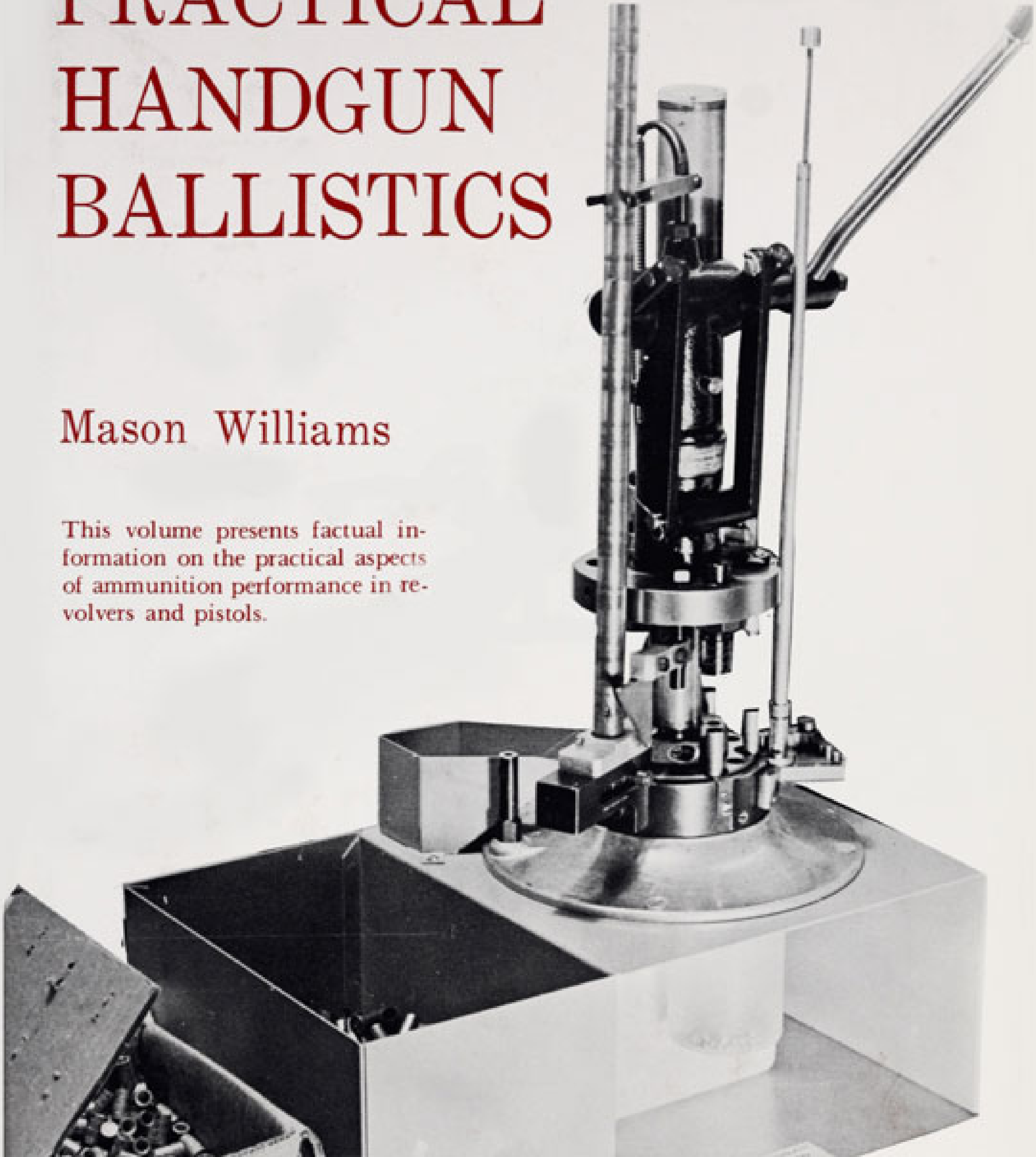
PRACTICAL HANDGUN BALLISTICS

Mason Williams

This volume presents factual information on the practical aspects of ammunition performance in revolvers and pistols.



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HANDGUN BALLISTICS

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By

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INTRODUCTION

MANY thousands of years ago somewhere on earth, a man stalked a succulent lizard sunning himself on a rock. The man held a small, rounded, worn stone in his right hand. Abruptly, he moved and brought the stone down onto the top of the lizard's head, crushing it.

Somewhere else, another man had lain in wait for hours. Now, the single line of deerlike creatures moved below the rock ledge. With sweat pouring down his body from the strain, the man slowly raised the large rock above his head and flung it down upon the deer creature, breaking its back. Other men leapt out from hiding places, their sharpened sticks readied for the death blow.

Somewhere else, another man studied the rocks at his feet and then bent down to pick up a smooth, round stone that fit his hand. His large eyes moved to the small, four-legged creature that crouched, ready to move at the slightest motion, about fifteen feet away. Slowly, the man drew back his arm and then, with tremendous force, flung the stone at the animal, killing it instantly.

Note that each incident required an evaluation of the situation, — ballistics. Throughout the ages, ballistics have played a very important part in the evolution of civilization. No matter how terrible the weapon of war, it still had to be moved in some manner from the sender to the target, whether it was the horrible Greek fire, the Khan's war elephants, or projectiles in all their varied shapes and types. Remember that spears, arrows, stones, clubs had to be delivered.

In each and every case, someone had to figure out just how the projectile could be delivered to the target. In earliest days, this proved relatively simple. Then came gunpowder and the study of ballistics as we know it today. Firearms in all their phases changed warfare and created problems that we continue to try to solve. The man knew he could fling the stone or hurl the rock only so far. Today, we demand results from ammunition and handguns that are unrealistic.

The study of ballistics is the study of the projectile in three places: within the handgun, in the air, and from the moment it strikes the target to the time it comes to rest. We cannot intelligently understand, or attempt to evaluate, a projectile until we have carefully examined to what the projectile has been subjected. It is one thing to pick up a spent bullet, look at it, state that it is a .38 Special, 158 grain, jacketed, probably hollow-point, soft-nose bullet and that it expanded to about caliber .65. This is fine, but a ballistician might scrutinize the same bullet and comment that if it had been fired from a revolver at the estimated distance, it could never have expanded to .65 caliber or be in the condition that it now is. In other words, something is not quite right. This is one of the problems encountered in ballistics: there are so few constants that it is nearly impossible to make many specific statements. Conditions that are right at eleven feet are all wrong at sixty feet. Distances vary, barrel lengths may run from one and one-half inches up to eight or nine inches. Tolerances within identical handguns can affect bullet performance, to a point. The condition (both mental and physical) of the target often controls whether it drops or continues to move. A load and a handgun that perform flawlessly month after month at fifteen yards may fail completely the next day due to basic alterations in the composition and make-up of the target, all other details remaining the same.

This is why handgun and ammunition manufacturers are continually carrying out evaluations and experiments in an attempt to "discover" the ideal load for law enforcement and for hunting. Actually the hunter has the better deal, because his targets usually fall within prescribed sizes and weights. He can stalk, choose his time and place, and fire when prepared. The police officer must take what he finds and do the best with what he has under conditions usually controlled by the criminal.

While it is true that ballistics is the study of the projectile, there are many other factors that must also be considered. If we could place the cartridge by itself, isolated from people and mechanical things, ballistics would be a true study of the projectile. Unfortunately, we cannot toss the cartridge into the air, cry "fire," and have it ignite and propel the bullet to the target. The cartridge must be enclosed so the propellants and pressures can be retained to exert all their forces upon the base of the bullet. The bullet must then be so located that it will be guided at an ever-increasing velocity in the direction of the target. Because of this, we must evaluate and examine everything that goes on within a handgun, not only to ignite the primer but also to start the powder burning. There are many details within the handgun that can affect the bullet, the cartridge case, and the primer.

Similarly, when the bullet leaves the muzzle of the handgun, it enters air to become influenced by an entirely new set of factors, such as wind, distance, and obstructions. When the bullet finally arrives at the target, it must be capable of dealing with the target composition. Many bullets are ideal for punching holes in paper, while others have been constructed to penetrate iron plate. What if the present target is neither paper nor iron plate?

Because of all this, we have interior ballistics, exterior ballistics, and terminal ballistics. Not until we understand these basics can we pick up a bullet, examine it, and make some good guesses. Only by examining thousands of bullets of different design, weights, and construction that have been fired from varying distances into greatly differing targets can we make an educated guess. Not until then can we say this bullet base should be rounded or concave, this bullet nose opened up slightly, the jacket fractured, or the lead composition was made harder with antimony. There are no pat answers in this ballistic business.

I hope this book will open up to many people the fascinating challenges that exist in ballistics. The unimaginative will be bored with the lack of specific answers and explanations, but those with searching, open, questioning minds will discover an entirely new world. It is time that the dull ballistic tables are put into their rightful place, just as a rock fitted into a fireplace. The rock is only a dull item within a huge structure that will, when completed, provide warmth, color, relaxation, and pleasure. The same is true of ballistics when knowledge is based upon tests, evaluations, shooting, handloading, and the whole range of empirical handgun experience. The knowledgeable could then say "this load will not put this bullet through the target at forty feet, but if we increase the powder charge, decrease bullet weight, and move up four feet, this load could be precisely what we are looking for." Being able to cut through hundreds of pages of tables and charts, put together by men with half a dozen degrees but who have never shot a firearm in their lives, would provide law enforcement with long-sought information. Being able to glance at a page of charts and instantly pick out the key problem and explain why — even though these charts are correct — they do not apply to the situation at hand can save money and time.

I am directing this book at the average person in the hope that it will help him to better understand how to evaluate problems and correct them. This book should provide information that will help departments and individuals to select the ammunition, and even handguns, that will do the job far better than existing equipment. We cannot separate the bullet from the ammunition, or the ammunition from the handgun; they are all wrapped up together into one unit. Therefore, we must touch on all angles that relate to ballistics.

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PART III — TERMINAL BALLISTICS

PRACTICAL
HANDGUN BALLISTICS

PART I
Interior Ballistics

Interior ballistics deals with what happens from the time the handgun firing pin strikes the primer metal to the time the projectile leaves the handgun muzzle and enters the air. Many things take place but nothing can change one single fact — the handgun is only a projectile launcher. All the handgun does is guide the bullet to the point of bullet impact. It does not, and cannot, affect or alter what the bullet does at the target.

However, the handgun can have a long barrel or a short barrel, thus slightly increasing or decreasing the expected bullet velocity with resulting change in what the bullet may do at the target. The handgun can have maximum tolerances or minimum tolerances. It can have a tight bore or an oversize bore. While these details can all affect, in some manner, what the bullet does at the target, basically, the handgun remains merely a projectile launcher just as a mortar barrel directs the flight of the mortar shell but has nothing to do with what happens when the mortar shell strikes the target.

Unfortunately, there are few things in ballistics that are always true. We do not have many constants and without constants, we cannot make definite, specific statements. I have talked with attorneys and quite often they become irritated because I answer questions with "yes, that's true providing . . ." or "right, that would work if . . .", and so forth. I have had top police brass pound on pamphlets and books and tell me that such and such is true because "it says so here." My reply is simple — "under those conditions what they tell you is right, but those conditions do not apply in 97 percent of the cases in your city/area". This is the fascination of ballistics. Each situation must be taken as an individual case. Even the handgun tolerances can, at times, affect the results or so influence deductions as to make them questionable. Barrel lengths have often contributed directly to the continued existence or demise of an officer merely by increasing or decreasing bullet velocity.

You should now realize that ballistics is not a cut and dried subject; rather, it becomes an extremely fascinating and challenging one. It is necessary to retain an open mind. Psychology plays a part in ballistics, and it must be correctly evaluated in order to reach logical conclusions. Let me give you a typical example. An officer that I knew had just made sergeant and had bought one of the heavy barrel .38 Special Smith and Wesson revolvers with a four-inch barrel. It was a nice piece. We shot it on my ranges, discussed it, and shot it some more. A couple of weeks later, he became involved in a narcotics raid. Two men attacked him simultaneously. He put both of them down. When he told me about it later, he said "Man, that was a close one. They both came through that door at me and if it hadn't been for that real heavy barrel," he patted the barrel, "they would have gotten me. It sure shoots hard, man, real hard." I let him go through the routine, then asked him where he had hit each man. He pulled out pictures showing the two men lying on the floor with a single bullet hole between their eyes. "Two shots, man," he beamed, "my old light barrel would never have done this." I then broke the news that it wasn't the heavy barrel but his highly trained shooting reflexes that had brought down the two attackers. He still needed convincing, so I set up my chronograph and proved it to him. This is the type of reaction that must be evaluated in order to arrive at the facts of the matter when dealing with ballistics. Barrel weight did not affect what the bullet did at the target.

Chapter 1

THE CARTRIDGE

CARTRIDGE components are an integral part of ballistics. For some reason, they are misunderstood by the average person, so I believe that we can only get into this subject by examining each component. There is no such thing as "the most important component." Leave out one component and you do not have a cartridge. It is true that you can use cheap components but you must have a cartridge of some kind.

First, nomenclature is vital. We do not speak of a bullet and mean a cartridge. We do not mention a cap and refer to a primer. We do not fire a bullet; we do fire a cartridge.

The cartridge consists of a brass case, a primer, powder, and a bullet. It is the cartridge that is inserted into the chamber and fired.

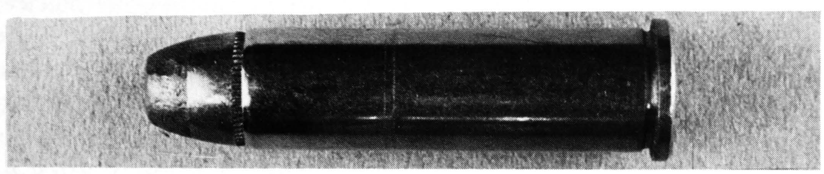

Figure 1-1A. A cartridge.

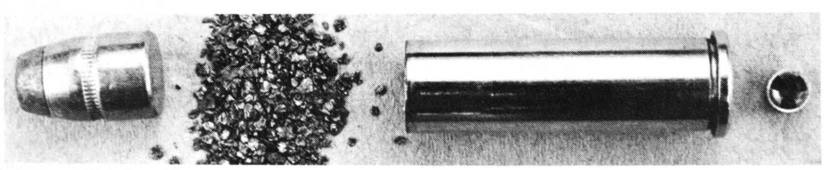

Figure 1-1B. Cartridge components: the bullet, the powder, the cartridge case, and the primer.

THE CARTRIDGE CASE

Once the cartridge has been fired, the fired case remains —

together with the fired primer — in the primer pocket. This is not a shell; it is a cartridge case. This cartridge case with its fired primer may then be removed from the chamber of the gun and either discarded or retained to be reloaded and fired again.

This cartridge case was produced as follows. Strips of sheet brass are run through a machine that punches out discs of predetermined size. These discs are then cleaned and run through a series of machines that cup and draw these discs to the desired length and size. Bases are formed, heads created, primer pockets punched into the case heads, flash holes either drilled or punched. Finally, the case length is checked and trimmed. It is a simple, but very noisy, operation.

There are two basic types of handgun cases: rimmed and rimless. Revolvers require rimmed cases, although Ruger produces a revolver that chambers and ejects the .30 caliber carbine cartridge using springs and cams fitted into the extractor head. Automatic pistol cases have rimless heads. Automatic pistols have been modified to use rimmed .38 Special cartridges, but generally, pistols fire rimless cases.

In the old days, it was far easier to punch out and create the case head and primer pocket by bending the brass to produce balloon head cases. Black powder pressures were low and this proved to be an acceptable and safe method of forming case heads. Today, case heads are solid brass and extremely thick to safely contain the pressures developed by modern handgun cartridge loadings.

Primer pockets come in two *sizes*: large and small. The small pockets take the 0.175 primers and the large pockets the 0.210 primers. You can still find .38 Special cases with large primer pockets. Many .45 ACP cases have undersize primer pockets to take Special primers developed by the government many years ago. The novice should never become upset when he runs into something unusual in the firearms and ballistic field. Just about everything has been tried at one time or another. Strangely, many of these oddball details continue to circulate today.

There are also two *types* of primer pockets. The Berdan primer pockets have a solid nipple jutting up from the bottom of the primer pocket that acts as a built-in anvil; on either side are two small flash holes through which the primer flame passes. The second type is the Boxer primer pocket that has only a single round flash hole in the bottom of the primer pocket.

Functionally, there is little or no difference between the two types. From a reloading point of view, the Berdan type is extremely slow and difficult to work with. The most common is the Boxer and is universally used today throughout the country, although the Berdan remains popular in Europe.

The primer is a small, metal cup created out of specially selected metal to meet the requirements of the average cartridge. This cup is partially filled with a primer compound that, when dry, can ignite and produce a flame. An anvil is inserted within the cup. The anvil is a three-legged cone with the high (top) side touching the primer compound in the base of the cup; the three legs rest on the bottom edges of the open base of the cup. When correctly seated into the primer pocket of the cartridge case, the three legs touch solidly upon the bottom of the primer pocket, presenting a firm base for the primer. Thus, the primer compound remains in position over the top of the cup. Then, when the firing pin strikes the center of the primer cup, it dents the primer cup metal and crushes the primer compound between the cup metal and the top of the anvil; if all has gone well, the primer compound fires, driving a long cone of fire into the inside of the cartridge case.

Each manufacturer has its own primer compound formula so that no two primers from different manufacturers are exactly the same. The force of the flame, its intensity, and its duration vary from manufacturer to manufacturer. There are primers created for small pistol cartridges, large pistol cartridges, small rifle cartridges, large rifle cartridges, and also for shotshells. Each type has its own characteristics. They should never be used for any cartridge for which they were not designed. Primers are literally miniature hand grenades and are extremely dangerous if mishandled or misused.

In recent years, another type of primer has been brought out. This is the Magnum primer designed for use with slow-burning powders in relatively large cartridge cases. It has no relation to Magnum cartridges; Magnum cartridges may be loaded with standard primers. However, the use of Magnum primers in Magnum cartridges is often advisable when slow-burning powders and heavy bullets are also used. Magnum primers have entirely different burning characteristics than standard primers. As Scott Heter of CCI once told me, "Standard primers are like gasoline. Toss in a match and they go blam! Magnum primers are like kerosene, producing a long, soft flame that, instead of shoving around the powder, will softly ignite the powder over a period of time." I have always thought this was an excellent description.

Primer cups are stamped out of strip metal, then the discs are cupped, trimmed, cleaned, and readied for filling. Because handguns have a lighter firing pin fall than rifles or shotguns, the metal used in handgun primers is thinner and softer than that found in rifle primers. Rifle and handgun primer cups come in the same sizes, large and small. Outside dimensions are critical because these cups must fit snugly into primer pockets, yet must not be too large.

The primer compound is a very touchy substance and is usually mixed wet. It is then pressed into the bottom of the primer cup and often covered with a sheet of foil or special paper. The anvil is then set into the cup, the top of the cone faces up, not quite touching the primer compound, and the three legs are firmly locked into the open end of the primer cup.

Primers are simple and yet more time, money, and control are lavished upon them than any other component part. Primers are extremely dangerous and should always be handled with great care. Do not attempt to pry the anvil out of a primer to show it to someone; also, do not scrape out the primer compound. Once this compound dries and is set, it is ready to fire. If it is absolutely necessary to remove the anvil or primer compound for some reason, soak the primer overnight in lubricating oil, then wearing glasses and gloves, use great care in prying the anvil out of the primer cup. There should never be any doubt as to the potentials of any primer.

Use care with powders, but with the exception of black powder, which can detonate for no good reason at the most embarrassing times, one can work with modern day production powders without any great danger — provided they are confined only within the original containers. Years ago, in New York State, I had to build a powder magazine. I had always kept my powders on open shelves; if a fire occurred, the powders would only pop the light containers and burn, there would be no detonations. I was told to place my powders within a heavy metal and wood container, because they "would then be safe." No amount of discussion could convince the authorities that they were ordering me to make a homemade bomb. If, for any reason, my powders had ever gone off within the mass of metal, it would have put to shame a three-inch shell. Powder should be kept within a very flimsy container far from flames, heat, primers, and other potential sources of dangerous materials. An old refrigerator is an excellent storage place for powders because they are protected from heat and flame and yet, if they do let go, they will merely burn and not detonate.

I continue to remain highly amused at the airline personnel who get panicky when they see a few cartridges lying around in my brief case. These are usually confiscated and I am then watched very carefully. I don't know when this attitude started, but it is of long standing. Throw a cartridge all by itself into a fire and it will go POP! A cartridge must be contained before it will fire in the normal manner, which is why there are chambers and recoil plates and breech blocks to securely hold the cartridge.

I once knew a man who would don a pair of asbestos gloves, hold a .38 Special cartridge between his fingers, and then hold a blow torch on the primer. When the primer fired, all that happened was that the bullet fell on the floor eight or ten feet away; the primer usually blew part way out of the primer pocket and his fingers remained unharmed. During the war, I watched men amuse themselves throwing bandoliers of machine gun ammunition into fires. Unless the case is confined, powder gases cannot build up sufficient pressure to produce normal firing specification. True, every now and then a case will rupture and that is why my friend wore asbestos gloves; as for being "dangerous," they are not.

Pour some powder onto a piece of concrete, then touch a match to it. Watch it burn slowly, intensely, and progressively. Never attempt this with black powder; black powder will detonate. Try various types and makes of smokeless powder and watch their burning rates. Learn how to work with powders. Respect them, but do not be afraid of them. If, at any time, you note a light brownish dust appear, or the powder grains seem to be disintegrating, get rid of the powder. It is decomposing and can become erratic in its performance. Normally, modern powders (by Hercules, DuPont, Olin) will last for years if kept in a cool, dry, clean place in their original containers.

We have three basic powders today: disc, ball, and granular. Look-alike powders are not necessarily the same or even close to having the same burning characteristics. A person should not get up on the witness stand and testify that "this is Unique powder because I can tell by the powder grains"; he should have a professional lab analyze the powder.

Handgun powders are a varied and assorted lot with tremendously varying burning rates and powder grain shapes. Rifle and shotgun reloaders will note that many of their powders are also excellent handgun powders for specific purposes. There is no one ideal handgun powder. Both the handloader and the ammunition companies must use the powder that appears to best do the job at hand. Powders are blended at the manufacturing plant so that each lot will perform within prescribed limits. When ammunition companies order powder, they usually develop a load from the specific lot that will do the required job. As an example, they may order a powder that is basically Unique; however, tests show that it is, perhaps, slightly faster burning than canister Unique sold on the market to handloaders. The ammunition company will then conduct its own tests to determine what loading should be used. For this reason, it is impossible to pull bullets from factory ammunition and make any intelligent statement about loading density, type of powder, etc.

THE PRIMER

We must now return to the beginning of the firing sequence.

In order to fire a handgun, somehow the firing pin must be struck by a hammer, or released to fall under its own spring tension to strike and fire the primer. Some mechanisms require the bolt to fall, rammed forward by a heavy spring to force a nipple, machined into the face of the bolt, to hit the primer and fire it. In any event, once the trigger has been moved to the point where it releases a mechanism that must move to actuate the firing pin, stresses and vibrations are instantly set up within the handgun. Remember that the primer has not yet been struck. I have watched these tests in factories. The length of time that it takes for the released hammer or firing pin to commence its fall right on through to the time the firing pin actually ignites the primer is known as lock time. The shorter the lock time, the faster the ignition. In precision handgun and rifle shooting, this lock time can be vitally important.

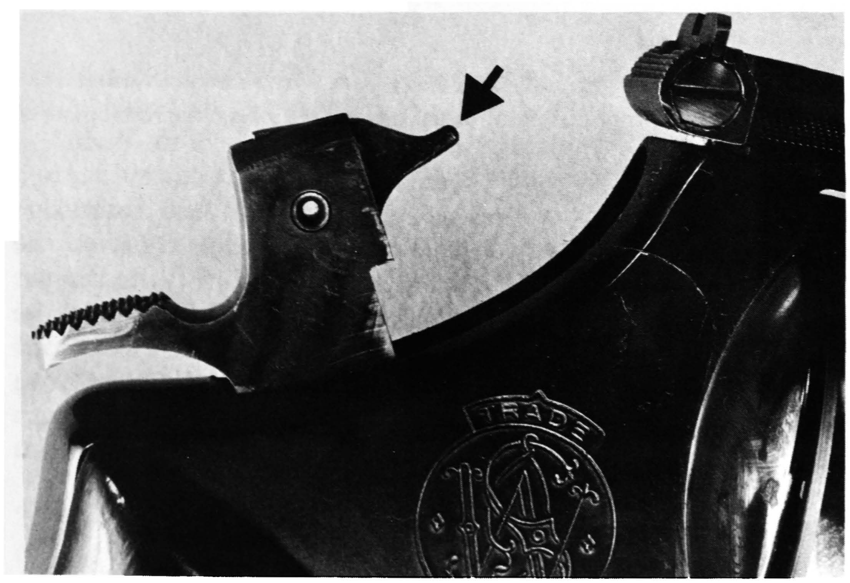

Figure 1-2A. The firing pin point strikes the primer and fires the cartridge. (Smith and Wesson revolver.)

Stresses and vibrations are set up and move throughout the handgun. The moment the firing pin hits the primer, additional stresses and vibrations commence. Few people appreciate

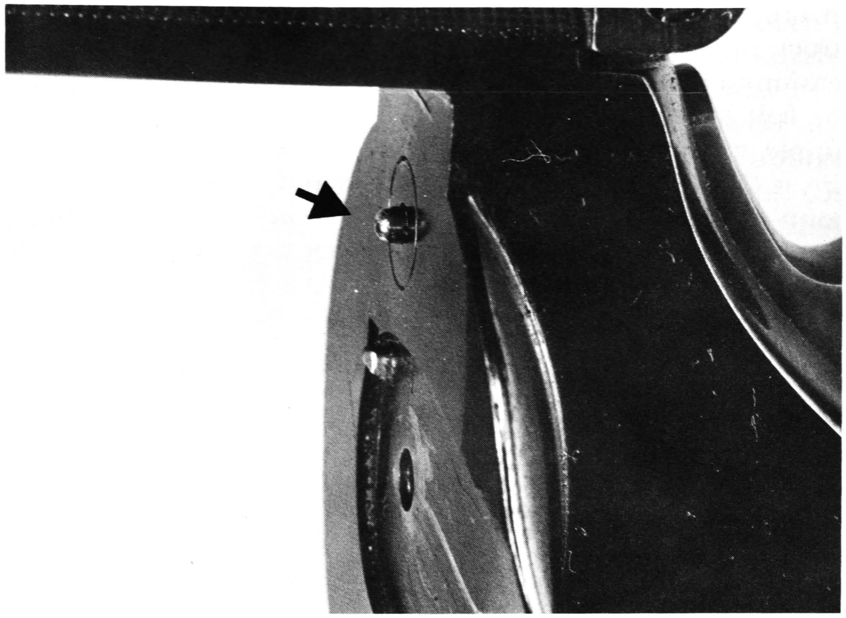

Figure 1-2B. The firing pin point or tip protrudes through the recoil plate of the revolver frame to strike the primer.

the potency of the primer. As a demonstration, load a cartridge case with only a primer — no powder or bullet. Turn off the lights, hold the handgun in front of you, and pull the trigger. Most people are awed by the pyrotechnic display put on by the lowly primer. Don't ever sell the primer short: a box of one hundred large rifle primers, correctly placed and detonated, can do some amazing things.

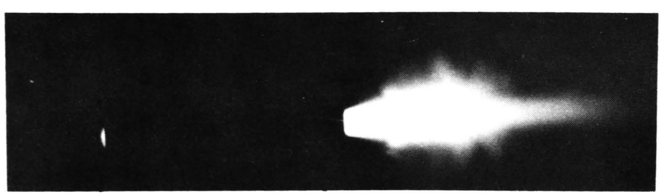

Figure 1-3. A Colt four-inch barrel revolver firing a .357 Magnum primer in an empty cartridge case. The flash is visible (left) in the gap between the front of the cylinder and the rear of the barrel throat. Note the amount and intensity of the flame as it bursts from the muzzle (right).

Most standard primers of the same type will produce similar results so that, by the time the primer flame has passed through the flash hole into the powder chamber, things begin happening, both to the handgun mechanism and to the cartridge. Up to this time, the cartridge has been a stable unit; it now begins to move back within the chamber. The primer itself will tend to move backward and out of the cartridge primer pocket, because it is far lighter in weight than the powder and bullet that lie ahead of it. Pressures on the primer come from in front of the primer, thus the tendency to move back and out of the primer pocket.

Usually, the cartridge case is fairly well filled with powder so that the primer flame is directed upon a mass of powder that will ignite at the rear and, as pressures build up, force the bullet forward out of the case mouth. As more and more powder burns, the space between the rear of the cartridge case and the base of the bullet increases, thus keeping down pressures and maintaining a steady mass of pressure against the bullet base.

This is an excellent place to discuss the 2.7 Bullseye Factor. During the past forty years, I have seen four detonations, three occurring with .38 Special revolvers and one with a .357 Magnum revolver. At the time, and even as recently as early spring of 1977, I chalked them off to carelessness in handloading or abusing the Star Machine. Since 1955, I have also been aware of problems with #4831 rifle powder. This rifle powder is very slow burning and superbly adapted to large capacity cases and heavy bullets. I have personally seen three rifles blown up by this powder

When we evaluate the traditional handgun target loadings of 2.5 to 3.0 grains of Bullseye with a standard small pistol primer, the 146 grain cast wadcutter bullet in the .38 Special cartridge, it appears to be both remarkably safe and superbly accurate. Why then is there any problem with this load and what is the problem? The problem is simply that this loading can detonate. It has only been recently that any attempt to seriously investigate these occurrences has taken place, due to the efforts of Jeff Cooper to obtain as much information about this as possible from all over the country. He did not pass off these detonations as human errors the way I did. The more I think about his comments, the more I believe they have merit. I do not believe that anyone can yet make any specific statements of fact. So far, all is surmise, but it is a situation that should be given thought.

Bullseye powder is a fast-burning powder. As a result, only small amounts are used. The .38 Special case is a black powder case and far too large for efficient powder burning potentials with any but the slowest burning powders. This indicates that under certain conditions, when the handgun is about to be fired, the powder can lie on the bottom of the case. This thin layer covers the bottom of the case from the rear to bullet base. If conditions are just right, when the primer flame passes through the flash hole, it does not directly strike the powder, or mass of powder, but continues through the flash hole to the bullet base *above* the powder; thus spraying the entire powder charge with flame all at one time. There is, therefore, no progressive burning and the powder charge detonates, blowing up the revolver.

There are reasons to believe something like this must take place. When one considers the many billions of Match Target .38 Specials loaded with from 2.5 to 3.0 grains of Bullseye that have been fired in the last forty years, the percentage in favor of a detonation is almost nil — yet, it does happen. It is possible that certain lots of powder lend themselves to a detonation; however, I have watched powders created, manufactured, blended, and mixed and then watched the testing and evaluation of every lot. It is difficult to imagine that the fault lies with the powder, so I am inclined to favor the explanation given above.

As for #4831 powder, let me explain that full charges have never created problems. If a full powder loading requires 71.4 grains of #4831 powder and if charges varying from 65.0 to 73.0 grains are used, there has never been any trouble. Problems arise when a handloader tries to use a reduced charge of perhaps 51.0 grains of #4831; not always, yet frequently enough to indicate that greatly reduced charges can cause detonations. It would appear that these detonations occur for the same reasons as with the .38 Special and .357 Magnum detonations:

powder lying on the bottom of the cartridge case and the primer flame igniting all of it instantly, rather than progressively.

Similar detonations have never, to my knowledge, occurred with any automatic pistol cartridge. This is probably due to the correct relationship between automatic pistol cartridge case dimensions and the powders used in these cases. Pistol cases are considerably smaller than the large black powder cases used for revolver ammunition and are thus far more efficient.

We must now turn to the powder charge and examine what happens when it commences to burn.

THE POWDER

Powders are very individualistic; each has its own very special burning characteristics, which may lend themselves to a wide range of loading potentials or, conversely, to an extremely limited loading potential. Some powders may be used for shotshell, handgun, and rifle cartridges, within limits of course. Others are not at all versatile. Some powders that look precisely like other powders will have greatly differing burning characteristics. Therefore, it is extremely dangerous to attempt to guess what a specific powder may be.

Great care is taken by the powder manufacturers to make certain that each basic powder remains the same, retaining its burning characteristics over a period of many years. Tests are constantly being run so that a constant uniformity exists. Because of this care and control, powders usually perform precisely as expected.

Obviously, fast-burning powders will be used in smaller quantities than slow-burning powders. As an example, assume that Bullseye powder will be used in a .38 Special cartridge. This powder will peak or reach its maximum pressure far faster than a slower burning powder like #2400. When powder burns, it creates heat; the higher the heat, the more erosion will occur in the chamber and barrel. On the other hand, slow-burning powders often cannot be used due to their inability to burn completely behind the selected bullet weight, nor can they always be counted upon to deliver the desired bullet velocities.