the common lock to full cock at once, and it then becomes quicker than the other. Another invention of Mr. Greener's, the "wedge bolt," has been highly praised.

184. It would be tedious to go over all or most of the many changes that have thus been rung on the old French invention. Almost every maker has a plan of his own, which, if you believe his advertisement, is the "only reliable" one. Not having tried a tithe of these systems, I should be sorry to give a decided preference to any; and can only specify those I have actually tried with satisfaction. In addition to the Greener and lockfast

systems mentioned above, I should notice Henry's breech-loader. His double Lefaucheaux rifles are much approved of by many good sportsmen in India, while his single-barrelled small-bore breech-loader is undoubtedly the best weapon of that sort out. On the whole, if price is no object, there is no system preferable, at all events for rifles, to the "lockfast" action.* At the same time even the latter is not to be trusted, unless care is taken by the maker that the action is of sufficient strength to stand the heaviest charge likely to be used with the rifle, and also that every part of the weapon is thoroughly well fitted. It could lead to no good result to conceal the fact that of the many large breech-loading rifles made for Indian sport, very few are found to have been constructed strong enough to stand heavy charges for any length of time. In every case of failure that I have observed this is easily traced to the desire to make the rifle look neat, forgetting that in guns, as in everything else, "handsome is that handsome does." The pin which receives all the strain is hardly ever strong enough, and the check-pieces in which it is set are also universally cut away too much in front of the pin. And this element of weakness is often found in the excessive width of the hook on the barrels, creating a long, and consequently severe, bearing on the pin. The narrower this hook is made, consistently with sufficient strength in itself, the less strain will there be

* Any gunmaker can make "lockfast" rifles, on payment of royalty to the patentee; but, as this puts them in a disadvantageous position, they prefer not to do so; and so Mr. Dougall has a virtual monopoly. He has accordingly more work than he can manage to the uniform satisfaction of his customers.

on the pin. It is a matter of great regret that carelessness and bad workmanship bid fair to delay long the general introduction of breech-loading rifles into the sporting field. Theoretically, nothing remains to be done; but the practical details of manufacture are still by no means so well attended to as they should be.

CHAPTER VI.

ORDERING A RIFLE.

185. In this chapter I propose to give the inexperienced reader a few hints derived from a somewhat extensive experience of "orders" and their results.

186. The first great difficulty lies in the selection of a maker. The depth of one's purse, to some extent, determines this; but from many direful disappointments I have experienced from inferior work in guns in places where, if one's gun failed, it was like losing his right hand, I earnestly recommend my readers to get the very best guns and rifles that money can purchase. I do not say, go to the most expensive maker you can find, but go to a reputable maker whom you can trust, and whose work you know, and pay him *his best price* for his best article. I would recommend a person going out to India to go to a maker whose reputation was established in India for his rifles, because, in the first place, he will be able to re-sell them, should he wish to do so, with less loss to his pocket than if they were built by unknown makers. During a long course of experiments which I undertook with a view to satisfy myself what principle is the very best for a game-shooting rifle, I had occasion to import a large number of rifles, and

soon discovered the truth of this. The high-priced weapons by well-known makers sold at a slight depreciation on the English price; while others, by "nobody," though at half the figure, were nearly unsaleable. Another reason is that the workmanship of high-priced London guns and rifles can always be depended on, while a faulty spring or screw, which often occurs in the provincial article, may prove a stopper sometimes to the best-planned excursion to some distant jungle, where gun-cases and apparatus cannot be taken. As an instance, I may mention a rifle I once had, the cock of which blew up one day and smashed the mainspring, the consequence of which was that the lock had to go a thousand miles or so to Calcutta for repair. I had loaded with no excessive charge, and the accident was solely owing to the miserable mechanism of the lock. The chief reason, however, is, that amongst the many double-barrelled rifles I have had, I have only possessed three that shot true with both barrels. The reason is, that to make a double shoot true from the shoulder, the barrels have to be inclined inwards from the parallel at a slight angle, varying with the gauge, metal, charge, and general build of the piece, only to be discovered by repeated trials by a good shot from the shoulder (vices give fallacious results,) and re-adjustments of the pair of barrels. All this a cheap maker, in or out of London, cannot afford to do. If he hits on the proper taper at first, good and well; if not, he endeavours to hide the error by dodges in sighting, and often by sham trials in presence of the purchaser, in which, being himself a good shot, he can make the rifle *appear* to shoot true by allowing for the barrel he knows to be faulty; as in such cases the buyer is always more inclined to mistrust his own shooting than that of the gun. I find that, when they have turned out an affair of this sort, gunmakers generally place the sights so as to divide the amount of error between the two barrels, as, each having then only half the amount, it is less likely to be discovered by the shooter. I generally, however, alter the sight of a rifle of this kind, so as to make one, at least, of the barrels carry quite true, which I can then depend on for long shots, while I allow for the error of the other in aiming. I possessed such a piece for a long time, and killed a great deal of game with it, but only by allowing about six inches for the left barrel at 100 yards. I have possessed another double rifle by a country maker, the error of which was even greater than the above—nine or ten inches at 100 yards, and which maintained its character to the last, by bursting in my hands when loaded heavily for buffalo shooting.

187. Mr. Greener, at page 393 of *Gunnery in* 1858, says:—

> "Many hold it to be essential that double rifle barrels should be put together perfectly parallel. I followed this rule, and was at considerable cost in perfecting tools for the purpose; yet, strange to say, in trial I found invariably that the right barrel threw the ball slightly to the right, and the left to the left. . . The cause of it is evidently the recoil not striking the stock in the centre, but on one side. . . To remedy this, it is necessary to incline the barrels in towards the muzzle to counteract that tendency; *but in doing this, another evil is created, for you can only do this to suit a given distance, either* 100, 150, *or* 200 *yards, as may be determined.*"

The part I have italicized is, I believe, erroneous.

Suppose he has regulated his barrels so as to shoot true at 100 yards (by "true" I do not mean that both balls shall hit exactly *on the same spot*, but merely that they shall shoot *parallel*, or that the distance between the two marks on the target shall be equal to that between the axes of the barrels at the muzzle—in the former case, of course, they would cross at 100 yards, and be many inches wide at long ranges), then he says they will not shoot true at 200 yards. Now, I ask, can a ball that has travelled in a perfectly straight line for 100 yards, diverge in the next hundred to the right or left, through a fault in the laying together of the barrels? If true at 100, I conceive that with due elevation they will be so also at 200, 300, or any longer distance. This appears to me to be a similar mistake to that made by the writer in question, when he maintained that projectiles gained in velocity after leaving the muzzle of the gun. The power of the gun to affect the projectile either in direction or velocity must surely cease on the separation of the two. I am aware that on one supposition Mr. Greener's idea might be correct. If the projectile quits the muzzle while the gun is still under the influence of the outward swerve, the ball will have a lateral motion communicated to it, causing it to diverge more and more to that side towards which the swerve takes place. The path then described by the projectile in the horizontal plane (I here make no reference to the forces acting in the vertical plane, such as gravity, &c., because these do not affect the present question,) will be the resultant of two motions, viz., the progressive motion, or the impulse given by the charge, and the lateral motion communicated by the swerve.

Now, were both these motions constant, this resultant would be a straight line, and, in that case, the direction of the balls could be controlled by sighting, and both barrels would shoot true at all distances by the same sights. But these motions are not constant, they are retarded by the resistance of the atmosphere, and in different degrees. The resistance of the air being proportional to the squares of the velocities, since the progressive motion has a vastly greater velocity than the lateral, it is retarded from this cause in an incalculably greater ratio; consequently the resultant, or path of the projectile, in this case is a curve, and cannot be controlled by sighting, except, as Mr. Greener says, to suit a given distance. For example: suppose a ball started with a progressive motion, such as to make it travel 300 ft. in a certain short period of time, say, for convenience, a second, and a lateral motion of 6 in. in the same time, the ball would then in the first 100 yards of its flight receive 6 in. of lateral compensation. It would then start on the second 100 yards with a progressive velocity of say 280 ft. per second, and with a lateral velocity of 6 in. per second, and the ratio of atmospherical resistance would be as 313,600 for the progressive, to 1 for the lateral motion. The disproportion of the resistances being so immense, that experienced by the ball in the lateral direction need not be taken into account, and we may calculate that in each second of its flight the ball receives an equal amount of lateral motion, viz., 6 in. On the other hand, its progressive motion being greatly resisted, it would not travel anything like the same distance during the 2nd second of its flight, as it did during the 1st second;

or, in other words, while it received 6 in. of lateral motion in the first 100 yards of its flight, it would receive the same amount of lateral motion in the next 70 or 80, and consequently would describe a curve. It will be understood at once from this, that if the ball leaves the muzzle while the rifle is still in motion from the swerve, Mr. Greener's theory holds good (although I do not believe it was on this ground that he advanced it), and a double rifle can only be made to shoot quite true at some given distance, the balls diverging at all others. Taking into consideration, however, the probability that the act of recoil takes place at the instant of ignition of the charge, and also the extremely minute arc through which the muzzle is moved by the swerve, (if the lateral compensation required by the rifle at 100 yards were 5 in., which is a large allowance, the arc would be about $\frac{1}{18}$ in. in a rifle with 26-in. barrels), I am inclined to think that the swerve is complete, and the barrel at rest when the ball quits the muzzle, and consequently the projectile does not leave the vertical plane at any point during its flight to the target. Practice, too, confirms this idea. By carefully conducted experiments with screens, I have ascertained that, in a good double rifle, if both barrels hit the first screen correctly at any given distance, they will also hit correctly the second screen placed at an equal interval beyond the first; while, in a badly made piece, the divergence increases uniformly with every increase of distance; that, is, if there is an error of 6 in. at 100 yards, there will be 12 at 200, 18 at 300, and so on. The late General Jacob also found that *better* practice was made by his double than by his single rifles at long ranges of 1,500 and 2,000 yards. His gunmakers would not venture to send him an imperfect weapon, we may be sure, but they could not in those days have *tried* them at anything like such ranges. They made them shoot very accurately at comparatively short distances; consequently they did not fail at the longer ones, as must have been the case were Mr. Greener's theory correct. The better practice is, of course, attributable to the superior weight of the doubles.

188. Since publishing the first edition of this work, I have communicated a good deal with several eminent gunmakers in England on this point, amongst others with Mr. Greener. He says, in reply to my query (paragraph 187), "Now, I ask, can a ball that has travelled in a perfectly straight line for 100 yards diverge in the next 100 to the right or left, through a fault in the laying together of the barrels?" that "It does diverge unquestionably; but I do not think from any fault in the laying together of the barrels, but from a principle inherent in combinations of taper tubes, where the line of sight is taken equidistant from the centre of each tube. Each barrel shoots perfectly correct; but having to be constructed to '*hit exactly on the same spot*,' the degree of inclination must be according to the required distance, be it 100, 200, or 300." Here, then, we have the cat fairly out of the bag; it is only because both barrels have to be made to hit "exactly on the same spot," that they cannot be made equally true at all distances. But we do not want this. We want them merely to shoot *parallel*, that is to say, that the right barrel shall hit at all distances so much to the right of the spot aimed at as the axis of the right

barrel lies to the right of the line of sight; which would be in a 12-bore rifle, if the centre of the bullet be taken, *about half an inch*, and if the inner edge be taken, about *one-tenth of an inch!* and so, *vice versâ*, with the left barrel. We shall not complain of this amount of inaccuracy at all ranges, if we thereby escape the much more serious deflections "due to the principle inherent in combinations of taper tubes," which principle, I suspect, is too frequently assumed as an excuse for sparing the care and frequent re-adjustments necessary to the building of a perfectly true shooting double rifle. Almost all the gunmakers I have communicated with say they can make their rifles shoot parallel at a given distance with a given charge; some few add that it is impossible to do so at all distances; while others undertake that their rifles shall shoot parallel at all distances with the same charge. In truth, this talk about parallelism and convergence is, after all, mere straw-splitting; and practice, as well as theory, shows that if a rifle throw its balls *practically together* at the longest ranges it is to be used at, they will be equally true at all shorter distances. But, in point of fact, a double rifle that does shoot true at any range long enough to show a divergence is very rare indeed; and this solely for the reason that hitherto very few gunmakers have made it their rule to re-adjust the taper of their barrels until they do shoot true. In cheap rifles they cannot afford to do this, and, consequently, unless they happen to hit on the correct taper at first, such rifles are never quite true. There can be no scientific rule by which a certainty of correctness at the first trial may be secured; nor, I believe, will mechanical measurements, however accurate, invariably secure success. The amount of taper depends on so many small matters, such as weight of ball and of charge, grooving, weight of rifle, length of barrels, &c.; in fact, it will vary with every rifle made. How delicate a matter this "taper" is, may be imagined from what a gunmaker once told me, that after he had got both barrels of a rifle quite true at 100 yards, when trying it in the rough, the mere putting on of the ramrod pipes so altered the taper as to make the finished weapon shoot some three inches across at 100 yards! Under these circumstances, nothing but the most consummate patience and care on the part of the gunsmith can ensure truth of shooting in a double rifle; and this patience and care he is bound to give to his best double rifles, even if it involve the re-adjustment of the barrels half-a-dozen times over. I have had considerable experience of the work of many of the London gunmakers, and can declare that very few of those even who charge the highest prices *do* give invariably this care and attention to even their best rifles. Now, however, if required, most gunmakers will give a warranty of correctness with their best rifles; and this I strongly recommend all purchasers to exact.

It would be unfair to specify any gunmakers in this place as being given to turning out true shooting rifles, or the reverse. I have got many rifles in my time from many tradesmen; but I have had bad as well as good from even the *most* trustworthy. The best general rule is, that you have most chance of being well served by an old firm with a character to maintain; but this rule, like most others, is not without its exceptions. If you get a warranty with your rifle you are pretty safe, as you invoke thereby to your assistance the most powerful of all charms, *self-interest.* Perhaps the following short extract from the second edition of *Shooting Simplified*, written by a gunmaker, may serve to explain why so few good double rifles are turned out:—"The strain upon the energies to produce these weapons (double rifles), and overcome difficulties in adjusting their shooting, is almost incredible, and in many cases hardly any price likely to be obtained will be remunerative."

189. It will be seen, then, that to get a perfectly true-shooting double-barrelled rifle is a very difficult thing indeed. Nevertheless, it is to be had, and at a more moderate price than may be supposed. *Cheap*, however, it cannot be had, and to such as cannot or do not feel inclined to go to the necessary expense, I say, do not have a double rifle at all; get a good single one, which any maker can turn out, and make up your battery with sound, strong, smooth-bored guns, 12 or 14 gauge. A muzzle-loading double rifle of perfectly sound and good workmanship, well, though not highly finished, accurately made to shoot parallel, and truly sighted, can be had, without case or apparatus, for forty guineas, and a breech-loader for about five more. But remember, *it is better to pay the forty guineas to a maker who charges that sum for his best rifles, than to a more expensive maker for* HIS *second best.* Whether a perfectly trustworthy and accurate weapon may be made cheaper or not than this, I do not know; but I doubt it very much, if materials and workmanship are really the best.

190. "I can get as good a rifle for 10*l.* in Birmingham as in London for 50*l.*," some people tell you. When I hear people talk in this strain, I am bound to doubt their capability of judging what *is* a good gun, for the thing is simply impossible, and involves a misunderstanding of the simplest laws of production. No article can long continue to command a higher value than that which is determined by its relative cost of production. Now this cost of production consists of the *wages of the labour* expended, and the *profits of the capital* employed. The wages of the labour expended in the production of an expensive gun are higher, but why? Because, in the first place, labour of a better quality is employed. The workmen are more skilled in their trade, and, *therefore,* obtain higher wages. Again more care is given in the details of construction by the necessity of an acquired reputation being maintained, or with a view to making a reputation. This entails repeated re-adjustments and re-doing of work, which of course adds to the *wages of labour.* The master workman himself may be more intelligent, experienced, and skilled in his business, and the reimbursement of the labour he expends on his guns is therefore justly higher. The profits of the capital invested in making guns can be no higher in one place than in another; for if they did become so, capital would inevitably gravitate there as an investment, and reduce the profits to the normal rate current in the country. But it is possible that the capital may have to be invested *for a longer time* in the one case than in the other, and in that case the profits due to the capital for the additional time, accumulated at compound interest,

enters into the cost of production. But no capitalist voluntarily prefers delay in the return of his capital; and this addition to the cost of production can only be caused by the customers themselves, who prefer paying it, to purchasing for cash. These considerations are the only ones which can affect the cost of a gun, where there is no monopoly (as in the case of a patent); and it will be seen that they all arise from the guarantee they give of superior excellence, in so far as the most skilful work and the greatest care can secure it; or from the accommodation they give to the purchaser. It will be observed that in the preceding explanation I have not been contrasting London with provincial guns, but high-priced with low-priced, wherever they are produced; for there is no reason why the same amount of skill and care should not be employed in Birmingham as in London; and if they are, and the other elements in the cost of production are equally present, it only wants the fact to be known for the Birmingham article to fetch the same price as the London made. In this case, however, the cost of production must have been the same in each case: for skilled labour can be had no cheaper in one place than in another, and the necessary materials are equally cheap (except the trifling cost of carriage) in one place as in another. A glance at the annexed list of prices will show that in point of fact the charges of the leading provincial makers are very nearly as high as London prices. Where the latter are exceptionally high, the reason must be either that they give unusually long credit, or that there are a sufficient number of fools left who believe them exceptionally good, to keep up the prices. The possession of a patent will of course enable the patentee to keep up the price to that point beyond which purchasers enough cannot be found.

There are one or two popular ideas on this matter of prices opposed to the above explanation, which I must shortly notice. It is often said that "you pay for the *name* of a London maker." Well, of course you do, but only in so far as the name is a guarantee of superior skill, attention, and science in producing guns. No doubt some firms trade on a respectable name, after the guarantee has ceased to exist, but it is the business of the public to find this out, and cease to consider the name as a guarantee, when it ceases to be one. Again, it is a prevalent idea that the real material on which the excellence of a gun depends, comes ready made from Birmingham, and that it is only put together in London. So it does: the rough material of almost all guns comes from Birmingham, and in so far most other gunmakers are only on a par with those of that place; but it is a mistake to suppose that the quality of this rough material is what constitutes the goodness of the finished gun. It is on the labour afterwards expended on it in boring, rifling, adjusting, and other operations, that its excellence consists, and this is done by the gunmaker himself, wherever he may be; and according to the value of the skilled labour, and the care and science bestowed on it, so must the price be regulated. Another common mistake is to suppose that a London maker must charge higher "to pay for his fine shop," &c. To any one conversant with the theory of rent, it will be evident that this cannot be an element in the cost of production; and to those of my readers who are not so, it would be in vain to attempt an explanation within the limits of such a work as this. The last popular idea—favoured by the provincial makers—is that the majority of the guns sold in London are made in the country. This is, no doubt, to some extent true; and, where it is not done avowedly, is downright roguery. But such guns can only command a higher value in the market than their quality warrants for a short time, until the purchasing public is undeceived: and when so much is granted, it only proves that there are *some* rogues in the gun trade as in all others, whom it should be the business of the public to detect and expose with the least possible delay. I believe, then, that as a rule the extra money you pay for a gun exactly corresponds to the extra quality and security of excellence you procure, except in the cases where you deal with a maker who gives long credit, and consequently has bad debts, or allow yourself to be swindled by a rogue.

If, then, you do not choose to pay a high price for your rifle, you are at perfect liberty to pay a lower one; but do not then suppose that you get an article in every way equal to the other. The relation of quality to price, expressed in the old and homely proverb, "cheap and nasty," is, I suspect, as true in reference to guns as to other commodities.

191. Some gunmakers do not object to work "to order," while others do. Established houses, with a good name, and a reputation for producing a certain description of weapon in perfection, would much rather not take an order at all for a gun or rifle on any other

LIST of the NAMES and ADDRESSES of most

NAME OF FIRM	ADDRESS
J. Purdey	314½, Oxford Street, London
C. W. Lancaster	151, New Bond Street, London, W.
J. D. Dougall	59, St. James's Street, Piccadilly, London
Manchester Ordnance and Rifle Company (Whitworth)	44, Charlton Street, Manchester
Alexander Henry	12, South St. Andrew's Street, Edinburgh
George H. Daw	57, Threadneedle Street, London
Westley Richards	Birmingham
Wilkinson and Son	77, Pall Mall, London
John Blissett	322, High Holborn, London
Wm. R. Pape	Newcastle-on-Tyne
Saml. and Chas. Smith (Sam Smith)	64, Princes Street, Leicester Square, London, W.
Wm. and Jno. Rigby	Dublin
Reilly and Co.	502, New Oxford Street, London
William Greener §	Rifle Hill Works, Birmingham

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* These prices are for spherical ball rifle

§ The W. W. Greener mentioned in pa

principle, and if they do take it, will probably pay little attention in carrying it out.

192. It is a good rule to go, if you can afford it, to every man for the thing he makes a *spécialité* of. To Purdey if you want a 2-groove solid-conical rifle; to Lancaster for an oval bore; to Dougall for a "lock-fast;" and to Henry for a "Henry" rifle. Daw has long devoted himself to "Jacob" rifles, and "Sam Smith" seems to have thoroughly apprehended the principles of the improved spherical-ball system. Above all, beware of wholesale gunmakers, those who freight ships with "carefully-made" guns and rifles for the colonies.

193. I here subjoin, in a tabulated form, the names and addresses of most of the leading gunmakers, with the prices they charge for their different classes of double and single rifles, so far as I have been able to ascertain them.

194. List of Apparatus.

	£	s	d.
A best Oak Case, brass screws, French polished, &c	2	6	0
A Leather Cover to Case	2	2	0
A Washing Rod and Mop	0	10	0
A Flask with extra Charger	0	10	6
A Key for Nipples	0	4	6
Three Turnscrews	0	7	6
A Bullet Mould, "Spherical"	0	3	0
A Metal Mould for Conical Ball	1	15	0
A Loading Rod with joint knob, drawball, and extra forcer	0	12	0
A Patch Punch	0	6	6
A Sling with Spring Hooks	0	8	0
A pair of Pincers	0	3	6
A Nipple and Cock-head Cleaner	0	4	0
A Metal Oil Bottle	0	3	6
A Bottle of Oil	0	1	6
A Waterproof Gun Cover	0	8	0

	£	s.	d
An extra Ramrod	0	7	0
A Lock Vice	0	5	6
Two pair of Nipples, a pair of Strikers, and Wrench in Wrapper	0	15	0

195. Having selected your maker, you may either require your rifle to be made according to your own design in whole or in part, or trust all, except the principle, to his discretion, and unless you can sufficiently rely on your own knowledge, this is the better plan. Gunmakers who work to order are often required to make the most preposterous and impossible weapons, and then too often abused for their turning out badly. If you prefer having it made wholly or in part according to your own design, put it in writing, and tell him that, if the rifle differs from it in any respect, or if both barrels are not found to shoot parallel with a certain charge at 100 yards, the rifle will be returned. The best rifles I have ever had were sent me in exchange for others I had returned. I shall now say a few words on the different parts of the SPORTING RIFLE.

196. THE BARRELS.—I strongly recommend the barrels of all sporting guns and rifles being made of the best and hardest laminated steel. A sporting battery has to go through a great deal of rough work, and hard barrels will show the effects much less than soft. As regards mere safety, most rifle barrels are made so thick that any of the best mixtures may be sufficiently trusted on that score, although shot guns, when used with large charges for ball shooting, are decidedly more safe when constructed of this metal. The shallow grooving necessary for the spherical and most expansive projectiles very soon gets perceptibly worn down in soft barrels,

particularly in breech-loaders, or when hardened balls are used, while no perceptible effect of this kind takes place with hard steel barrels. At the same time, many gunmakers have particular mixtures they have been in the way of using for years in their best barrels, and it will be wise in such a case to let them work in the metal they have been accustomed to.

197. Having, during the past year, had two cases under my notice in which one of the barrels of a double rifle bulged at the breech when heavily charged for buffalo shooting, I have been led to examine more closely the provisions of the Proof Act as at present in force, and I am astonished to find how very little security they afford to the sportsman against the carelessness or roguery of gunmakers who have no established character to maintain, or are content, in case of an accident, to shelter themselves under the excuse that their barrels have been proved according to law. Take, for example, the case of an 8-gauge rifle on the expanding conical ball system—a species of weapon much used by sportsmen. The *definitive* proof for such a barrel (which is the only test of the finished barrel) is, I find, only 11 drachms of powder equal in strength to that used by the Board of Ordnance, and a *spherical* leaden ball (of 2 oz. weight) having ·02 in. of windage; whereas, the sportsman will use from 5 to 8 drachms of the strongest rifle powder, with an *expanding conical ball* of at least 3 oz., and possibly of 4 oz. weight. Now, the latter charge will, without doubt, cause at least as great a strain on the barrel as the former, and thus there is positively no margin of strength whatever left to cover the thousand-and-one accidents that may at any

time double or treble the amount of strain. The bullet may start from its seat (an accident very probable with loose-fitting expansive conical balls); or it may have got firmly fixed through lying long in the barrel; or two bullets or charges of powder may be put in by mistake, &c. The amount of insecurity to purchasers of fire-arms on modern principles, thus disclosed, is fearful to contemplate. It is much to be feared that the enormous increase in the demand for small arms that has occurred of late years has had a tendency to induce carelessness in the gun trade, and sportsmen would do well to protect themselves by calling for greater stringency in the proof of their rifles. An alteration of the existing law, in so far as conical ball rifles are concerned, appears, at all events, to be imperatively required. It is insane to test the safety of a barrel that is to be used with a heavy expanding conical projectile, by using a simple non-expanding, loosely fitting sphere in the proof.

198. The length of the barrels is, to some extent, a matter of taste, although I think that, the shorter a rifle can be made without sacrificing strength of shooting, the better it is for sporting purposes. The aim can be secured much quicker with short barrels, particularly in running shots, and, the weight being more compact, it tires less in carrying. I am aware that in advocating short barrels, I differ from some good sportsmen and writers, but I think the majority agree with me. For rifles under 12-gauge, I prefer 26 in.; and heavy close-quarter bone-smashers may be from 2 to 4 in. shorter with advantage. You will get as great velocity out of these lengths with the spherical ball as if you used much longer barrels. Expansive balls

require longer barrels; an Enfield-principle barrel should never be under 32 or 34 in. Smooth-bored barrels, if made solely for ball shooting, may be made as short as rifle barrels; but they must, in that case, be bored truly cylindrical, and will consequently shoot weak with shot. If a smooth-bore is wanted to be good with shot and also with ball, it cannot have short barrels, for this reason: To shoot shot strong and close, a barrel must be relieved at the breech and muzzle ends; that is, it must be bored in the shape of two slightly-tapering cones, with their small ends meeting in the centre. Now, although in long barrels this boring out must extend to a greater length along the barrel, yet it is required to be less in degree than in short barrels; that is, there will be a less difference between the maximum and minimum diameters of the bore. When ball is used in such a barrel, it must fit the minimum diameter of the bore, and consequently there will be more or less windage in the bored-out parts, and less inaccuracy in the long than in the short barrel. Hence it is that some gunmakers are more celebrated for ball-shooting smooth-bores than others; they manage to make them carry shot well with less "relief" than others. John Manton, of Dover Street, *used* to be particularly distinguished for this property in his guns; and I know of no maker who turns out guns better for *both* purposes than Blisset of Holborn. I never saw a fowling-piece made for shot shoot ball well, if under 30 inches in the barrel.

199. In rifle barrels, I prefer the metal to be of nearly equal thickness throughout, as I believe that this construction obviates much of the vibration so fatal to accuracy of shooting in rifles. A slight difference there

must and should be, or the barrels of a double cannot be made to shoot parallel; but the taper is much too great for good shooting in many rifles. This also gives the breech end a great elevation, and we have no true point-blank range. It is very often done with a view to giving the rifle the *appearance* of requiring but slight elevation; for the greater the elevation actually given by the rib, the less will the height of the folding sights require to be; and it is by the height of these that the superficial observer generally judges what amount of elevation a rifle requires. The only way to form a judgment on this point, without measurements or trials, is by observing the *difference* between the *first* and the *second* folding sights.

200. Air vents alleviate the recoil and facilitate loading with tight-fitting bullets; and I have never found that they injured the strength of shooting. The best nipples are those with a platinum-lined small orifice at the end of the tube next the powder and the larger hole at the top. The powder is never intended to come up into these nipples, and is never exposed to the action of the air, which is the cause of most of the missfires that occur in common nipples. I have used them for years and never had but one missfire, which was owing to my own carelessness in neglecting to change the caps after my guns had been exposed to pouring rain for the best part of a day and night. It is needless to say that *the* missfire was at a tiger standing at thirty yards broadside; had it been an antelope or such like, it would have gone off all right. Some people object to these nipples on account of not being able to see that the powder is up to the nipple; but if the proper method

of loading be observed, this is of no consequence. I first blow through the nipples with my hand at the muzzles, then snap a cap on each barrel, pointed *downwards* at a straw or such like, and if this is blown away by the gas, I load. When the gun is clean, moreover, a few grains of the powder, if it is not very coarse, generally appear in the cone of the nipple, which is a sure sign. But on no account must such nipples be primed with powder after loading, as it destroys their efficiency by blocking up the passage of the percussion flame to the charge, and causing the explosion to be effected, if it is so at all, by the burning of a train of gunpowder down the tube, as in ordinary nipples, which, it stands to reason, must be slower than the lightning-like flash of the percussion flame unobstructed.

201. The Grooves.—If you determine to have your rifle on any of the well-known modern systems, the rifling best suited to them is equally well known, and need not be here discussed; you have only to go to any reputable maker, say what you want, and you are pretty sure to get it as it ought to be. The principles of constructing shell rifles have been already set forth in the chapter devoted to that subject. I shall therefore now confine my remarks to the rifling suitable to the spherical ball. In this, the object is to reduce friction to a minimum, giving at the same time sufficient hold between the ball and the barrel to avoid stripping with the great velocities given in this style of rifle. This is done, simply by reducing the rate of spiral in the barrel, so far that the ball has no tendency to leave the grooves; that, in fact, it is nearly as easy to follow the grooves as to go out straight; and such a rate of spiral is found to

be quite sufficient to prevent the ball assuming any other axis of rotation up to sporting ranges. As before stated (para. 93) a 14-gauge barrel rifled at the rate of one turn in 8 ft. 8 in., may be depended on up to 200 or 250 yards. It is evident that, with this rate of spiral, the ball requires but a very slight hold on the grooves to induce it to follow the sweep of the rifling, and in practice, I have found, that the lead need not even be indented by the lands at all, a substantial patch giving the spiral motion quite as effectually. The ball thus leaves the muzzle a true sphere, perfectly smooth, and with no irregularities of surface for the atmosphere to act on. Even without the rifle motion it would have little tendency to assume any other axis of rotation than that it starts with, which accounts for the ease with which this very low rate of spiral prevents its changing to any prejudicial rotation. The tendency to strip, then, in such rifles being very small, the grooves may, and should be made as shallow as possible; seven or eight grooves very broad and shallow, the lands being almost knife-edged, have been found to answer best with these rifles.

202. On account of the above-laid-down principles in these rifles, balls formed of an amalgam of mercury and lead give superior shooting. Independently of their superior overcoming power, owing to the greater specific gravity of the material, they preserve their sphericity better under the operations of loading and firing.

203. In grooving breech-loaders for spherical balls, *the bottom of the grooves* should be exactly flush with the inner surface of the cartridge case. The lands cannot be too narrow, and should, I think, be gradually sloped

off to nearly the level of the grooves in front of the chamber. In expansive rifles again, *the top of the lands* will be nearly flush with the surface of the cartridge.

204. Although as before shown (paras. 44, 49, 50), theoretically the rate of spiral in the grooves of a rifle should vary with every change of gauge, of velocity, and of elevation, yet in the present stage of the gun-making art, it would be vain to expect more than the very roughest approximation to such exactness. Yet there is a limit beyond which neglect of these considerations would involve serious consequences. Conceive, for instance, the angle of the grooves in a cannon of 20 ft. diameter, rifled at the rate of one turn in 3 ft., a common rate in small rifles! Yet to rifle an 8-gauge at the same rate of turn in the length as a 16-gauge, is a piece of folly only less in degree than this.* The following table shows approximately the scale of rifling required theoretically (para. 44) for the spherical ball in

* A very convenient instrument for examining the interior of gun-barrels, and by means of which the rate of spiral in a rifle may be ascertained, is sold by gunmakers. It is simply a reflector set in a small brass cylinder the size of the barrel; this, when allowed to slide down to the breech, shows clearly the whole of the interior of the barrel. In the absence of this instrument, the rate of spiral may be ascertained by casting a short cylinder of lead on an iron rod in the barrel. This must be worked loose in the barrel with oil till it passes up and down freely. Then fixing a disc on the rod when the leaden cylinder is at the breech, note a point on the barrel opposite a mark on the disc; draw the cylinder to the muzzle and mark the point on the disc which is now opposite the mark on the barrel. The proportion of the space between the marks on the disc to the whole of its circumference, will be the amount of twist in the length of the barrel. Thus, if your barrel is 30 in. long, and you find that the disc has turned through half the circle, it will show that the barrel is rifled at the rate of a turn in 5 ft.

some different gauges, but until further careful experiment shall have determined the very best rate for some one gauge, this scale can only be taken as an approximation to the truth. I have also added the ordinary charge of powder and weight of rifle for each gauge :—

Gauge	Rate of Spiral Required	Charge.	Weight of Rifle.
6	1 turn in 16 feet 1 inch.	8 drs	15 lbs.
8	" " 12 " 1 "	6 "	13½ "
11*	" " 10 " 3 "	4½ "	11¼ "
14†	" " 8 " 8 "	4 "	9 "
18	" " 7 " 2 "	3½ "	8 "
25	" " 5 " 0 "	2¾ "	7¾ "
36	" " 4 " 7 "	2¼ "	7 "
52	" " 3 " 6 "	2 "	6 "

205. Locks and Triggers.—Have strong and heavy cocks, and strong mainsprings, and the hammer ¾ inch from the nipple at half-bent, or it is sure to blow up to half-cock when using large charges. Locks of the very best quality to bolt *in front* at half-cock. I have more than once been in a serious fix from the bolts of a rifle bolting behind slipping on by accident. With breech-loaders bolts are not desirable, I think. The pull of both the triggers of a double barrel must be the same. Hair triggers are an abomination, and, moreover, can only be applied to one of the barrels of a double; if applied to both, one barrel will go off by the jar of discharging the other. This will also sometimes occur with rifles,

* Corresponding to 12 in breech-loaders.

† Corresponding to 16 in breech-loaders.

Note.—At this rate a 10 inch cannon, to be equally accurate *at the same distances*, would require to be rifled at the rate of a turn in about 600 *yards*.

although not furnished with these arrangements; and, in particular, the right barrel will sometimes go off on firing the left, although the left is not affected by firing the right. This is owing to the fact, that the actual *hold* between the scear and the tumbler* is stronger in the left than in the right lock; although, owing to the greater leverage of the longer left trigger, they both *pull* equal. This is a very bad fault in a rifle, as you may want to fire the left first, both being on full cock, and then, where would you be in case of a charge relying upon your empty second barrel? It is, moreover, entirely the fault of the maker, for by giving both triggers sufficient leverage, perfect safety in both barrels can be secured, retaining at the same time a sufficiently light pull. It is to be noted, that many rifles will act properly, in this respect, when loaded with the ordinary charge, which, when overcharged, will show the defect; but as rifles must be heavily charged for extraordinary game, makers should not "draw it so fine" as this. Another defect in gun-locks which I have observed in India is, that the "detant"† often gets clogged with oil or dust, and works irregularly, the consequence being that the scear fails to fall quite into the notch at full cock, and the barrel may perform that act of which guns are so often falsely accused, viz, "go off of itself."

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* Tumbler: the part of the lock works in which the notches for half and full cock are cut. Scear: the lever that works in the notches of the tumbler.

† Detant: the little triangular bit of steel that works on the face of the tumbler, found only in rifle locks. It acts by facilitating the passage of the scear over the half-bent notch when the hammer is falling, so that a very light "pull" may be used without danger of catching at half cock.

That this is the true cause when this does occur, I have proved in several instances, both in my own rifles and others brought to me to be "doctored," by taking out the "detant," which immediately corrected the fault. For this reason, I do not think detants desirable for India, although they can easily be taken out if found not to work well. Good shooting is impossible unless all your guns pull the same. Instruments are sold by gunmakers for testing the pull of a trigger. If one of these is not available, weights may be suspended from the centre of the right trigger, the rifle being held in full cock in a vertical position. The number of pounds and ounces required to set it off is the "pull."

206. Locks are often made now-a-days with the scear working on one of the screws that fasten the "bridle" to the lock-plate, instead of on a separate one. Although neatness is thus gained, such locks are much more inconvenient to the sportsman. In such a lock, in order to get at the tumbler, the scear must be taken out, and without skill and proper tools is very difficult to put in again, so that the scear spring is often broken by amateurs in the attempt. For this reason all rifle or gun-locks for foreign sport should, I think, be made with the scear working on a separate screw of its own; which it is not necessary to remove to take off the tumbler, &c., for cleaning.

207. Lockfast and many other breech-loading rifles are made with "back action" locks, in which there is no disadvantage, that I can see.

208. The Sights.—These are of the utmost importance, and ought to be regulated by the maker with the charge you intend to use in the field. The point-sight

should present a beaded appearance to the eye, but should be lengthened out in the line of the barrels for the sake of strength till about half-an-inch long. It is set on a plate, which again is fixed in a cut in the rib. This cut should be made lengthways—not across the rib—as the sight is then less likely to get displaced. The point-blank * aim is taken with this sight brought down flush with the rib or centre plate of the barrels. This will give a slight elevation, varying with the build of the piece. It should not give more than will cause the ball to rise 1 inch above the line of aim. Now this 1 inch of elevation will carry the ball to different distances in different rifles, and this is the test of a good sporting rifle in the matter of elevation. I like a standing hind-sight, *slightly* notched in the centre, giving no additional elevation, but only defining the centre of the rib more accurately; this is a pure matter of taste, however, and all the sights may be made to fold flush, if preferred. The first folding sight will be for 100 yards, the next for 150, and the third 200. You may have any number you please beyond this, but extra sights are neither useful nor desirable in the sporting rifle; indeed, I am of opinion that most people would make better shooting at game were they debarred the use of sights altogether, except one low one to be used at all distances, the eye being raised off the breech end as the distance increases. For running shots the latter is the only plan; no good shooting will ever be made by raising hind sights at running game. The notches of the elevated hind sights should be a very clear cut V, deep or not, according

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* Point blank will be afterwards explained.

to taste, with a fine line of platinum or gold, inlaid from the centre of the notch to the hinge. I am not sure that for the folding sights the notch might not be altogether dispensed with. In deliberate firing the gold line defines the centre, and a perfectly horizontal back-sight conduces to clearness.

209. It would be a great improvement if gunmakers were to engrave somewhere on the rifle the charge and ball with which its sights were regulated; as flasks are often lost, the gun falls into other hands, and great difficulty is experienced in discovering the charge, and determining which of the several bullet-moulds found in the case is meant to be used. Finally, with regard to sights, *avoid complication;* for target-peppering complicated sights are necessary, but for game-killing they cannot be too simple, and those you have, *learn thoroughly to use.*

210. The Stock should be of the best heart-walnut, and unpolished; elbow-grease and boiled linseed oil will give a better and more lasting polish than any other method, and, if constantly applied, will tend much to preserve the stock, particularly in hot climates. I have seen some Indian sportsmen who, with a view to preserving their gunstocks from injury, covered them with leather. This is a great mistake: on removing the leather, the ironwork will generally be found a mass of rust, and even the wood gets dry and brittle. I like what is called a "pistol-grip." If ordering from a distance, you must give the length and bend that suits you: use the longest and straightest stocks you can manage; a straight stock is a great thing for running shots. The method of measuring is as follows:—Take

off the locks and sights; lay the rifle, triggers upwards, on a table; measure the perpendicular distance between the point of the swell on the cheek-piece just behind the grip and the table, and between the extreme end of the stock and the table. These measurements give the *bend* of the stock. For the length, measure the distance from the right trigger on half-cock to the centre of the edge of the heel-plate. I think, if the sportsman can manage it, all "throwing off" of the stock sideways is to be avoided. By "throwing off" is understood a horizontal bend given to the stock, so as to bring the barrels more nearly opposite the eye when the stock is held to the shoulder. It no doubt occasions an irregular swerve in the recoil, but it is found necessary with short-necked, broad-shouldered personages, to enable them to get their eye over to the breech. For people who shoot from the right shoulder the stock is bent to the right, and *vice versâ*. A gun made especially for a person who shoots with the *left* eye from the *right* shoulder—and such there are—is a curiosity in the matter of "throwing off."

211. I do not approve of "safety" dodges; if you cannot trust yourself with a gun as commonly made, you had better give up shooting altogether. They are all liable to go out of order, just when most wanted.

212. A patch-box in the butt is a great convenience if you use loose patches, but it is far better to have your balls ready patched before taking the field. Of course it is not required with a breech-loader.

213. A list of GUN APPARATUS was given in paragraph 194, and from this you will be able to select what you require. The fewer fittings you have in addition

to the bare rifle the cheaper you will get it, of course. I strongly recommend you to have your bullet moulds marked with your initials. If you keep that end down in loading, you will almost always be able to recognize your own bullet, in case of a dispute. With a muzzle-loader, I recommend your getting, in addition to the ordinary powder-flask, a small compact one, fitted with a swivel ring and strap. In India, particularly, one cannot carry many rounds of ammunition, but it is necessary to have a few charges in case of emergency. Strange to say it is almost impossible to get such powder-flasks ready-made in England. If small enough to carry, they are sure to have a charger only large enough for a pistol. They must, therefore, be made to order; a state of affairs which it is to be hoped will not last very long. With a breech-loader many of the articles are dispensed with altogether, and all you require is a cleaning rod, bullet mould, powder measure, and apparatus for turning down the ends of the cartridge cases, and for recapping them in case the caps get injured. The cases *may* be used twice, or even three times over, until they split; but I do not recommend their use *in a rifle* more than once. The best machine for choking the cases is Bartram's patent; its cost is 1*l.* Recapping instruments cost 7*s.* 6*d.*; best cartridge cases (empty) cost 50*s.* a thousand, and none but the best should be used. Have them put up in soldered tin cases of 250 each.

CHAPTER VII.

SOME HINTS ON SPORTING MATTERS, WHEREIN IS DESCRIBED THE CRUCIAL TEST OF A RIFLE.

214. HAVING now procured your double rifle, before you can expect to make your best shooting with it in the field, you must *ascertain its trajectory* and *gain confidence* in its shooting powers. Without the former, good shooting cannot be made; and if you have any suspicion on the latter head, it is equally problematical. For these purposes, a number of screens of thin paper must be prepared. Frames of thin wood (in India, split bamboos) 2½ ft. square answer well. Thin paper (newspapers will do) is then pasted over them, and the whole of them, except the one that is to be at the extreme end of the range, must then be cut across with a sharp knife at about 6 in. from the bottom stick, and the lower portions of the paper removed. Across the centre of the uncut one, draw a horizontal black line about 1 in. broad, and at right angles to its centre, another of the same width, thus forming the figure of a cross.

215. You must also devise a rest, one from which you can shoot steadily, which a very little ingenuity will effect with materials at hand. It must offer a steady

support to a sandbag on which should rest the rifle, also a seat for the shooter, and a rest for his elbows. A strong solid table, with an armless chair securely lashed backwards against it, is a good substitute for the regular "table-rest" used by gunmakers. You sit a-straddle on the chair, leaning over its back on the table whereon rests the sandbag.

216. Select, now, a level piece of ground 150 yards long, and at the end of it plant two poles, and suspend thereon your cruciform target, making one of the lines accurately vertical with a plomb; set up your rest at 20 yards, and fire both barrels at the intersection of the black lines, aiming along the line of metal on the plate between the barrels. The result will be different with different rifles, according to the amount of elevation given by the inclination of the plate to the axes of the barrels. If the rifle has been properly constructed, the balls should have struck on the upper half of the horizontal black line if your aim was correct; and to make sure of this, five or six pairs of shots should be fired at this distance. Perhaps you will find that the balls strike 1, 2, 3, or more inches *above* the line, which shows that the rifle has been improperly made, and that it possesses no true point-blank range. Remove, now, your rest 10 yards farther back, *i. e.*, to 30 yards' distance, and repeat the same experiment. If the rifle is properly constructed, the balls will now break the upper edge of the line, and those which rose 1 inch will be ½ an inch or so higher than before. Do the same at 40, 50, and 60 yards, and you will find that, at one of these distances, your well-made rifle will have risen an inch above the centre of the line. Continue removing

farther off, and you will find that it will begin again to droop towards the line, will again be on it, and will shortly after fall an inch below it. When you find this, stop; for you have reached the extreme point-blank range; for I define the point-blank of the sporting rifle to be, *that distance up to which a shot may be taken at any object without allowing anything for the rise or fall of the projectile.* A rise or fall of 1 inch will not require any allowance to be made even in the finest shooting that ever occurs in actual sport; therefore, this amount of rise and fall will regulate the length of the point-blank range. *A straight line* you cannot have, until the existing laws of nature are upset; we, therefore, must be content with *the next thing to it.* Now, all sporting rifles should be constructed so as to give a point-blank range with this amount of rise and fall, by aiming along the rib; but all are not so constructed, very few are; and, consequently, with very few can very fine shooting be made at very short distances. If you have been shooting with a rifle that requires, and has, a great deal of elevation, you will have found that the balls struck at 20 yards, say 3 in. above the line; at 30, 4 in.; at 40, 3 in.; at 50, 1½ in.; and at 60 on the line, which I suppose was intended by its maker to be its point-blank range; now *the vast majority of large-bored rifles of the present day have trajectories resembling this;* and I ask, can any one shoot accurately at small objects (say an animal's brain) with such a weapon? If your rifle has been well made, you will find that its point-blank range will be about 80 or 85 yards; that is, it will be 1 in. above at 50, on the line at 75, and 1 in. below at 85 or so. It is a glorious thing when you can get a point-blank range like this *with a large-bored rifle;* and the only system that will give it is that of the spherical ball. A distinguished sportsman, recently writing on Indian sport, mentions that he had a two-grooved rifle, which threw a belted ball 9 to the lb., with a charge of its bullet-mould full of powder, point-blank, without rising or falling from the muzzle, up to ninety yards. This would indeed be a desirable weapon to have, but I need hardly say that, until the laws of nature are upset, such a thing is physically impossible. Curiously enough I have had an opportunity of shooting with this identical rifle, and satisfying myself that this wonderful point-blank range ascribed to it by its former owner is purely imaginary. Its bullet-mould full of powder is about 2½ drachms, and with that charge I found that in its 100-yard trajectory, its ball rose fully 8 in. above the line of sight. Having now determined the point-blank range of your rifle, that is, the distance up to which you will shoot at game without raising the first folding sight, you must proceed to determine the trajectory, or path of flight described by the ball, up to 100 yards. I pre-suppose that the rifle has been furnished by its maker with a folding sight accurately calculated to throw the ball true on the line at 100 yards.* Set up your cruciform target as before, and at every 25 yards plant two poles, and suspend thereon one of your paper screens, aligning the bottom edge of

* Some makers have a practice that cannot be sufficiently reprehended, of sighting their sporting rifles by aiming at the bottom of the bull's-eye, intending to hit the centre. This, in an 8-in. bull's-eye, makes a difference of 4 in. What is meant to be *hit* should also be aimed at in sighting.

each accurately with the top of the black line. This may be readily done with a surveyor's level, but if such an instrument is not at hand, other methods of assisting the eye will readily occur. The screens at 25, 50, and 75 yards from the rifle must be marked with these numbers respectively. Now, set up your table-rest at 100 yards. The upper limb of the black cross on the target will be obscured by the screens, but a prolongation of the lower limb may be drawn on the nearest screen one-fourth of the thickness, which will have the same effect to the eye. Aim, as before, at the intersection of the cross, with the 100 yards' sight up; and if the ball strikes on the black line, mark a number on the hole made in the target, and the same number on the perforation in each screen. Fire a dozen shots thus, and mark all those that strike the line with a peculiar number, and the same on each screen. When you have 10 or 12 shots all on the line, you may cease firing, and take home your targets. To draw out a diagram of the trajectory of your rifle is now a simple matter: procure a long sheet of paper; draw a horizontal line 100 yards by scale; at 25 yards erect a perpendicular, and finding the average of the heights of all the numbered perforations in the screen No. 25, above the bottom of the paper, lay it off on your perpendicular; do the same at 50 and at 75; and if you draw a curve through the tops of the perpendiculars, meeting the horizontal line at each extremity, it will represent pretty nearly the path of flight, or trajectory, of your rifle. Similarly, by placing the target beyond the 100 yards at 125, and having a screen at 100, you can find how much the ball falls in the next 25 yards. Suppose your rifle is a good one, you find its trajectory to be something as follows which is the trajectory of a 14-gauge rifle I possessed:—

Distance	25	50	75	100	125	yards.
Height above line of sight	1	2½	2⅝	0	—	inches.
Fall below line of sight	—	—	—	—	3	inches.

The point-blank of this rifle is upwards of 80 yards so that in firing up to 125 yards for extreme accuracy you would aim thus—under 80, straight at the mark; 90, raise the 100 yards' sight, and aim an inch low; 100, straight at the mark; 115, 1½ in. high; 125, 3 in. high; beyond this you would use the 150 yards' sight when you had settled its trajectory, which you would do in the same manner as before, but you would only set up screens at 125 and 150, placing the target at 175. You would probably find that, at 125, the height above the line of sight was about 4 in., on the line at 150, and about 5 in. below it at 175; and in shooting you must aim accordingly; that is, at 135, aim about 2 in. low; at 150, hold straight; 165, 2 in. high; and 175, 5 in high. Beyond this, you must proceed in the same way but the difficulties increase in an enormous ratio as the distance gets longer. It is evident that, *with such a rifle*, the allowances to be made are very small, and in ordinary shooting, for instance, firing at the shoulder of a deer, may be altogether disregarded. Not so with the vast majority of large-bored rifles now made. Some of them require the allowances to be made in *feet*, not in *inches*, and consequently, if they are disregarded, no good shooting can be made. With the former rifle practically all shots up to 80 yards in fine shooting, and in game shooting, all up to 100, would be fired point blank, and if sights are raised, all from 80 to 125, wit the 100 yards' sight; and from 125 to 175 with the 150 sight, no other allowances being required. With the style of rifle so commonly used, if this be done, you will just as often miss as hit; and as there is no time for calculations in the jungle, such is in fact the case.

217. I have hitherto supposed your rifle to have been furnished with folding sights for 100, 150 yards, &c., accurately regulated with the proper charge of powder by the gunmaker. This is, however, most frequently not the case. It is only in the most expensive rifles that the sights are properly regulated. You will frequently find that rifles are fitted with a standing hind sight, regulated for 100 yards with an absurdly small charge of powder; and with this charge and sight the weapon will throw many inches, or perhaps feet, above the line of aim at 50 yards. This must be altered, or you will never be able to make any decent shooting with it. Often a gunsmith is not available for this purpose, and a few directions how to do so will therefore not be out of place. First, you will ascertain the largest charge your rifle will bear without stripping or too violent recoil. If you use a conical projectile you will know that so long as the holes cut in the target are perfectly round, they do not strip. If you use a sphere, regularity of shooting is the test, or you can mark the point placed next the powder, and by digging out the balls discover whether they have struck with this point to the rear; if so, the balls must have followed the grooves. Having ascertained this charge, you will proceed to cut down the hind sight with a fine file (obtainable at a gunsmith's shop), till you find the rifle shoot at the proper height at 50 yards, and by proceed-

ing as before with the screens, you can discover tl rifle's point-blank range. The other sights must nc be regulated for 100, 150 yards, &c., in the same wa and finally, the bright file marks obliterated by heatiı the sight-piece over a charcoal fire till it shows t proper blueish-grey tint, and then quenching it in grea§ You will probably make but a rough job of this, aı should take the first opportunity of having a new set sights put in at a gunmaker's shop. Possibly your ri may be so constructed that the mere taper of the barr and rib, without raised sights, gives too much elevati for the proper charge. In this case the only cure is fit in a new point sight with a longer stalk.

218. In ascertaining the trajectories of your rifle, y will also, probably, have remarked whether either bar or both threw regularly to the right or left of the verti limb of the cross. If both barrels do so in the sa degree, they can be made to shoot straight by driv the hind sight in the opposite direction. If you h any suspicion, however, that the barrels do not sh *parallel,* a number of shots must be fired at 100 yaı taking particular care that your aim is true on vertical line, and firing only one barrel till the amo of its error is determined. You must be very care to load, each time, with the exact charge for whicl was regulated by the maker, and also to hold the ı perfectly square in firing. If all the shots from l barrels strike on the vertical line, you may congratu yourself on the possession of an exceptionally g double rifle; but very, very few even expensive r will stand this test, and second-rate ones hardly e In the vast majority of rifles, either one barrel

shoot true, and the other to one side; or, what is more probable, both will err from the true line in opposite directions. This error may be of two sorts; the balls may *cross;* that is, the right shoot to the left, and the left to the right; or they may diverge, that is, each shoot to its own side. The amount of error will vary. I lately tried a rifle by a provincial maker (whose name I am strongly tempted to give, but refrain), the error of which was 10 *in. at* 100 *yards!* but the usual error is 3 or 4 in. with each barrel at that distance—an amount I have seen in a rifle that cost upwards of 70*l.*, by one of the best London makers. Another defect I have seen, in very badly made doubles, is both barrels not shooting at the same height with the same elevation. If you ever meet with such a piece, smash it—or sell it to a friend! When you have discovered that your rifle possesses an horizontal error, I strongly recommend one of the barrels being made to shoot true, which you can then use for long shots, reserving the other for close quarters, where it will not so much matter. To do this, you must shift the hind sight to one side or other. Suppose the barrels cross each other 3 in. at 100 yards, and you wish to make the right shoot true, you must shift the hind sight more to the right until you find it answer. The easiest way to do this, without scratching the barrels, is to apply the edge of a silver or copper coin to the edge of the sight, and tap it with a light hammer. Sometimes the sight plate is fastened to the rib with a screw, in which case you must first draw the screw. By thus correcting the right barrel of your rifle, you will find that you have doubled the error of the left; that is, if it formerly shot only 3 in. to the right, it will now diverge 6 in. to the same side. This is, however, better than being unable to depend on either barrel of your rifle.

219. Having settled all these points, that is, having come to an understanding with your rifle, you will find your shooting at game very much improved. You must, however, always use the same charge of powder in the field which you used in your experiments. This should be the largest charge the rifle will bear without stripping or violent recoil. It used to be a prevalent idea that, by increasing the charge of powder, no increase of velocity or power was obtained. It is true that every increase of powder does not give a *proportionate* increase of velocity, but up to the extent the barrel will burn, it will in *some* degree increase the velocity: ordinary barrels will burn a great deal more powder than it is ever advisable to use; and, practically speaking, there is *no* additional charge which will not give additional power. The true state of the case seems to be that, by increasing the charge of powder, you increase the velocity in the proportion of the square roots of the charges. But the penetrations into ordinary substances are as the squares of the velocities; you therefore obtain increased *penetration* in proportion to the charge you use, provided that the shape of the bullet remains unaltered.

220. It will be observed that I am an advocate for large charges in all sorts of shooting. The charges for the 16-gauges, given farther on, are much larger than are necessary for any sort of deer shooting; for I have driven the ball of that gauge through both shoulders of a Sambur stag, at 250 yards, with only 2½ drachms.

It may be fancied that a lighter charge may be used for deer, and the heavy one only for tigers, &c. This is a mistake; for, besides the advantages of the larger charge in the matter of elevation, it must be remembered that all deer shooting in India can only be considered as the means to an end—that end being to perfect yourself in the art of shooting animals in all positions, in order that you may safely encounter the ferocious beasts of prey; for you cannot have the requisite practice on *them*. But you will never gain this accuracy of shooting if you alter your charges; for when you have perfected your shooting with the small charge at deer, &c., you will find yourself all abroad when you come to use the larger charge at tigers and bears. The minimum charges for spherical-ball rifles of different gauges were given in paragraph 204. They may be increased indefinitely almost, with increase of power, provided the weight of the rifle rises in proportion, and the following circumstance be attended to.

221. I have stated above, that the penetration will increase in proportion to the charge, *provided that the shape of the bullet remains unaltered*. It has been found in practice that certain bodies, such as water and hard earth, are more penetrable with lower velocities than with extremely high ones; this is owing to the form of the bullet being more rapidly destroyed by the reaction of the object struck, the atoms of which have not time, as it were, to get out of the way of a projectile striking with a very high velocity. This effect is to some extent perceptible also in firing at the bodies of animals. A bullet travelling at a certain velocity will always have the same *vis viva*, or *amount of work*, in it, and this must

all be expended *on something* before it can stop. If it is so soft as to be quickly flattened out, its *vis viva* is expended in driving a larger surface for a shorter distance into the object struck; if, however, it is so hard as not to lose its shape, the same amount of work is done by driving a smaller surface for a greater depth into the object. We have thus the power of adjusting the nature of the work to be done by the amount of *vis viva* at our command, so as to suit the purpose we wish to attain. The object in firing at an animal is generally to drive the ball through and through him in any direction it may strike, and no more. All that the bullet does after going through is power wasted. If, then, the animal is comparatively small, we shall gain if we use a soft ball, which will still go through, but in doing so will get flattened out, and so make a wider hole. If, again, we are firing at large animals, and require the utmost possible penetration, we must use a hard ball, which will not lose its shape, and be content with a somewhat smaller hole. By thus using harder or softer projectiles, we can attain any amount of penetration while retaining the use—so essential to good shooting—of the same charge of powder. Many substances may be used to harden lead; such as zinc, antimony, tin, and mercury. The three first, however, have the defect of making the ball lighter than lead, while the last, although increasing the weight, renders it brittle. The best alloy for hard balls, I have found to be the following—

Lead, 89 parts by weight.
Tin, 1 part by weight.
Mercury, 10 parts by weight.

This makes a very hard ball, not brittle, and heavier than pure lead. In making bullets of this composition, the lead and tin should be melted together in small quantities; and the moment they melt, the mercury dropped in and stirred, and the casting done as rapidly as possible. The reason is, that lead melts at 594 deg., and mercury evaporates at 660 deg.; so that if the heat gets above the latter point, the mercury flies off in vapour. I should here observe that my experience in this matter differs from that of a very high authority—Mr. Baker, of Ceylon renown. He maintains that a plain leaden ball gives superior penetration to one formed of any alloy. I can only say that I believe he is entirely singular in this opinion. I have myself driven a ball formed of the above alloy *longways* through a wild buffalo, when similar leaden balls, fired from the same rifle with the same charge, had failed to go through buffaloes standing broadside on. All sportsmen are, I think, of one mind on this point, except Mr. Baker.* If hard balls are used in breech-loaders, they must either be coated with lead, or made so small as not to be cut by the grooves, and used with a thick patch sown round them. When hard balls are to be used, then an extra mould, to cast smaller balls, should be procured with the rifle.

222. What constitutes an efficient sporting "battery" for India is a question answered by every one in his own way. Many have said their say, and in my own book I think I am entitled to say mine. I presuppose my reader to be, like myself, a man of average strength, and intending to follow every branch of sport with gun

* I notice that Mr. Baker, in his Nile book, after his African experience, has changed his opinion on this point.

and rifle that may come in his way. Under these circumstances he will find, or I am very much mistaken, the following as complete a battery for general purposes as he could well get:—

1. A double-barrelled, breech-loading, spherical ball rifle—16-gauge,* 26 in. barrels, 9 lbs. weight, charge 3½ to 4 drachms.

2. A double breech-loading, smooth-bored gun—16-gauge, 7 lbs. weight, to be used with shot or ball; charge for the latter, same as the rifle.

3. Double-barrelled, muzzle-loading shell rifle—12-gauge, 24 in. barrels, 11 or 12 lbs. weight, charge, 4 to 5 drachms; to be used also with steel-lined tubular projectiles, and 5 drachms.

If you choose to go to 11 lbs. in the breech-loading rifle, you may have it a 12-gauge, and the gun the same; and if you do not object to 13 or 14 lbs. in the shell rifle, it may be a 10 or 8 gauge, with advantage.

223. Special purposes will, however, necessitate changes in, or additions to, the above battery. For purely large game, such as elephants, bison, buffalo, &c. —ponderous animals, which require unusual power in the rifle—a pair of breech-loading spherical ball rifles, 12, 10, or 8 gauge, weighing about 11, 12, or 13 lbs. respectively (or more), should be used; † while for wild antelope and bustard shooting, or for some sorts of hill shooting, where a long, accurate range is required, a mechanically fitting muzzle-loading double rifle, 30 to 40 gauge, 30

* In breech-loaders, 16-gauge corresponds nearly to 14 in muzzle-loaders.

† The tables given in paras. 156 and 204 will enable a choice to be made for all purposes.

to 32 in. barrels, 8 to 9 lbs. weight, as described in paragraph 121, may be found a useful addition. But for all ordinary purposes, the three weapons above mentioned will be found sufficient.

224. All the muzzle-loaders should take the same caps and the same nipples, and the breech-loaders the same cartridges, and all the screws, &c., should be fitted for one set of implements. They should all have leather slings. Cases are rather in the way than otherwise; a strong leather blanket-lined cover being all that is necessary for each. A separate box carries all the moulds, cleaning implements, and ammunition, and goes on one side of a mule, in the howdah, or anywhere.

225. When after game, you carry No. 1 yourself, or if tired, No. 2, and the others are carried by your gun-bearers. If you have a particularly long-legged guide, who is taking the wind out of you, weight him with No. 3 and your bag of bullets; if this won't do, pretend to fasten your shoe or gaiter, and give him No. 1 to hold, forgetting to take it back again when you start! By the above arrangement of your battery you have but two sorts of ammunition to carry, so different that a mistake is impossible. Of course, in a hot climate you do not carry much yourself; only a few cartridges, one or two bullets, in case of emergencies, a few caps, and a small pistol powder-flask, with a ring and swivel to sling round your shoulder by a strap; it rests in a side pocket, and neither flops about nor can it be lost. There is a sort of belt, made with loops of elastic, for holding breech-loading cartridges, and which is, I think, the best way of carrying a large supply. They may, however, be safely carried loose in the pocket.

226. The best powder for India is, I think, for short rifles, Hall's No. 2, and for long barrels, Curtis's and Harvey's No. 6. The latter should always be used in breech-loaders. I strongly recommend that gunpowder be procured direct from England, as it is not to be got good in India. There is no secret in keeping rifles clean; constant inspection is all that is wanted. Breech-loaders require nothing but an oiled rag to clean them; but muzzle-loaders want plenty of cold, followed by hot, water, passed through them before oiling. Refined tiger's-fat, or bear's-grease, is excellent for rifles during the monsoon in India; these substances should therefore be preserved. To the locks none but the finest chronometer oil should ever be applied. In India, where everything gets spoilt by the damp during the monsoons, cartridge cases for breech-loaders should be kept in well-soldered tin boxes; indeed, it is well, when ordering supplies of cartridges, to get them ready packed thus in boxes of 250 each. Breech-loading cartridge-cases should not be kept loaded long before using, as powder in small quantities deteriorates very rapidly.

227. I have been asked, since the publication of the first edition of this book, why I had not touched on the use of the rifle in the field, as well as on its principles of construction. The reason was because, although, regarding the latter,

I have perhaps some shallow spirit of judgment,

I do not pretend to be a better shot than my neighbours; still perhaps, for young sportsmen who have never handled the rifle, a few remarks on this subject, gleaned from the experience of some ten years' continual rifle-shooting at game, may be useful. Simple as it may seem for a good target shot to bring his skill to bear on game, there are few accomplishments more difficult than really good rifle shooting at running animals. Although India holds some as good rifle-shots at game as are to be found in the world, yet I am bound to say that but a very small percentage of the men who use the rifle there are good shots. Much of this arises from their using rifles with which it is next to impossible to shoot well; but in some measure it is to be attributed, I fancy, to want of early practice in shooting. Next to the possession of a proper rifle, and acquaintance with its use at the target, the great essential to good game-shooting lies in obtaining a sufficient command of nerve to shoot as calmly at game as at a mark. This, indeed, applies to almost all games of skill, cricket, rackets, billiards, &c. The first thing is to see your mark clearly and calmly, which is never done until the excitability which seems to attend on every effort of skill has been overcome. With some men, this is constitutionally more easy of accomplishment than with others; such men are of a phlegmatic temperament, a quality which, although much facilitating the acquirement of a certain degree of skill, seems to be incompatible with *first-rateness* (to coin a word) in anything. Indeed I am certain that, in shooting, a man who has never known what it is to be overcome with excitement will never make a first-rate shot. Such men pot antelope on the plain, without fail, from the beginning; but never learn to turn over in style the spotted deer going his best through long grass. Practice, then, and self-control, are the things pre-eminently required to form a good shot. The art of shooting running animals from an elephant requires the *acme* of skill, only to be acquired by great practice.

228. As a rule the place to hit all animals is through the shoulder; the lungs or heart are thus penetrated, and, besides, the bones of the shoulder may be broken, and escape prevented. Half way up from the bottom of the chest, in the line of the leg, is the spot to aim at. To this rule there are, of course, numerous exceptions. If an animal shows a full front, the root of the neck is the place; if very close, the brain may be aimed at, but it is necessary, before attempting this, to learn its exact position. In most animals it lies much farther back than is generally supposed, so far indeed that the traditional shot "between the eyes" will very rarely kill. In the buffalo and bison tribe, the aim at the shoulder should be taken lower down than the centre, about a third from the bottom of the girth; but unless you are shooting with a very powerful rifle, it is well with these animals to fire rather behind than at the shoulder; the ribs are then the only obstacle to the ball reaching the vitals. The neck is a very deadly shot with most animals, but much practice is wanted to accomplish this shot with any regularity; with tigers I always fire at the centre of the shoulder, and last year hit six out of seven in that place, dropping five of them on the spot, with plain round bullets from a Dougall lockfast rifle at distances from 100 to 150 yards. The Asiatic elephant is always shot in the head; but this shot is rarely successful with the African variety.

229. What amount of success constitutes really good shooting, is doubtful. There are fabulous men, heard of, but never seen, who never miss; and there

are also men, often seen, but rarely heard of (from themselves), who never hit. Baker says, if I remember right, that a good shot should be able to bag, *without fail,* everything fired at standing at seventy yards, or running at fifty. I have never met a man yet, who could bag, *without fail,* all animals at any distance. I think myself that if one fires at all fair standing shots within 150 yards, and running within 100 yards, he should kill two out of three in the former case, and one-half in the latter.

230. But even this degree of skill will never be attained without having a rifle with high velocity, so as to obviate the necessity for thinking of elevation, and reduce to a minimum the allowance to be made in crossing shots. Such a rifle it has been the object of this book to describe; and in the hope that I have succeeded, I shall now say good-by for the present to my readers.

"THE END"

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