The World of Firearms and Ammunition

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Introduction

Ammunition and firearms are broad, diverse, and dynamic topics. New products are regularly introduced to the marketplace; new companies appear on the landscape; and there is constant change. In addition, the uncommon, rarely seen older example comes out of the woodwork, occasionally challenging even the most knowledgeable person in the field so that, in effect, the students of these subjects must look in both directions to where the industry is at the moment and what has already transpired to round off their knowledge. Inevitably, the examiners who claim to have seen it all are taken to task when that which they did not know suddenly appears after they already thought they knew it all.

Ammunition and firearms are academic subjects unto themselves and can be viewed from any number of different viewpoints:

- Historians seeking to understand the implications and uses of firearms and how they affected past events
- Collectors of arms and ammunition seeking to expand their knowledge base about their particular interests and ascertain the value of the artifacts they hold
- Designers, engineers, and gunsmiths seeking to innovate and develop new products or improve an existing one
- Legislative and regulatory entities contemplating legislation or regulation with respect to firearms and ammunition
- Special-interest groups seeking to forward their respective agendas
- Law enforcement and investigative agencies focusing on the criminal aspects of the use of firearms and ammunition
- Marketers and users evaluating the suitability of firearms and ammunition for particular uses or markets: tactical, sporting, or otherwise

Balancing Firearm Safety with Evidence Preservation

The paramount consideration when handling firearms in any situation is safety. The devotion to safety overrides evidentiary and investigative concerns. Of course, the intent is always to avoid disturbing potential evidence, but a certain amount of handling is inevitable to ensure that an accident will not occur. In the case of firearms, the procedures needed to render them safe are, unfortunately, generally in the reverse order of those applied in preparation for safe use. Familiarity with the potential hazards can establish a comfort level that will allow the evidence collector to minimize the impact of safety considerations on the evidentiary value of the firearm.

In general, the rules for handling firearms are as follows:

1. Always treat a firearm as if it were loaded.
2. Always keep the muzzle of the firearm pointed in a safer direction.*
3. Never press or allow anything to contact the trigger unless you are ready to and intent on discharging the firearm.
4. Never point a firearm at anything that you do not intend to destroy or damage.
5. Be sure of what your target is and what lies beyond.
6. Understand the mechanical and operational characteristics of the firearm you are handling.
7. Always ensure that the proper ammunition is used.
8. Ensure that the barrel is clear of obstructions before firing.
9. Never rely on the mechanical safeties of the firearm to prevent it from discharging.
10. Always handle the firearm in a diligent, conscientious manner.

For the law enforcement/investigative professional or firearm examiner, there are additional rules to consider given the context of evidentiary concerns, agency policies, and the particular circumstances under which the contact with the firearm has occurred. When encountering a firearm in an investigative context, the following procedures should be observed, keeping the basic rules of firearms safety in mind:

1. Document the condition of the firearm *in situ*† by way of photographs and field notes.
   a. Does the firearm appear loaded or unloaded?
   b. Note the position of a manually selectable safety device, if the firearm is so equipped.
   c. Note the position of an external hammer, if the firearm is so equipped.
   d. Note the presence of a malfunction.

      Stovepipe: There is a spent casing stuck in the ejection port of a self-loading firearm. A stovepipe can have several root causes. From the perspective of a firearms instructor, the stovepipe indicates that the shooter is not maintaining a proper amount of grip pressure on the firearm to allow it to cycle, such as if the grip is relaxed while shooting or an insufficient amount of grip and wrist strength were applied during shooting, a condition often referred to as "limp wristing." From the perspective of an investigator, the stovepipe condition may be observed in cases of suspected self-inflicted gunshot wounds because the person's grip relaxed when the individual succumbed to the gunshot injury. It is important to note that the presence or absence of a stovepipe condition in such a scenario is not singularly indicative that the injury was self-inflicted, but rather it can be used in consider-

* Fired projectiles can travel through walls and ricochet unexpectedly. An absolutely safe direction may not exist, but a *safer* direction will minimize the risk of injury or damage should an accidental discharge occur.

† A Latin term meaning *literally*, or *in place*. Contextually, the term is used to describe when something is unaltered from its original condition. The term has gained acceptable use in other fields, such as crime scene photography, where the first series of scene photographs can be described as *in situ*.

ation of the totality of circumstances surrounding death or injury when an apparent suicide is being investigated.

Double feed: A combination of live cartridge and spent casing in the chamber that jammed the firearm. As in the case of a stovepipe, the double feed has several root causes, and can be a shooter-induced error, a mechanical malfunction on the part of the firearm, a lack of preventive firearm maintenance, a magazine-related failure, or the result of ammunition with a powder charge below specification.

Misfeed: A live cartridge did not properly load, causing the action to jam. Misfeeds are generally attributed to a firearm-related failure, such as a mechanical malfunction or maintenance issue; however, magazine-related issues cannot be ruled out, particularly a weak magazine spring. Misfeeds may also be the result of improperly sized ammunition being loaded.

Misfire: A live cartridge failed to detonate in the chamber. A misfire can be caused by mechanical failure in the firearm, such as the firing pin or striker failing to contact the primer of the loaded cartridge, or the strike being weak and thus having insufficient pressure to cause detonation. A slight impression in the primer of the loaded cartridge will reveal a weak firing-pin strike. It may also be possible that the firing-pin surface is sufficiently worn to be incapable of operating as designed. Ammunition is the other possible cause, such as a bad primer, a primer that is harder than normal specification, a dud cartridge (no powder charge), or ammunition that has somehow been rendered completely inert, such as by exposure to the elements.

e. If the firearm has a detachable ammunition magazine, is a magazine inserted?
f. Note the presence of blood or other biological material that presents a biohazard to the handler.

2. When adequate documentation is made, pick up the firearm; keep away from the trigger and note additional observations as necessary.
   a. When handling handguns, it is often easiest to grasp the right and left sides of the grips.
   b. With long guns (rifles and shotguns), handling is often easiest by the edge of the stock and by the fore grip or hand guard forward of the trigger.
   c. If the action can be opened, do so slowly and carefully so as not to eject a chambered cartridge. If there is a cartridge in the chamber, take additional photographs with the action opened slightly to depict the presence of the loaded cartridge. When documentation is done, slowly close the action.
3. Identify and isolate the ammunition source. Determine where on the firearm the ammunition source is located. When the ammunition source has been identified, remove or unload the ammunition source.
   a. Remove the detachable magazine using the magazine release button or lever.
   b. Open the action of a breech-loaded firearm using the release lever, button, or knob.
   c. Open the cylinder of a revolver using cylinder-release mechanism, or remove the cylinder.
   d. Remove the magazine tube assembly from a tubular magazine and remove cartridges.

e. Open the action of a belt-fed weapon and remove the belt.
f. Slowly pull the slide back on a slide- or pump-action firearm. A loaded cartridge will reveal itself from the chamber. This should be done gradually, and the working of the action should be short, or not completely open. This process may require manipulation of an action bar release knob or lever to allow the action to open. If the firearm does not have separate loading and ejection ports, it may only be possible to slowly work the action to eject any loaded ammunition from the magazine.
g. If the firearm is a bolt action, open or remove the floor plate from the internal magazine; caution should be exercised because the loaded cartridges will spill out. Otherwise, once the ammunition source has been identified and isolated from the action, open the bolt.

4. When the ammunition feed source has been isolated and removed, unload the chamber and leave the action open. Inspect the chamber visually and by feel, using a flashlight if necessary.
5. It may be required that the person clearing the firearm then band the weapon with a wire tie to visually confirm that the firearm is unloaded.

It is recommended, if possible, that two persons participate in rendering a firearm safe, even if one or both are fluent with firearms. One person handles the firearm while the second person can aid by having a camera handy to photograph the presence of the cartridge or casing in the chamber, which can be instrumental in certain types of investigations and recoveries. Figure 1.1 depicts an example of such an image; the action was slowly opened to reveal that a live cartridge was chambered, although no magazine was inserted in the weapon at the time it was inspected. In Figure 1.2, there is a ring of burnt powder surrounding the charge hole in the 12 o'clock position; however, the other charge holes do not indicate this same appearance, suggesting that only a single round had been discharged. Investigators should refrain from excessive handling or "dry" (unloaded) operations to the firearm (pressing the trigger, cycling the action, etc.) during the recovery phase. Consideration must also be given for the presence of latent fingerprints or potential DNA sampling, should the circumstances of the case call for it. The investigator is reminded that the recovery and documentation process should be treated as a

Figure 1.1 **(See color insert.)** A semiautomatic rifle action is opened, revealing the presence of a live cartridge in the chamber. Such a find can be of great investigative interest. (Image from author's collection.)

Figure 1.2 A close-up photograph of the front side of a revolver cylinder. Note the burnt powder ring around the charge hole at the twelve o'clock position. (Image from author's collection.)

"one time shot," and evidence not collected at the time may not be available later if the need presents itself. It is inevitable that the evidence may be compromised to a certain extent due to the necessities of collecting and rendering the arm safe, and this must be factored into the equation as the cost of doing business. Investigators making the collection under more controlled circumstances can exercise more diligent handling. The first responding officers who must take control of a loose weapon in the interest of their own safety are not generally afforded this luxury.

Crimes Involving Firearms and Ammunition

The value and accuracy of capturing and assessing accurate firearm and cartridge evidence early in the investigation cannot be understated. This statement must be balanced with other investigative, safety, and evidentiary concerns, as the condition of a firearm *in situ* is subject to change very quickly in the course of a criminal inquiry, so as many details as possible must be captured. In the criminal context, firearm-related crimes do not necessarily include the actual discharge of a firearm or that anyone was injured. Broadly, firearm-related crimes can be broken down into several categories, each with a subtly different evidentiary concern that supports the element of the crime:

1. Possession of a firearm or ammunition by a prohibited person:
   a. Unlicensed possession in venues were licensing or permits are required
   b. Possession by convicted felons whose civil rights have not been restored
   c. Persons adjudicated mentally incompetent
   d. Possession by a person who is an unlawful user of narcotics or who habitually uses narcotics
   e. Possession by illegal aliens
   f. Possession by underage persons
   g. Possession by a fugitive from justice

   h. Possession by a person who has renounced U.S. citizenship
   i. Possession by a person discharged from the armed forces under conditions other than honorable
   j. Possession by persons otherwise prohibited by statutory objection
   k. Possession in sterile areas such as airports, public buildings, and other similar places
2. Possession of an unlawful or contraband firearm:
   a. A firearm deemed unlawful by its present configuration
   b. Unregistered automatic weapons either as manufactured, converted, or remanufactured into such
   c. Unregistered firearm suppressors or silencers
   d. Unregistered improvised weapons
   e. A firearm with an obliterated, defaced, or altered serial number
3. Use of a firearm as an instrument in crime:
   a. Homicide
   b. Assault and battery
   c. Robbery
   d. Poaching
   e. Reckless or careless handling or display
   f. Storing of a firearm in a manner readily accessible by minors
   g. Situations involving culpable negligence
4. Ammunition offenses:
   a. Possession by prohibited persons
   b. Contraband ammunition
   c. Possession of ammunition in a controlled or sterile environment
   d. Possession of ammunition in a criminal context, such as in connection with drug trafficking

In each instance, evidentiary concerns are subtly different and must be considered on a case-by-case basis. The focus of the investigation from the standpoint of the technical examination is either to satisfy the elements of the crime under investigation and assist in establishing the requisite burden of proof, or to contradict investigative presumptions. In an investigation where a prohibited person is in possession of a firearm and/or ammunition, the focus of the evidence lies in merely demonstrating that the possessed article is, in fact, a firearm or ammunition by the applicable legal definition of such. The firearm examiner or subject-matter expert must be granted access to the evidence and render an opinion of whether the article meets the applicable definition or not.

If a firearm is suspected of being a contraband firearm, the examiner must be able to ascertain that the exhibit is in a configuration that does define it as being unlawful or contraband. If, in the opinion of the examiner, the exhibit in question is one that is contraband, the examiner should be prepared to fully explain the rationale for this opinion as well as the technical reasons that justify the opinion. These observations should specifically outline the observed modifications or alterations. Modifications can take several forms to include modification of the firearm itself, replacing factory specification components with nonstandard ones, or the modification of existing components. Hence, the examiner is able to recognize modifications, replacements, or configurations and call them out specifically to support the assertions. The examiner also understands what effects were desired

by the modifications or alterations by understanding the purpose and function of the components in question, whether the desired results were realized or not. Configuration questions ordinarily focus on such items as the overall length or the barrel length of a long gun; if the article is a machine gun by manufacture, conversion, or remanufacture; if the article has some other form of alteration that renders it contraband; or if a device is defined as a firearm suppressor. Above all, examiners must be fair, honest, and ethical in their rendering of the opinion, even if the opinion does not coincide with the lay interpretation of the evidence. This may put the examiner at odds with others, but it must be understood that the opinions of others, regardless of their credentials, are not applicable in the court of law; the only opinion that matters is that which the examiner renders and goes on the record to support.

A number of years ago, an attorney in private criminal defense practice sought out the author in a case. His client had been arrested for various charges, including possession of a short-barreled rifle. In the venue where the crime was alleged to have occurred, as well as under U.S. Code, the minimum barrel length for a rifle is 16 inches. The seized firearm was stored in evidence by the investigating law enforcement agency, which permitted the article to be viewed by the defense as part of the discovery process. When the author viewed the exhibit, the firearm was identified as having been manufactured by Universal Firearms, a firearm manufacturer then based in Hialeah, Florida. The exhibit was the Enforcer model, caliber .30 M1 carbine, equipped with an 11-inch barrel, short wooden pistol grip, no buttstock, and perforated metal upper hand guard. The Enforcer model was a postwar commercially manufactured copy of the World War II–era U.S. M1 carbine. What differed about the Enforcer was that it was manufactured as a handgun, not as a rifle; thus neither the minimum barrel length requirement of 16 inches nor the overall minimum length of 26 inches applied. When seized, the supposition by officers was that the firearm was a cutdown M1 carbine—not an unreasonable assertion to make. Given the author's opinion, the firearm charge was dropped, as no violation of law had in fact occurred with respect to the configuration of that particular firearm. In another instance, the author was asked to examine a shotgun with an obliterated serial number. The shotgun had been seized during a criminal investigation and was being held as evidence. The author obtained the shotgun for review and determined that the serial number had not been obliterated from the shotgun. The shotgun in question, a department store brand dating back to the 1950s, never had a factory serial number affixed, as it predated the serial number requirement enacted in the Gun Control Act* of 1968. As such, the criminal case was dismissed, as, once again, no violation of law had taken place.

In cases of murder, assault, battery, robbery, and other violent crimes where a firearm is brandished or used as an instrument, the evidence lies not only in that the article is a firearm, but it opens the dimension of the comparative forensics aspect. The comparative ballistics aspect seeks to establish the presence or lack of a relationship between candidate firearm/s and cartridge casings and ammunition that may have cycled through or been fired by the candidate firearm/s. Ballistic comparisons focus on the markings that occur because of the interaction of the firearm with the ammunition. Cartridge casings may bear a firing-pin impression, breech face markings, scratches from the magazine-fed lip if cycled from a magazine, feed-ramp marks, and ejector or extraction marks. The fired

* Title 18, Chapter 44, United States Code.

projectiles may have sufficient transfer of the barrel profile impressed onto them to effect a comparison. Even without a firearm, casings and projectiles suspected of being fired from the same firearm can be compared to one another to form a nexus between the events should a match be established by examination and formation of opinion by a credentialed examiner. Ballistic comparisons are separate from firearm examinations in that not every firearm case requires that comparisons of fired projectiles, spent casings, and suspect firearms be made, rather just that the submitted exhibit be evaluated and defined.

In crimes where gunfire has occurred, it may be of benefit to bring the firearm subject-matter expert into the scene investigation early on to assist in assimilating the available firearm evidence into the overall investigation. Since the behavior of firearms is often in question within the scope of certain investigations, the firearm subject-matter expert may be able to interpret the scene and make certain determinations that might otherwise be overlooked. If possible, it is always advisable to conduct such inquiry at the scene itself, with minimal scene disturbance, as reconstructive efforts *ex post facto* may result in incomplete analysis due to gaps in documentation or a loss of context when removed from the original scene. Shooting-scene reconstruction is a discipline all unto itself, but this reconstruction can only be enhanced by bringing in a firearm subject-matter expert who can explain firearm "behaviorisms" within the context of the broader investigation.

As with firearms cases, criminal cases where the ammunition is the evidence can be prosecuted. Persons prohibited from possessing firearms are likely prohibited from possessing ammunition as well. In court, a subject-matter expert would be consulted to determine if the suspected exhibits are ammunition, as well as any particulars about the ammunition. From the investigative standpoint, the expert should be consulted about identification of ammunition that may serve as good intelligence during the investigative process. Certain examples of ammunition or the firearms chambered for that particular cartridge are rare or unique, and may prove to be valuable investigative intelligence to possess.

Firearm "Expert"? A Complex Question

What defines a firearm expert? The topic of firearms is so broad that the term is somewhat elusive. Persons with in-depth knowledge of the subject have tended to follow firearms with some degree of specificity, including interest in specific makes and models and firearms of a particular era. The person may have a specific interest in sport and competition shooting, law enforcement and military hardware, hunting, or purely as a collector. From a pure forensic standpoint, the examiner is familiar with all varieties and types of firearms. There will be voids in any examiner's knowledge by virtue of exposure, and there are certain firearms that seldom, if ever, are encountered within the criminal context. This is not to mean that the credentials of the examiner should be impeached on this point. Defined, the *expert* becomes recognized as such based on having gained comprehension of the topic from five sources: knowledge, skill, experience, training, and education. Moreover, the expert's comprehension of the subject matter is greater than that of the layperson. Experts are able to theorize about controversies that are presented to them and engage in hypothetical discussions, avenues not open to the fact witness whose testimony is limited to direct firsthand knowledge. Article VII, Rule 702 of the Federal Rules of Evidence state that a "witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion."

Individuals seeking recognition as an expert collectively draw upon these five sources to support their claim, and such individuals should expect such claims to be thoroughly vetted. In the courtroom, the prospective expert should reasonably expect to undergo the legal process of voir dire, that is, to present and clarify the witness's credentials to the court and jury, as well as permitting opposing council the chance to challenge the credibility of the witness under cross examination.

- *Knowledge*: Knowledge is in direct proportion to the proficiency one has with information obtained from the other four sources. In other words, how much information does a person have related to the subject in question? This information can be obtained by research, independent thought and observations, as well as through practice, training, and education relevant to the field. In general, knowledge can be taken from both formal and informal settings, but it must be credible. Where did the shared information come from in the first place, and how was this information obtained?
- *Skill*: Skill is the adeptness that one has for successfully undertaking and completing a task. Anyone, regardless of their competency, is capable of making a mistake; however, the apparent skill level of a person can be used as a general indication of that person's competency in the field. Skill is acquired over time through prolonged and repetitious exposure. Some practitioners can learn very quickly, and the practice of the craft becomes second nature, whereas others require more exposure. Skills may diminish and become obsolete over time if the practitioner is not actively engaged in the field.
- *Experience*: How long has the person been involved with the subject? Experience can be somewhat misleading, and it must be balanced between several considerations to establish what an accurate relative experience level is. Questions to ponder are how long a person has been involved in the field versus what that person's exposure to the field has been during that tenure. Another factor to consider in experience is how productive the person has been in the field, such as caseload, success rate on cases, complexity of cases, as well as outstanding achievements. Prospective witnesses should be prepared to answer not only how long they have been in their profession, but also be prepared to discuss their workload. In an ideal setting, practical experience bolsters learning through education or training, and they become complementary.
- *Training*: Training is generally associated with improving or expanding job skills, such as changes in work processes or completion of work tasks. Training can take the form of an apprenticeship, topic-specific courses (armory course given by a particular manufacturer about a particular product or the product line), technical seminars, trade conferences, and the like. Training may have been obtained from the law enforcement community and/or military service. The advantage of training is that it tends to be concurrent with the state of the art, more relevant to the consumer, and typically can be applied immediately. Reference materials that accompany training sessions tend to be technically focused and are designed to be workbench aids. Although these materials may become obsolete, they never go completely out of date; you never know when an old source will come in handy.
- *Education*: Education involves the presentation of programs for the student to engage in long-term learning goals. The line between training and education can indeed be thin; however, education can most generally be applied to formal

> education in the setting of an academic environment, especially the university or college setting. The gateway into career paths in modern forensics is a degree, and this is true even with firearm examiners, although it is unlikely to find firearms taught as a specific course of study in any university or college catalog. Nonetheless, a degree rounds off the resume or curriculum vitae of persons seeking to become subject-matter experts, and this is no less true with firearms.

Rule 702 also stipulates that "the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact at issue." In furtherance of this, "The testimony is based on sufficient facts or data; the testimony is the product of reliable principles and methods; and the expert had reliably applied the principles and methods to the facts of the case." In addition, Rule 703 states,

> An expert may base an opinion on facts or data in the case that the expert has been made aware of or personally observed. If experts in the particular field would reasonably rely on those kinds of facts or data in forming an opinion on the subject, they need not be admissible for the opinion to be admitted. But if the facts or data would otherwise be inadmissible, the proponent of the opinion may disclose them to the jury only if their probative value in helping the jury evaluate the opinion substantially outweighs their prejudicial effect.

The expert must therefore prepare to answer the following questions:

- What underlying facts and information were used to form the opinion?
- Was relevant case information reviewed or not reviewed when the expert contemplated the question?
- What was the process of reasoning, and what theories and methods were used to form the opinion?

Recognition as an expert does not necessarily give the person carte blanche within the field; the subject matter must be appropriate to the expertise demonstrated by the prospective expert witness. As an example, a recognized, renowned expert in the field of the Austrian Rast-Gasser revolvers and Steyr-Hahn pistols may not necessarily meet the definition of *expert* if the judicial controversy at hand concerns defining an article as a firearms suppressor by virtue of design and construction—unless, of course, this same person is prepared to offer evidence supporting expertise in that subject as well.

Exculpatory Evidence

Exculpatory evidence is any evidence that tends to prove, or at least suggest, the innocence of a party against whom an allegation has been levied. When exculpatory evidence is uncovered, it must be disclosed to the defense, even in the absence of formal requests for discovery of the state's evidence. If the examiner is working for the defense, it is obviously in the client's best interest to make the prosecution aware of this evidence in the timeliest manner. The expert cannot simply choose to ignore exculpatory evidence when confronted with it. A common error on the part of inexperienced examiners is the failure to research the question put before them. The examiner is reminded that, as part of due diligence, a reasonable amount of research must be invested before

formalizing an opinion that will serve as the basis of the examiner's expert conclusion. To frame this in the context of the firearm examiner, as a hypothetical example: Was the examiner aware that the firearm in question was subject to a manufacturer's recall due to a faulty component that could have caused an accidental discharge to take place? If the examiner was aware of this recall and had evaluated the significance of such a recall with respect to the behavior exhibited by the firearm at the time of the event, then the examiner can still form an opinion but must be prepared to address the possibility that the errant behavior that prompted the recall did or did not come into play within the circumstances of the case. Nothing could hurt the overall credibility of the expert or the soundness of the case more than being blindsided by the startling development that counsel for a defendant produces such evidence that the examiner was completely unaware of.

Experts should remember that they are objective purveyors of fact, and although most firearm examiners are employed by law enforcement organizations, this should not serve as a justification to cause them to present their testimony in such a way that attempts to sway the jury toward a guilty verdict. Simply put—the facts are the facts. This should in no way dissuade the expert from rendering a well-founded opinion and the basis for it; however it should be presented in such a way that is firm without being prejudicial or inflammatory.

The *Frye* and *Daubert* Standards

Legally, the recognition and the definition of experts has fallen upon the two legal standards: *Frye* and *Daubert*. Both standards are used in the United States, but which standard is applied varies from state to state. The basic premise of the *Frye* Standard is that the underlying method or procedure utilized is accepted in the relevant scientific community. The *Frye* Test—that is to say, the question that must be answered to qualify under the standard—is that the *proponent* (the proposed expert) must first identify the pertinent scientific circle, and then the theory, instrument, circle, or test is accepted—not the conclusion. The *Frye* Standard does not apply to purely scientific opinion but, rather, asks if the expert testimony is reliable. An opinion that is based upon training and experience versus the application of scientific methods, principles, and testing is not subject to the *Frye* Standard. Recall that the expert relies not only upon training and experience, but also education, skill, and knowledge. There is a very fine yet distinctive line separating the two.

As an example, a law enforcement officer encounters a particular firearm that is suspected of being a machine gun. The officer forms the opinion because of military experience and training, having become familiar with this particular type of weapon in the course of military service, and having received specific training in weapons that would include the particular type and model of firearm in question. The officer acts on the basis of training and experience as substantial reason to seize the weapon and further the investigation. In this illustration, the officer did not apply scientific methods, principles, or testing to arrive at a conclusion that the article in question was, in fact, a machine gun. At face value, the actions taken by the officer would not be scrutinized under the *Frye* Standard, as the officer did not make any conclusive determinations concerning the exhibit. When the exhibit is later in the hands of a firearm examiner, who conducts examinations and draws conclusions based upon an examination, the conduct and conclusion of the examiner becomes subject to the *Frye* Standard as to the methods and techniques used and the principles that were applied.

The U.S. federal courts and certain states observe the *Daubert* Standard. *Daubert* is both similar and dissimilar to *Frye*. There are parallels between them, but distinct differences as well. Under *Daubert*, the presiding judge acts as a form of gatekeeper in determining the reliability, the relevance, and hence the admissibility of the expert testimony that is being offered. The role of gatekeeper permits the judge some flexibility, subject to some basic criteria. The judge must decide if the offered scientific method, procedure, or technique has been subjected to testing or could be tested, and considers whether it has widespread acceptance within the relevant scientific circle. The judge may also clarify whether the method, procedure, or technique has been tested; what the margin of error is; what controls or standards were in place when the work was conducted; and whether the testimony is scientifically oriented or not. To properly credentialed subject-matter experts acting within their field of knowledge, *Frye* and *Daubert* are practically transparent.

It is not the position of the examiner to attempt to interpret a statute and apply it against contemporary case law per se; rather, it is the function of the examiner to conduct reviews and report findings. This is separate and distinct from the contemporary legal interpretations of any particular law as it relates to a firearm or ammunition, which are solely the responsibility of the attorneys arguing the controversy before the court. The results of an objective, scientific examination of the evidence may yield a result that is not desirous for the prosecution. However, examiners must bear in mind that they are, in effect, a witness of the court that is called upon to render objective, unbiased testimony in the legal question or controversy at hand. The expert cannot opine on questions of law, the guilt or innocence of the accused, or the credibility of other experts. The expert, however, can challenge the methodology applied by another expert or comment on the deficiencies in the opposing expert's methodology, short of personal attacks and making libelous or slanderous claims and statements. Experts should view themselves as educators to the jury and seek to facilitate a level of understanding of the subject matter within the parameters of the testimony they are providing.

The firearm examiner or subject-matter expert often plays a more intrinsic role beyond just the typical investigation and prosecution of an alleged crime. The expert may be called in to opine when an organization is in the process of selecting potential candidate firearms. The expert may evaluate a firearm for its uniqueness, rarity, technical properties, or historical significance that may call for the preservation of the firearm for future study. Even if the organization in possession of the firearm does not have the desire or facilities to retain it, countless museums, laboratories, and reference collections may be eager to take possession of the firearm. When firearms of an unusual nature or having unusual characteristics are encountered, the examiner conducts a thorough inquiry and publishes the findings for fellow examiners and other concerned parties in the form of intelligence bulletins or other mediums of communication. All examiners benefit from the network of information sharing and cooperation.

Gunsmiths versus Armorers

Gunsmithing is the oldest profession acquainted with the firearm. Before mass production, guns were handmade creations that were the work of a knowledgeable artisan. Every component was fabricated from raw material and hand fitted together into a workable product, as much a work of industrial art and artisanship as a tool. With mass production, the role of manufacturer transitioned from the gunsmith to the machinist, who fabricated

components for production, and engineers, who fine-tuned the ideas of the inventors and turned them into working products.

The role of the gunsmith did not disappear with the industrial revolution, as there were always firearms needing repair or owners who wanted some type of custom work or modification to their firearms. The gunsmith's trade was to address the functional and aesthetic issues of a firearm. It may have been a modification, restoration, repair, or replacement of the stock. It could have been the refinishing of the firearm, but frequently it concerned repair of a broken firearm. The gunsmith had to diagnose the symptoms of the malfunction and then begin deducing what the issue was: a broken part, a slight modification required to a certain component, replacing a spring, and even fabricating a replacement part that might not be available through ordinary channels. Their knowledge was gained through such avenues as apprenticeships, trade schools, experience, and learning from new projects that came through the door. It was a matter of routine for a gunsmith to fabricate a firearm from a prefabricated receiver (the frame of a firearm) as well as modifying an existing firearm to suit the desires and needs of the client. As such, gunsmiths became experts in their own right, having an understanding of any number of firearms they handled during the course of their careers. Gunsmiths worked from reference guides and schematics in addition to using their own eyes, hands, and experience to guide them. Modifying an action was not an exact science; gunsmiths relied on their competence and best judgment to achieve the desired result.

The armorer possesses a similar, yet distinctly different skill set from the gunsmith; a principle distinction being that gunsmiths are involved in the fabrication of arms and parts, whereas armorers are not. The armorer is not trained in the same skills and, in fact, while performing similar labor, is going about the task differently. The armorer still diagnoses the functional issues of a firearm, but the philosophy of the armorer is affecting repair through replacement of parts, and not necessarily modifying the firearm or tweaking a firearm action through machine work and hand fitting. This is especially true in law enforcement and military circles. There is no need to try to rebuild a part; simply replace it through spares kept on hand.

Firearm design has evolved a great deal in a relatively short time. For the most part, firearms contain fewer internal components and offer a degree of inherent flexibility that in previous generations of arms would have required the services of the competent gunsmith to successfully modify or repair. This approach has strong merits: It allows customization to suit the user while retaining predictable behaviors and a margin of safety in keeping with the manufacturer specifications. In contrast, the modification of parts creates the potential for undesirable firearm behavior that can result in adverse actions, such as increased potential for accidental discharges. Liability issues permeate firearm design, and manufacturer specifications and parts keep the behavior of the firearm well within a predictable and acceptable tolerance, something that simply cannot be guaranteed otherwise.

Most major firearm manufacturers present courses that cover their specific products. Third-party instructors often fill the gap for weapon systems when there is no factory support or when no single manufacturer is available to offer the training. Armorer training is often restricted to official entities, licensed firearm dealers, and recognized gunsmiths; thus such training is generally not available to the general public. Armory courses are a great way for novice examiners to get started, regardless of what direction they wish to take their career. Lasting one to five days, these courses are very much hands on, requiring that the student assemble and disassemble firearms, identify components, and diagnose various mechanical failures. The courses often end with a written and practical exam, ensuring

that the student demonstrates a level of proficiency and competency with the product. Once an armory course is successfully completed, the manufacturer will generally permit the student to order parts and perform work that will be sanctioned by the factory.

Firearm Examiner

The firearm examiner works with firearms on a different level altogether from gunsmiths and armorers. Examiners may receive armorer training as a matter of course in their career; this allows them to see the concepts, principles, and theories behind a particular firearm or weapon system. However, examiners typically do not apply their knowledge to repair firearms. Examiners apply their accumulated expertise to conduct a review of a submitted firearm as a matter of investigation. The examiner is able to make functional determinations and obtain whatever data is required from the firearm—identifying unknown firearms, restoring obliterated serial numbers, or obtaining other pieces of information that the circumstances may call for.

In the modern paradigms, most firearm examiners are far removed from the scene of the crime, and they typically do not play any role in the investigation other than evaluating the firearm submitted to the crime lab. This approach has both pros and cons. This approach is beneficial in that it allows the examiner a measure of independence from the investigation, eliminating the suggestion of improprieties or conflicts of interest, or that the examiner's opinion will somehow be tainted by having direct contact or knowledge of the particular circumstances of the case. The downside is that because of a general lack of context given the examiner, there is the possibility that the results returned from the examination will be incomplete in the context of the investigation. This distance may also create a communication barrier between the examiner and the investigator; thus pertinent information that could be shared in either direction may not ever be exchanged.

Firearm Subject-Matter Expert

Within the community of firearm subject-matter experts are those that choose to specialize in one or more specific fields: ammunition, firearms, and comparative ballistics. To draw an analogy, neurologists and cardiologists are both physicians; however, their fields of practice and expertise are different, although both practice their respective specialty under the broad field of medicine. Firearm examiners, in particular, may be engaged in comparison work as well as other firearm-related matters, but there are those who work with firearms to an extent that does not include comparative examinations. Such examiners are engaged in the practice of identification, classification, and answering other questions related to firearms, short of doing comparative ballistic work. Such examiners require a degree of competence commensurate with the work they conduct. A simple function test can be completed by anyone familiar enough with a firearm to safely use it. However, a simple function test may not rise to the level of expertise as defined by the *Frye* or *Daubert* Standards, as it can involve testimony that is based on firsthand knowledge as opposed to being based on expert opinion.

Not every case presented is simple. Consider the question of a submitted exhibit that appears to be a firearm but does not function. Does inoperability disqualify the exhibit as a firearm under applicable legal language? For example, Florida State Statute 790.001(6) states:

> "Firearm" means any weapon (including a starter gun) which will, is designed to, or may be readily converted to expel a projectile by the action of an explosive; the frame or receiver of any such weapon; any firearm muffler or firearm silencer; any destructive device; or any machine gun. The term "firearm" does not include an antique firearm unless the antique firearm is used in the commission of a crime.

The term *operable* should not be confused with the term *functional*. In an instance where the exhibit is inoperable, can the examiner explain why this could be the case? What defect is present that prevents the exhibit from operating as designed? If the examiner were to remedy the problem so that the exhibit could then function as a legally defined firearm, how could this discrepancy be explained? An operable firearm cannot be deemed nonfunctional purely on the occurrence that it did not fire when tested. In such a scenario, this is where the expert opinion comes into play. The examiner must be able to diagnose the probable cause(s) of the inoperability, and then perhaps seek to experiment with the different possibilities to ascertain the actual cause(s). The opinion therein lies in the articulation of a device that "is designed to, or may be readily be converted to expel a projectile." Based on the legal definition, it is also possible that the mere presence of a firearm frame or receiver would be sufficient to meet the definition of a firearm. The examiner must be able to identify the exhibit as a frame or receiver. Once again, as a matter of opinion, is the frame or receiver present, and could it be readily restored to function/operation?

For example, most pistol receivers can be made into fully functioning firearms in a matter of minutes if the balance of parts are at hand. Thus a frame or receiver that is disassembled could be articulated to be a firearm by definition, despite the fact that, in its current state, it is inoperable yet functional. Consider further, within the definition of a firearm, all of the following terms apply: *antique*, *machine gun*, *muffler* or *silencer*, and *destructive device*. Examiners must be able to articulate each one in relation to an exhibit before them if it is to be classified as a firearm. If an exhibit is a homemade or improvised device, does it meet any portion of the definition? In the opinion of the assessor, is the device or apparatus designed to act as a firearm? That is, is it designed, or can it be converted, to expel a projectile by the action of an explosive?

Basics: Understanding What Makes a Firearm Operate

For all the technological advancements that have occurred in firearm design, the majority of these advancements have affected everything else about a firearm except the basic tenets of function, which is how a firearm operates. The firearm has a sole purpose, but the means by which this purpose is achieved are, from a mechanical perspective, quite varied. The majority of operating systems and principles are old, well-established ideas that have changed very little.

It is ironic that one of the most popular handgun designs in the world, the Colt-Browning Model 1911, remains virtually unchanged since first conceived. Functionally, the 1911 design is still a 1911, regardless of which manufacturer produced the article and what aesthetic qualities may have separated one version from another. There have been subtle improvements to the basic design during its century-long existence, but the basic premise remains unchanged. The Mauser 98 design went into service in 1898 and was directly descended from the Mauser Gewehr Model 1871. Today, it remains a top choice for bolt-action rifle

builders to copy, as there apparently is not much room for improvement to the basic mechanisms of the action. Before the introduction of the Soviet AK pattern firearms, the Mauser 98 was the most prolific battle rifle the world had ever seen, in terms of both quantity manufactured and adaptation by nations on every continent. Nations from Argentina to Israel and from Iraq to the Orange Free State used a Mauser at some time during the first half of the twentieth century and even later. Ordinarily, these rifles can readily be identified by the appearance of national crests, a manufacturer's mark, and a date on the receiver ring. Numerous firms manufactured the 98, including firms not located in Germany, such as Fabrique Nationale in Herstal, Belgium, and the Radom arsenal in Poland. Between 1934 and 1945 alone, a combination of German and foreign firms turned out over 12 million rifles, roughly 1 million per year. A Model 98 rifle can still turn up anywhere.

A firearm is basically a machine. A machine fulfills a specific purpose and accomplishes the work by a process. The purpose of a firearm is to expel a projectile under the force of an explosive. To accomplish this work or operation, the ammunition cartridge is first introduced into the chamber or breech of the firearm. This introduction, called *loading* or *charging*, can come by hand insertion to the breech or chamber, by loading from a clip into an internal magazine, by inserting a detachable magazine, by charge holes in a cylinder, or by being fed from an ammunition belt. Once ammunition is loaded into the chamber and the action is closed, the firearm is ready to fire. A breech-loaded firearm would be closed by hand, whereas a firearm that that is self-loading would be closed by working the action manually or by the manipulation of a release in preparation for firing.

Once loaded, the firearm is fired by the press of a trigger. The trigger press is subject to resistance that can be measured in pounds or other metrics of force that must be overcome by the pressure exerted by the shooter. There is not a universal standard that dictates how much resistance a trigger should have, but it is noted as a matter of safety that the trigger press should not be excessively light. An exception to this would be weapons dedicated to sporting competition, where the trigger press is greatly reduced to increase the speed of the shooter.

Firearms can be capable of two different firing conditions—double and single action—each having a separate trigger-resistance weight. Many firearms are capable of either firing condition, whereas other firearms are capable of acting under one to the exclusion of the other.

Trigger Travel

The *trigger travel* should not be confused with the mechanical force required to overcome the trigger resistance. The trigger travel is the physical distance the trigger must move to the rear to cause the firearm to discharge. When the trigger travels a given distance, the firing train or mechanical linkage that connects the trigger to the hammer or firing mechanism disengages, releasing the trigger from the firing mechanism and causing the firearm to discharge. This point is often called the *trigger break*. Once a complete pull of the trigger is made, the trigger must be allowed to return forward. The trigger *reset* is the distance that the trigger must travel forward to reengage the firing mechanism and enable the firearm to be capable of firing again, assuming there is ammunition chambered and ready to fire. Experienced shooters train their trigger finger to know the exact point of trigger return where the reset takes place, allowing for minimal trigger press, thus firing more quickly and likely more accurately as well. Trigger *overtravel* is the physical distance that the trigger can continue to travel rearward after the discharge has occurred. Certain firearms have adjustable triggers that permit the amount of trigger overtravel to be tailored to shooter preference.

Figure 1.3 A modern replica of the single-action-only 1847 Colt Walker manufactured by Uberti. (Image courtesy of A. Uberti/Benelli USA.)

Single-Action Firearms

Single-action firearms require that the hammer be cocked, either manually or by the action of the firearm, such as working the action by using the charging handle, pulling back on the slide, or by pulling the hammer back if the firearm has an exposed hammer. Single-action automatic firearms automatically reset the hammer during the cycling action. The slide or bolt travels to the rear and cocks the hammer automatically.

There are semiautomatic firearms that have exposed hammers, found at the rear of the slide above the grip. However, there are also semiautomatic firearms that have internal hammers whose actions and firing condition are not visible to the shooter until the firearm is disassembled. Firearms with internal hammers are often called *hammerless designs*, but this may not be technically correct. The hammer may not be exposed to view from the exterior, but there is a part that transfers force by impact onto the firing pin. This is frequently the case with long guns, where there is a hammer, in the purest technical sense of the word; however, it is not visible, as it is contained within the receiver. There are true hammerless designs that completely omit the hammer, instead relying on the trigger to directly interact with the other fire-train components to cause the loaded cartridge to discharge.

Single-action-only revolvers represented the first major step toward modern firearms and were among the first to employ modern self-contained cartridges. Figure 1.3 shows a modern replica of the Colt Walker model, an atypical example of a single-action-only revolver. The single-action-only mechanism exists in all varieties of firearms. Specification data for such firearms will abbreviate the action as SA (single action) or SAO (single action only). The typical range for a single-action trigger press is generally set between 3 and 6 pounds; however, it can be significantly less if modifications or adjustments have been made to the trigger mechanism. Certain firearms are capable of user-adjustable trigger-resistance weights or are equipped with a set trigger. A set trigger is a second trigger, located within the trigger guard, which is pressed not to discharge the firearm, but to preset the amount of trigger resistance on the firing trigger. The Swiss Vetterli 1871 carbine* is an example of a firearm equipped with a set trigger. The set trigger is located behind the firing trigger. A set trigger must not be confused with double triggers used to fire individual chambers on multiple-barreled arms such as double-barrel shotguns and drilling-type firearms.

* A carbine is defined as a short rifle. Carbines initially were developed by reducing the barrel length of a full-sized main battle rifle, primarily intended for use by cavalry or other specialized types of infantry. Carbines were simply shorter versions of existing firearm platforms. Later, unique pattern firearms expressly designed as carbines were introduced, and were not necessarily reconfigured from an existing platform.

Double-Action Firearms

A *double-action* firearm requires that the press of the trigger must first cock the firing mechanism and then cause it to release. The shooter presses the trigger, which, through mechanical linkage, first cocks the hammer and then releases it once there is sufficient trigger travel. Suffice it to say, a double-action trigger press is generally much greater than a single-action press, both in the physical distance the trigger must travel and the amount of effort that must be exerted by the shooter to cause the discharge to occur.

Many double-action firearms are also capable of single-action operation by simply cocking the hammer or working the action in preparation to fire. A firearm capable of both double and single action will behave exactly like a single-action firearm in this condition. Many firearms are double action only, often abbreviated as DAO; likewise, single-action-only firearms are abbreviated as SAO; and firearms capable of either firing mode are abbreviated SA/DA. The typical range for a double-action trigger press ranges between 5 and 15 pounds, although there is no set standard that must be observed. Like single-action-only firearms, double-action trigger resistance may be altered by modifications made to the trigger and the other components in the firing train.

The revolver in Figure 1.4 is capable of both single- and double-action operation. The first visual cue is the spurred hammer, which allows for thumb cocking to a single-action condition. Modern revolvers of this design are not single action only. Figures 1.5 and 1.6 demonstrate the movement of the revolver's mainspring and how it relates to the behavior of the hammer. There are variations in mainspring design and exact placement within the grip, which varies by designer and manufacturer; however, they all serve the same purpose.

There are two distinct types of double-action trigger. The first type has to be cocked, such as the Glock or Springfield XD. Some view this type of trigger as having a distinct disadvantage. In the event of an ammunition failure, the shooter must perform a clearance drill to strip the dud cartridge from the chamber, reset the action, and prepare again to fire. However, not all surveyors of this fact deem it to be a disadvantage from a tactical perspective. The other type of double-action trigger is one that offers a second strike or restrike capability. In such a system, the function of the trigger cocks and releases the action, such as in the case of a double-action revolver or a semiautomatic pistol such as the Smith & Wesson Sigma, the Beretta 92, the Beretta 96, or the H&K USP series. In the event of a cartridge failure, the shooter simply presses the trigger again.

Figure 1.4 Most modern revolvers are capable of single- and double-action firing, as is the case with this Taurus Model 856, chambered in .38 Special. (Image courtesy of Taurus International Manufacturing.)

Figure 1.5 A Smith & Wesson Model 19 in double action firing condition, the hammer is "at rest", note also the position of the mainspring, the flat metal piece revealed by removal of the grip. (Image from author's collection.)

Figure 1.6 A Smith & Wesson Model 19 in single action firing condition, note the movement of the mainspring as compared with its position in Figure 1.5. The side plate has also been removed, revealing the hammer block safety and the linkage between the hammer and trigger. (Image from author's collection.)

Sequence of Operation

Regardless of whether the firearm is double or single action, when the hammer releases its fall, or when travel causes it to impact directly (or through intermediate parts) onto the firing pin, the force of the impact is passed on to the primer or rim of the loaded cartridge. This is the percussion detonation that is used in modern, self-contained cartridges, as opposed to archaic ignition systems such as the wheel lock, matchlock, or flintlock.

In some firearms, the firing pin is integral to the hammer or is attached to the bolt face; in other designs, the firing pin or striker is a separate piece from the hammer or bolt. Various safety designs exist that may act as intermediaries that prevent direct hammer/firing-pin connection, instead passing the impact pressure through this intermediary, such as the case with a transfer-bar-type safety on a revolver.

Upon impact, the primer or priming compound detonates, which causes an intense super-hot fire to pass into the main cartridge chamber through small holes called *flash holes*, which detonate the contained powder mixture. Once ignited, the contained powder charge starts to deflagrate, creating gas as a by-product. Once sufficient gas pressure has been achieved within the casing, the gas forces its way through the path of least resistance: the seated projectile. The casing is sitting snuggly within the walls of the firearm receiver and is thus well reinforced. When this is not the case—if the chamber is eroded or if subsized ammunition has been chambered into the firearm—a ruptured casing may occur as a result of this gas pressure. This may jam or even damage the firearm. Firearms have been known to come apart when an overpressure cartridge detonates within the chamber, damaging the host weapon and possibly resulting in death or injury of the shooter or others in proximity. Once the loaded cartridge is fired, the cycle of operation must be successfully repeated to allow fresh ammunition to be loaded, either by hand, by manual manipulation of a control (as in the case of a bolt-action or lever-action firearm), or automatically by independent operation of the firearm without input by the operator short of pressing the trigger.

Methods of Operation

Automatic* or self-loading firearms function by capturing the gas pressure created by the discharge of the ammunition cartridge that pushes the projectile out of the barrel. This energy can be captured, redirected, and utilized to cause the firearm to continue to operate by automatically ejecting and extracting the spent casing, then loading a fresh cartridge into the chamber while resetting the action to permit an immediate follow-up shot, assuming there is ammunition available. This principle is called *gas operation*. There are numerous methods and subvariations of gas operation, and although all gas-operated weapons do work by the same principle—by way of this gas pressure—mechanically they work differently. The first cartridge must be loaded by interaction of the operator, typically by inserting a magazine or loading cartridges into an internal magazine, and the action must be manually cocked. The automatic sequence only occurs when discharge has taken place.

Gas Impingement

A firearm that operates on gas impingement, which is also called direct gas operation, uses gas pressure returned to the receiver from the muzzle that automatically cycles the firearm's action. The gas pressure returns to the receiver through a gas tube or channel, where such gas pressure strikes, collides, or impinges directly on the firearm action. The Swedish Ljungmann AG42, introduced in 1942, was such a self-loading rifle that used a gas impingement system, and it became the inspiration for a series of early gas-operated rifles used around the world. The best-known application of gas impingement is the AR-15, a derivative of a prior rifle, the AR-10, and developed in the 1950s. The AR-15's gas-impingement system has been subjected to criticism since the rifle was adopted in 1962 by the U.S. Air Force and in 1964 by the U.S. Army. A fact that is often overlooked historically is that

* The term *automatic* should not be inferred in this text to exclusively define a firearm capable of sustained automatic fire with a single press of the trigger, called a machine gun. An automatic firearm is also meant to include a semiautomatic firearm, which still operates automatically when cycling, yet fires once per press of the trigger.

Eugene Stoner, the designer of the AR-15, did in fact develop the AR-10 as a gas piston-driven system. However, as history would have it, the gas-impingement system won out.

Gas-Piston Operation

Gas-piston operation represents an alternative to the direct gas action and may be referred to as an indirect gas-action system because the gas pressure does not directly work with the firearm action; instead, the piston acts as the intermediary between the two. A gas-piston-operated firearm uses the gas pressure generated by the expanding volume of gas in the fired cartridge to move a piston. The stroke of the piston may be long, or short, relatively speaking. As is the case with all types of firearm actions, there is no singular method by which the gas piston system is employed; there are numerous variations of how the gas-piston action is set up.

John Garand's M1 rifle was a piston-driven semiautomatic, although it is often just called a gas-operated rifle. The Garand's piston pushes an operating rod that interacts with the bolt, allowing the automatic cycle of extracting, ejecting, loading, cocking, and chambering to occur. A counteracting spring returns the operating rod and piston to close the action in preparation for repeat firing. The components in the Garand's gas piston system are located underneath the barrel. In contrast, during World War II, German forces fielded a gas-operated semiautomatic rifle, the G.43 (*gewehr* meaning rifle), which also used a gas-piston system, albeit more complicated than the Garand. The G.43 used a fixed gas piston that was acted upon by a moving gas cylinder. Gas entered the system from ports in the barrel and propelled the cylinder, not the piston. The cylinder linked to a connecting rod that linked to an actuating rod that worked the action. At the end of the train was a spring that countered the actuator rod, closing the gas system in preparation for repeated fire. When viewed, it looks like an excessively complicated system; it contained more pieces than the Garand, and in contrast to the Garand, these parts were located on top of the barrel. The G.43 was not an innovation; there was likely influence from the Soviet SVT 38, also a gas-piston-operated rifle.

The SVT 38 and its simplified successor, the SVT 40, used a short-stroke gas piston that, like the previous examples, received gas pressure from gas ports cut in the barrel. The piston pushes an operating rod, which pushes the bolt. The operating rod is spring loaded to cycle the action. A forward-looking and novel feature of the SVT gas system was an adjustable gas-regulating valve. The presence of an adjustable gas valve is almost a universal feature on gas-piston-operated firearms since 1945.

The Austrian Steyr AUG (Armee Universal Gewehr) and copies of it are examples of contemporary rifles operated by the gas piston method. Introduced in 1977, the AUG is still a rather futuristic looking weapon that made extensive use of polymer construction and was a compact, "bull pup"* design. An interesting feature of the AUG is that its gas piston serves double duty, as it also acts as one of the two bolt guide rods in the receiver, a design touch that reduces the number of parts and contributes to the compactness of the design.

Mikhail Kalashnikov, the designer of the AK47, AKM, and AK74 series of rifles, took the gas piston concept in a slightly different direction. He further simplified the method by combining the piston and the bolt carrier.

* A bull pup is a long-gun design concept that moves the receiver to the rear of the firearm, often incorporating it into the shoulder stock, allowing for a shorter overall dimension while maintaining a full-length barrel.

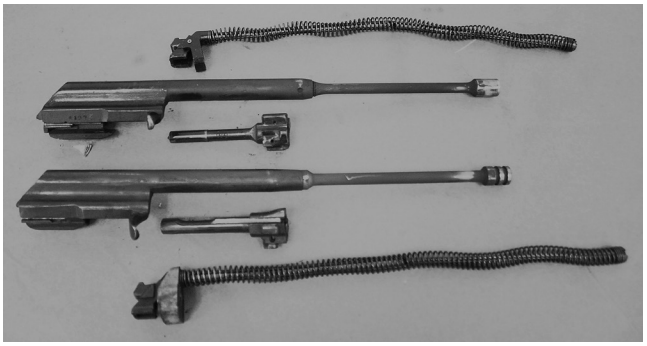

Figure 1.7 Two styles of bolt carrier, bolt, and recoil spring for an AK-pattern weapon. The piston threads into the bolt carrier to form one piece. (Image from author's collection.)

The piston threads into the bolt carrier and essentially makes the two one piece, eliminating the need for additional operating or actuating rods and other linkage that is found in other designs. This approach to the gas-piston system is widely acclaimed for its reliability and general lack of required maintenance to ensure reliable operation. Figure 1.7 shows two different designs of the Kalashnikov combination piston, operating rod, and bolt carrier. The bolts are shown, as are the recoil springs and recoil spring guides. The recoil spring attaches to the rifle by two lugs at the back of the receiver, and the front part of the recoil spring sits within the piston/operating rod. The bolt carrier rotates within a channel on the bottom of the unit.

Gas-piston systems have been widely touted as the replacement for gas impingement in the AR-15/M16-pattern weapons. Recent entrants to the market, such as the Heckler & Koch 416 and 417 rifles,* the FN SCAR 16 and 17, Sig 556, and the Remington/Bushmaster ACR (Adaptive Combat Rifle), are all gas-piston-driven designs. Two potential disadvantages of piston-driven systems versus gas impingement are the added weight of the additional pieces required in a piston system as opposed to a gas tube and a lower cyclic rate of fire if the firearm in question is a machine gun. Both of these potential disadvantages can be abated by engineering adjustments that make the components lighter to reduce weapon weight and increase the rate of fire.

Gas-operated semiautomatic pistols are not typical, but they do exist. There is nothing technically or inherently wrong with a pistol that functions using gas, if one can get past the complication and additional engineering of such a pistol, relative to the simplicity of the recoil-operated or blowback designs. Akin to gas-operated rifles, a gas-operated handgun must have a means or method to capture and channel the gas generated by the discharged cartridge, which ordinarily entails a gas trap and the associated plumbing to return the gas to the action. The Israeli Weapons Industries manufactures the Desert Eagle line of handguns, one of the few examples of gas-operated pistols. The Desert Eagle, marketed by the American subsidiary Magnum Research, features a fixed-barrel design in a configuration somewhat reminiscent of a blowback pistol, but looks can be deceiving; the pistol uses gas bled from the bore that drives a piston that acts upon the slide, pushing it open. The design features a rotating bolt, like the AR-15/M16. The smallest pistol of the

* The H&K 416 and 417 are Heckler & Koch's interpretation of the M16 rifle, but feature the gas-piston system of operation as well as some ergonomic and other improvements over the basic M16 rifle in its current configuration.

line, the Micro, also uses gas-assisted blowback. The Desert Eagle is best known for its big bore caliber, .50 Action Express, rivaling the .500 Smith & Wesson Magnum, .460 Smith & Wesson Magnum, and others for the largest handgun cartridges available. The Desert Eagle is physically not a small pistol, and it features the ability to change calibers quite easily. Pistolized versions of rifles, such as the AR or AK pattern, retain fidelity to their original operating principle of gas operation.

Recoil Operation

Semiautomatic handguns, also called pistols, are almost universally recoil operated save for those few gas-operated examples. Recoil operation allows pistols to be simplified in parts content and keeps them reasonably compact. Recoil or blowback pistols rely on a recoil spring (or springs) that serves to compress against the rearward motion of the slide as the projectile travels down the barrel, generating the "opposite and equal reaction" caused by the detonation of the cartridge. The rearward travel of the slide ejects the spent casing and resets the hammer. The recoil spring then rebounds, forcing the slide forward, loading a fresh cartridge, locks the action, and prepares the firearm for a subsequent shot. This impulse occurs within fractions of a second.

The recoil spring can be installed on a recoil spring guide, essentially a metal or plastic shaft, and is installed beneath the barrel. Most designs in modern times have centered on recoil-operated pistols that employ locking lugs or cams at the bottom of the barrel that interact with a locking block in the frame during the recoil sequence of firing. Some designs have a locking block that is integral to the frame; others use a locking block that is a separate component and is installed in the frame. There are also dual recoil spring designs, as is the case with the Walther P.38 and its descendents such as the P-1. The Walther P.38 featured dual recoil springs on steel guide rods on either side of the frame above the grips and beneath the barrel. Another interesting feature of the Walther P.38 is its locking block, which is a separate piece from the barrel that pushes down at an angle into a recess in the frame.

Single-recoil springs on a recoil spring guide that are fixed underneath the barrel are most prevalent on modern pistols. Other pistols, such as the Colt Woodsman, Colt Huntsman, Browning Buck Mark, and the Smith & Wesson 22 series, have a barrel fixed to the frame, but the slide does not fully enclose it, nor does it rest upon the entire length of the frame. In these instances, the slide is behind the barrel and reciprocates, extending forward only to the breech.

Blowback Operation

The blowback method of operation is the simplest means to make an automatically repeating firearm function. A blowback-operated firearm functions by the pressure generated in the breech when a loaded cartridge is expelled, causing the entire bolt assembly or slide to reciprocate when cycling. When cartridge detonation occurs, it pushes the reciprocating part rearward, which then returns to battery by the counteracting pressure of a recoil spring. Blowback firearms have fixed barrels that are integral to the receiver or locked in place by other means. Blowback firearms generally are extremely reliable because, with so few pieces, there is little that can go wrong. They can be lightweight and compact because they do not require the added parts and plumbing of other gas systems; everything is contained within the receiver.

Due to the simplicity of the blowback principle, it has been a regular choice for semi-automatic handgun designs. The Israeli UZI submachine gun, one the most easily recognized examples of a blowback firearm, is well known for its simplicity, ease of manufacture, low maintenance, and utter reliability. Gordon Ingram certainly looked to the UZI both in form and in function when designing the MAC pattern firearms. The AR-15 platform firearms chambered in 9×19mm and in .22 operate on the blowback principle, since these cartridges develop insufficient gas pressure to work effectively using gas impingement; this includes the Colt Model 635 9×19mm submachine gun. The 635 is often called the CAR-9, a name apparently meant to indicate that the firearm was a carbine chambered in 9mm. Pistols such as the Mauser HSc, Walther PP and PPK, and the SIG Sauer P230 series are classic blowback pistols, having fixed barrels and a recoil spring that shrouds the barrel.

As with all operating systems, there are variations to the basic blowback principle. The delayed blowback pistol is a subtle variation of straight blowback. In a delayed blowback system, there is an intermediate step that prevents the immediate retraction of the slide or bolt under the force of the recoil. The Fabrique Nationale (FN) Five-seveN pistol is such a design, owing to the chamber pressure developed by the 5.7×28mm cartridge. Figure 1.8 shows the Five-seveN pistol field stripped.

The simplicity of the blowback system meant that it was ideal to develop a more complex system that was, in effect, blowback but with some twist or addition. The toggle action of the Luger pistol is one such example. The slide recoiled very little; however, the toggle action absorbed the recoil energy and returned the gun to battery. The roller-lock bolt system is another example of delayed blowback, and is one of the few successful examples where blowback worked with full-power military cartridge applications. The roller-lock bolt system was developed in Germany in the late stages of World War II and found its way back to Germany by way of Spain, where the system was more fully developed. The firm Heckler & Koch is best known for employing the

Figure 1.8 The FN Five-seveN is a delayed blowback pistol. Although there is no externally visible hammer, this is not a hammerless design. The hammer is seen at the rear of the frame, next to the ejector, which has a hooked appearance. (Image from author's collection.)

system in its entire long-gun line, from precision rifles to general purpose machine guns. In an ironic twist, the readily recognized Thompson 1928 submachine gun was originally designed to use a form of delayed blowback and ended up as a straightforward blowback when the design was simplified for mass production as the M1/M1A. The simplification did not seem to hamper the Thompson's reputation as a reliable and effective submachine gun, and it probably went unnoticed except by the technical aficionados.

The Israeli Galil, which borrowed heavily from the Kalashnikov system, operates on a gas-piston system that also provides for a delay where gas pressure is reduced. Rather than accomplish this delay by mechanical means, it is done by having loose tolerances in the bolt carrier parts, including a notched gas piston, which allows some gas pressure to bleed off but reserves a sufficient quantity to cycle the weapon. The Beretta Model 92 operates by delayed blowback. This is accomplished by a locking block that locks the barrel and slide until chamber pressure has abated. The barrel maintains a flat plane during the course of cycling.

Other methods of delaying blowback include using a lever to moderate the movement of the bolt; using gas pressure to retard the rearward movement of the bolt, in essence a reverse of gas operation; or the recessed-ring delayed blowback. The recessed ring is unique to the Seecamp LW32 and LWS380 pistols, which are identified as *retarded blowback* by the manufacturer, although the company website references a recessed ring in the chamber "into which the case expands on firing, making the weapon a retarded blowback" (L.W. Seecamp Co. n.d.). Unsuccessful attempts at blowback include the screw-delayed and the Pederson hesitation lock, both of which are unlikely to be encountered or appear again.

Recoil-Operated versus Blowback Firearms

What differentiates a recoil-operated firearm from a blowback firearm is that the recoil-operated firearm has a measure of barrel travel. There are two approaches to recoil operation: short and long recoil. As the names imply, either recoil operation is based purely upon the physical distance that recoil takes place. The classic example of short recoil, the Colt 1911, uses a swinging link. The barrel has a hinge that is connected to the frame by the takedown pin, and there is a locking cam on top of the barrel to fix it to the slide when the action is closed (see Figure 1.9). Interestingly, Browning abandoned the swinging link approach when he designed the heir apparent to the Model 1911, the Hi Power, which uses the now familiar locking lug located underneath the barrel, and which locked during recoil into a steel bar in the pistol frame. The continuation of this popular design has a barrel equipped with locking lugs that connect to a locking block as the firearm is fired and the barrel is pushed slightly rearwards because of the recoil. Nearly every handgun manufacturer uses or has used this method at one time or another, and this system is still defined as a short recoil or modified Browning action, as the barrel and slide travel rearward together for only a short distance before the barrel is locked into place by the locking lugs. Figure 1.10 shows the modified Browning action as applied in the H&K USP Tactical 45 pistol. The barrel has locking lugs on the bottom side, and the recoil spring guide locks to the barrel and to the guide on the frame. Another design variation to recoil operation does not require that the barrel necessarily be captured by locking lugs or by any other linkage, but instead the barrel travels along a rail or guides that are part of the receiver, and the barrel does not tilt as it travels.

Figure 1.9 The classic Browning short-recoil action. Note the swinging link under the barrel. Although this is a Colt 1991A1, not much has changed from the original 1911. (Image from author's collection.)

Figure 1.10 The Heckler & Koch USP Tactical pistol chambered in .45 ACP. The USP is recoil operated, using a modified Browning action. Note the differences between this recoil action, swinging link, and blowback designs compared with Figure 1.9. (Image from author's collection.)

Long-recoil-operated arms are primarily long guns, as handguns generally are physically too small to accommodate a long recoil action. A long-recoil-operated firearm operates in much the same way as a short-recoil firearm, save for the fact that in a long-recoil arm, the action and barrel remain locked together in the recoil sequence and are counteracted by recoil springs, whereupon the barrel returns in advance of the bolt, which recoils after the barrel has returned forward. This delay allows the bolt to complete the sequence

of ejecting and loading a fresh ammunition cartridge and chambering same when returning forward. An unusual form of recoil operation is the *blow-forward* action. As the name implies, it works by recoil but in reverse of a blowback design. A blow-forward action pushes the barrel forward by the force of the recoil.

Striker-Fired Firearms, a Contemporary Trend

The recent trend in pistols is a polymer frame using a striker-fire design. The striker is not a new idea, having appeared quite early in the twentieth century at the dawn of the automatic pistol era. The Colt Model 1908 Vest Pocket is an example of an early striker-fired firearm and was quite novel for the time. The striker design eliminates a hammer as part of the fire-control train. The striker instead can rely upon a direct action of the trigger sear releasing a spring-loaded firing pin. In a single action, striker-fired design, the firing-pin spring is placed under tension, and therefore the pistol would have to be charged by pulling back the slide, which would in turn cock the firing-pin spring. In the case of the Colt 1908 Vest Pocket, two safety devices were built into the design. The first was a grip safety, consisting of a pressure plate located on the back of the grip. The pressure plate disengaged the trigger from the firing train and thus disabled the firearm until it was depressed, presumably by gripping the pistol. Later Colt further enhanced the safety of the model by providing a manual safety operated by a lever on the left side of the frame, but it was really redundant given the other positive safety features. The 1908 Vest Pocket was in stark contrast to the Colt Model 1905. Although they shared the grip safety, the 1905 used an internal hammer.

The firearms designed by Bruce Jennings that emerged in the early 1970s were blowback striker-fired pistols. The design used a fixed barrel on the cast-metal alloy frame. In 1971, Raven Arms entered the market, followed by Jennings Firearms in 1978, Bryco Arms, and later CalWestCo. Phoenix Arms succeeded Raven Arms in 1992. A Raven MP-25, the .25 ACP pistol, is shown in Figure 1.11. The name of the company that made

Figure 1.11 The Raven Arms MP-25, chambered in .25 ACP, is a striker-fired blowback pistol. The striker spring is cocked when the slide is retracted. The other spring is the recoil spring, which sits in the shroud surrounding the barrel. (Image from author's collection.)

the casting, Lansco, as well as the MP-25 is visible with the grips removed. The simplicity of the design is readily apparent from this perspective. Jimenez Arms has continued manufacture of the basic Jennings designs, albeit with a slightly more modern appearance. Cobra Enterprises also mimicked the basic Bryco design, with subtle cosmetic differences. These firearms were available in several calibers during their production run: .22 Long Rifle, .25 ACP, .32 ACP, .380 ACP, and even 9×19mm in a larger frame. Like the Colt 1908 Vest Pocket, these firearms were single action. The pistol must first be loaded by inserting a magazine and then the slide worked to charge the weapon. The firing train was a simple trigger bar married to a cam that locks and releases the sear. These designs suffered from two major flaws: The firing pins have a tendency to break due to substandard material used to construct them, and the feed ramps can be of irregular quality. It is not uncommon to encounter misfeeds due to ammunition being unable to chamber due to a rough feed ramp. This is especially true with the .22 firearms, particularly when the same ammunition has been cycled through the firearm a number of times by loading and unloading.

The Hi Point family of pistols, to include Haskell, Iberia Firearms, and Bee Miller, are also striker-fired, blow-back designs using a fixed barrel. These firearms feature a cast frame with a distinctly large slide, relative to the size of the frame. They are available chambered in .380 ACP, 9×19mm, .40 S&W, and .45 ACP.

Emergence of the Polymer-Framed Pistol

The polymer-framed, double-action, striker-fired pistol appeared in the form of the 9×19mm H&K VP-70, introduced in 1970 and produced until 1989. There were two variations of this pistol: The VP-70Z was semiautomatic. The second version, the VP-70, was capable of operating as a submachine gun by attaching a shoulder stock. The stock contained the selector switch to permit full-auto firing, as attaching the stock interfaced with the sear within the pistol. The VP-70 had a cross-bar-type safety that was manipulated by a push button located by the trigger, similar to many rifles and shotguns. H&K marketed the VP-70 in the late 1970s, but neither version achieved significant commercial success. However, they set the stage for the polymer-framed firearm that featured high-capacity double-stacked magazines, hammerless double-action-only operation, and a matte parkerized finish.

The appearance of the Glock 17 ushered in the new era of handguns. The tremendous success of Glock in the commercial, law enforcement, and military markets has prompted nearly every handgun manufacturer in the world to follow suit. The Glock's patented "Safe Action" is a variation on the striker system that incorporates three internal safety devices: a trigger safety, a drop safety, and a firing-pin safety. None of the Glock safety features is set manually, but each is defeated in series by a complete press of the trigger, and is reset automatically when the trigger is released. The trigger is designed to have a "slack" travel, whereupon resistance is encountered only after the first ½ inch of trigger travel. The amount of resistance is determined by the installed trigger spring and trigger connector. To the shooter, the physical feel of the trigger is more akin to single action, not double action; however, the Glock is truly a double-action firearm. The press of the trigger, in addition to defeating the safeties in succession, causes the trigger bar to move, which causes the firing pin to cock against the firing-pin spring until the trigger bar releases the firing pin when a complete trigger press is made. Since the trigger first cocks the action and then

Figure 1.12 The Smith & Wesson Sigma SW40E and magazine. The Sigma series were the first polymer-framed pistols from Smith & Wesson. The trigger press had a more traditional double-action feel: long and smooth. Smith & Wesson chose to use steel-bodied magazines instead of polymer. (Image from author's collection.)

releases it, this is a double action in the true sense of the definition, even if it does not physically or tactilely conform to the expectation of the shooter in that sense.

The overwhelming commercial success of Glock has prompted many other manufacturers worldwide to adopt a similar product. In 1994, Smith & Wesson responded to Glock with their Sigma series handguns featuring a polymer frame for a striker-fired, double-action-only pistol. The Smith & Wesson SW40E, chambered in .40 S&W, is depicted in Figure 1.12. The appearance of the Sigma prompted litigation between Glock and Smith & Wesson, later settled with Smith & Wesson paying an undisclosed sum in damages and making a design alteration to the Sigma. The movement toward the polymer-framed, striker-fired pistol did not end with the Sigma series; Smith & Wesson released their M&P series pistols that featured polymer frames and were double action and striker fired. The M&P series also includes AR pattern rifles and a series of revolvers. The success of pistols in this configuration has prompted Taurus International, Springfield Armory, Ruger, Kel-Tec, and others to develop their own similar pistols. Even manufacturers that have resisted the movement toward polymer have accepted polymer or composite frames as the new norm, such as Beretta; the H&K USP pistols; Fabrique Nationale's FNP, FNX, and Five-seveN pistols; Walther's P99, PPS, and P22; and numerous others, especially in the very compact concealed-carry pistol market. Brazilian manufacturer Taurus produces an extensive line of hammerless automatic handguns that are both single and double action. This slight technical variation is given away only when the trigger is pressed. There is a lighter press if the slide is retracted and released. Due to the fact that these pistols are hammerless, there is no visual indication of the firing condition, prompting many manufactures to install some form of indicator that reflects a loaded chamber condition.

The double-action-only striker-fired firearm is deceiving. Many have difficulty in grasping that such a design is truly double action only, because the trigger feel does not

behave in a manner consistent with that expected of the traditional double-action trigger press as a shooter rooted in the traditional single/double action would expect. In the traditional sense, the single-action trigger press was very short, crisp, and light compared to a double-action press, which had a physically longer travel and heavier resistance; however, modern double-action-only firearms have engineered this out of the design.

Manually Operated Firearms

Figure 1.13 shows examples of different types of manually operated rifles.

Breech-Loaded Firearms

Breech-loaded firearms are single shot. The breech is opened, and a single cartridge is hand loaded. The breech is opened by a release lever, and the receiver hinges open to allow loading or unloading. Typically, breech-loaded firearms have spring loaded, automatic ejectors built in that eject the fired casings from the breech when opened. These firearms operate on single action and require the exposed hammers be cocked in preparation to fire. Double-barrel and combination firearms are breech loaded. Double-barrel shotguns in particular have two separate triggers, one for each chamber (see Figure 1.14). Breech-loaded firearms are also called break action, break tops, or hinged action. Gilbert Harrington, cofounder of Harrington & Richardson, patented the automatic shell ejection system and first applied it to a revolver-type firearm (Harrington 1871). The Harrington & Richardson firm later expanded this concept to include breech-loaded shotguns.

Figure 1.13 Examples of different types of rifles. Top: lever action. Bottom: bolt action. (Image courtesy of BATFE.)

Figure 1.14 The Benelli Renaissance Classic, an over/under configured shotgun. The 20- and 28-gauge barrels are shown. (Image courtesy of Benelli USA.)

Lever-Action Firearms

Lever-action firearms were the first practical repeating arms to appear as the era of the breech-loaded firearm was being eclipsed. The lever action operates by a lever, usually comprising the trigger guard with a loop to permit the insertion of fingers through it. The lever is flipped, which ejects the spent casing, loads a fresh cartridge, and cocks the hammer in preparation to fire. The first lever-action rifle, the Spencer, appeared at the start the American Civil War. Unlike later lever actions, the Spencer did not automatically cock the hammer when the lever was worked; instead, the Spencer's lever only unloaded and loaded the firearm. Later designs combined these two separate operations into a single operation by working the lever. American firearm manufacturers are well known for long and distinguished lines of repeating rifles from such companies as Winchester, Marlin, Stevens, and Remington. Lever-action firearms are fed by tube magazines located underneath the barrel. Repeating rifles remain popular with hunters and cowboy action shooters and are basically unchanged.

There are few examples of lever-action shotguns. The Winchester Model 1887 is probably the only significant example, and it has been copied by other companies subsequent to Winchester discontinuing production. The Model 1895 by Marlin is likely the only lever-action shotgun currently in production.

The popularity of the lever-action rifle has kept it in production for over a century. The Winchester Model 1894 practically set the standard for lever-action rifles. The Model 94 was the product of continuous improvement on the part of Winchester and was continuously manufactured until 2006.

Bolt-Action Firearms

Bolt-action rifles such as the Lee Enfield, Mauser 98, Mosin Nagant, Mannlicher, and the Carcano rely on the operator to manually operate the bolt per shot fired. On such weapons, there is a handle attached to the bolt. Bolt-action rifles can either be a straight-pull bolt or a turning bolt. In the case of a turning bolt, the bolt must be opened by lifting the handle up to unlock the action and eject the spent casing. Sliding the bolt forward and turning the bolt handle downward then loads a fresh cartridge and locks the action in preparation to fire. Straight-pull bolts work differently than turndown bolts. The Steyr Mannlicher M95 is an example of a straight-pull bolt. In such a system, the bolt is pulled straight back from the receiver, ejecting the spent casing; when the bolt is returned forward, the action is cocked, and a live cartridge is then chambered. The bolt action was quite an advancement in firearm technology. The first bolt-action rifles began to appear in the early 1870s, and they remained in front-line military service until the end of World War II, when they were superseded by the appearance of automatic rifles, submachine guns, and the introduction of intermediate-caliber firearms. Despite this, bolt-action rifles remained in service with smaller nations and were scattered all over the world during the late nineteenth and the first half of the twentieth centuries.

Bolt-action rifles can draw their ammunition supply from an internal magazine, from a detachable magazine, or they can be single-shot firearms. Bolt-action arms are equipped with an extractor on the bolt that automatically ejects the loaded casing when the action is opened. Despite their age, bolt-action rifles are still very much revered for hunting, match target, and precision-shooting operations. U.S. Marine Corps Gunnery Sergeant Carlos Hathcock used a Winchester Model 70, a bolt-action rifle, as a sniper during his service in the Vietnam War. The most recent addition to the arsenal of rifles available the U.S. Army is the XM-2010, a

heavily modified Remington 700. It may appear to be a totally different firearm, but its action is still that of the 700. It is chambered in .300 WIN-MAG (Winchester Magnum).

Bolt-action shotguns mimic their rifle counterparts in operation and may be single shot, contain an integral magazine, or have a detachable magazine. Mechanically, the bolt-action firearm is extremely reliable and not generally subject to malfunction. Manual safety devices are generally flip-type levers that lock out the trigger from the firing pin, or crossbar-type safeties that consist of a push button on the trigger guard.

Slide- or Pump-Action Firearms

Slide- or pump-action rifles and shotguns are manually operated by the action of a slide or pump that ejects and reloads the firearm each time the trigger is pressed, which unlocks the action and permits the slide to be moved to the rear and then pushed forward. The slide action operates by means of an action bar that connects the slide to the bolt. Some designs use two action bars; other designs use a single action bar. When the action is cycled, it locks the action closed and can only be released with a press of the trigger or by using an action-bar lock-release lever.

The majority of slide-action firearms have internal hammers and are fired from a single-action firing condition. Retracting the slide cocks the hammer, pushing the slide forward, which loads the chamber and locks the action. Typical slide-action malfunctions involve a "short stroke," where the slide is not pulled rearward with enough force or the travel of the slide is incomplete, hanging up the action. The result is typically a double feed, where the casing from the chamber cannot be ejected because a cartridge has been partially pushed into position in preparation to load.

The Winchester Model 97 shotgun, perhaps one of the most famous shotguns ever produced, has an external hammer. This allowed the Model 97 to be cocked or carried loaded but with the hammer uncocked. The hammer could be cocked by action of the slide or by hand. Another unique feature of this shotgun was its ability to "slam fire"; as long as the trigger was held down, it would continue firing each time the slide was worked because the design omitted a trigger disconnector. The Chinese company NORINCO later copied the Model 97 and sold several versions of it in the United States, although redesigned with a disconnector so that it would not slam fire. The Winchester Model 12 is also capable of slam fire.

Slide-action firearms can be fed through internal tube magazines located underneath the barrel or by a detachable magazine. There are slide-action firearms that do not have separate loading and ejection ports. One such example is the Remington Model 10 shotgun; it has a single loading/ejection port located on the bottom of the receiver. Slide-action shotguns (see Figure 1.15) are practically universal for use with law enforcement and military organizations. Slide-action rifles were never as popular as shotguns, probably because the availability of auto-loading and lever-action rifles negated market interest.

Figure 1.15 Benelli Super Nova 12-gauge slide-action shotgun. The tactical configuration model is depicted. (Image courtesy of Benelli USA.)