From Ingot to Target: A Cast Bullet Guide for Handgunners

A joint effort by Glen E. Fryxell and Robert L. Applegate

Chapters

Foreword: by John Taffin

In many ways it seemed like only yesterday I began casting bullets. In fact it has been nearly one-half century since I started pouring that first batch of molten alloy into a single cavity mould, or mold if you prefer. It was in my mother's kitchen, at my mother's stove, next to my mother's refrigerator. It wasn't long before the whole top half of the side of her refrigerator was covered with speckles of lead. Now my mother was the most fastidious of housekeepers, however she never complained. Looking back I can only assume she thought it better to have me making a mess in her kitchen rather than running around doing something of which she didn't improve.

At the time I was working for a large wholesale warehouse catering to plumbing and building contractors. This gave me access to both 100# bars of lead and one pound bars of tin. There was also a reciprocal agreement with a few other businesses allowing employees from one place to purchase from the other at wholesale prices. From the now long gone Buckeye Cycle I was able to order two Lyman single cavity molds, #454190 for the .45 Colt and #358311 for the .38 Special; a Lyman #310 “Nutcracker” Reloading tools with the dies for both .45 Colt and .357 Magnum, and I was ready to cast bullets. Those two molds are gone as it wasn’t long before I graduated to multiple cavity moulds, however, I still use that #310 tool to pop primers from cartridges cases fired with black powder.

Living as we do in the Instant Information Age, it is sometimes difficult to believe how little information was available or how difficult it was to find in the middle of the 20th century. I had read Elmer Keith’s “Sixgun Cartridges and Loads” which gave me the very basics. Much of the rest I learned over the next four decades by trial and error and casting and shooting thousands upon thousands of cast bullets in hundreds of sixguns. Casting bullets opened all kinds of doors for me. Most importantly, casting allowed the shooting of vast amounts that would never have been had I found it necessary to buy my bullets from other sources. The only way to become even reasonably adequate with a sixgun is by shooting a lot, and only casting my own bullets allowed this. All of my shooting experiences, the vast majority of which has been with home cast bullets eventually led to my position as Field Editor with “American Handgunner” and Senior Field Editor with “Guns” magazines. Along the way, I not only managed to acquire a pretty good knowledge of cast bullets but also a working collection of approximately 250 bullet moulds from virtually every manufacturer. With this background in mind I now turn to the volume you hold in your hands.

Glen Fryxell is a chemist by trade and a bullet caster by choice. He knows more about casting bullets than anyone else I know. Rob Applegate is both an excellent gunsmith as well as a maker of custom bullet moulds. Put the two of them together, and virtually every aspect of cast bullets is covered in what comes the closest to ever being called “The Complete Book of Cast Bullets.” Only their modesty prevents them from using this title and instead of going with “From Ingot to Target: A Cast Bullet Guide for Handgunners.”

I found two things of major importance as I read this book. 1) The things I've learned about cast bullets and casting bullets are true. 2) There was still much I needed to learn. Both what I know and what I needed to know are found in this book. Any well-informed sixgunner, even if they never intend to cast their own bullets, will find information here that simply make shooting more enjoyable. Which is better, plain-based or gas checked bullets? Why do soft bullets shoot well while hard bullets lead the barrel, and vice versa? How does bullet lube work? What is this mysterious thing called flux? How important are cylinder throat and barrel dimensions? Do cast hollow point bullets really work? Can one hunt with cast bullets, and if so which ones work the best?

As important to me as the how-to information is the historical background. Over the years many men have contributed to our knowledge of bullets in general and cast bullets in particular. In these pages you will find such cast bullet pioneers as Elmer Keith, Phil Sharpe, Jim Harvey, Ray Thompson, Veral Smith, and my dear friend, J.D. Jones. Understanding their contributions simply makes shooting sixguns all that more enjoyable.

If you have never cast a bullet but are planning to start, read this book first. Keep it at hand, and refer to it often. If you are an experienced bullet caster, stop, do not cast another bullet until you have read this book. You might be surprised at how much you have to learn. Rob and Glen have done an admirable job of gathering and presenting valuable information on what many think is a somewhat mystical or magical art. The doors are open, the lights are on, and the magic and mystery have been dispelled. This volume is a most valuable addition to both my loading room and my library. I expect all other dedicated sixgunners to also find this to be true.

John Taffin
Boise, Idaho

Acknowledgements:

I am a student of the gun; or perhaps more accurately, I am a student of the bullet. I learn something every time I cast, load or shoot. Such an education clearly did not take place in a vacuum. I have the unwavering support of my lovely wife (who is still the nicest person I have ever met), a couple of great kids, and the most wonderful grandkids in the world (OK, so I'm a little biased!). My parents have always been loving and supportive teachers, who valued education (and paid for much of mine), ensuring that I would have the ability to be a good provider. The resulting career has provided me with the wherewithal (and occasionally enough free time) to pursue those things that have fascinated me since early childhood; guns, hunting, bullet casting and handloading ammunition. Building upon that foundation are the contributions of a multitude of teachers, who have taught me these things, as well as gunsmithing, metallurgy, machine work and the art of integrating all of these disciplines in the pursuit of my own personal vision of ballistic perfection. The list of such teachers is far too long for any sophomoric attempt at completeness, but there are several men that I have been privileged to call friend whose guidance and insights must be acknowledged; Colonel Loveless of Pleasant Acres (College Station, Texas), who taught me marksmanship and ethics as a part of the NRA Junior Marksmanship Program when I was growing up back in central Texas; Dale Harber, who adopted me as a "kid brother" and took me hunting and nurtured my fascination with guns and handloading; Reo Rake, who got me started handloading and taught me the joys of the lead pot; Lyle Eckman, who taught me much, including how to shoot, listen and teach (once again, as a part of the NRA Junior Marksmanship Program); Dave Ewer, who is patiently teaching me the art of gunsmithing, and has helped me rediscover the joy of plinking; and John Taffin, for his guidance, advice and encouragement, for contributing to this book and for being a shining example of what a gentleman and gun-writer should be. Each one of these men is a crack shot, seasoned competitor, knowledgeable handloader and darned fine man. Thank you gentlemen.

Lastly, I would like to thank Rob Applegate for being the ideal partner to write this book with. Rob is the kind of man that is met all too rarely these days, unfortunately. He is a hard-working, good Christian man. He is honest and industrious not just because he was taught that was the right way for a man to handle himself, but because he simply cannot operate any other way. It is his fundamental nature. He is a quiet gentleman, usually of few words, but when he speaks I listen, because Rob is a goldmine of knowledge on all things ballistic (among other things). Rob is the kind of friend that you can walk for miles through the mountains with and never say a word, because nothing *needs* to be said -- the mountains, wildlife, wind and clouds speak volumes, and he hasn't the rudeness to interrupt. He's the kind of man that can be caught a mile and a half from the truck in his shirt sleeves in a surprise rainstorm and in conversation during the soggy walk back never once complain about the weather. He's a giddy little boy who can spend hours out in his shop talking about the vice he made to cut mould blocks with, and while he's justifiably proud of his gadget, his real joy comes from the fact that his skills have created the ability to build *new* things, and to build them *right*. Much of Rob's life revolves around building things. My Mother taught me many years ago, "Any fool can destroy. It takes a real man to build." Rob is a real man, a man who builds. He is a meticulous craftsman whose attention to detail is exquisitely apparent from the exceptional quality of his work. His nickname is "Persnickety", and for good reason. Rob, we live too far apart. We should get together more often, you and Marilyn are special people. Thanks for everything, my friend.

This book is a partial summation of these educational gifts, my primary contribution being my fascination with the subject and my unquenched desire to learn (and shoot) more. If the reader finds this book enlightening, educational or in some way of value, it is simply a reflection that I have been blessed with so many good teachers. Any flaws in the presentation are clearly my own.

Glen Fryxell
Kennewick, Washington

Without Glen, this book would most likely have never happened in its completeness of text on the subject of casting bullets for handguns. His education in the sciences put a finality to the quandary about how and why alloys perform (or don't perform), both in the mould and in the bore. Glen is one of a handful of friends I have who looks past my stubbornness and basic anti-social behavior to have many deep discussions about cast bullet use and performance.

To the men who were responsible for my education and training (my father, Uncle Rex, great-Uncle Gus Perot, etc.), I have said thank you and farewell, for they have all passed from this earth, as I will one day also.

I have a few of the dearest friends anyone could hope for. To them I owe many thanks, not only for their encouragement for me to keep writing, but in many other things as well. For anyone who learns anything from this book, or who receives much needed help of advice, you can thank my lovely wife Marilyn for sorting out my hand-written scribbling and putting it all into an intelligible type-written manuscript. Without her, none of this would be possible.

Each and every day, I thank God for the wonderful life I've had and for his Son, Jesus, the Great Forgiver.

Robert L. Applegate
Prineville, Oregon

About the authors

Glen Fryxell has been fascinated with guns and hunting his entire life, and started hunting early, primarily with a bow and arrow during his teen years, and more recently with handguns. He obtained his B.Sc. in chemistry from the University of Texas at Austin in 1982, and his Ph.D. in chemistry from the University of North Carolina in 1986. Professionally, his interests have centered around environmental chemistry, nanostructured materials, molecular self-assembly and biomimetic processes. On the personal side, he is a hunter, shooter, reloader, and guitar player (of marginal ability). He has been casting bullets and reloading since the 1980s, and has hunted primarily with handguns over the last 20 years, taking dozens of head of big game and thousands of varmints, over much of the western US. His fascination with the use and performance of cast bullets in the hunting fields, in conjunction with his technical background in materials science and chemistry, led him to study the fascinating field of metallurgy in his spare time in an effort to more deeply understand bullet performance in the hunting fields.

Rob Applegate was born with an innate passion to explore anything mechanical. If it moved, or had moving parts, he could not resist the temptation to dismantle all of the various parts in their entirety and find the causes of all the various movements and the forces behind the movements. In short, he was fixated on levers, grooves and pressures.

The keen interest he had in mechanics manifested itself with firearms. As a little boy, he sat in stillness and watched with awe as his father patiently dismantled his sporting weapons and carefully cleaned and oiled each part before reassembling the rifle, revolver or shotgun upon which he was plying his gifted skills. This interest continued throughout all of his young life and beyond high school.

His post high school education was centered around learning as much as possible about mechanics and eventually led to further education as to all of the various methods used to make the parts necessary to assemble machines of all types. After twenty five years of working "under the time clock", the opportunity presented itself for Rob to become a full-time gun maker.

Being an avid shooter and tireless experimenter, Rob eventually became interested in casting bullets for a couple of old rifles passed down through the family to his dad. Bullets for the .40-82 Winchester were not readily available back in the late '50s and '60s, so Rob decided to he would make his own from the Winchester mould that was with the old '86. At that time, all that Rob knew about casting bullets was that "you melt lead in an iron pot, poured it into a mould, and after it cooled you opened the mould and out fell a bullet". Ahem, to say that he had much to learn is an understatement! But learn he did. As time passed, his skills and knowledge about casting bullets improved, along with this skills and knowledge about machining and tool-making.

Most of his work as a custom gun-maker centered around single-shot and leveraction rifles, as well as revolvers. Nearly all of his barrel jobs and related work was for firearms that were dedicated solely for shooting cast bullets. Whether they were black powder cartridge rifles, or the highest quality cast bullet bench rest rifles, the majority were to be used shooting cast bullets. All of the work on rifles and revolvers eventually led to the culmination of a dream and desire that Rob had had since childhood -- to make a bullet mould. Once he had refined mould-making to his satisfaction, he decided to make moulds on a full-time basis. For a number of years he made mould cherries and bullet moulds. During these mould-making years he learned more about bullet design than he thought possible. Eventually, several personal crises befell him, and the shop had to be closed. With most of these tragedies behind him, he would like to share some of his knowledge with the bullet casting fraternity.

With Glen Fryxell's excellent help in all aspects of the entire bullet casting science, we have compiled a work that is hoped will provide assistance to those who desire to shoot cast bullets in handguns. Glen is one of Rob's closest friends.

A few words about safety...

OK, let’s get one thing straight right from the beginning: casting bullets from molten lead can be dangerous. So can handloading ammunition, shooting a gun, driving a car, or operating power tools. However, if one thinks about the hazards associated with each of these practices, recognizes what and where they are, applies a little common sense, follows established safe practices and takes appropriate preventative precautions, the risks can be mitigated to the point that bullet casting is pretty much as safe as collecting butterflies. If you choose to cut corners, ignore safety rules, be lackadaisical or just flat don’t think about what you‘re doing, you *will* get burned, and you may well poison yourself and those around you. Just like handloading, bullet casting is as safe or as dangerous as you make it.

Bullet casting inherently involves hot metal, both the molten alloy that we fashion bullets from and the hot moulds and lead pots. Leather gloves are a good idea (and remember, a hot mould looks just like a cold mould, this is why we put wooden handles on them!). Even very small splashes of molten lead can cause nasty burns and leather does wonders for preventing them. And lead pots do splash -- when adding metal, stirring in flux, or if (heaven forbid!) they encounter any moisture. Keep all sources of moisture well away from your lead pot! A single drop of water can empty a 10 pound lead pot explosively, coating everything in the immediate vicinity with molten lead. If your lead pot is out on an open work bench, even minor splashes mean that safety glasses are a must. I cast with my lead pot wholly enclosed in a laboratory grade fume hood, with a glass sash in place between my face and the lead pot. I leave the little lead splatters in place on the glass sash as a reminder to myself as to how easily these things happen, and for instructional purposes for any new casters that I may be teaching.

Good ventilation is very important to the bullet caster. My fume hood also serves to provide suitable ventilation, not only for the smoke coming off the pot but also for the heavy metal fumes emanating from the pot. Lead fumes are an obvious concern, but more subtle is the fact that wheelweight alloy also contains small amounts of arsenic. Arsenic is kind of a quirk in the periodic table in that it forms an oxide that is more volatile than the metal, and in fact at lead pot temperatures, some forms of arsenic oxide are fully gaseous, so if the arsenic gets oxidized all of it evaporates from the lead pot and is easily inhaled. Use of a reducing cover material helps to prevent this oxidation (see chapter on fluxing).

Fumes are not the only exposure vector that we need to be aware of, teething children like to put anything small and chewable into their mouths, especially if it’s bright and shiny. This includes cast bullets and discarded sprues, making housekeeping an important issue if small children have access to your casting area. This is easily dealt with, keep the sprues contained (heck just recycle them!) and keep the bullets packaged and out of reach of small fingers. Big fingers are an issue too: wash your hands thoroughly after each and every casting session, and again before you eat.

We've all heard about lead poisoning, but what does it really look like? The symptoms of lead poisoning in adults include: loss of appetite, a metallic taste in the mouth, constipation, pallor, malaise, weakness, insomnia, headache, irritability, muscle and joint pain, tremors and colic. Lead poisoning can cause elevated blood pressure, sterility, and birth defects. The most significant site of lead toxicity is the central nervous system, but lead poisoning also impacts the red blood cells and chronic exposure to lead most often results in kidney problems. A child's body is more efficient at absorbing and retaining lead than is an adult's, and lead gets stored in a child's growing bones. The net result is that children are far more vulnerable to lead poisoning than are adults, and since their central nervous systems are still growing and developing, the impact of lead poisoning on a child's life can be far more severe than it might be for an adult, and may include brain damage, mental retardation, convulsions and coma. Responsible handling of lead can prevent these exposures, symptoms and health hazards.

Remember, safety first. Think about what you are doing, take appropriate precautions, use adequate ventilation, and keep your lead out of reach of small children. Bullet casting is a wonderful hobby and one that will allow you to get so much more out of your shooting, but just like handloading, bullet casting is only as safe (or as dangerous) as *you* make it.

Chapter 1. Introduction

A Brief History of Bullet Casting: American Independence

Bullet casting contributed significantly to the independence of the western cowboy, trapper and mountain man. That independence is still valuable today. Just like the mountain man, once the modern caster buys a particular mould he can produce that bullet for the rest of his life, and he doesn't have to worry about whether commercial bullet makers will alter or drop a particular favorite from their line. The ability to produce countless thousands of identical bullets for decades to come reveals what a miniscule investment a bullet mould really is.

History

Originally bullet moulds were made and sold by the firearms manufacturers themselves. Colt was an early player in the mould manufacturing game, making ball and conical bullet moulds for their early cap-n-ball revolvers. Shortly after the advent of the self-contained centerfire (*i.e.* reloadable) cartridge more sophisticated reloading tools became available. Soon after S&W graduated from rimfire cartridges to their centerfire Number 3 .44 American in 1870, they also added loading tools, including bullet moulds, to their product line. In the Remington catalogs of the 1870s are listed bullet moulds made by the Bridgeport Gun Implement Co. (BGI was a partner company, started around 1870 specifically to make loading tools for Remington). Winchester started making iron-handled bullet moulds in 1875 (and in a humanitarian gesture added wooden handles in 1890). In their 1876 catalog, Sharps advertised bullet moulds to make paper-patched bullets for their popular and powerful rifles. Marlin (Ballard) was also making moulds in the 1870s, and in 1881 enlisted none other than John M. Browning's input for a mould/loading tool that he designed and patented, and was subsequently manufactured by Marlin. The Maynard 1873 cartridge had a 5-piece case, very thick cartridge head and Berdan primer. The Maynard loading tools had a bullet mould, as well as a hook and a chisel for prying the spent primers out of the spent cartridge case. One of the more unique moulds from this era is that for the Maynard exploding bullet, a HP designed to be fitted with a .22 blank cartridge, advertised in the 1885 Maynard catalog in .40, .44 and .50 caliber. The 1870s were indeed a time of great change in the firearms industry.

In 1884 John H. Barlow took his experience as a shooter and as a tool and die maker and founded the Ideal Company, offering his patented tong tools to reload spent cases, and later separate bullet moulds for those using bench-mounted presses. These bullet moulds were either single cavity, or 6- or 7-cavity Armory moulds, all with fixed handles at this point.

The landscape was changing dramatically in the firearms industry in the late 1800's and early 1900's, and John Barlow kept pace with his contributions.
His Ideal Handbooks (first published in the 1880's) were the first reloading guides published in America, of critical importance as shooters moved into the relatively

uncharted territory of the then new smokeless powders. In Ideal Handbook #4 (published in 1890), he described the use of cast hollow-pointed bullets for enhanced performance on game animals. In Ideal Handbook #9 (1897) he unveiled the now familiar mould numbering scheme for Ideal's first 150 mould designs. In 1906, Barlow patented the first American gas-checked cast bullet designs to take advantage of the higher velocities available from the new smokeless powders (described later that year in Ideal Handbook #17). In May of 1910, after leading the Ideal Manufacturing Co. for 26 years, Mr. Barlow retired and sold the company to The Marlin Firearms Co., with whom he had worked closely for many years. Marlin sold Ideal a few years later during the first World War to Phineas Talcott (but Marlin remained involved with production of the Ideal Handbook). By 1925 things were not going well and Phineas Talcott sold the struggling Ideal Reloading Tool Company to the Lyman Gun Sight Corporation (founded by William Lyman in 1878), along with the rights to the Ideal Handbook (which was later renamed “The Lyman Handbook“ with #27, published in 1926). Lyman scaled up manufacturing capacity and continued production of the Ideal line of bullets moulds, using the Ideal name into the late 1950s. During this time Lyman introduced interchangeable mould blocks in their single cavity moulds (first advertised in the *American Rifleman* in 1927, and cataloged in 1931), and phased out the older fixed handle style. In 1940-1 (Ideal Handbook #34), Lyman added a special retaining pin to hold their hollow point plug in place during casting. Interchangeable double cavity mould blocks didn’t appear until after World War II (first listed in the Ideal Handbook #36, which was published in 1949), followed soon thereafter by venting lines cut in the faces of the mould blocks. Interchangeable 4-cavity mould blocks were introduced in 1958. Lyman continues to produce many of these mould designs to this day.


Note the lack of alignment pins and the hand-cut vent lines.

Early Ideal rifle bullets were designed not only by John Barlow, but also by such notable shooters as Harry Pope, Col. Townsend Whelen, and Phil Sharpe, among others. In the early 1920s, a vociferous northwestern cowboy, rancher and competitive shooter named Elmer Keith went to Belding & Mull with some of his ideas for experimental revolver bullets. Belding & Mull made the moulds (interestingly, B&M moulds were made out of solid nickel) and Keith assembled and evaluated many test loads using these bullets. Keith learned much from these experiments with cast bullet design, but he never quite got to where he wanted to be. In 1928, shortly after


An Ideal Armory mould for the 360344 wadcutter.

Lyman bought the Ideal Co., he turned to Lyman and asked them to make some bullet moulds according to his optimized designs. Thus was born the Keith SWC. The Keith SWCs have 3 equal width driving bands, a square-cut grease groove, a beveled crimp groove, a sharp wad-cutting shoulder, a compound-radiused ogive for stable long-range flight, and a healthy, meat-crushing meplat. They have proven themselves over the last three quarters of a century as some of the finest revolver bullets of all time. The original Keith SWC was for his beloved .44 Special (#429421), but Keith/Lyman went on to produce similar moulds in other calibers (*e.g.* .357, .45, *etc*.) and in hollow-base and hollow-point variations.

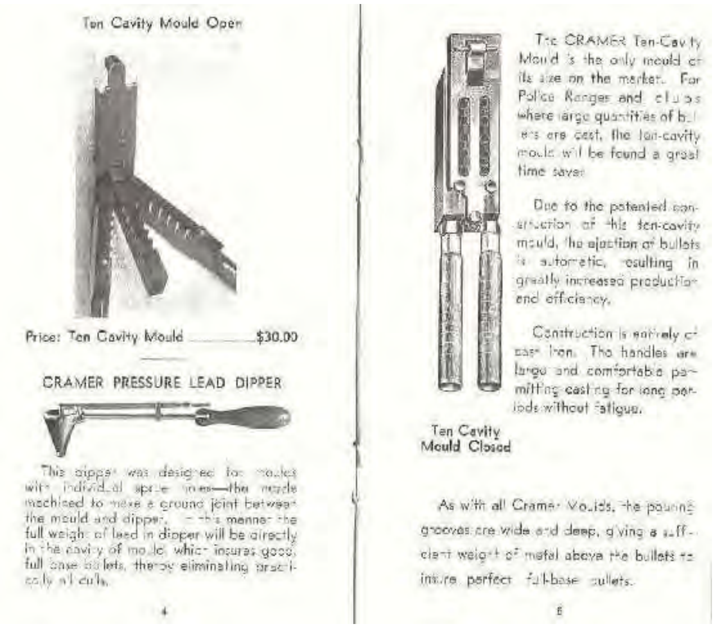
Similar fixed handle moulds were also made by the Yankee Specialty Company. These were made out of bronze and were commonly cut with the same designs as used by Ideal, including the Keith SWC's. Yankee Specialty made 1, 2 and 3 cavity moulds, as well as HP moulds (they claimed to have over 600 designs available). Yankee Specialty was in business from 1916 until the owner died in 1954, although their business volume after 1940 was small. Yankee moulds are commonly unmarked and have simple cylindrical wooden handles that are wired on (although a few are reported to have ferrules).

A copy of the Ideal 452423, made by Yankee Specialty Co. with integral handles (Yankee Specialty also made a few moulds with interchangeable blocks). This Depression-era mould is made from bronze, not iron.

Things got busy on the American bullet casting scene in the second quarter of the 20th century. George Hensley was a machinist involved in the manufacture of all sorts of things (like bicycles, a gasoline fired marine engine, etc.), as well as doing general machine work and repair, with his company that he started in 1893. In 1932, he started turning out some top-notch moulds from his shop in San Diego in response to the demand for multiple cavity moulds needed by police departments. The P.D.'s had to supply practice ammunition for their officers and needed moulds capable of casting larger numbers of bullets than what was generally available at the time. The Great Depression meant that budgets were tight, and affordable practice ammo was a significant need, just as it is today. James Gibbs was a farm boy from the Midwest who was very mechanically inclined and was operating a small gunsmithing shop on his own. James met up with George Hensley in the late 1930s as a result of their common interest in firearms, and Mr. Hensley quickly saw James' talents and the two struck

A well-used Hensley & Gibbs 10-cavity #51BB .38 semi-wadcutter mould (note the particularly massive sprue plate).

on an agreement for James to help George out in the shop making moulds. Hensley & Gibbs worked together from 1938 to 1940, when George became too old to work in the shop. Eventually, he sold the business to James in 1950. The partnership of Hensley & Gibbs produced some of the finest moulds ever made, including 6, 8 and 10 cavity gang moulds that were the mainstay for many police departments and shooting clubs. Their reputation for quality was such that Elmer Keith went to H&G in the early 1960s to get them to re-introduce the original Keith SWC designs after Lyman had modified his design (much to his displeasure) by changing the width of the driving bands and going to a smaller, rounded grease groove. Keith was very pleased with the H&G products. Initially, H&G operated out of San Diego, but in 1964-1965 moved to Oregon's historic Applegate Valley, to the small town of Murphy. Wayne Gibbs eventually took over for his James (his father) and Wayne continued to run the family business until the mid-1990s. Hensley & Gibbs moulds are now available through Ballisti-Cast Manufacturing.



Ten Cavity Mould Open

Price: Ten Cavity Mould $30.00

CRAMER PRESSURE LEAD DIPPER

This dipper was designed for moulds with individual sprue holes—the nozzle machined to make a ground joint between the mould and dipper. In this manner the full weight of lead in dipper will be directly in the cavity of mould, which insures good, full base bullets, thereby eliminating practically all culls.

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The CRAMER Ten-Cavity Mould is the only mould of its size on the market. For Police Ranges and clubs where large quantities of bullets are cast, the ten-cavity mould will be found a great time saver.

Due to the patented construction of this ten-cavity mould, the ejection of bullets is automatic, resulting in greatly increased production and efficiency.

Construction is entirely of cast iron. The handles are large and comfortable permitting casting for long periods without fatigue.

Ten Cavity
Mould Closed

As with all Cramer Moulds, the pouring grooves are wide and deep, giving a sufficient weight of metal above the bullets to insure perfect full-base bullets.

5

Advertisement (circa 1939) of the unique Cramer 10-cavity gang mould.

Cramer Bullet Mould Co. (of North Hollywood, CA) started producing some very well-made cast-iron moulds sometime around 1937. They made 2, 3 and 5-cavity moulds, as well as the more typical 6, 8 and 10-cavity gang moulds. Cramer's 10-cavity gang moulds were constructed of a unique, patented design. There were two parallel rows of 5 cavities each, with 3 mould blocks (a center block, and the two outer blocks with handles mounted). The sprue plate, instead of swinging through an arc (as most do) was grooved such that it was struck to move down the long axis of the mould, away from the caster. Only after the sprue had been struck could the mould be opened. It was claimed that this enhanced production rate and efficiency. In December of 1951 Santa Anita Engineering Co. (better known as SAECO, who made lead-pots and lube-sizers in Pasadena, CA) took over production of the Cramer line of moulds, and focused mainly on 2 and 4-cavity moulds. In 1971, Saeco added 8-cavity gang moulds to their product line. In 1985, Saeco was bought out by

A Cramer 5 cavity .38 wadcutter mould.

Redding (the well-respected makers of precision reloading dies) and moved to Cortland, NY. Redding has made Saeco bullet moulds ever since. The 8-cavity bullet moulds were phased out in 2002.

Bond Manufacturing Co. appears to have started in the mould-making business sometime around 1910. Shortly before WW I, they teamed up with Modern Equipment Corp., and officially changed the name to Modern-Bond shortly after the War to End All Wars. They made all manner of reloading tools, but especially bullet moulds. Modern-Bond appears to have closed up shop in 1951. “The Modern-Bond Corporation was the originator of the interchangeable block moulds which have been extensively copied by other manufacturers.”, so states the


Picture of a Modern-Bond F-257-730 mould (a .25 caliber 86 grain GC-RN), showing the unique black lacquered handles of the Modern-Bond moulds.

Modern-Bond ads appearing in the *American Rifleman* back as early as 1927 (in response to Lyman/Ideal's ad claiming to have invented the concept). This was turf-staking claim was brought on when Lyman/Ideal started making interchangeable single-cavity mould blocks in 1927 (even though they weren't cataloged until 1931). Modern-Bond may have had some sort of patent protection on multiple cavity moulds with exchangeable blocks, which might explain why Lyman didn’t produce such moulds until 1949 (although George Hensley certainly did in the 1930s). In any event, Modern-Bond turned out an extensive line of both rifle and pistol designs in well-made 2-cavity moulds during the 1920s up through about 1950. If a prospective customer wanted to examine a Modern-Bond bullet design “in the flesh” they would send sample bullets through the mail for a nickel apiece.


A single-cavity Herter's .38/.357 SWC mould mould cut by Lyman, with a 358156 cavity, with the Herter's sprue plate.

The Herter’s mail order catalog contained gear to outfit just about any flavor of outdoor adventure, from fly-fishing, to back-packing, to bow-hunting, to fur trapping. Included in this Nirvana of the Northwood's was an extensive selection of bullet moulds for the casting enthusiast. Generally, these mould designs and mould numbering scheme were identical to Lyman's, revealing the origin of their mould blocks (which by the way are un-marked), although sometimes Herter's just labeled the mould with bullet diameter and weight. All of the Herter's moulds I've seen were single-cavity, but their catalogs listed double-cavity moulds as well. The Herter's sprue plates were slightly different than the Lyman sprue plates, having a small tab bent over the edge of the blocks to serve as a stop instead of the Lyman method of having a stop-pin mounted in the mould blocks. The sprue plate was also stamped with "HERTER'S INC. WASECA, MINN. U.S.A.", along with the mould design number, and the sprue plate pivot screw had no "keeper" screw. Herter's extensive selection of moulds included HP moulds for the .32-40 and .45-70 rifles, but the only pistol HP cataloged in 1969 was for the .32-20 (31133). A number of HB mould designs were cataloged for both rifles and pistols. The 1968 Gun Control Act seriously bit into Herter's business, and they eventually folded up shop. Used Herter's mould are still encountered today, albeit it infrequently.

Lachmiller of Glendale, California entered the loading tool business in 1952, and offered a complete line of reloading tools, dies, sizers, presses, etc. In 1969 Lachmiller introduced a line of well-made 2 and 3-cavity bullet moulds. Lachmiller continued to make bullet moulds into the 1970s, but then sold off their product line to RCBS in the later part of that decade.

A Lachmiller 3-cavity .38 SWC mould.

RCBS mould .40 caliber FP.

Ohaus started offering bullet moulds in a big way in 1972, entering the market with 68 different bullet designs, as well as 19 round ball moulds. Ohaus moulds were cut with tungsten carbide cherries for durability and consistency. A few years later RCBS bought out Ohaus, and continues to produce many of these bullet moulds today.

Lee entered the bullet mould market in 1973, offering inexpensive aluminum moulds that have allowed beginning casters to get started affordably. Their 6-cavity pistol moulds (which were introduced in 1989) provide an affordable way to make a pile of pistol bullets in a hurry.

Lee 6-cavity .45 ACP TC mould.

Stepping back and looking at the overall picture of bullet mould manufacture in America, we see production of bullet moulds shifting from the firearms manufacturers to stand-alone companies that made reloading tools from the 1880s through the early 1900s. This was followed by a flurry of activity in the middle half of the 20th century, especially in the post-war 40s and 50s. Then, through the course of mergers, buy-outs, and closures we see the number of outfits making bullet moulds dropping off towards the end of the century. As the 20th century closed, there were 4 major manufacturing houses still producing bullet moulds; Lyman, RCBS, Saeco (Redding) and Lee. Of course, there were also a number of smaller shops offering specialty and custom mould making services, such as NEI, Hoch, LBT and Rapine. Sadly however, great mould makers like Cramer, Lachmiller, and Modern-Bond are heard from no more. To cast with one of their rugged moulds is to relive history with sweat, smoke and vintage iron in your very hands.

Why do we cast?

Back in the days when Elmer Keith was drawing up 429421, a shooter's *need* for bullet casting equipment was much more of a driver than it is for us today. Living on remote ranches in the Pacific Northwest in the 1920s, availability of reloading components was limited and mail-orders were slow and of spotty reliability. Keith's ministrations (as well as those of other gun-writers of the day) were well-received by the American shooting public and the popularity of casting grew in the 1940s and 50s to a kind of Golden Age of Bullet Casting, in which most serious handgunners had an assortment of moulds with which to feed their "flock". In recent decades, this tendency has all but disappeared. Today, we have more manufacturers turning out a greater selection of higher quality components than ever before. High-volume businesses, with massive inventories, have sprung up to scratch most every conceivable shooter's itch. As a result, in today's world of e-business, it's no problem to rattle off an online order and have it accurately filled and on your doorstep in 24-48 hours. Time's have changed, indeed! Given this "Land of Milk and Honey" why would anyone want to cast their own bullets? Why not just reap the advantages of cast bullets by shooting those available commercially? There are quite a few cast bullets available commercially, and virtually all of them are have a Brinnell hardness number (BHN) of 20 or greater, and are decorated with some mysterious flavor of gaily colored hard lube. We, as Americans, have a tendency towards the thinking that "if a little is good, then more is better", so if Elmer Keith's beloved 429421s cast of 16-to-1 alloy had a BHN of 12 and were good, then a commercial hard-cast bullet with a BHN of 22 must be better, right? Nope, hard bullets certainly have their place, but they are generally not ideally-suited for routine revolver shooting (these reasons behind this will be developed in more detail in the alloy selection chapter). So why are commercial cast bullets so hard? Remember the bit about living in a world of overnight delivery? The reason that commercial casters make their bullets so hard is so they can withstand the rough and tumble conditions of shipping. What good are those lovely 429421's at a BHN of 12 if they show up on your doorstep, dinged, dented and out-of-round? Commercial cast bullets are cast that hard as a means of damage control, plain and simple. The home-caster has the freedom to cast bullets whatever hardness his specific load and gun require, without worrying what some unknown freighter is going to drop on them. Once again, the ability to cast one's own bullets provides independence from external worries.

Commercial casters generally tend to cast only those bullets that are available for casting machines (*e.g.* Magma), in an effort to maximize their output. After all, their bottom-line is "time equals bullets, and more bullets equals more money".

Almost invariably, these machine moulds have rounded features, and are bevel-based (BB) to insure that the bullets release easily from the mould, thereby speeding up production rate. If you don't want one of these generic designs, or you're looking for a specific profile for a specific application, or if you don't like BB bullets, then you're pretty much stuck. On the bright side, there are a few shops that still cast from hand-held moulds and offer traditional PB designs like the Keith SWC's, etc. But remember, these are hand-made bullets, not mass-produced from a casting machine, so you can expect to pay extra for their hand-crafted services.

If you want designs that are even more time-consuming to cast, like traditional hollow-base bullets for some of the old black powder cartridges, or cast hollow-points for hard-hitting hunting loads, not only are these mould designs slow to cast and therefore more expensive to produce, but they are very poorly served by the hard alloys used by commercial casters (BHN of 20). Casting your own bullets provides the independence to produce these bullets at will, in your exact alloy of choice -- no worries, no waiting.

Commercial bullet casting is a business, plain and simple, and the product line is going to be dictated by business volume. The commercial caster is going to sell a lot of .38 WC's, 9mm RN's and .45 SWC's, so that's what they are going to produce. That's just good business sense! But what if you have a .40-50 Sharps Bottle-neck, or a .405 Winchester, or a .41 Long Colt, and need bullets of an unusual diameter and you don't feel like paying a buck apiece (or more) for custom jacketed bullets? Or you don't want to wear out a valuable old, soft barrel? The purchase and use of one bullet mould will keep you and your cherished piece of firearm history shooting for many, many years.

Imagine being able to call up Hornady (or Nosler, or Sierra, or Speer) and saying, "You know, I really like your .357 JHP's, but they don't expand quite the way I want in my favorite load. I need some with a core composition of 2% tin, no antimony. When can you have, say, 500 of them ready for me?" Or, "Your 250 grain .45 RNFP is a great bullet, but it's .451" diameter and I need it made with a diameter of .454" for my old Colt SAA. How soon can I get a couple hundred?" Obviously, a major commercial bullet manufacturer would go broke trying to satisfy such requests, but the shooter who casts his own bullets can make these adjustments easily, and have the results ready to shoot *today*. Once again, we return to the central theme of "independence".

With the resurging interest in cowboy action shooting and traditional guns and loads, once again shooters are turning to hot, smoky moulds to produce their projectiles. Partly for nostalgic reasons, partly for period authenticity, but also I think partly because the modern day shooter likes to feel that same independence that the cowboys and mountain men of the late 19th century felt. There is something very satisfying about making your own bullets.

Yes, the hobby of bullet casting can fuel large volumes of inexpensive shooting; yes, cast bullets are gentler on the rifled bore; yes, it is a very satisfying hobby that allows the shooter to put more of themselves into their shooting and therefore to get more out of it; and yes, cast bullets allow some fine old guns to be shot that could not be shot otherwise, but in the end, bullet casting all boils down to independence. It provides the shooter with the ability to produce as many bullets of whatever diameter, whatever design, and whatever composition, as they want, for the rest of their life. It is precisely this sort of self-reliant independence that made America strong. God bless America!

Chapter 2: Casting 101
Casting Basics

Shooters who cast their own bullets add a whole new dimension to their handloading endeavors. As a bullet caster, you will open new doors to experimentation with ammunition and you will become your own bullet supplier. This chapter will deal with the physical details of casting bullets.

The old phrase “the best place to start a task is at the beginning”, is in a way, humorous, but also very true in learning the techniques and the science involved in casting bullets. Safety of the bullet caster is of utmost concern to the authors and it is at this point that you are reminded to please study the chapter on safety before undertaking the melting or pouring of lead alloy. Assuming you have studied the chapter on safety, we will proceed to learn the art and science of casting your own lead alloy bullets. The chapters following this one will go into detail about the various bullet alloys, bullet hardness, bullet lubes, to gas check or not to gas check, and fluxing the alloy.

Cleanliness and purity in the alloy you use and a good clean mould are paramount to making good bullets. Any volatile solvent, even in the form of vapor, will prevent complete fill-out in the cavity and no useable bullets can be made until the mould is completely free from any petroleum distillates or other solvents.

If you are a beginning caster and are starting with a brand new mould, you may have a patience-taxing task ahead of you; please do not lose heart! Breaking in a new mould will net more than just a good casting mould, it will give you a life-long companion for your shooting activities. Mould break-in involves oxidizing the cavity interiors. This is accomplished first by pre-heating the mould on top of your melting pot (provided you have a large enough ledge on your pot to safely hold the mould with it’s handles), and second, by casting bullets in the mould. The time you spend pouring bullet alloy into the cavities of your new mould will give you experience in the techniques of pouring, controlling the alloy, learning how it reacts to temperature changes, and the effects that the pouring rate and temperature have on the quality of the bullet.

Working with good equipment will make it easier for you to learn the skill of bullet casting. High quality expensive equipment is not mandatory for casting good bullets, although it certainly makes learning easier for the beginner and lessens the likelihood of frustration. As our good friend John Taffin likes to say, "Cheap equipment is too expensive!". Good tools make the job go easier, and will provide a lifetime of service.

Your first need in getting started will be a very well ventilated and dry area in which to set-up your equipment. No water can be allowed to come in contact with the molten alloy. A fan may be necessary to move hot and contaminated air away from the casting area. It is best to situate the fan so the moving air flows over the top of the pot and does not blow directly on it.

A good quality melting pot will be your first large investment. Whether the pot is a ladle pour or a bottom pour, it should have a temperature control on it calibrated in degrees (although this calibration scale may not be all that accurate, it gives you a means of reproducing those conditions that work best for your particular equipment). If you choose a bottom pour pot, it should have a rugged, adjustable pouring valve. If you choose to use a separate heating source and melting pot, it will be necessary to purchase a casting thermometer so you can keep track of the alloy temperature (these are available from a variety of sources and commonly cost less than $10).

Your next investment will be a mould suitable for the caliber you wish to supply bullets for. Generally it is easier to cast bullets of .38 caliber or larger and of short, simple design. Learning the skills of obtaining good quality bullets will require much less effort and concentration on your part by starting out with a mould designed to cast bullets designed for handgun use. The beginning caster will learn how to regulate the flow of the alloy to achieve complete fill-out of the cavity for high quality, uniform bullets. You will become familiar with the feel of the mould/handle assembly in your hand as the alloy fills the cavity and the sprue countersink. Each type of cavity and each size of sprue hole has a particular flow rate and temperature where it produces the best results.

The next two purchases you make will be the alloy and flux you intend to use. As mentioned earlier, separate chapters on fluxing and the properties of the various alloys follow this one and you will need to study those before doing any casting or making any purchases.

The next two items are ones you most likely already have. You need an old towel folded up so the still hot and slightly soft bullets will have a soft surface to fall upon ejection from the mould. The other item is a hardwood stick or piece of 1” dowel about 12” – 14” long. The length and diameter are not critical as long as you are comfortable using it. This hardwood rod will be used to either push or tap open the sprue plate after making a cast in the mould. A piece of handle from a rake or hammer can work well for this purpose and may be something you already have in your garage or shop.

The last remaining item will be a scooper/stirrer you can use to stir in the flux and scoop the sludge from the top of the melt. A wooden handle is very valuable here as this tool routinely gets very hot in use. Do NOT use aluminum or anything containing zinc in your alloy. Also do not use any kind of eating utensil, as it will be heavily contaminated with lead in use and might get mixed back in with the silverware, poisoning whomever eats with it.

Now that you have accumulated all of the necessary tools and equipment and have studied the pertinent casting information in this book, you are ready to heat up the pot, warm the mould blocks which are assembled to their handles, and start pouring bullet alloy into your mould cavities.

Just a reminder before you start heating up the pot: REVIEW THE CHAPTER ON SAFETY FIRST!

Make sure the mould is completely clean. Alcohol can be used for a final cleaning (and is good for removing petroleum distillates and other solvents). Most of the solvents used for electrical and automotive brake lining degreaser work well for initial cleaning and removing preservatives and cutting oil residue left in the mould from the manufacturer.

Assuming you are using an electric melting pot, plug in the power supply cord as per the manufacturer's recommendation. Set the thermostat to about 750^{O}. While the pot is warming with the ingots of clean bullet alloy resting inside the pot, place the complete mould on the ledge of the pot so the blocks themselves are actually on the ledge and NOT the wooden handles. This will allow the mould blocks to slowly preheat.

Once the alloy in the pot has melted, it will need to be fluxed, stirred, and later skimmed of the dross (crud) that has floated to the top. After the fluxing operation is concluded, you are then ready to take hold of the wooden end of the mould handles and start filling the cavities with molten bullet alloy from the pot. If you are using a ladle, place the ladle over the pot and begin allowing it to heat, by very slowly lowering the ladle into the melted alloy. When fully submerged, leave the ladle head in the alloy for a couple of minutes to thoroughly heat soak it to the same temperature as the alloy. Go ahead the remove the ladle full of alloy and pour the alloy back into the pot using the pouring nozzle. Repeat this process a few times to get used to the feel of pouring through the nozzle and seeing how the alloy behaves while being poured. The lead alloy, when at the correct pouring temperature, will flow much like water or very thin oil. Now you are ready to pour lead alloy from the ladle into the mould cavities.

If you are right handed, it may be easier to hold the ladle in your right hand and the mould in your left. Turn the mould top face (sprue plate) vertically so the sprue holes face to the right. Now place the ladle's pouring spout (or nozzle) up against one of the sprue plate holes with the ladle pouring nozzle firmly pressed to the sprue pouring hole, and turn both the mould and ladle together as a unit upright, thereby causing a portion of the alloy in the ladle to flow into and fill the bullet cavity in the mould. If you have a two-cavity mould, repeat this process with the second cavity. Place the ladle back in the pot. Wait a few seconds for the alloy in the sprue hole countersinks to solidify (this metal is commonly referred to as "the puddle"). With your wooden rod, push or knock the sprue plate open. Swing the plate fully open. Open the mould and let the bullets fall onto the soft towel you prepared. It may be necessary to tap the handle hinge to eject stubborn bullets. Repeat this whole pouring procedure as many times as needed until you are comfortable with the entire process. As you cast with the ladle you will see a dull looking sludge begin to build up on the ladle and inside the pot. This needs to be fluxed and stirred back into the melt. Now that you have some experience in pouring bullets, you can refine your technique by learning to pull the ladle back enough after the cavity is filled, to leave a puddle of alloy in the sprue countersink. Filling the countersink prevents voids in the bases and concave bases. Both conditions invite leading and inaccuracy caused from improperly filled-out bullet bases.

The process with bottom pour pots is essentially the same as with using a ladle except that the alloy flows directly from the bottom of the pot through the nozzle. A valve to which the handle is attached controls the flow. The handle is mounted toward the front of the pot for easy access.

Some casters have trouble casting good bullets with a bottom pour pot. The only difference between the ladle method and bottom pour method is that the bottom pour pot has the entire vessel full of alloy sitting on top of the nozzle. This condition is generally termed head pressure. Only experience wrought through trial and error will teach you how best to adjust and regulate the flow of alloy on a bottom pour pot for complete fill-out with each design of mould cavity you cast bullets in. Normally, higher temperatures are required when using a bottom pour pot. It may be necessary for the pot temperature to be set as high as 850^{O}. It is recommended that a layer of charcoal or sawdust be placed on top of the melt to protect it from oxidation. This subject is discussed in the fluxing chapter. Keeping the pot only half full may also help eliminate some of the fill-out problems and render the regulation of flow easier to adjust and less sensitive to the technique of the caster. Whether using a ladle or bottom pour casting, the flow of alloy into the cavities of the mould has to be sufficient in volume and pressure to adequately fill out the cavity. You may need to develop a technique of rocking the mould away from the pouring nozzle ever so slightly just as the cavity comes to near full. This allows any air to escape from the top of the cavity during the critical base fill-out phase and it makes it easier to leave a full size sprue puddle. It may be necessary to have a slight air gap between the sprue hole and the nozzle. The amount of gap will vary from one mould to the next and can only be determined by experimentation. Different moulds have can have differing "tastes" in terms of how they "prefer" to be fed: some cast best with a half an inch of free fall for the alloy below the pour spout, whereas others (especially HP moulds) may perform best when "force-fed" (i.e. the mould held directly against the pour spout so the full force of the head pressure helps to force the alloy into the cavity). Recording the settings and adjustments for each mould may save you much set-up time in future casting sessions. Mould guides are available from the pot manufacturers for most of their bottom pour pots. Always fill the sprue plate countersinks with a puddle of alloy after the cavity is full to allow for any shrinkage as the bullet cools. Keep your pour constant and fill both the cavity and the sprue in one continuous smooth motion. Experience is the best teacher in learning these skills, and the more you do it, the better caster you will become.

Do not expect your first bullets to be shootable. You will be very disappointed if you think your new mould will make perfect bullets the first time out. They WILL get progressively better with time (and practice), and soon you WILL be casting perfect bullets. Bullet casting is both fun and profitable because it is something you do for yourself. Relax and enjoy doing it and don’t demand too much from yourself at first. As you progress further along with your casting practice you will notice that your bullets will improve in quality and appearance. This is due to the mould warming up and breaking in and improvements in your skills as a bullet caster. Under normal circumstances once a mould is broken in, it stays that way. Our learned skills and abilities are pretty much the same way. Once learned, they are not quickly forgotten.

Bullets that come from the mould wrinkled, not well filled out, are bright and shiny indicate either a too cool mould or alloy or both. When bullets become frosted and possibly eject stubbornly from the mould, the mould itself is too hot. Moulds that have small cavities and large blocks may need to be placed on a warm hot plate until they begin casting properly. You may need to do this occasionally throughout the casing session. Moulds with small blocks and large cavities may need to be set aside for brief periods to cool throughout the casting session. Advanced casters sometimes cast with two moulds alternating between the two to keep them at ideal operating temperatures. If the mould has a tendency to overheat, a fan can be located to blow on the mould while you are ejecting the bullets. NEVER, EVER, PUT YOUR MOULD IN WATER WHILE IT IS HOT! The mould will be warped beyond repair and steam and hot water may scald you.

Bullets with unfilled bases or air pockets may need a bigger sprue puddle. If the bullets are frosted, you will need to cool the mould slightly and turn down the temperature setting on your pot to about 50^{O} – 100^{O}. Bullets that show a cold mould condition will require the alloy temperature to be increased by 50^{O} – 100^{O} and more casting with the mould to bring it up to efficient operating temperature.

The following paragraphs are a brief summary of what we have covered in this chapter and can be used as a quick reference.

1. Safety is the primary concern when working with molten metal. A ventilated workplace is mandatory. Make sure the type of ventilation method you choose, pulls the harmful vapors and hot air AWAY from you. Always dress yourself in suitable protective clothing, such as closed top work boots, leather apron, gloves, and face protection before the alloy

melts. NO WATER should be allowed anywhere near the casting area. Water coming in contact with molten lead will cause a violent explosion.

2. Pre-heat the mould on the large ledge at the top of the pot. Cast bullets for awhile to finish warming the mould.
3. Shiny, wrinkled bullets indicate a cold mould. Keep casting bullets until the mould is up to temperature and/or turn up the pot temperature 50^O to 100^O.
4. Frosted bullets indicate a too hot mould. Allow the mould to cool for awhile and/or decrease the pot temperature 50^O – 100^O.
5. Wrinkled, poorly fill-out bullets coming from a hot mould indicate petroleum distillate in the mould or on the sprue plate. If the mould was thoroughly cleaned before casting was begun, the heat from the alloy should eventually remove the petroleum vapors with further casting. This will be obvious if the quality of the bullets improves with further casting.
6. An adequate flow of lead has to be maintained while the cavity is filling and to also fill the sprue countersink. Alloy has to be forced into all areas of the cavity to make a fully formed bullet. Head pressure in bottom pour pots can only be regulated by the level of the lead in the pot. The flow is regulated by the adjustment at the handle that limits the amount that the valve is opened. Too much head pressure accompanied by overheated alloy can actually force lead into the cavity with such force that it causes bullets to stick in the cavity and will also cause fins on the bullet where the lead has flowed out into the vent lines. Sticking bullets will require using the wooden rod that you use to open the sprue plate with, to whack the hinge area of the handles to jar the bullet loose from it's stuck position in the cavity. If the alloy is at normal casting temperature and the bullets are not filling out, try either increasing or decreasing the rate of flow at the nozzle. And record your settings for future set-ups.
7. If the sprue plate swings back over any part of a bullet's base, it will prevent that bullet from falling freely from the cavity.
8. Drop the bullets from the mould onto a soft towel-like surface to prevent damage to the still hot and somewhat soft bullets.
9. SAFETY FIRST!

Before the bullets can be loaded and shot, they must be lubricated and sized. Several manufacturers of casting equipment offer excellent sizer lubricators. The basic lubrisizer unit is fitted for interchangeable sizing dies and nose punches. Study the chapter on determining the correct size bullet for your application. Once the correct bullet diameter has been determined and the die and nose punch has been acquired, you are ready to fill the lubrication reservoir and ready the device for use. Follow the manufacturer's directions for installing the die, nose punch, and filling the reservoir. For flat-nosed bullets, a universal nose punch can be used, which insures that the bullet will self-center in the sizer die.

Some bullets require the use of a gas check. So long as the gas check shank of the bullet fits the gas check, the check can be placed on the shank with the fingers before placing the bullet on the plunger of the die. A separate section on annealing gas checks is included in Chapter 11.

Once the lubersizer is set-up and ready for operation, you are ready to set your first bullet on the sizing die, lower the operating handle and push the bullet down into the die. For the Lyman and RCBS style lube-sizers, turning the handle counter clockwise on the lube plunger screw pulls the lube plunger into the lube changer and forces lube through the holes in the die and into the lube grooves in the bullet. It may take several cycles of lubricating bullets to bleed all the air from the chamber and die. Air pockets in the lubricant chamber and die will result in incomplete filling of the lube grooves. On occasion, portions of lube grooves will not want to fill and will require cycling the bullet back into the die with lube pressure applied on the die to fill in the vacant area in the lube groove. It may not be necessary to tighten the screw any further if enough pressure is already applied. Most of the time, passing the bullet back through the die once will be adequate enough to fill in the groove with lube. The die has holes drilled through it at intervals to allow the lubricant to pass from the chamber of the lubersizer into the interior of the die. With handgun bullets it is a fairly easy matter to align the grease groove(s) in the bullet with the holes in the die by adjusting the depth stop located at the bottom of the lubersizer. With most handgun bullet types when the grease groove in the bullet is aligned with the grease hole in the die, the groove will fill with grease on the first pass. Bullets with multiple grooves will have the grooves filled as the grooves pass by the holes in the die on the way down into the die and on the way back. Now that your first batch of bullets are lubricated, sized, and/or gas-checked, the lube chamber plunger screw needs to be backed off about one full turn. This prevents grease from bleeding past the die plunger and from between the die body and lubersizer bore. It also relieves pressure from the internal parts and body.

Backing off the screw between uses is also important, if the tool is going to sit unused during seasonal changes where the weather passes from the cold of winter to the heat of summer. Bullet lube expands as it warms. As a result, excess pressure can build inside the tool and crack the housing of the pressure chamber ruining the tool. Heaters are available for your lubersizer in the event that you want to use a hard lube that requires heat to flow properly. Always remember to back off the screw BEFORE using a lube heater. A light bulb placed near a cold tool can warm overly stiff grease so as to make it more fluid to better fill the bullet grooves. Pressure to the screw should only be applied AFTER the lube is fully warmed. If pressure is applied before or during the warming process, excessive pressure can build in the tool and crack the housing. During the lubricating process it will be necessary to maintain enough grease (lube) pressure to fill the grease grooves of the bullet and at the same time not to allow excessive pressure to build that will force lube between the die plunger and the bullet base. With combinations where the bullet is slightly smaller than the die lube will leak around the bullet. Other than being messy and wasting lube this is not a problem as long as the grease grooves are being filled. As in the skill of casting, lubricant pressure regulation will be learned through the experience of operating the tool.

Some bullet designs have a smaller front driving band than the bullet body. With such designs it is essential that you do not allow the bullet to go too deeply into the die. If the undersized driving band of the bullet is allowed to pass below the lube holes in the die, lube will push out into the void and make a mess, which slows production and wastes lube.

Moulds that are not made properly or are out of adjustment may cast slightly out of round bullets. For handgun use this is not generally a problem. The authors of this book have shot surprisingly tight groups from handguns shooting bullets up to .009" out of round. In some cases, no difference in group size was detected between groups shot with perfectly round bullets and these out of round bullets. In other cases, this asymmetry can make a tremendous difference. The only way to know for sure if out of round bullets will have an impact on your shooting, with your gun, is to shoot them and see (adjusting an out of round mould is addressed in more detail in the “Idle Musings“ chapter). When sizing bullets that are slightly out of round, the only noticeable effect will be that of varying depths of crimp and lube grooves. One side will have normal depth grooves and the other side will have more shallow grooves and the variation in depths will depend on the amount the bullets are out of round.

Occasionally, a lubersizer will leave the factory with the bores for the ram and die slightly offset from one another. If you happen to obtain one of these units, please do not attempt to repair it. Return it to the manufacturer for a replacement. It is easy to determine if the unit you are using has offset bores. The bullets you size, no matter how perfectly round they come from the mould, will always be sized heavier on one side than the other. Normally, lubersizers are perfectly made and will last most folks an entire lifetime.

The care you give your equipment both while using and in storing it will determine how well it performs and how long it will last. The modest investment of a bullet mould and a lead pot can provide you with a lifetime supply of bullets.

Chapter 3. Alloy Selection and Metallurgy

Lead was one of the first metals that Man learned to purify and manipulate. There are lead figurines still in existence that date back to 3800 BC. Ancient Phoenician trade in lead is described in Ezekiel, XXVII, 12. The ancient Greeks, Romans and Hebrews also mined and worked lead long before the birth of Christ. It has been used for millenia, in a wide variety of applications. Lead-based plumbing (from the Latin name "plumbium" and hence its chemical symbol "Pb") and lead containing pewter goblets and wine casks were thought to be one of the primary reasons for the downfall of ancient Rome. Lead-based solders made the graceful beauty of medieval stained glass windows possible. Chronic lead poisoning is now known to have killed the musical genius Ludwig von Beethoven (although the source of lead is still a mystery). The United States continues to be a leading producer of lead and it has been mined here since 1621, when the first North American lead mine and smelter were opened near Falling Creek, Virginia. Lead has played a central role in human history.

Lead has been the principle ingredient of bullets for centuries, and its choice for this application is logical: it is dense, easily formed, and widely available. Back when projectiles were patched round balls, it wasn't necessary to alloy it with anything to make it harder, or to get it cast well, because the surface tension of the molten lead made it "want" to go to a sphere anyway. But when bullets started taking on convoluted shapes and started getting stuffed into cartridge cases, then the limitations of pure lead surfaced. In order to get the molten alloy to properly fill out the ridges and grooves of the mould cavity it was necessary to add something to the lead to lower the surface tension. In addition, breech-loading cartridge rifles had arrived on the scene, and brought with them higher velocities that required harder bullets. Initially the answer to both of these problems was found in the addition of small amounts of other metals (e.g. tin) to harden the alloy moderately. To form a simple substitutional alloy, it is necessary that the added metal have a similar atomic size and electronegativity to the primary metal. Tin satisfies these requirements, mixes with lead very easily, significantly improves castability by lowering both viscosity and surface tension, and hardens the alloy moderately well. Everything was rosy, but then those confounded chemists started playing with nitrate esters of various organic materials and suddenly smokeless powder made its somewhat awkward, but spectacular entry. These new developments meant that much higher pressures and velocities were now possible. The cast bullet would need to get harder.

Cast bullets have always been a natural fit for handguns. But keep in mind that the American handgunner of the first quarter of the 20th century was working with loads at less than 1000 fps for the most part. The .38 Colt Automatic and the .38-40 were the hot-rods of the day at roughly 1100 fps (the exception being the .30 Mauser, but there weren't that many in the US during this time, and the .38 Super wouldn't appear until 1929). Men like Phil Sharpe, Major Wesson and Elmer Keith experimented with high pressure loads in some of the stronger guns of the day, but the .357 Magnum wasn't to see the light of day until 1935, and the .44 Magnum had to wait until 1956 to make its appearance. The handloading handgunner of the first quarter of the 20th century was, for the most part, loading cast bullets at about 850 fps. The modest binary alloys of the black powder era (e.g. 20:1 to 30:1 range) were entirely adequate for this ballistic regime.

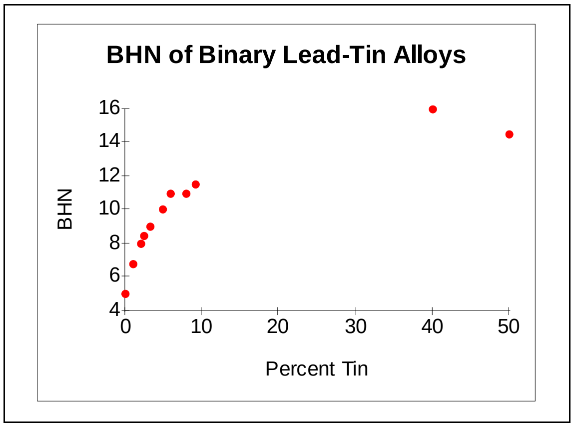
Three things happened, slower pistol powders were developed (2400 came out in 1933), magnum revolver cartridges were invented, and tin got to be progressively more and more expensive. It was found that magnum handguns could be made to shoot well with cast bullets IF they were sufficiently hard ("hard" in this case being somewhere in the 10:1 to 16:1 range, with a Brinnel Hardness Number, or BHN, of 11 to 12). One of the cast bullet's desirable attributes is affordability, but if you're dumping a full *pound* of tin into every 10 pound pot of bullet metal, it can get expensive fast! Thus other solutions were sought for hardening bullet metal.

Metallurgy of the Cast Bullet

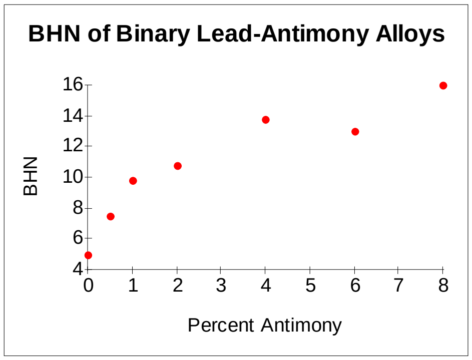
Lead-tin (Pb-Sn). Which metals do we add to lead to make better bullet metal and why? The first and most obvious need here is to make the alloy harder, but there are other factors that play into this answer as well. Historically, tin was used because it was readily available in pure form, mixed easily with molten lead and contributed desirable properties to both the molten and solidified alloy (castability and hardness, respectively). Tin also increases the hardness of the alloy but does not interfere with the malleability of lead (a key point that we'll return to). Tin lowers the viscosity and surface tension of the molten alloy, allowing it to fill out the mould more effectively, resulting in a higher quality bullet. Tin is limited in its ability to harden lead, achieving a maximum hardness of about 16 BHN at 40% tin. These binary lead-tin alloys undergo slight to moderate age softening upon storage (1-2 BHN units), with the harder alloys undergoing more of a change than the softer alloys. The hardness of a binary lead-tin alloy generally stabilizes after about 2-3 weeks. Heat treating binary lead-tin alloys does not provide any change in hardness. At typical lead pot temperatures, lead and tin are infinitely miscible with one another, at the eutectic temperature (361 F) tin is still soluble to the tune of 19%, but at room temperature tin is still soluble in lead at the 2% level, meaning that as the bullet cools down there is significant precipitation of a tin-rich solid solution in the form of granules and needles in a matrix of lead-rich solid solution.

It is important to recognize that tin is well-mixed in the matrix and it hardens lead by making the matrix itself harder.

Lead-antimony (Pb-Sb). Antimony on the other hand hardens lead alloys much more efficiently, with only 1% antimony producing a BHN of 10 while it takes 5% tin to do the same, and it takes only 8% antimony to achieve a BHN of 16,



as compared to 40% tin. The name "antimonial lead" refers to binary lead alloys with 1-6% antimony, with the higher antimony alloys (i.e. those with >1% antimony) commonly being called "hard lead" in industry. While antimony increases the hardness of lead, it does so by impairing its malleability. At typical lead-pot temperatures (ca. 700 F), antimony is only moderately soluble in lead alloys, and as the temperature drops, the solubility of antimony is markedly lower than that of tin. At the eutectic temperature for a binary lead-antimony alloy (484 F), only 3.5% antimony is soluble (note that this is 123 F hotter than of the tin eutectic temperature, but the antimony solubility is less than 1/5 that of tin). At room temperature the equilibrium solubility of antimony in lead is only 0.44%. The precipitated antimony appears as small rods, at the grain boundaries and within the grains themselves. Electron micrographs of lead-antimony alloys clearly show discrete particles of antimony surrounded by a matrix of lead-rich solid solution. In contrast to lead-tin alloys, lead-antimony alloys age *harden*, sometimes as much as 50% or more. When these alloys are air-cooled, some antimony is retained in the lead-rich matrix, and as a result these alloys age-harden as this antimony continues to slowly precipitate. This usually takes 10-20 days to achieve full effect.



It is important to recognize the antimony hardens lead alloys by a fundamentally different mechanism than does tin. Antimony hardens the alloy by precipitation of a separate crystalline antimony phase, which reinforces the squishy plastic lead phase that's in between the hard antimony crystals. These alloys tend to be brittle because the plastic (squishy) lead phase gets its hardness from the reinforcing hard antimony rods. As the matrix gets deformed the brittle antimony rods shear off and the soft metal fails. In the case of the lead-tin alloys, the tin is more uniformly distributed through out the matrix, making the matrix itself harder, so plastic deformation of the alloy is more uniform and progressive, not the slip/shear of lead-antimony alloys.

Multi-component alloys. Tin still improves castability by lowering viscosity and surface tension. Antimony hardens the alloy via precipitation. The tin also helps to alleviate brittleness by combining with the antimony to form an intermetallic adduct thereby improving the solubility, maintaining the hardness. Antimony also helps to reduce shrinkage as the alloy cools. The harder the alloy, the less it shrinks (lead shrinks 1.13%, linotype shrinks 0.65%). In molten lead alloys, tin and antimony react with one another to form an intermetallic compound (shorthand is “SbSn” to show the adduct between antimony, Sb, and tin, Sn). This does a number of things. First of all, SbSn is more soluble in lead than is Sb. In addition, both free Sb and Sn are soluble in SbSn, as is Pb, meaning that the formation of this phase serves to enhance the mixing of the alloy and limit phase segregation and precipitation. When Sb and Sn are present in roughly equal amounts, the alloy behaves as though it’s a pseudobinary system of SbSn in Pb. Electron micrographs of 94% Pb, 3% Sb and 3% Sn (an excellent bullet metal, very similar to WW alloys with 2% added tin) shows globular grains of lead rich solid solution, with an interdendritic pseudobinary eutectic of SnSb phase (for example see: the Metals Handbook: Volume 7, Atlas of Microstructutres of Industrial Alloys, page 304). Similar electron micrographs of linotype alloys show very thin dendrites of lead-rich solid solution, surrounded by a matrix of SnSb intermetallic phase, with much precipitated antimony rich solid solution (this precipitated phase is why linotype bullets are so brittle and tend to shear upon impact).

How these alloys are hardened depends on the composition. The malleability of lead-tin-antimony tertiary alloys depend heavily on composition, particularly on the tin/antimony ratio. When the concentrations of tin and antimony are equal, the alloy behaves as though it’s a binary system with “SnSb” as the diluent in the lead matrix. The phase behavior of SnSb is notably different than that of Sb -- both in terms of solubility and in terms of crystal morphology. Sb is highly crystalline and only soluble in Pb to the tune of 0.44% at room temperature. SnSb appears to be significantly more soluble in Pb and based on electron micrographs of chemically etched samples, significantly more amorphous. As mentioned before, the SnSb phase serves as a mixing agent, serving to help dissolve excess Sb (or Sn for that matter), and having greater solubility in the Pb matrix. This enhanced mixing, along with the reduced crystallinity means that the lead alloys with a 1:1 ratio of tin to antimony behave somewhat like simple binary lead-tin alloys, only harder (this is why Lyman #2 is 90% Pb, 5% Sb, 5% Sn). Hold this thought…

As the concentration of antimony increases over that of tin, at first the SnSb phase serves to dissolve the small amount of excess Sb. At higher Sb concentrations however the SnSb phase becomes saturated and a separate antimony phase begins to precipitate. At this point, the alloy begins to take on some of the brittleness properties of the binary lead-antimony alloys. As the antimony concentration increases, this brittleness becomes more pronounced. So those tertiary alloys which have 2 or 3 times as much antimony as tin (e.g. linotype, 12% Sb, 4% Sn) tend to be more brittle than those alloys of similar hardness with similar Sb and Sn levels. OK, here’s a subtle point, WW alloy (3% antimony, 0.3% tin) can fall prey to this issue as well, although not as severely since its not as hard. But by *adding* tin and making the alloy slightly harder, the alloy also becomes *less* brittle and more malleable due to the formation of SnSb and the elimination of the precipitated Sb phase. Thus, WW alloy with approximately 2% added tin makes an excellent bullet metal with hardness suitable for a variety of applications, and it still can be made harder through heat treating or water quenching. This can also be made using Lyman #2 mixed with an equal amount of pure lead.

Hardness of Tertiary Lead/Antimony/Tin Alloys

Alloy	Composition	Hardness
Lead	- - -	5
Wheelweights	95% Pb, 3% Sb, 0.3% Sn, 0.2% As	12
Lyman #2	90% Pb, 5% Sb, 5% Sn	15
Linotype	84% Pb, 12% Sb, 4% Sn	22
Lead based Babbitt	85/10/5	19
Lead based Babbitt	80/15/5	20

In "Cast Bullets" by E. H. Harrison (NRA Publications) WW alloy +2% tin is listed as giving very good castability and a BHN of 13.6. My own measurements run more like a BHN of 11-12 (undoubtedly due to the variation in WW content), but this alloys does indeed cast very well. Recovered range scrap varies from range to range, depending on the nature of the shooting at that particular locale, but it commonly runs fairly soft (in the BHN range of 8 or so) as a result of all the .22 Long Rifle and swaged .38 wadcutter ammo deposited in with the jacketed and hardcast bullets.

Age hardening of the tertiary alloys is more pronounced in the softer alloys, suggesting that at the higher antimony concentrations precipitation occurs more readily during the cooling process. This age hardening can be accelerated by increasing the aging temperature. In general, measuring bullet hardness 24-48 hours after casting provides the most useful, and timely, information.

Age Hardening of Tertiary Lead/Antimony/Tin Alloys

Alloy	As-cast	6h	48h	6 days	6 months	
Lead	5	no change				
97/2/1	9.2	17.1	20.2	21.6	18.0	
94/3/3	12.4	14.1	16.9	18.2	16.6	(electrotype)
82/12/6 20.3	20.3	20.3	20.1	19.9	17.7	(stereotype)

In addition, arsenic (As) is commonly added to industrial lead-tin-antimony alloys to improve the strength (this strength enhancement is only observed when As is added to a Sb containing alloy, As is virtually worthless in the absence of Sb). Arsenic also significantly enhances the ability of the alloy to be hardened via heat treatment. All that is needed is 0.1% (more does no good). Wheelweight alloy commonly contains about 0.17% As.

Heat treating and water quenching. This age hardening of antimony containing alloys can be accelerated at higher temperatures, i.e. heat treating the bullets. This is most commonly done by sizing the bullets first (since lead alloys work *soften*, and hence sizing would negate a significant portion of the hardness imparted by the heat treating process) then heating them to about 450° F in the oven and quenching by dumping them in cold water. The hardened bullets are then lubed using the same sizing die that was used before (so that no actual sizing takes place). Done in this manner, bullets cast with an alloy containing 5% antimony, 0.5% tin and 0.17% arsenic, which would normally have a Brinnell hardness of a little over 16 (after aging for 6 days), can be hardened to a BHN of over 35 (see Dennis Marshall's chapter "Stronger Bullets with Less Alloying" in "Cast Bullets" published by the NRA). Notice that this alloy is not tremendously different from the common wheelweight. Much the same sort of result can be obtained by casting with a hot mould and water quenching directly (place a towel over the water bucket with a 4" slot cut in it to contain the splashes). Mould temperature is critical for maximum effective hardness. Bullets water quenched from a "cool" mould (i.e. one from which the bullets were smooth and shiny) were found to be similar to air-cooled bullets. But bullets dropped from a mould that was "hot" (i.e. hot enough that the bullets were frosty over their entire surface) were found to have BHN of over 30 when water quenched. In a separate study, such a mould was found to have temperature of 430° F, very similar to the optimum oven temperature found in the heat treatment study (ca. 450° F). I don't normally cast quite this hot, but even so, water-quenching WW alloy routinely gives me bullets with a Brinnell hardness of 18. One of the advantages of hardening bullets in this manner, as opposed to using linotype to make them hard, is that they are tougher and not as likely to shear or fragment on impact.

Why are we so worried about hardness?

In the old days, there was a lot of talk about bullet hardness, and how soft bullets could cause leading by having the bullet metal getting scraped off as the overly soft bullet traversed the bore. But keep in mind, in the old days, they considered a pure lead bullet "soft" (with a BHN of 5) and a 16-to-1 bullet "hard" (with a hardness of 12 BHN). We cast with harder alloys today, and what is considered "hard" and "soft" today is very, very different than in pre-WWII America. The problem is, the Oldtimers spoke in terms of "hard" and "soft", not in terms of measured hardness values, so a new caster going back and reviewing the older casting literature is easily confused about what causes leading (addressed in detail in a later chapter). Commercial casters almost universally exploit this confusion and use it as a part of their sales pitch, touting their hard-cast bullets (commonly with a BHN of 18-22) as being the perfect remedy to prevent leading. T'ain't necessarily so, Compadre. Extra hard alloys can actually *cause* leading (again, see the chapter on leading for a detailed explanation of this). The bottom-line is if you're casting bullets for typical revolvers (standard and magnum, ignoring rounds like the 454 Casull, which is a case unto itself, see chapter on GC bullets), and you are using an alloy with a hardness of at least 11 BHN, any leading you observe is not caused by the alloy being too soft. Remember, Elmer Keith used the Lyman 429421 cast of 16-1 with a BHN of about 11 for the .44 Magnum. What is surprising is that today is all these newcomers that get all hot and lathered worrying over whether their 20 BHN bullets are too soft!?!

Obturation. OK, if we know that soft bullets with a BHN of 6 can cause problems, why don't we just cast everything out of linotype? If a little hardness is good, then more is obviously better, right? Well, aside from being a really expensive way to make cast bullets, there are some physical drawbacks to this approach. Obturation is the plastic deformation of the bullet metal in response to the applied pressure (from the burning powder). Cast bullet obturation was extensively studied and characterized by Dr. Franklin Mann over a century ago, and summarized in his most excellent treatise *The Bullet's Flight from Powder to Target*. Using soft cast bullets, he observed bullet swelling from several thousandths of an inch to several calibers, depending on the conditions employed (pressure, barrel condition, etc.). Modern barrels are exceptionally well-made, but there are minor imperfections (one or two ten-thousandths of an inch) in groove diameter, the width of the lands and grooves, minor local variations in twist rate, etc. As the bullet is engraved, these minute imperfections result in an imperfect seal between the bullet and the bore. The defects in this seal will be the same size as the variation in the dimensions. Since the hot gas molecules that are driving the bullet down the bore are less than one ten thousandth this size, gas leakage is a problem. A lot of attention has been paid to groove diameter and hand-lapping or fire-lapping to make this diameter more uniform through the length of the bore. Another issue that is also addressed by such lapping is that of the grooves and lands. If the grooves and lands vary in width, then this seal also is compromised. The forward edge of the land isn't so much of an issue because the bullet's forward momentum continuously drives it into this edge, forcing this seal closed. It's the trailing edge where the seal is compromised if the dimensions vary. This is why it's not uncommon to see leading "follow the rifling", the trailing edge seal was compromised and the gas-leak cut the bullet metal at this point and deposited the metal fouling at its point of generation. By matching the bullet hardness to the pressure of the load, we can exploit obturation to prevent this problematic fouling. By reacting to the applied pressure, the bullet metal can undergo plastic deformation to conform itself to the local profile of the barrel, and help to maintain the seal.

It is important to recognize that obturation is not simply an increase in bullet diameter, it is also a backfilling of defects obtained in the engraving process, and therefore plays a role in every shot fired with a cast bullet, even those that are properly (or over-) sized for the bore.

Some folks don't like to believe that obturation plays an important role in cast bullet performance. These "naysayers" like to point out that this mechanism only operates at the peak pressure of the load, which only applies to a short period of time and a small stretch of the barrel. This is not true. The models and correlations that experimental ballistician's have put together to explain the observed behavior generally tend to correlate peak pressure to bullet hardness. This is simply the model that we use to explain the observed data. All metal undergoes some response to applied pressure, the magnitude and speed of that response depend heavily on the hardness of the metal, but lead alloys are soft and the degree of deformation is proportional to the applied pressure. It is important to also note that the rate of gas leakage (and hence gas-cutting) is also a direct function of applied pressure. Thus, peak pressure induces the most and fastest obturation, and enhances the bullet/bore seal when it is needed most, at peak pressure. Lesser pressures at other points along the P vs. T curve induce smaller (and slower) degrees of obturation, that still play a role in maintaining this seal. Obturation is not an on-off switch that only operates at peak pressure, that is simply how the models that have been applied to explain it work.

Obturation is also supported by the sealing effects of the bullet lubricant (see lube chapter). In the absence of obturation, the entire burden of sealing the bullet/bore interface falls on the lube. With a top-notch lube this can be accomplished, but building teamwork between the alloy and the lube is a better way to do things. Is obturation necessary for good cast bullet performance? No. But it IS a tool that we can make use of and make work for us, so why not take advantage of it?

Hardness. So we want to make sure that a bullet isn't too soft, or leading will result through galling and abrasion, and we want to make sure that it isn't too hard so we don't lose the beneficial effects of obturation, and fall prey to leading through gas-cutting. Does that mean that we have to hit a very specific hardness for each cast bullet application? Thankfully, the answer to that question is "No". Rather, there are a range of hardness's that serve very well for each pressure/velocity level.

Application	**Useful Hardness Range**
Light target loads (<800 fps and 10,000 psi)	BHN 6-12
Standard revolver loads (800-1000 fps, 16,000 psi)	BHN 8-14
+P revolver loads (1000-1200 fps, 20,000 psi)	BHN 10-16
Magnum revolver loads (1200-1500 fps, 35,000 psi)	BHN 12-20
454 Casull (1400-1800 fps, 50,000 psi)	BHN 16 and up

The lower end of each of these hardness ranges will expand somewhat in each of these applications. Harder bullets can be used, but they won't obturate meaning that you'll have to use a lube capable of sealing the system, since the bullet cannot contribute to this critical job. Hard lubes probably won't work here. Note the recurrence of BHN 12 in many of these ranges, and remember that's what the Oldtimers used to think of as a hard bullet. We'll come back to this thought….

Alloy Selection

OK, let's review: antimony hardens lead alloys considerably more effectively than does tin, and costs much less, meaning that you get significantly more hardness for your casting dollar. Where do we get lead-antimony alloys so we don't have to use up all of our valuable tin? In the first half of the 20th century, the most common source of lead/antimony/tin alloys was linotype (84% lead, 12% antimony and 4% tin). As this was the age of offset type printing and “spent” linotype could be found virtually anywhere that had a local newspaper. By mixing linotype and pure lead in various ratios, one could obtain bullet metal suitable for widely varying applications. Now that various electronic printing methods have displaced offset type, linotype is becoming increasingly difficult to come by, and relatively expensive. On the bright side however, we have more automobiles in the United States than ever today, and with cars come tires, and with tires come wheelweights (96% lead, 3% antimony, 0.3% tin and roughly 1% “mixed stuff”, some of which is added intentionally, some of which is just junk). The lowly wheelweight has supplanted linotype as the bullet caster’s antimony source of choice -- it is cheap, widely available, easily processed, and makes an excellent foundation for bullet metal.

Wheelweight alloy can be used directly to cast perfectly good bullets, but it has a tendency to be a little difficult to work with if alloy and mould temperatures aren’t ideal. Due to the variation in composition of wheelweight alloy, bullet hardness tends to vary somewhat, but generally comes out in the range of BHN of 10 to 12 for air-cooled bullets. Please note the similarity to the “hard” bullets of yesteryear (10:1 at BHN of 11.5). WW bullets are considered moderately soft today, when in fact they are just as hard, if not harder, than what Elmer Keith, Phil Sharpe or Major Wesson considered “hard”. What’s more, since WW alloy contains not only antimony, but also trace amounts of arsenic, WW bullets can be heat treated for additional hardness. For example, water quenching bullets cast of WW alloy produces a bullet with a BHN of about 18. Heat treating WW bullets can get this number well above 20. Also note that upon the addition of about 2% tin, the bullet metal now becomes very similar to the old electrotype (94% lead, 3% antimony and 3% tin) which casts beautifully, has been reported to age harden to over BHN 16, and can be heat treated to a BHN of well over 20. We are now in the hardness range of linotype (which can cost upwards of $1 a pound), from a metal source that is either free or at most 20% the cost of linotype. In addition, the hardened WW bullets are tougher and not nearly as brittle as the linotype bullets, meaning less likelihood that the bullets will shatter on impact. Extensive field testing by a number of different hunters has borne this out.

At magnum handgun velocities (e.g. 1400 fps), bullets with a BHN of about 12 (e.g. air-cooled WW alloy) will expand somewhat. This is an excellent alloy for deer and black bear sized game. Water quenched WW alloy at BHN 16-18 is quite tough and will neither expand or shatter at these speeds. This is an excellent alloy for maximum penetration. For higher velocity applications (e.g. .357 Maximum, .454 Casull), these harder bullets also commonly provide better accuracy.

So, what alloy do we want for what applications? After experimenting extensively, my choices are:

Standard revolver loads. For this category, a Brinnell hardness of 11 to 12 is desired, so WW alloy + 2% tin is an excellent all-round alloy. It casts well, shoots well and is very versatile. Included in this group are the +P loads (up to about 20,000 psi and 1100 fps).

Standard revolver HP's. To get a cast HP to expand at velocities below about 1000 fps, it is generally necessary to keep the alloy hardness down to around 8. Traditionally, the preferred alloy for this application was 20:1 lead: tin, which both casts beautifully (if you have that much tin to spare) and expands well at around 1000 fps. Today this level of hardness is more easily achieved using a 1:1 mixture of WW to pure lead, sweetened with a pinch of tin (roughly 1.5% antimony and 1% tin). Field testing at ~1000 fps reveals that this alloy expands just fine (depending on the mould design). Another way to make a similar alloy would be 1 1/4 lbs of linotype and 8 3/4 lbs of pure lead. Remember that Sn hardens lead without any sacrifice in malleability, while Sb increases hardness at the cost of malleability. Thus the linotype approach to this alloy may be somewhat more brittle than the WW recipe, which in turn may be slightly more brittle that the traditional 20-1 (however, brittleness shouldn't be a major issue since the added tin takes us below the Sb solubility limit, and since these bullets are being shot at only ~1000 fps). In addition, both of the tertiary alloys can age harden which will have a negative effect on HP expansion in this velocity range, so the best alloy is still 20:1.

Magnum revolver loads. The target hardness here is generally something in the range of 12-18 BHN. Achieving this hardness is easy, use the same alloy as described for the standard revolver loads (WW + 2% tin), cast hot and water quench the bullets as they drop from the blocks. According to my LBT hardness tester, these water quenched WW bullets (WQ-WW) has a Brinnell hardness of about 16 and is useful up to about 1700 fps. For loads above 1700 fps, I generally just use linotype (although WW alloy heat treated up to a BHN of over 30 can also be used with excellent results).

Magnum HP loads. Here the target hardness is generally around 12 (depending on the HP design). I use the same thing use for standard revolver loads (WW sweetened with 2% tin), or if I want them a little softer I sometimes use 8 lbs WW alloy + 2 lbs Pb. Either way, they are going to expand at magnum velocities.

Do you note a recurring theme here? WW + 2% tin (or its equivalent) gets used in a lot of my shooting, sometimes air-cooled, sometimes water quenched. The two specialty applications are low velocity HP's where I turn to 20:1 or 1:1 WW/Pb (or its equivalent), and extremely high velocity, where I use linotype. It's really pretty simple. I have the raw materials and can custom mix virtually any alloy I want for my cast bullets, but I almost always start with the lowly wheelweight. Why? Because it's an excellent starting point for a lot of my shooting.

Bullet hardness measurements are an imprecise science, bullets cast from the same pot can, and do, give different hardness values due to the nature of the measurement. In addition, alloys that on the surface appear to be identical can produce bullets with widely different hardness's based solely on issues like casting technique, mould temperature, pot temperature, and where and how the bullets are dropped. The results you obtain may, or may not, agree exactly with those reported in this chapter as a result of these variables, but the general trends presented here will hold true.

Much of the technical information presented in this chapter was obtained from the following references:

These first three references are invaluable and should be in every bullet caster's library:

"Cast Bullets" by Col. E. H. Harrison, published by the NRA, 1979.

"Lyman Cast Bullet Handbook" 3rd Edition, C. Kenneth Ramage, Editor; published by Lyman Publications, 1980. Since this printing the Lyman 4th Edition has been published.

"The Art of Bullet Casting", published by Wolfe Publishing Co., 1981. Available from Wolfe on CD/DVD

Additional information on the history and metallurgy of lead alloys was obtained from:

"Metallurgy of Lead", by H. O. Hofman, 1st Edition, McGraw-Hill, New York, 1918.

"Lead" by J. A. Smythe, published by Longmans, Green and Co., New York, 1923.

"Lead in Modern Industry", published by the Lead Industries Association, New York, 1952.

"Metals Handbook: Volume 7 -- Atlas of Microstructures of Industrial Alloys" 8th Edition; published by the American Society for Metals; Metals Park, Ohio; 1972.

"Metals Handbook" Edited by Taylor Lyman, published by the American Society for Metals, Metals Park, Novelty, Ohio; 1948.

Chapter 4. Fluxing the Melt

In metallurgical circles, “flux” is defined as “a substance that can be added to a molten alloy to entrain impurities in a fusible mass, making them easy to remove”. When we dig up an ore out of the ground and process it, there are invariably problematic impurities carried along with it. The nature of these impurities will vary from ore to ore, but the general concept of using a flux to combine with these impurities to form a fusible slag, allowing their easy removal has value throughout the industry. Fluxes have been used for millennia to purify ores and metals, and slag heaps dating two thousand years before the birth of Christ are known.

The use of a flux to purify metals is a simple, brute force chemical separation. As with any separation process, fluxes can be alkaline (e.g. calcium carbonate), acidic (e.g. silica) or neutral (e.g. calcium fluoride). What kind of flux gets used depends on the nature of the ore, its impurities and the requirements for the separation. Silicate fluxes are commonly used throughout the metal industry, but have little application for lead processing because their melting temperatures are much too high.

Fluxes can also be oxidizing or reducing, and can be used to selectively remove a targeted impurity by oxidizing it or reducing it. Oxidizing fluxes include the various peroxides (lead, manganese and sodium are the most common), and nitrates (sodium and potassium) which are used in refining precious metals. True reducing fluxes are few in number, but include compounds like sodium or potassium cyanide; however their danger and cost limit their use to high return processes like refining precious metals. Although not strictly satisfying the formal definition of “flux” (since they don’t form a fusible slag) there are a number of reducing agents that are also useful in processing metal alloys. Such reducing agents would include coke, coal and charcoal. We will return to this concept of using a reducing agent to process bullet metals shortly.

Perhaps the most commonly encountered use of flux would be in welding and soldering. Here the “impurity” is the inherent oxide coat on the metal being worked and the purpose of the flux is to remove this oxide coat to expose a bare metal surface. Molten metal (e.g. solder, or molten steel) wets the surface of bare metal much more effectively than it does an oxide coat, allowing for more intimate contact between the molten and solid metal phases. Therefore, the soldered or welded joint is much stronger if a flux is used to remove the oxide coating.

The important thing to recognize is that all fluxes are not born equal. Just because something is used as a flux in one application, doesn’t mean it will have any value whatsoever as a flux in a different application. For example, a calcium carbonate flux used to remove silaceous impurities from iron ore would be useless for removing calcium from lead battery plates. A flux is used to effect a chemical separation of specific contaminants from a specific metal (or alloy). As such, it must be tailored to fit the metal, the impurities and the temperature of the process in which it is being used. Just because a material shows up in a can with “Flux” printed on the label doesn’t mean it will perform the separation you are asking of it.

A related concept used in the metal industry is that of the “cover material”. A cover material forms a physical barrier between the surface of the melt and the atmosphere. Molten metal is hot, and hot metal oxidizes more rapidly than does cold metal. Since the rate of oxidation of the molten alloy will be proportional to the amount of surface area exposed to the atmosphere, the cover material effectively inhibits the oxidation of the molten alloy. The cover material can be something as simple as an inert atmosphere (e.g. argon or nitrogen), a liquid pool (e.g. molten paraffin on top of lead) or a floating layer of solid material (e.g. granular clay, aka “kitty litter“). In each case this cover layer forms a physical barrier between the molten metal and the oxygen in the atmosphere, thereby preventing the combination of the two. Some cover materials (e.g. charcoal) also serve as a sacrificial reductant and react with oxygen, essentially forming an oxygen depleted zone immediately above the barrier layer.

OK, so much for the definitions and generalities, what do we want to accomplish by fluxing our bullet metal? What are we asking our flux to do for us? To answer these questions, let’s review a little basic chemistry first (I promise to keep this relatively painless). The elemental state of a metal is that in which it has it’s original compliment of electrons, it is neither positively or negatively charged. This is also referred to as the metallic state. Removal of one or more of those electrons is called oxidation, and the most common form of oxidation is for a metal to combine with oxygen (hence the name). Addition of one or more electrons is called reduction, so if we have a metal oxide and want to get back to the metallic state, we must reduce it and we do this by adding some material that can give up electrons easily. Different metals undergo oxidation with varying ease. By placing the metals in descending order of reactivity, we obtain what is called the “activity series” (also called the "electromotive series"). Those metals high on the activity series are easily oxidized, while those lower on the activity series are less easily oxidized. Of importance to the current discussion is the fact that calcium, magnesium, aluminum and zinc are all fairly high on the activity series (i.e. easily oxidized), while lead and tin are much lower (less easily oxidized, or conversely, their oxides are more readily reduced back to the metallic state). This difference in reactivity can be exploited to effect the desired separation. When a metal is oxidized it forms a positively charged ion (called a “cation”). These cations can be bound by negatively charged ions (called "anions"). OK, now that didn't hurt much, did it?

Remove impurities from lead -- Ah yes, "impurities"! That wonderful catch-all heading that encompasses everything except the desired metals. If we want to effect an efficient separation we need to know what these impurities are, which depends heavily on the source of the lead. Battery plates are commonly contaminated with calcium; some kinds of wheelweights contain small amounts of aluminum; Babbitt metals can have zinc or copper; and range scrap can have a little of all of the above in it (not to mention dirt and gilding metal jacket material). The good news is these impurities are all electropositive metals, that are more easily oxidized than is lead (i.e. they are higher on the activity series) and the oxidized metals are all Lewis acids meaning they can be entrained in a sorbent matrix that has suitable anionic binding sites for them. We want to accomplish this without removing any of the tin, antimony or arsenic present in our bullet metal (WW alloy, linotype, etc).

Reduce tin -- Tin helps to keep surface tension and viscosity of the alloy down so it can fill out the mould cavity properly. If the tin metal gets oxidized to tin oxide, then it is no longer soluble in the melt (oxidized tin is insoluble in lead and forms a "skin" across the surface) and thus is no longer able to impart its desirable qualities to the alloy. Therefore, we want our flux to be able to give up electrons and reduce any oxidized tin back to the metallic state to keep it in the molten alloy.

Prevent oxidation -- Ideally, the flux material could also be a cover material and form a barrier layer to protect the molten metal from subsequent oxidation, thereby maintaining optimum casting properties throughout the course of the casting session. We also want to prevent the oxidation and loss of arsenic. Arsenic oxides have very high vapor pressures and are readily lost through evaporation, not only depleting the alloy of a potentially valuable component (arsenic allows the alloy to be heat treated, if desired), but also creating a significant health hazard to the caster. A reducing cover material prevents this loss.

So, in summary, the job description of bullet metal flux is to remove, reduce and protect.

OK, so how do all the different materials that have been used to flux lead alloys work, and which ones work best for the bullet caster? Pretty much everything that smokes, fizzles, pops and burns has been used to flux bullet metal. What do each of these candidate fluxes offer and how do they work? Or do they?

One of the more common classes of "flux" (the quotation marks are being used here because these materials don't form a fusible mass and hence don't fully satisfy the formal definition of "flux") described in the older cast bullet literature are the various oils (e.g. used motor oil, vegetable oil, etc.) and waxes (e.g. paraffin, beeswax, etc.). Whoever came up with using used motor oil to flux his lead pot was either a lifelong bachelor, or must have liked sleeping on the couch, 'cause that CAN'T be a good way to make points with one's Better Half! Aside from smoking like a chimney and stinking to high heaven, used motor oil also has the disadvantage of being a *source* for contaminating metals (ferrous alloys, aluminum alloys, bearing metal alloys, even magnesium depending on what motor it came out of). Oiled sawdust was another popular choice in years gone by. It would have suffered from many of the same smoky, stinky drawbacks that used motor would have. Let's all do ourselves (and our families) a favor and just scratch those two off the list….

Various waxes have also been used to clean bullet metal. Most commonly these have been paraffin, beeswax, various forms of tallow, or even lard. These have the advantage of being cheap, universally available, and working reasonably well (depending on the alloy). These materials are very good at satisfying two out of the three selection criteria for bullet metal flux in that they are excellent reductants and can reduce any oxidized tin present, and they can be used in sufficient quantity to form an excellent barrier layer, thereby preventing any subsequent oxidation of the alloy. Unfortunately, they offer no means for removing any Ca, Zn or Al impurities. If one is working with a relatively clean source of bullet metal (e.g. linotype or foundry metal), then the waxes can serve admirably in this capacity. However, if one is using a dirtier source of lead (e.g. range scrap, battery plates, or WW alloy), then there are probably better choices. Then there is also the minor issue of distraction; using lard as a cover material makes the lead pot smell like a deep fryer. To this displaced Southern Boy, the odor of fried chicken coming from the lead pot makes it difficult for me to concentrate on the matter at hand. One should not be licking one's fingers while casting bullets….

One of the materials that is currently sold as bullet metal flux includes pine rosin. While pine rosin smells nice (it makes the lead pot smell like a pine campfire) and does a reasonably good job, it operates pretty much the same way that the oils and waxes discussed above do, and is therefore limited in its ability to remove detrimental impurities.

Some of the commercial fluxes on the market today contain boric acid, borax, or other borate containing materials (e.g. Marvelux). These materials are fluxes in the true definition of the term since they melt to form a borate glass which entrains any oxidized materials and extracts these contaminants into the molten glass phase. These fluxes have the significant advantage of being smoke-free and odorless. They are also extremely effective at removing contaminants.

This is because the borate anion binds *all* metal cations and extracts them into the molten borate glass. Unfortunately, this includes any oxidized tin, and so the alloy is depleted of this valuable component. The borate fluxes do nothing to reduce the oxidized tin, nor do they protect the melt from further oxidation. You'll note that this behavior is exactly opposite to that of the waxes, described above.

Is there anything that combines these two modes of operation so that we can get all three of the desired attributes? Fortunately, there is. What's more, you probably already have a pile of it in your shop. It's good ol' fashioned sawdust (hold the motor oil, thank you). The benefits of sawdust are that it's a sacrificial reductant that can reduce any oxidized tin back to the metallic state, and it's cheap enough that the caster can use enough to form an effective barrier layer to protect the alloy from subsequent oxidation. What's more, as the sawdust chars on top of the melt, it forms activated carbon, which is a high surface area, porous sorbent material that has a large number of binding sites capable of binding Lewis acid cations like Ca, Zn and Al. So it not only keeps the tin reduced and in solution, but it effectively scavenges those impurities that raise the surface tension and viscosity of the alloy (Al, Zn and Ca), keeping the alloy in top shape for making good bullets. Vigorously stirring in a heaping tablespoon of sawdust into a pot full of bullet metal does a fine job of conditioning and protecting that alloy. Sawdust doesn't really qualify under the formal definition of "flux" as it doesn't produce a fusible slag, but it does very cheaply and very effectively accomplish the three primary goals that we set out for cleaning up bullet metal. Reduce, remove and protect, sawdust does it all!

Chapter 5
Cast bullet lubrication

In the days of the matchlock and flintlock, the cast lead balls used for all military and hunting operations had no need for lubrication. The cloth patch served as a physical buffer to prevent galling and abrasion, thereby limiting metal fouling. In addition, it (in conjunction with the ejected solids inherent to black powder) helped to seal the gases behind the projectile, limiting gas cutting. Everything was fine until it was discovered that bullets flew straighter if spun in a tight spiral. Although numerous methods for imparting this spin were tried out, it was found that the best method was to cut rifling grooves into the barrel, which in turn cut into the bullet's surface and forced it to spin, resulted in significantly more predictable flight (i.e. better accuracy). Prior to this the ballistic inefficiency of the round-ball projectile was not considered a problem because accuracy of the smooth-bore was more of a limitation than was the arching trajectory of the ball.

However, once rifling was introduced into the mainstream, the limitations of the round-ball projectile quickly became apparent. In order to take advantage of the new accuracy capability, longer, heavier and more ballistically efficient projectiles were necessary. It was also necessary to engrave the metal bearing surface of the projectile in order to impart the desired spin, a cloth patch was no longer adequate (although greased wads were occasionally loaded beneath the elongated bullets). Several problems were immediately encountered. First, it was very hard to engrave these bullets during the muzzle-loading process. Something was needed to ease and speed this process. Second, the newfound accuracy quickly degraded after only a few shots. In an ideal world this wouldn't be a significant limitation in the hunting fields since (hopefully) the first shot would drop yon buck and feed the family, but in a military or defensive situation this was clearly unacceptable (and keep in mind the American frontier during this time, the middle part of the 19th century, was not a gentle place, the family firearms might well be needed on a moment's notice for defense from outlaws, hostile tribes, or pack of wolves). Thirdly, metal fouling was severe when these longer bullets were loaded and fired "bareback". What resources did the frontier sharpshooter have on hand to address these problems? Darned few, but one of the commodities that everybody hoarded in those days was tallow. If these longer bullets were cast so that they had a groove around their waists, then a dab of tallow, grease, wax or whatever could be applied to this groove. This material would then lubricate the passage of the bullet down the bore during loading, significantly speeding up the loading process. In addition, it was found that by adding this dollop of grease, the accuracy of the firearms lasted for significantly more shots than earlier, and when cleaning was required to restore the fading accuracy, metal fouling was considerably less (now the problem was primarily black powder fouling). Given this history, it's easy to see why we call it "bullet lubricant" today – it lubricated the passage of the bullet down the bore and made it easier and faster to load the early muzzle-loading rifles.

Modern sixgunners don't need to ram a ball down a rifled bore, so is lubricant really still necessary? After all, the projectile starts off lovingly seated into a carefully prepared brass cartridge case, crimped into exact position, over a precisely measured powder charge. Once the primer is struck, the burning powder provides all the horsepower needed to drive the bullet from the case and out the barrel, so why would we need to lubricate it? In fact, *how can* grease contained in a simple groove in the cast bullet lubricate the bearing surface of the bullet, much of which is *in front of the lube groove*? Is this gooey stuff really serving a function to the modern sixgunner, or is this just an archaic holdover from days gone by? This chapter aims to address these, and other, issues.

Phil Sharpe, in his landmark treatise "Complete Guide to Handloading" encourages the novice handloader to load 10 *unlubricated* cast bullet rounds for his favorite revolver, and carefully and deliberately fire them from sandbags at a fixed target and watch accuracy degrade with each shot. Direct experience can be a powerful teacher! Suffice it to say that we still need to lubricate our cast bullets. Without lubrication, the cast bullet will lead a barrel horribly, and in very few shots. You can think of it as being rather like a lathe bit and turning stock – the steel rifling grooves are the hard cutting edge of the lathe bit, and the softer bullet metal is the round stock being turned. The bullet lubricant serves the same sort of role that cutting fluid does in preventing galling of the soft metal onto the harder cutting edge. However, a key difference is that instead of having a steady stream of cutting fluid directed straight onto the cutting tool from a conveniently located nozzle, the bullet is asked to carry its entire supply of cutting fluid with it across the entire bore surface. What's more, it is asked to efficiently and uniformly deliver that limited pool of cutting fluid to the entire bore surface in a matter of milliseconds. As a result, the flow properties of bullet lube are one of its most important properties (we'll come back to this in just a little bit). This is a tall order indeed.

OK, so we know that we need to use bullet lube, that lubrication of the cast bullet is necessary to prevent leading and that how it flows under applied force is important to how well it performs in your loads, but how does bullet lube work? And how can we make it work better? How can a groove full of grease lubricate those portions of the bearing surface that are in front of it?

Lube flow properties. Many things can act as lubricants, and virtually anything that can be squirted into a cast bullet's lube grooves has been evaluated at one time or another as bullet lube. Oils have been found to leak out of the lube grooves of bullets, contaminate the powder charge and severely impact the performance of the propellant. Historically, tallow of various descriptions has been used to lubricate bullets with moderate success. Many different greases have been tested (petroleum based, animal fat based, etc.), but most greases are mobile enough that some sort of stiffening is required to achieve the necessary consistency. Such stiffening is usually accomplished by the addition of some sort of wax, most commonly beeswax which is ideally suited to this application. Also used have been ozocerite, Japan wax, Carnauba, paraffin, and numerous others. Ozocerite (also spelled "ozokerite") is a non-crystalline naturally occurring hydrocarbon wax, mined from Miocene formations near petroleum deposits. It is slightly higher melting than beeswax, and not as brittle as paraffin. Japan wax is another wax encountered in some of the older bullet lube recipes. Japan wax is obtained from the berries of certain Oriental species of sumac trees. It is not a hard wax, but rather malleable and slightly tacky. Japan wax is a softer wax and has notably lower melting point than beeswax, making it less effective as a stiffening agent than beeswax. It is a fat (a triglyceride) composed largely of palmitin and palmitic glycosides, as well as other fatty acids and diacids. As a result, like any other fat, Japan wax eventually breaks down and becomes rancid, which may explain the accuracy problems commonly encountered with Japan wax based bullet lubes. Carnauba wax is obtained from tropical palm trees, and is an amorphous, hard, lustrous wax (hence its use as car polish). It is composed of hydrocarbons, higher alcohols and their esters. It melts considerably higher than beeswax, and in fact is one of the hardest, and highest melting, natural waxes used commercially, making it a very effective stiffening agent for bullet lube (in fact Winchester used pure carnauba for years as a bullet lube). The fatty alcohols and fatty acids themselves have also been used for bullet lube, but were found to be of limited efficacy. Greases derived from the fatty acids have been found to have excellent lubricating properties for cast bullet shooting (especially the lithium-based greases, like Alox 2138-F), but these greases require stiffening. Various synthetic polymers have also been used in bullet lube formulations. The polyglycols, better known as "Carbowaxes", have been used effectively in lubes, as have microcystalline polymers like polyethylene and fluoropolymers like teflon.

A detailed discussion of tribology (the study of friction and lubrication) is beyond the scope of this book, but suffice it to say that there are several different mechanisms by which a material can lubricate the passage of one material over another. The wettability of the lube on both steel and lead surfaces is a critical parameter for enhancing lubricity. If the lubricant doesn't "wick out" and wet these surfaces efficiently (and remember, to lubricate the passage of a cast bullet, it only has a couple of milliseconds in which to do this), it will not do a very effective job of lubricating. However, lots of hydrocarbon greases are very effective at wetting polished metal surfaces, so the wettability issue is pretty well addressed by virtually all bullet lubes (except perhaps the fluoropolymers like Teflon). So, while lubricity is indeed an important property for cast bullets, the flow properties (viscosity, thixotropic properties, etc.) are perhaps the most important. This is because even the slipperiest lubricant won't do you one whit of good if it doesn't get to the surface in need of lubrication, and to get where it's needed it needs to flow. But faster flow isn't necessarily better since this is a pressurized system and if the lube flows too quickly, then it gets squirted right past where it's needed, and still can't do its job. So it really comes down to a balancing act. Nor is it simply a question of viscosity, since the viscosity of the mix can, and does, change as a result of applied shear (thixotropic flow), pressure and heat. So it really becomes a question of the integrated flow properties over a range of conditions that dictate the success or failure of bullet lube. This is a particularly important issue for the hard bullet lubes (we'll come back to this later).

This is why the stiffening agent chosen can be so important to the performance of a given bullet lube. The lube will perform better if the stiffener has an intermediate plastic phase that allows for viscous flow. Paraffin isn't nearly as effective as is beeswax as a stiffener for bullet lube – paraffin is a microcrystalline wax that goes directly from a crystalline solid phase to molten liquid phase, there is no viscous plastic phase intermediate. Beeswax on the other hand has an extended plastic range exactly where it does the most good as far as bullet lube is concerned.

Lube pumping mechanisms. Now that we recognize that lube must be able to flow from its reservoir (I.e. lube groove) to wherever it's needed, the question becomes "What makes it flow from point A to point B?" The fluid dynamics of lube flow has many components: simple displacement, compressive pumping, linear acceleration, radial acceleration, and pressure-induced pumping. When the bullet is engraved, the lands displace not only bullet metal in the driving bands of the cast bullet, but they also displace a certain volume of lube in the lube grooves (assuming the lube grooves are completely filled). This displacement serves to compress the lube somewhat, thereby forcing it into contact with the rest of the bore, as well as into the nooks and crannies of the bullet/bore interface. This is the first and simplest lube pumping mechanism. As the pressure builds, the force applied to the base of bullet may grow to the point that it surpasses the compressive strength of the alloy (particularly for magnum revolver or rifle cast bullet loads). At this point the central core of the bullet in the lube grooves is compressed, getting fatter and shorter, which in turn reduces the volume of the lube groove. Once again this compresses the lube within that groove and forces it to the bullet bore interface. In the early moments of the fired shot, the bullet is being subjected to tremendous acceleration forces. The inertia of the lube in its groove forces it to the rear of the lube groove as the bullet essentially gets accelerated out from underneath it. As the lube encounters the rear face of the lube groove (either beveled or radiused), it is forced outward until it hits the bore surface. This is the linear acceleration mechanism, and it operates primarily in the first few inches of the barrel, and so is of particular interest to handgunners. As the bullet starts to rotate faster and faster as it travels down the bore, the radial acceleration (think “centrifugal force”) increases to the point that it starts to pump lube from the bullet’s lube groove outward to the bullet/bore interface. This mechanism starts to take over later in the trip down the bore, so is more of an issue for longer barreled revolvers, carbines and rifles. The last mechanism for pumping lube from the lube groove to the bore surface, and perhaps the most important mechanism of all, is pressure induced pumping. As the bullet is engraved and travels down the bore, small defects are created on the bearing surface of the bullet, particularly along the trailing edge of the land. While these defects are usually quite small (almost always smaller than .001”), they are nonetheless large enough for high pressure gas molecules to traverse. This channel basically constitutes a microscopic high-pressure gas nozzle. The high pressure, high temperature gas molecules that are driving the bullet down the bore are buzzing like a mad swarm of hornets. When they find this leak, they run up it instantly. What this does is it virtually instantly pressurizes the lube groove and drives the lube forward. There are also microscopic defects in the bearing surface of the forward driving forward of the lube groove, so the pressurized lube gets forced into these crevices and forced to the forward portions of the bearing surface, where it is desperately needed because all of the other lube pumping mechanisms (coupled with the forward motion of the bullet) favor the rearward bearing surfaces of the bullet.

Lube grooves. Elmer Keith designed his semi-wadcutters with what he called “square-cut” lube grooves. These grooves were flat-bottomed with sharply beveled sides (but not actually a full 90 degrees). Some of the older cast bullet designs did indeed have lube grooves cut at 90 degree angles, but these old moulds can be frustrating to cast with as the bullets commonly “hang-up” in the mould and don’t release easily. When bullet metal cools, it contracts, shrinking towards the geometrical center of the bullet. With 90 degree lube grooves, the shrinking bullet metal can “pinch” these grooves and hold fast. Keith avoided this problem by putting a slight bevel on the edges of his lube grooves (on the order of 60 to 70 degrees) so the bullets would release from the mould more readily. Sometime later Lyman modified Keith’s designs by going to a rounded radiused lube groove, which was easier to manufacture and released bullets very smoothly. Keith was highly critical of the radiused lube grooves because the rounded groove didn’t hold as much lube as his original design (he was firm believer in using enough lube). It’s important to recognize that there is nothing wrong with the *shape* of the radiused lube groove, and it *does* allow the bullet to release more readily from the mould, but what Keith didn’t like was the *size* – it just didn’t hold enough grease to satisfy the Old Master.

One can make up for this lack of capacity by using multiple lube grooves, and that is exactly the tact taken in the excellent SSK and LBT bullet designs – several smaller, rounded grease grooves instead of one large flat-bottomed groove. The overall lube capacity is similar, it's just spread out over a larger area in these more modern designs. When one looks at each of the designer's goals this only makes sense; Keith was generally interested in making his bullets the "standard" weight for the caliber (e.g. 250 grains for .44 and .45) as a general purpose all-round bullet, and thus didn't have room for multiple lube grooves, while J. D. Jones and Veral Smith (of SSK and LBT respectively) were primarily interested in making bullets that were heavy for their caliber, for deep penetration while big game hunting. These designs, by their very nature, have significantly more bearing surface and thus benefit from having their lube supply somewhat more spread out.

Note that the angled rear faces of both the beveled flat-bottomed lube groove and a radiused lube groove are equally well-suited to pump lube to the bullet/bore interface by the linear acceleration mechanism (the only form that is handicapped in this regard is the old BP lube groove with the 90 degree edge).

One place where the two groove designs may well differ in performance would be in the compressive lube pumping mechanism. The radiused grease groove may well distribute the compressive stress more effectively and thus resist compression somewhat, limiting how effectively lube might be pumped by this one mechanism. The flat-bottomed grease grooves have stress risers at the vertices which may very well serve as inherent "crumple zones" whose buckling would subsequently benefit this mode of pumping lube to the bullet/bore interface.

The other lube pumping mechanisms should work equally well for all of these lube groove designs.

Sealing the bore. The microscopic defects discussed earlier are also the source of leading as a result of gas-cutting. Bullet lube plays a very important role in preventing this source of leading by acting as a sort of "stop-leak". The most important bore sealing mechanism is obturation of the bullet metal itself, but the bullet lube can play a strong supporting role if the lube is of the proper consistency. When the hot gases driving the bullet start to leak through the channels left by engraving, they pick up lube and force it into the crevices as they both move forward. By filling these channels with lube, the flow of gases is effectively stemmed, thereby limiting gas-cutting. If these defects are sufficiently large (i.e. rough bore, undersized bullet, irregular lands/grooves, etc.) then the lube simply gets blown forward and out the bore, leaving the bullet naked and severe leading is the observed result. Once again, we see that the flow properties of lube are critical – if it's too thin (i.e. liquid) and has a low viscosity, then this sealing mechanism is lost and the lube isn't not able to do its job because it's an aerosol out in front of the bullet. Thus, the "stiffness" of bullet lube is a compromise between being fluid enough to be effectively pumped from the reservoir (i.e. lube groove) to the bullet/bore interface, and being thick enough to form an effective seal once in place. The old adage “Moderation in all things” once again holds true – *viscous flow, with moderate thickness is a key virtue for a quality bullet lube*. There is no such thing as a perfect bullet/bore seal, there will always be channels and defects that are not sealed. It’s a question of whether or not obturation and lube can team up and make an effective seal.

Hard lubes vs. soft lubes. A veritable plethora of bullet lubes are commercially available today, both hard and soft, and the hard lubes can be had with a variety of melting temperatures (usually by varying the molecular weight of the polymer used to stiffen the formulation). Most commercial hard-cast bullets come with some gaily-colored hard lube, sometimes with a well-defined pedigree, other times from a somewhat more mysterious origin. Is this because hard lubes are better than more traditional soft lubes? No, it’s because hard lubes handle the rigors of shipping better and are amenable to simple bulk packaging, whereas bullets lubed with soft lube need to be packaged a little more tenderly to keep the lube in the groove and not smeared all over the packing materials. The extra packaging and handling makes them more expensive.

But do hard lubes offer any substantive performance advantages over soft lubes? Aside from being a little less messy, no, not really. It all comes back to the flow properties of the lube. Obviously, a solid doesn’t flow very well, at least not in the few milliseconds the bullet is traveling down the bore, so many of the lube pumping mechanism outlined above really can’t do much with a solid hard lube. The modest lubrication needs of low-pressure cast bullet loads are generally satisfied by the hard lube being displaced by the lands during engraving, but the other mechanisms are pretty much shut down. The key here is that for a hard lube to be pumped, it must melt first. The key word in that sentence is “melt”, as in “undergo a phase transition from the solid phase to a liquid phase”. The current formulations of hard lubes use stiffeners that melt (and they are advertised according to their melting temperatures) instead of going to a plastic flow phase (which is how the soft lubes work). Once a hard lube melts, it can be pumped to the bullet/bore interface very efficiently, but it requires that the bullet metal do virtually all of the bore sealing since the low viscosity liquid lube will get blasted out past the bullet if there are any channels left unsealed by bullet obturation. So for effective use of a hard lube, the shooter needs to pay closer attention to alloy hardness than he does when using a soft lube.

For magnum revolver loads, hard lubes tend to work pretty well because the higher pressure of the load is generally sufficient to induce obturation of all but the most extreme of alloys, the higher operating temperatures (as a result of both the larger powder charges and the frictional forces from the higher velocities) can melt some of the hard lube to ensure adequate delivery of lube by the various pumping mechanisms, and the higher pressures can inject small amounts of lube to the forward portions of the bullet and effectively lubricate those surfaces as well.

Where hard lubes run into trouble is in the intermediate pressure/temperature ranges of +P loads. There are greater needs for lubrication in these velocity ranges than in the range for “standard” revolver loads (i.e. 16,000 CUP and 850 fps). However, current hard lubes generally melt very little in this range, so the only lube pumping mechanism is still simple displacement by the lands. Since very little of the lube has melted, it can’t play much of a role in bore sealing and significant leading is commonly encountered with loads in this ballpark that are lubed with hard lubes.

Most American shooters are devoted magnum fans, and so they push commercial hard-cast bullets at full-house magnum levels, and the hard alloys and hard lubes do just fine in this ballistic regime. There are also quite a few bullseye shooters running .38 WCs at 725 fps and these commercial offerings do just fine in this regime as well. Where problems are encountered is in the +P range, around 1000-1100 fps. The 6-2 alloys, with their Brinnel hardness of 20 or so, are too hard to obdurate at intermediate pressures, and the hard lubes are not effectively melted or efficiently pumped in this pressure regime, so the bore sealing process breaks down and severe leading can result. Shooting oversized bullets may help, but probably not much because this leading is caused primarily by variations in the land/groove width, and once the bullet is swaged down to groove diameter in the forcing cone it is subject to all of the same variations that a groove diameter bullet would be subjected to. Softer alloys and/or softer lubes are the key to success here.

Not all of the hard lube has to melt to lubricate, only partial melting is needed, so when a shooter tells you that a hard lube is no good because he’s recovered bullets from the backstop that still had lube in their grooves, he’s raising an interesting observation, but one that needs to be looked at in more detail because only part of the hard lube has to melt to effectively lubricate the bullet’s passage, some may very well be left behind (and wasted). What we really need is a formulation for hard lube that doesn’t melt to a liquid phase, but rather undergoes a pressure-induced transition to a plastic phase that demonstrates moderate viscous flow.

Molybdenum disulfide. Molybdenum disulfide is an excellent dry (i.e. solid) lubricant with exceptional chemical and thermal stability. Moly coating bullets and barrels has gotten a lot of press in recent years. For jacketed bullets, Moly coating is claimed to reduce metal fouling, reduce barrel erosion/wear, increase barrel life, lower pressures, allow the use of more powder for higher velocities, and protect the bore against oxidation. Some of these issues may well apply to cast bullets, others may not. So the question arises does Moly coating a cast bullet provide any of the same advantages as Moly coating a jacketed bullet? If so, how do we best apply Moly coating to a cast bullet?

Two issues need to be remembered, bullet lube serves to lubricate the bullet's passage and it also serves to help seal the propellant gases behind the bullet's base. A dry coat of Moly can contribute somewhat to the first issue, but can do nothing for the second. What's more, while a dry coat of Moly is highly adherent to a metal surface, it's only a fraction of a thousandth thick. Therefore, if it gets damaged or abraded away, there is nothing left to do *either* job, and dry Moly coat cannot be pumped from one spot to another like a soft lube can be. The net result is that a dry Moly lube can be useful for those loads that have modest lubrication demands and do not require the lube to actively support the sealing operation, i.e. relatively low pressure loads. In non-magnum applications, dry Moly can provide entirely adequate performance, assuming a good, smooth bore. Lee's tumble lube, which paints a thin coat of "lubricant" over the entire bullet's surface in a thin coat of varnish, operates in much the same manner, and with much the same limitations. Both of these lubricants fail when used in a revolver with a significant barrel/frame constriction.

However, if Moly is incorporated into a traditional soft lube formulation, then the benefits of both the soft lube and the Moly are obtained. The soft lube lubricates the bullet, is pumpable and goes to where the leaks are and helps to seal the propellant gases. It also serves as a carrier for the Moly and helps to deliver it to the bore surface, where little by little it forms an adherent coating that protects against adhesion of lead fouling and oxidation. So how does soft Moly lube stack up against Moly coated jacketed bullets? Well, in both cases the Moly clearly serves to reduce metal fouling. In terms of barrel erosion/wear, cast bullets are already considerably more gentle on throats and bores than are jacketed bullets, and I doubt that Moly can really do much of anything to improve on that situation. Likewise, it is doubtful that Moly lube does much to lower pressures with cast bullet loads since relatively little energy is required to engrave the projectile to begin with, and my personal experiments have revealed little velocity difference between Moly lubed cast bullets and those lubricated with more traditional soft lubes. So in conclusion, many of the benefits obtained by the jacketed bullet rifle shooter are lost to the cast bullet handgunner, but the elimination of metal fouling is clearly a benefit shared by all. In a sense, shooting Moly-lubed cast bullets is bore conditioning at its finest.

Sizing/Lubing bullets.

Sizing a lubing cast bullets is the act of pushing a cast bullet into a steel die that is the desired diameter (and *round*, which many cast bullets are not as they fall from the blocks), and then lubricant is forced into the lube grooves, either concurrently, or in a separate step. Before we get into the details of sizing, a decision must be made as to what size you want the bullet to be, and therefore which sizing die to buy, so let's address that first.

For the subject of this book (cast bullets in handguns) there are basically three different classes of handgun that we need to consider -- revolvers, single-shots and semi-autos. As a general statement, the fastest road to good accuracy with cast bullets it to size the bullet to fit the throat (if there is one). For a revolver, you want to size the bullet fit it to the cylinder throats. You don't need any special gauges or tools to determine this, just find out what size bullet will pass through the throat smoothly and snugly. You can use either jacketed bullets or cast bullets for this test. This will commonly be about .001" over nominal groove diameter, but not always, so see what fits (and shoots) best in your gun. If your revolver's cylinder throats are smaller than the groove diameter, then you might want to consider opening them up to match the barrel.

For a single-shot (like a Contender) size your bullets to fit the barrel throat, this can be as much as .003" over groove diameter (e.g. .311" for a .308" barrel). Making a chamber casting is really helpful for this determination, but if you aren't set up for that, then you can drop an oversized (and unsized!) cast bullet into the throat and give it a light smack with a hammer and piece of wooden dowel, then knock it back out and mic it to see what the throat diameter is on your barrel. I generally aim for about .001" less than actual throat diameter to insure ease of chambering.

In the case of semi-autos, the way these guns are chambered there isn't really much of a throat at all, so I generally size these cast bullets for nominal groove diameter.

Sizer dies. You can use RCBS sizer dies in a Lyman sizer, and vice versa, but Star sizer dies will only work in Star sizers, and Saeco sizer dies will only work in Saeco sizers. Some of the really old Lyman/Ideal sizer dies were made with a step inside the sizer die so that they shaved the bullets down. I don't like these dies as they can distort a bullet upon sizing (if I come across one of these dies they get chucked up in my lathe and tapered very quickly). Newer sizer dies are all tapered and swage the bullet to size. This works very well.

Sometimes old sizer dies have been abused and can be scratched. Scratched dies will give you scratched bullets, so take a close look at old sizer dies before you buy them. A light polish will generally clean them right up. Many of my sizer dies are older than I am and are still going strong.

Nose punches. Nose punches fit the nose of the bullet and keep it centered as it goes into the sizer die (assuming that your sizer is square, and while most are pretty good, a few individual sizers are out of square....). These are generally made by the bullet mould manufacturers to fit the exact nose profiles of their respective moulds, and are available for a few dollars. Since the vast majority of my handgun cast bullet shooting involves flat-pointed bullets, I have cobbled together a short-cut that works pretty well for me. I've made myself a couple of "universal" flat-point nose punches which allow the flat-nosed bullets to self-center in the sizer die by trapping them between parallel planes (this approach doesn't work for bullets smaller than about .30 caliber, but for .32 caliber and above this works pretty well). This allows me to use 2 different universal flat-point nose punches (one about .300" diameter, and a second about .350" diameter) for virtually all of my bullet-sizing chores. (I still use regular nose punches for round-nose bullets).

Lube-sizers. Again, Lyman sizer dies can be used in RCBS sizers, and vice versa, but Saeco machines only use Saeco dies, and Star sizers only use Star dies (the Star sizer is available through Magna), etc. Lee push-through sizers fit into a standard reloading press and offer the advantage of being a nose-first (i.e. self-centering) systems that does not need different nose punches for different nose shapes. The Lee system is intended for their tumble-lube. I'm not a big fan of tumble-lubing as it puts lube in all kinds of places where it does no good, and it doesn't put very much lube where it IS needed, but the Lee sizing system is a clever idea for getting bullets the right size, round and square to the base.

Lyman/Ideal has been making lubrisizers since the 19th century, and their tools have used the traditional way of sizing/lubing a bullet -- push it down into a sizing die, squeeze lube into the lube groove(s), then pull the sized/lubed bullet back up out of the die. Lubrisizers from RCBS and Saeco use the same basic principles. This is a simple and straightforward process, but it involves 2 separate strokes of the press to size/lube a bullet (not to mention that the operator has to remove the sized bullet manually). While perfectly adequate in terms of the quality of final product, the overall process can be somewhat slow in practice. This has led folks to try other designs in an effort to speed things up. For example, Lee Precision has come with a clever sizing method that uses sizing dies that screw in to a standard reloading press and have a container to capture the sized bullet as they come out the top of the die. This allows the caster to use equipment that he (or she) already has, and has the added advantage of being nose-first sizing (i.e. self-centering and doesn't need separate nose punches for different bullet profiles). The Lee sizer has no provision lubing the bullets, but they have addressed that by inventing their Lee Liquid Alox Bullet Lube and the Tumble Lube method. In short, the sized bullets are coated with an Alox containing varnish and allowed to dry, then loaded normally. Some folks really like the Lee tumble lube method. The Lee sizer is probably the most affordable sizing tool available today.

Another clever approach to speeding up bullet sizing was reduced to practice by Star. In the Star lubrisizer (now available through Magma Engineering Company, PO Box 161, 20955 East Ocatillo Road, Queen Creek, Arizona, 85242, (602)987-9008) the bullet enters the sizing die nose down and the ram is pressing on the bullet's base. After the bullet is sized, there is no need to remove the bullet as it passes all the way through the sizing die and out the bottom. By placing a small shelf below the sizer and putting a box on that shelf a caster is able to size a lot of bullets in a hurry, and they all go straight into the box waiting below. The Star system is a very fast system, and being a nose-first sizing system it allows the bullet to self-center and you can use the same ram for all bullets of the same caliber (i.e. no need for separate nose punches for different bullet shapes). Perhaps the only drawback of the Star system is that it requires a certain amount of "tweaking" to make sure that the lube only goes where you want it, and not all over the rest of the bullet. The Star sizer is one of the more expensive sizers on the market, but those folks who use them tend to go to great lengths singing their praises, and about the only time you see one on the used market is when an old caster passes away and his estate is being liquidated. Folks don't tend to let go of Star lube-sizers voluntarily...

I have used many of the lubrisizers available (RCBS, Ideal, Lyman, etc.) and I must confess that my primary tools are a pair of old Lyman 450s, both equipped with Midway heaters, one typically set up with whatever commercial hard lube I may be working with at that time, and one set up with my homemade Moly lube. I have an extensive set of sizing dies (Lyman, Ideal, RCBS, unknown and custom) to fit these sizers and see no reason to retool to another format. These two sizers have sized many, many thousands of cast bullets each, and will likely still be going long after I'm gone. I have a third Lyman 450 that I picked up at a gun show for cheap, sitting on the shelf above my sizing bench just in case I need a back-up, but so far all it has done is accumulate dust.

Commercial lubes. There are all kinds of bullets lubes available to the bullet caster today. Some are brightly colored, some are soft and gooey, and some are hard as a rock. Which ones work best? Well, let's take a look....

The traditional favorite for smokeless cast bullet loads is the old NRA Alox formula. Back in the 1950s E. H. Harrison, working on the NRA's *American Rifleman* staff, set out on a detailed, systematic study of cast bullet lubricants, and this formulation was the final product of all of his research. This lube is simple made by using equal parts (by weight) of beeswax and Alox 2138F grease (a lithium based grease used in automotive applications). This lube has been used for decades and has come to be the landmark by which all other bullet lubes are judged. Javelina, RCBS, and Lee lubes (as well as several others) use this basic formulation. It is a very good lube for general purpose cast bullet shooting and will handle all of the shooting chores that a revolver shooter will have.

SPG is a special formulation of soft lube that is put together specifically for black powder shooters (but it can be used with smokeless loads too). It helps to keep BP fouling soft and helps to preserve the accuracy potential of the rifle and load. SPG is arguably the best BP lube out there (although there are also some homemade formulations that are also quite good).

Over the last 20 years, with the growth seen in the commercial cast bullet industry, the prevalence of hard bullet lubes has increased significantly (e.g. Thompson, Rooster, Apache, etc.). Commercial bullet casters want to be able to ship their bullets to their customers and not have to worry about the lube being smeared all over everything when they arrive. Thus, a hard bullet lube, that forms a solid ring of lubricant in the lube groove, stays in place and doesn't smear readily during handling or shipping has become the standard of the industry. New casters, seeing all these gaily-colored hard lubes on commercial wares, commonly go with hard lubes when they start casting their own thinking that the commercial casters use the hard lubes because they offer some ballistic advantage that the soft lubes don't. While they may paint a glorified picture of the performance these lubes will deliver for the shooter, the main reason they are using these hard lubes is to avoid customer complaints from using a messy lube. That's not to say that hard lubes don't do a good job, in many cases they perform superbly. For example, for many years I used various commercial hard lubes for my bullseye target loads, and I shot thousands and thousands of .38 wadcutters in practice and in competition with these hard lubes, all with complete satisfaction. Similarly, for many years I used a commercial hard lube for all of my magnum revolver hunting loads (circa 1400 fps), with zero complaints. These loads were accurate, clean and easily assembled. However, when I went to put together mid-range loads for these same guns using the same bullets at 1000-1100 fps, there were times that I got leading so severe that I couldn't see the rifling after only 6 rounds! In a number of other cases there were no overt leading problems, but accuracy was so poor that not all my shots even hit the paper at 25 yards! As a result of these mid-range experiences, my fondness for hard lubes has waned somewhat. Hard lubes can be very good, but soft lubes are far more versatile, particularly in mid-range loads.

Hard lubes require some sort of heater to warm the lube up so that it can flow through the lube-sizer. These heaters come in a variety of sizes and varieties, but there is a cute little base-plate heater marketed by Midway that works very well for this application (I've had two for over 15 years, and like them). For folks that would rather cobble together their own solutions, I understand that but some hard lubes can also be softened suitably with a 100 watt light bulb placed right next to the lube-sizer.

Homemade lubes. Making your own bullet lube is one of the oldest traditions in shooting. Pretty much everything that was slimy, gooey, greasy or smoky has been tried as a bullet lube at one time or another. In the early days it was mainly things like bear fat or deer tallow because those were the only greases they had available. In more recent years folks have incorporated all sorts of high tech lubricants into bullet lube like fluorocarbons, various polymers, or exotic Polynesian waxes. Flow and consistency is very important for a bullet lube, so homemade recipes tend to include both lubricants (e.g. greases and oils) and stiffeners (e.g. waxes and polymers), and in some cases mixing agents (soaps and surfactants). Occasionally, a component can serve multiple roles (e.g. lard). We've already talked about the NRA Alox formula, and mixtures of beeswax and grease are in general a good starting point for bullet lube (as described above, beeswax has a number of very desirable properties for bullet lube in terms of plastic flow range, most waxes don't work as well as beeswax in this role), but what other combinations work well?

My friend Charles Graff has been making his own bullet lube for decades and his preferred recipe is simply a mixture of beeswax and Vaseline (which is petroleum jelly, not a lithium or aluminum-based grease) in approximately a 60/40 ratio of beeswax to Vaseline (this recipe is based on achieving a particular consistency, not exact weight ratios). Charles reports that he has used this lube for all of his handgun cast bullet shooting for 50 years, and that it has served admirably.

Recently, in cast bullet circles "Felix lube" has taken on almost mythical attributes. Competitive target shooters report unequalled accuracy is possible with Felix lube, and hunters report that they can achieve much higher velocities using Felix lube than they can with other lubes. Everybody who uses Felix lube reports that barrels remain shiny and clean, with no leading. So, what is "Felix lube"? It is the creation of Felix Robbins, a master caster that has been an active cast bullet experimenter for many years who has shared the fruits of his research and his optimized bullet lube recipe for others to use. Making Felix lube is a somewhat complicated process, but it results in a product that is *very* highly regarded. With no further ado (this recipe was taken from the Research and Data section of http://www.castpics.net/):

Felix Lube formula

2 Tablespoons mineral oil
1 Tablespoon castor oil
1 Tablespoon Ivory (sodium Stearate, grated)
1 Tablespoon Lanolin
Beeswax - Piece approximately 3 1/2" X 3 1/2" X 1 "

Heat mineral (baby) oil until it starts to smoke. Add castor oil, and then raise the heat until the smoking level is again approached while continuously stirring for at least a 1/2 hour. Grate the soap, or very finely sliver it, and then barely add it into the mixture until all of it is thoroughly melted. Now, add the carnauba wax slowly, again raising the heat until just below the smoking level. After the Caranauba is well mixed into the solution, add the beeswax while maintaining the heat level high. Finally, reduce the heat of the mixture to about 125F, using a thermometer when available. Add the lanolin while stirring continuously until the whole shootin' match is homogenous. Lanolin is extremely sensitive to heat during the mixing stage, but not otherwise after the mixture had been cold for a while and the mixture (new lube) reheated for modification(s). The lube can be re-melted effectively using a microwave, and then poured into a lubrisizer.

Adding paraffin to the batch makes it a harder pan lube, or it can be used when beeswax is scarce. A special ingredient which impresses friends is the Carnauba wax. It's not required to do the job, but it keeps the barrel mirror bright after each shot. The next time a cheese shop is visited, pick a selection having a thick "plastic" looking wrapper. The Laughing Cow brand comes to mind. After enjoying the cheese, wash off the cover and mash up about a rounded teaspoon (not tablespoon) and melt this into your freshly made lube. Also, Maker's Mark whiskey has the same type of sealer and can also be used for it's carnauba content.

A little more info on this lube -- beeswax is the base, castor oil is the real lube, lanolin makes the lube sticky (viscosity), sodium Stearate glues the mess together so it does not separate into components upon cooling, carnauba wax adds the shine, and paraffin is the ultimate hardener, only to be used as a last resort. Add more castor oil to make the lube slicker for smaller bores and/or a winter lube. There are also variants of Felix Lube made with peanut oil and Dexron III automatic transmission fluid, but the bottom line is they all work well.

Actually, reheating the lube multiple times improves its shooting qualities. This is because castor oil requires polymerization with the other ingredients to prevent a leaking lube. Polymerization is a function of both time and heat level, and this is why there is a minimum 1/2 hour requirement at the highest heat level without the production of smoke.

Favorites. Invariably the question arises as to what our favorite bullet lube is. Well, this is one case where our tastes diverge. Rob swears by the old Lyman "black goo". While there is no question that "black goo" is a very good bullet lube, I have never liked the almost Vaseline-like consistency, or the mess that I inevitably make when working with it. But the bottom-line is that it goes through a lube-sizer with ease, prevents leading very effectively and delivers very good accuracy.

Personally, my favorite is my homemade Moly lube, made from equal parts by weight of beeswax (either yellow or white, color doesn't matter) mixed with Sta-Lube Extreme Pressure Moly-Graph Multi-Purpose Grease. This grease, like Alox 2138F, is also a lithium-based grease, so this lube is basically just a variant of the old NRA formula for Alox lube, with a little molybdenum disulfide and graphite thrown in. I have used this lube in loads that operate from 500 fps to over 2300 fps, and it has worked well in all of them. This lube is easily handled (i.e. not overly tacky/messy), flows smoothly through a lube-sizer, and delivers good accuracy. In addition, it helps to condition the bore by laying down a little bit of Moly with each shot. I have found that over the course of testing a wide variety of diverse load combinations that sooner or later, even with the best of lubes, one stumbles across evil-tempered loads that lead up a barrel. If the bore has this Moly conditioning, then these leading deposits don't stick as steadfastly and are easily cleaned up. This lube is also quite affordable to make -- between beekeeper friends and clearance sales at auto parts stores, I am pretty much set for bullet lube for life (and all for less than $20).

Making lube. In order to mix beeswax with anything, you have to be able to melt the wax in a controlled fashion. Done over direct heat (i.e. on the stove) this is invariably a smoky process and one that will likely get you in trouble with your Better Half (do not use any of her cookware for this process!). One solution is to perform this maneuver on a camp stove outdoors. Another solution is to boil water on the stove and heat your lube mixture in the boiling water (like a double-boiler). A friend of mine related a slick solution that he has used for years -- he mixes his lube components in a mayonnaise jar and melts them in the microwave and pours the melted lube directly into his lube-sizer. I tried this and was amazed at how well it works -- no smoke! I used this method for a couple of years and then had the mayonnaise jar break in the microwave during heating, and make a *big* mess, so I switched over to 1-quart canning jars (tempered glass to handle the heat better). This worked fine for another couple of years, but eventually I had one of these break in the microwave too, so I moved to a thick-walled Pyrex measuring cup, complete with a convenient handle and pour spout for pouring the melted lube into the lube-sizer (bought at the grocery store for less than $2). Ultimately, this shattered too, so I have moved over to using a ceramic coffee mug to melt my bullet lube in the microwave now. I have friends that use hot-plates, old coffee pots, even a Fry-Daddy deep-fryer to melt their lube; there are lots of ways to do it.

Summary and conclusions

Cast bullets require lubrication to prevent leading. Bullet lube serves not only to lubricate the passage of the bullet down the bore but also to seal the propellant gases behind the base. One of the most important properties of this lubricant is that it must be able to flow to be most effective. This property allows lube to be pumped to the bullet/bore interface by a variety of mechanisms. The shape of the lube grooves (i.e. either beveled or radiused) are not overly important, as both are able to effectively pump the lube to the bore. Hard lubes need to melt partially before they perform their best as lubricants, soft lubes simply flow in their native state, and as a result are more versatile. Lubes that form a hard film (for example either dry Moly or Lee's tumble lube varnish) can only lubricate the bullet, they can't flow and form a seal, and these lubes therefore have their effectiveness limited to lower pressure loads. Putting Moly into a soft lube formulation combines the advantages discussed for of all the above bullet lubes.

Reference material:

An entertaining read on all manner of waxes, both natural and synthetic, can be found in:

"Commercial Waxes", edited by H. Bennett, published by the Chemical Publishing Co., Brooklyn, NY, 1944.

Chapter 6

Throat and Groove Dimensions: Cast Bullets and Revolvers Do Mix

Inaccuracy and leading are problems normally associated with cast bullets and often are caused by the handgun itself and not the cast bullet. Cylinder mouth diameter is often overlooked as a cause of problems with firing cast bullets. The ideal cylinder mouth diameter is about one half a thousandth over the maximum groove diameter of the barrel. Sometimes it is impossible to achieve this magical combination since the cylinder mouths are occasionally larger than the groove diameter of the barrel. In this case the bullets will need to be sized the same diameter as the cylinder mouths. Extreme cases do exist where the cylinder mouth is as much as .005 larger than the barrel groove diameter. This is an extreme case, but it does happen occasionally. The only thing you can do here is to shoot exceptionally light loads and hard or gas-checked bullets, or resort to jacketed bullets. More than one revolver has been traded off because of this situation. When the cylinder mouths are too small, they can be opened up to a larger diameter by honing or lapping. Yes, reamers can be used to resize small cylinder mouths; provided you can purchase one the exact size you need. Reamers leave a good, but imperfect finish. After reaming each hole, the finish will need to be polished afterward with a lap or very fine abrasive cloth. This little bit of polishing will remove more material and that needs to be accounted for before obtaining the reamer. Normally about one half to three quarters of a thousandth will be removed in the final polishing process to remove the tool marks left behind from the reaming operation. The finish inside the cylinder mouth, ideally, needs to be as smooth as a well polished die since the expanded bullet will be forced through it at high speed upon firing. Can opening up a cylinder mouth cause any other problems? Yes, one. When large amounts of material are removed from cylinder mouths (say about .005" or so), a burr and sharp ledge can form at the front end of the chamber (where the taper leads from the chamber into the throat), and where the bullet begins its journey into the cylinder mouth. As the bullet leaves the cartridge case and enters the throat, the burr and/or sharp ledge actually shears off a ring of lead and leaves it in the front of the chamber. This reduces the diameter of the bullet (probably asymmetrically), causing loss of accuracy, leading and deformation of the driving bands. A polishing or lapping tool will be needed to remove that sharp edge and will be turned from the rear of the chamber. Brownells sells a product called the flex hone and it might be enough of a lap to remove a sharp edge or small burr.

Barrel constrictions. Restrictions can occur over the threaded area of the barrel where it screws into the frame. This mechanical malady is loosely called "thread crush" in the machinists' trade. It is more relevant in the larger calibers where the barrels are much thinner than, say the .357 variety of calibers. The thinner, more fragile, .44 and .45 caliber barrels crush more easily, and it is not uncommon for these big bore barrels to have a slight constriction just beyond the forcing cone as a result of this phenomenon. Sometimes this constriction is modest enough that it's not a problem, and in other cases it can completely ruin a sixguns accuracy. In these cases, the constriction needs to be removed before cast bullets can be shot successfully. Some success with removing this restriction has been obtained by fire lapping. Fire lapping is nothing more than impregnating cast bullets with lapping compound and shooting them out of your revolver (preferably at modest velocity). Several commercial cast bullet companies sell fire lapping kits. “Beartooth Bullets” sells cast bullets specially made for fire lapping.

If you are a good enough gunsmith or bench fitter, you will be able to hand lap the restriction without the fire lapping. A barrel can be ruined from improper lapping practices, so hand lapping is best left to the trained and experienced hand.

After reading the above information on how to check out and prepare your revolver for cast bullet shooting, you may well ask why it is necessary for the bullet to have such a perfect transition from the chamber for it’s journey down the bore. Well, consider what it is we are doing with the cast bullet. Basically, the cast bullet is a slug of nothing more than cheap solder that is lubricated, loaded into a cartridge case in front of an adequate charge of propellant which, when ignited becomes a mass of extremely hot gas, forcing the slug ahead of it into the tube of twisting spiral grooves. The spiral grooves cruelly force themselves into the sides of the bullet now speeding through the bore, perhaps as fast as 1600fps. Three factors come to play against the bullet. Hot gas from behind, rapid forward motion and the resistance and damage caused by the rifling. In short, we need to tune our firearm to be as kind to the bullet as possible. Restrictions (reduced diameter) anywhere inside the cylinder mouth or barrel cause the bullet to be reduced in size. After the bullet leaves the tight spot it is smaller than the remainder of the spinally grooved tube through which it has to travel. The bullet then being smaller than the bore has lost its ability to keep the hot gasses safely sealed behind it. Once this seal is broken, the hot gases are free to rush past the delicate sides of the bullet and act as a circumferential cutting torch blowing liquid alloy ahead of the bullet essentially tinning the bore ahead of the bullet causing even more lead to be wrenched from the already damaged circumference of the bullet. What all this boils down to is severe leading and poor accuracy. These are the two main reasons why many shooters are scared away from using cast bullets. Ideally, a cast bullet should be fired through a long taper. A taper of about .0015 is ideal, if it can be achieved. The old time barrel makers who made match grade target rifles actually lapped a long taper into their barrels tapering from .002 larger at the breech to minimum diameter at the muzzle. This allowed the bullet to maintain a positive gas seal though the entire length of the bore. If such a condition could be achieved in a revolver starting with the cylinder mouth, that revolver would shoot cast bullets with perfection. Tapered barrels are not commonly encountered today. Smoothness and continuity of diameter throughout the cylinder mouth and bore will ensure accuracy and cleanliness in shooting.

Chapter 7
Leading -- The Cast Bullet Nemesis

In Greek mythology, Nemesis was the goddess of retribution, justice and divine vengeance. She was the daughter of Nyx (the goddess of night), making her the granddaughter of Chaos. She was "the woe of all gods and mortals" and held a deep disdain for excessive pride, boastful or violent behavior, and the absence of moderation. She and her sisters (the Fates) inspired fear due to their vindictive punishment of mortal transgressions. Young Greeks were taught that her wrath was best avoided, and this was done by leading an honorable and humble life, paying homage, and not being proud or boastful. Some stories have the beautiful Nemesis (said to be even more beautiful than Aphrodite) taking the form of a swan and mating with Zeus. From this union an egg was laid, that ultimately delivered Helen of Troy, teaching that even from an angry, vengeful, chaotic force, beautiful things can be born (even though they may be awash in both conflict and controversy, as the rest of Helen's life would be). The parallels to cast bullet shooting are almost poetic. The cast bullet is unleashed upon the world from the chaos and darkness of a revolver's cylinder. Moderation is well tolerated with cast bullets, and excessive behaviors are punished. The wrath of leading is best avoided, and this is easily done, simply by being sensible. Those who pay homage through attention to the details of fit, hardness, lubrication and care of assembly are rewarded with beautiful shooting ammunition (although raucous disbelievers may challenge the virtues of their ammo).

Leading is the number one fear that most non-casters have that prevents them from starting to cast their own bullets. Part of the problem is however, that many of these would-be casters aren't really even sure what "leading" really is, or what causes it; it's just something they've heard, or read, about, and they understand that it can have a negative impact on a gun's accuracy. It is basic human nature to fear the unknown. Some shooters experiment with commercial cast bullets to see how they work and find foreign looking deposits in their barrels and think it must be leading, when in fact it's just residual bullet lube. Sometimes these shooters will experience legitimate leading at intermediate velocities (say 1000 fps or so) and wrongly assume that these deposits would be more severe at higher velocities, and just give up on cast bullets in general. The purpose of this chapter is to define what leading is, what it's root causes are, how a shooter can avoid it, and if afflicted, how a shooter can remove it easily; in short, to dispel the unknown.

Definition of leading. Leading is the deposition of significant amounts of bullet metal on the bore. It can take many forms -- streaks, chunks, splotches, films, etc. (more on this in a minute). It's important to recognize that the mere presence of streaks in the bore is not an indication of leading; many types of bullet lube (especially the commercial hard lubes) leave perfectly innocuous streaks in the barrel that have no negative impact on firearm performance (if a wet patch removes the deposit, it probably wasn't lead). Nor is a gray "haze" on the bore surface necessarily a problem; it *can* be an indication of a leading problem, but it can also be simply a reflection of the alloy of barrel steel used, how the rifling was cut, or a reflection that the barrel isn't "broken in" yet. The inexperienced cast bullet shooter commonly (and falsely) believes that leading has but a single cause -- the bullet was too soft for the velocity, and lead was stripped off the bullet as it raced down the bore. To this novice shooter, the only solution to leading is to cast the bullet harder, which may solve the problem, but in many cases it won't (and in certain cases it will actually make the leading *worse*). If the harder bullets don't solve his leading problem, the novice generally walks away thinking that it's impossible to shoot cast bullets without leading a barrel, when in fact the real problem is simply one of misdiagnosis. So let's look at some of the firearm and ammunition issues involved in leading, so our forensic examination of a leaded revolver can provide an accurate diagnosis of the cause.

Location of the leading

Location, location, location! Perhaps the single most telling piece of evidence is the location of the leading in the gun. Are the dark gray, firmly adherent metal deposits in the forcing cone of the revolver, a patch just forward of the forcing cone, random splotches over the central portion of the bore, do they form a light general gray haze of the entire bore, do they specifically "follow the rifling", or are they concentrated near the muzzle? Clues, my dear Watson. The answer is written in the clues.

Throats. Starting from the rear of the revolver and working forward: the first place that leading can appear is in the cylinder throats. This is rare, but it does occasionally happen when the throats are rough or undersized. For example, I have a Ruger SP-101 .22 revolver that used to build up long streaks of lead in the cylinder throats every time I shot it. Turns out the throats were undersized and rough, and a quick regimen of fire-lapping with 600 grit silicon carbide cured the problem nicely. That gun is a nice little shooter now, and no longer leads at all. Another potential cause of leading in the throats is severely oversized throats or undersized bullets, but these extreme dimensional mismatches are rarely encountered today.

Cylinder gap/barrel face. Leading can also be found on the face of the cylinder or the rear face of the barrel. In this case there are multiple possible causes. Most often this is seen in revolvers with an oversized cylinder gap. Ideally a cylinder gap should be between .003" and .006", and most quality production revolvers fall in this range, but every so often one happens across a gun with a gap of as much as .020", and these invariably plate the forcing cone area when shooting lead bullets. Bevel-based bullets are significantly more prone to this kind of leading than are plain-based, for the simple reason that the cylinder seal is broken while there is still a large amount of ablatable lead exposed in the gap, allowing gas-cutting of the beveled face. Seriously oversized throats also can contribute to this form of leading as well.

Forcing cone. Leading found in the forcing cone proper can be the result of the cast bullet being significantly over-sized relative to groove diameter and being swaged down as it enters the forcing cone. It can also be due to the forcing cone being poorly or roughly cut, or cut off-center (it does happen...). Or it can be due to poor cylinder timing leaving the chamber(s) in poor alignment with the barrel at ignition. This last case will generally have an asymmetric build up on one side or the other, and the revolver will commonly "spit lead".

Immediately in front of the forcing cone. If the leading is observed immediately in front of the forcing cone, then it's almost always due to a constriction in the barrel caused by an overly tight barrel/frame thread. This is most readily diagnosed by slugging the bore, and feeling for added resistance as the slug passes through this portion of the bore. Fire-lapping will usually clean this up pretty quickly and effectively. Hand-lapping requires more knowledge and experience, but allows the shooter to feel when the job is done and results in a more uniform bore surface throughout the length of the barrel.

Random splotches in the bore. Perhaps the most commonly observed form of leading is that composed of random splotches of metal throughout the bore. This can be caused by the bullet being too soft for the velocity/pressure (e.g. a bullet with a BHN of 6 being fired at 1100 fps) and it is this single case that has spawned the widespread knee-jerk reaction among the uninformed that all leading is caused the bullet being too soft. Historically, "soft" bullets were cast with 40-to-1 lead to tin (BHN of about 6.5) and "hard" bullets were cast from 10-to-1 (BHN of 11), and if velocities crept much over 1000 fps, it was necessary to be closer to the harder end of the spectrum. Hence, the Oldtimers spoke of the need for "hard" bullets with rounds like the .357 Magnum. They were speaking of bullets with roughly the same hardness as everyday WW alloy (BHN of 10-12), which seems to be considered moderately soft these days. With commercial hard-cast bullets having a BHN of 22 or more and virtually all home-cast bullets falling in the range of BHN 12-18, overly soft bullets are rarely the cause of leading in handguns today (rifles can be a different story).

Random splotches of leading in the bore can also be due to rough or pitted bores. Diagnosis of this problem should be obvious.

These days, random splotches of leading are most commonly due to poor lube flow. This has become a much more common problem over the course of the last decade or so, due to the popularity of the various hard lubes, both on commercial hard-cast and bullets cast at home. Before anyone gets "their tail tied in a knot" over that statement, let me emphasize that this is not meant as a condemnation of commercial hard lubes. A bullet lube must be delivered to the bullet/bore interface for it to do any good. For low pressure loads (e.g. mid-range target loads), hard lube works just fine since the lube displaced by the engraving process of the lands is sufficient to provide for the modest lubrication needs of the bullet in these mild loads. For high-pressure loads (e.g. .44 Magnum), hard lubes also work just fine since the heat and friction of these loads is enough to melt a portion of the lube, and the melted portion of the lube flows extremely well and lubricates the bullet's passage very nicely. Where I have encountered leading with commercial hard lubes is in the intermediate pressure regime, a little over 1000 fps and 20,000 psi. In this regime the lubrication needs of the bullet are not met by the small amount of lube displaced by the lands, and at these more moderate pressures and velocities, little if any of the hard lube melts. *A lube that does not flow cannot do its job*. In the past, poor lube flow was not an issue because virtually all bullet lubes were soft lubes (e.g. the NRA's Alox formula), and they flowed just fine (in fact, some involving motor oil flowed too well and would leak down and contaminate the powder charge of the round; recall the value of "moderation in all things"). If a shooter is encountering this problem, a quality soft lube is called for.

Streaks, following the rifling. If the leading is seen to "follow the rifling" (i.e. streaks that twist down the barrel in close association with the rifling grooves), then this is a tell-tale sign that the bullet is cast too hard and failing to obturate. Obturation is usually thought of as a plastic deformation that swells the bullet's diameter, but it also leads to a back-filling of engraving defects along the trailing edge of the land. If the bullet is cast too hard to obturate, these defects will not be back-filled and gas-cutting will take place through these voids, following the trailing edge of that particular land. This effect can be mitigated somewhat through judicious choice of lube, but lube by itself can only do so much. The real solution here is to go with a softer bullet *and* a better lube.

Splotches near the muzzle. If the first half of the revolver barrel is shiny and clean and the lead deposits are only found near the muzzle, then that's a clear indication that the lubrication capacity of the lube/bullet system is being overwhelmed. The shooter has several options to fix this: if the bullet has multiple lube grooves and not all of them were filled, then fill more lube grooves (I know shooters who refuse to fill more than one lube groove on bullets with multiple grease grooves, "Don't wanna waste lube!", I guess they prefer cleaning guns to shooting...). If the bullet has no other lube grooves to fill, then a shooter can move to a more efficient lube, or one with better viscous flow properties. If all else fails, the shooter can go to another bullet design capable of carrying more lube. The problem of muzzle leading is more commonly encountered in rifles than it is in handguns.

General haze over the entire bore. If the lead deposits show up as a gray haze over the entire bore it may not be an indication of a leading problem. Sometimes this is just an indication that a barrel still needs to be broken in. The way some barrel steels behave when cut, there can be microscopic surface roughness that accumulates a fine-grained film of lead over the surface for the first few hundred rounds or so (this used to be particularly common with stainless revolvers, especially Rugers, but the situation has improved in recent years). If this haze bothers you and you want it to go away, just go out and shoot then gun, alot! If you're impatient, then fire-lap it.

If the haze is more than just a fine-grained, light gray haze, and amounts to more serious leading over the entire bore, it is most likely due to the cast bullets being undersized relative to groove diameter. Slug the barrel and throats and make sure that the throats are indeed larger than groove diameter, and that the bullets are sized at least as large as groove diameter.

Causes of Leading

Now that we've seen what leading looks like, and have some idea as to where it's coming from, let's look at the different factors that cause leading and what we can do to eliminate it. In other words, let's look at it from the other side of the fence and start with the cause and work backwards.

Leading caused by the bullet. The cause of leading can be traced to the bullet if it's the wrong hardness for the application, the wrong size for that particular gun or a plain base design in an application that calls for a gas-check. As discussed above, too soft of a bullet (e.g. BHN < 8) can be stripped if pushed too fast, while a bullet that's too hard (e.g. BHN 22) can fail to obturate, and lead the trailing edge of the lands. This is a common problem with commercial hardcast bullets pushed at intermediate velocities. The bullet can also be the source of leading if it is sized too large (lead build up in the forcing cone) or too small (coated over the entire bore). The bullet can also be the cause of leading if the sixgunner is using a PB bullet in a load that generates more than about 40,000 psi peak pressure or 1500 fps muzzle velocity; these applications are better served by GC bullet designs.

Leading caused by the lube. Lube can also be the cause of leading, either by there not being enough of it on the bullet, or by having poor lubricating abilities, or by having inadequate viscous flow properties. The tell-tale signature of a bullet running out of lube is leading concentrated up near the muzzle. The solution here is to go to a thicker lube or a bullet design with more lube capacity. Make sure that your bullet carries enough grease, and that you put good stuff in those grooves. Soft lubes (e.g. NRA's Alox formulation) are much more versatile, hard lubes work well for soft loads and magnum loads, but can be problematic in between.

Leading caused by the gun. There are certain critical dimensions of the gun that can cause leading if they are "out of spec". Again, starting with the rear of the gun and moving forward, the first of these would be the cylinder throats. If the throats are grossly oversized (> .004" larger than groove diameter) then if the cast bullet is soft enough it can "bump up" when fired, becoming oversized for entry into the forcing cone, creating lead deposits when it gets swaged back down at this point. With harder bullets, oversized throats do not usually cause a leading problem (although accuracy may suffer due to poor alignment during the cylinder gap transition). On the small side, tight throats can be more problematic. If the throat diameter is .001" (or less) under groove diameter, poor accuracy and serious leading are commonly the result since the cast bullet gets swaged down too small and rattles down the bore with poor alignment allowing lots of gas leakage. Fortunately, this is an easy problem to fix, just hone (or polish) the throats to the proper diameter. It's important to recognize that not all revolvers with tight throats will necessarily shoot poorly, or lead the bore (tight throats coupled with the right amount of barrel constriction will often shoot just fine with moderate pressure loads), but the general trend is that tight throats are usually problematic.

If the barrel/cylinder gap is excessive (> .010") then the forcing cone area can become plated with lead deposits. This is fairly common with .22 revolvers, but is also occasionally seen in centerfire revolvers as well. The solution here is to have a gunsmith set the barrel back one thread and re-cut the barrel face so that the gap is more reasonable (say .004-.005").

Perhaps the most common cause of leading that can be blamed on the revolver is the barrel/frame constriction. Sometimes, when the manufacturer cuts the threads on the barrel and screws it into the frame, it's a tight enough fit that the frame slightly constricts the barrel so that the groove diameter in that portion of the barrel is ever so slightly smaller than in the rest of the barrel (the difference is usually less than .001"). The crude swaging process that occurs when a bullet is fired generally results in a heavy lead deposit at the barrel frame juncture. Fire-lapping (or hand-lapping) will generally cure this problem in straightforward fashion.

Variations in steel hardness or slippage in the indexing of the cutting tools when the rifling grooves were cut the barrel can be left with inconsistent groove diameter, or groove/land widths, or tool chatter leading to a roughly cut bore. All of these inconsistencies can be treated with some degree of success by fire-lapping or hand-lapping. Likewise a bore that has become pitted can also be smoothed out in this fashion (but only up to a point). Note that most of the gun related causes of leading are “treatable” by fire-lapping.

Leading caused by the load/components. Perhaps the most common source of leading resulting from the components is due to the use of too little, or inappropriate, bullet lube. Some bullet designs have skimpy little shallow lube grooves and simply do not carry enough lube to be shot at any kind of serious velocity without leading. These bullets will never provide satisfactory service at anything other than moderate velocities. Lube quality is a little muddier issue; one of the things that confuses many cast bullet shooters is that a lube can be very well suited for one velocity range and lousy at another speed. A common (and somewhat shaky) belief is that a given lube will be good up to a certain velocity (at which point it will reach the limit of its lubricating/sealing ability), therefore if it works at one velocity it will work fine at all velocities below that point. This is commonly true, especially for the soft lubes (also the varnish lubes and dry Moly coatings), but not always true for the hard lubes (particularly the crystalline hard lubes). If you're getting leading that you can trace to the use of a hard lube, try replacing it with a quality soft lube.

Another source of leading that can be traced to the components of the load is the mismatch of the powder burn rate to pressure generated by the load. Many years ago Elmer Keith used to write about the "balance point" of a given powder; the range of pressures at which that powder delivered smooth uniform ballistics. Basically this boiled down to fast powders for light target loads (e.g. Bullseye, W231, HP-38, AA #2), medium burners for standard pressure loads (like Unique, Universal Clays, AA #5), medium slow powders for +P loads (powders like HS-7, Blue Dot, AA #7) and slow powders for full-house magnum loads (like W296, H110, 2400 and AA #9). Match the powder to the pressure curve. The use of fast powders for higher than normal pressures with plain-based bullets can cause bad leading, due to the very rapid pressure rise time early in the P-T curve leading to high pressure faster than the bullet alloy can obturate in response to the pressure, and as a result severe gas cutting can result. The other issue here is that the slow pistol powders reach their pressure peak when the bullet is an inch or two in front of the forcing cone, when the bullet is fully supported and contained by the barrel. Sealing and lubrication are fully functional in this environment. The fast pistol powders reach their peak pressure when the bullet is in the throat or traversing the cylinder gap. This is fine if the load involves modest pressures, but if a plain-based cast bullet is subjected to magnum pressures as it crosses the cylinder gap, then serious leading problems can arise. The take-home lesson here is to not use fast powders for magnum pressure levels in the first place! Just match the powder to the pressure curve.

The bottom line of all this analysis? Use a bullet that's the right size, of a hardness suitable for the pressure/velocity, with a healthy dose of quality lube, in a decent gun, powered by a well-balanced powder charge, and you'll be able to shoot all day long with no leading. It's really pretty easy, all told.

Removal of leading

The default method for removing lead deposits is a bronze bore brush, a healthy dose of elbow grease and an hour of two of scrubbing. If your time is as valuable to you as mine is to me, this is not a good solution!

One solution that gets recommended is to fire a couple of rounds of jacketed ammo to clean up majority of leading deposits -- in my experience jacketed ammo tends to remove most, but not necessarily all of the lead (it seems to iron some of it into the grooves since jacketed bullets tend to be slightly undersized). Some have even gone so far as to suggest loading jacketed bullet upside-down to enhance the scraping effect -- I've never done this, but it seems rather odd to me, all you need is the harder jacket metal in contact with the leaded bore so what purpose does loading the bullet upside-down accomplish? And if the jacketed bullet is undersized it won't make any difference whether it's right side up or upside-down. The best solution I've found yet, is to simply shoot some GC ammo through the leaded bore. The sharp forward edge of a GC seems to do a much better job of removing lead deposits than a typical bullet jacket, and I can't think of a better way to clean a gun than to keep shootin'!

What if you don't have any GC ammo handy? Well then, there are a few other options....

Veral Smith, of Lead Bullet Technologies (LBT), published a method in his excellent (and highly recommended) book *Jacketed Performance from Cast*, a nifty and highly effective method for removing lead deposits from inside a barrel. His method involves taking a copper or brass kitchen scrubbing pad (commonly marketed under the "Chore-Boy" or Chore-Girl" brand names) and cutting a patch off of it and wrapping it around a bronze bore brush. The way this "tool" cuts through even severe lead deposits has to be seen to be believed! I have had revolvers that I literally could not even *see* the lands that came clean and lead free in less than a minute!

The only drawback to Veral's method is that it requires a pair of scissors to slice off a patch of the scrubbing pad, and scissor slicing launches a thousand little pieces of shrapnel off into the unknown (at least its unknown until you walk back through that particular room barefoot), and it only allows you to get a dozen or so swatches out of one scrubber pad. If one replaces the copper (bronze) kitchen scrubbing pad with a pad of bronze wool (available for refinishing work at your local hardware store), one can take a small pinch off the pad with your fingers and get about a hundred or so pinches from one pad -- and there's no mystery shrapnel to stab your (or your Better Half's) tender tootsies! It's important to emphasize that one should use bronze wool, and not steel wool. Steel wool *will* scratch the bore, and why a shooter would want to save a few cents and use steel wool instead of bronze wool and risk damaging several hundred dollars worth of barrel is beyond me when he could just as easily buy a cheap cleaning accessory where a $3 investment will last the next couple of decades with zero risk to his precious barrel steel. Your call...

Shooting bullets lubed with Moly lube not only prevents leading, but also makes lead deposits easier to remove when they do occur. This is the one case where a wet patch *can* remove light leading deposits, they don't stick very well and good tight-fitting patch wrapped around a bore brush can remove leading deposits from a lightly leaded barrel if that barrel is Moly treated.

Chore-Boy and bronze wool can be used to remove leading very quickly and easily.

Conclusions

So look at the variables involved with your gun -- bullet diameter, bullet hardness, throat diameter, groove diameter, lube quantity and quality, possible barrel constrictions, bore roughness, cylinder gap, etc. Gentle fire-lapping can cure several, but not all, of the causes of leading. It may very well be that your gun just needs to be broken in, so just get out and go shootin'!

Fear of barrel leading is one of the greatest barriers to shooters taking up cast bullet shooting and bullet casting. In the final analysis, leading is easy to avoid, and it is much easier (and quicker) to get rid of than is copper fouling from shooting jacketed bullets. That a cast bullet shooter must live with leading is a myth, just like Nemesis of ancient Greece.

Chapter 8
Idle Musings of a Greybeard Caster….

There are a number of things that a caster learns with experience that don't necessarily fit neatly into a well-defined, compartmentalized chapter format. We decided to include these tid-bits in kind of a catch-all section to pick up all the "little things" that we would like to teach a new caster that might not fit in elsewhere. With no further ado….

Getting started. A very common question is, "I'm thinking about getting into bullet casting. What's the best way for me to get started?" Well, that depends on what kind of shooter you are, how much shooting you do, and what you want to get out of your shooting. While shooters and goals differ, there is a common solution that will teach a great deal to the novice caster, do it affordably and generate a lot of fun in the process. Stock up on .38 Special and .357 Magnum brass, buy a pound of Bullseye and a pound of 2400, pick up an RCBS 150 grain SWC mould and a 10-pound lead pot, and a 5-gallon bucket of wheelweights from your local tire store. Cast as many SWCs as you can, and try a variety of loads to satisfy yourself what works best. Try a handful of different lubes, crimps, primers, etc. so you get a feel for what works and what doesn't. When you've finished either the 2 pounds of powder or the 5-gallon bucket of wheelweights, you will be a better pistol shot, and you will have a good working knowledge of the fundamentals of bullet casting, cast bullet loading and you'll be ready to move on. Now you can start picking up new bullet moulds to scratch different itches...

Flaring the cases. ALL CASES (straight, tapered, bottleneck, etc.) need to be flared before seating a cast bullet. A cast bullet needs to be able to enter a case smoothly and easily. If you just cram a cast bullet into a re-sized case like you would a jacketed bullet, you will almost certainly damage the bullet and get very poor accuracy when you fire the round. The case mouth needs to be flared slightly to allow the bullet to slide in as though it was greased (it is, after all). If you can feel the stop-n-go resistance of the driving bands during the seating process, you are almost certainly damaging the bullet, and you'll need to flare the case mouth a little more. This can be done with a standard flaring die (e.g. .38 Special), with a Lyman M-die, or by using a home-made universal flaring die.

Excessive Processing. Excessive manipulation of bullet metal will lead to a depletion of some of the valuable components (e.g. tin). Fluxing too often is one way to do this. A friend of mine likes to "flux" the metal even before it's melted! ("It makes it melt better." he says…) He is confusing the use of road salt to melt snow (colligative properties of liquids, solutes lower the melting point) with fluxing molten metal (which does not dissolve in the alloy and serves to extract certain impurities, and minimize the oxidation). He also likes to flux the pot about every 10 or 12 pours. All this activity does nothing to improve the alloy, is a waste of flux, and just cruds up the lead pot (he prefers pine rosin for flux, which does a fine job and smells nice). When he skims the dross after each of these fluxings, then the alloy can be depleted of some of the minor components, like tin, arsenic, etc., resulting in the quality of the bullet metal dropping off with time. Melt the alloy, skim the dross, flux the metal once at the beginning of the pot and cast your bullets. If you're oxidizing your tin too quickly to make it to the bottom of your pot, then you're casting too hot, turn the pot temp down. I prefer to use a heaping tablespoon of sawdust for flux and leave it in place to inhibit oxidation from taking place.

Smoking moulds. The same casting buddy likes to smoke his moulds 2 or 3 times during each casting session. Smoking bullet moulds is a time-honored tradition in bullet casting and is done to help the mould release the bullet by coating it with a thin layer of soot (poor man's graphite). I have seen cases where his moulds were so sooted up that the blocks wouldn't close fully and bullets were coming out frosted -- not because of crystallization of the antimony, but rather because the cavity surface of the mould was physically roughened as a result of the carbon deposits. The idea behind smoking moulds is to enhance their ability to "let go", but if the cavity gets rougher, just how easily is it going to "let go"? In addition, soot quickly fills up and blocks the vent lines in the mould faces, preventing the mould from venting properly during the pour, leading to a steady stream of rejects. I have much better results getting moulds to release easily by cleaning them with a toothbrush and cleaning solvent (e.g. Ed's Red or WD-40) than by smoking them. If you must smoke your moulds, do it once. If the bullets start to get sticky after that, then clean mould before you smoke it again. Building up coal deposits inside your mould cavity is a lousy way to make good bullets.

Cleaning the Lead Pot. I've heard of just about every method imaginable for cleaning lead pots -- wire-brushes, electric drills, cold chisels, scrapers, even sand-blasting. By far the easiest and best way to clean out the residues that eventually accumulate is with hot water. Take a cup of near boiling water, pour it into the room temperature pot (it should be obvious that you DON'T do this with a hot pot!), let it stand for a minute or two (stirring occasionally), then drain it out. Your pot (and pour spout) will come out remarkably clean. A word of caution: don't try to heat the water by putting a cup of cold water in a cold pot and then turning the pot on. It takes a while to heat the water to its boiling point, and by the time the water approaches boiling, the heating element has gotten MUCH hotter. The water will go from warm and steaming slightly, to Mt. St. Helens in a matter of seconds. Bad idea…..

Heating the Sprue Plate. Mould temperature and pot temperature are two variables that are addressed in virtually all of the cast bullet literature. A

Picture showing heating an aluminum mould sprue plate down.

problem that is commonly encountered and not generally addressed is bullets that are poorly filled out and wrinkled, and frosty, suggesting that the mould and/or alloy might be too hot. This problem is especially prevalent in the aluminum moulds that are so popular today. The caster usually figures his alloy must be too hot since the bullets are frosty, so he turns the temperature down and the problem just gets worse. His next conclusion is that problem must be with his alloy or how it was processed, and so he goes back and fluxes it again and again, and once more no improvement is seen. The mould and pot temperatures may well be too hot, but the *real* problem is that the sprue plate is too cool. The steel sprue plate takes longer to heat up than does the aluminum mould, so the molten alloy is getting poured through a chiller before it gets into the mould cavities, the viscosity increases, the alloy is no longer able to fill out the cavity properly, and the bullet comes out wrinkled. It's frosty because the mould blocks are indeed hot and it takes a long time for the alloy to cool down from that point on so the antimony gets a chance to segregate, but the problem lies in the fact that the alloy is too cool when it enters the cavities. The solution to this problem is to make sure the sprue plate is fully heated up before casting. For typical iron/steel moulds, this is no big deal since both the mould blocks and the sprue plate have similar thermal conductivities and heat up at the same rate (this is why the problem isn't addressed in the classic casting literature, historically ferrous moulds have been used). But for aluminum moulds, the aluminum blocks heat up much faster than does the sprue plate. The caster can either heat up the sprue plate by casting a bunch of rejects, or he can pre-heat the mould *upside down* on the rim of the pot, so the heat enters the mould blocks *through* the sprue plate, thereby ensuring good thermal equilibrium between the two. This is also an issue when casting with the 8 and 10 cavity H&G gang moulds, with their gargantuan 3/8" plate steel sprue cutters. There's more steel in one of these sprue cutters than there is most 2 cavity moulds! The sprue plate must be hot to cast good bullets!

Seating stubborn GCs. Most of the time, I just snap them on with my thumb, but as we all know, every so often you run across a mould that has an oversized GC shank and getting the GC onto that shank takes more than thumb pressure. In the past, the way I dealt with this was to place a small piece of 1/8" flat-stock over the sizer die and use the nose-punch to push the bullet down into the GC. This works fine (if the bullet isn't too long), but it's kinda slow.

Recently, I found a pair of well-used channel lock pliers at a pawn shop that a previous owner had taken the jaws to a belt sander and ground off all the teeth, leaving the jaws smooth. They cost me all of 50 cents, and it turns out that they work quite nicely for seating GCs onto recalcitrant shanks. I use the channel locks to seat the GC's onto the bullet shank, then I size the bullets normally. The flat faces of the channel locks get them seated squarely on the base, and the crimp keeps the GC solidly in place. The adjustable jaws of the channel locks allow me to keep the jaws more or less parallel, and squarely seat GCs on a wide variety of bullet lengths. And my thumb is grateful...

Preventing damage. Anytime your mould faces are open or when the mould blocks are not attached to the handles, the mould is vulnerable to damage from dings and dents. Please remember that any time the mould faces or top are exposed, they can be easily nicked, dinged, or dented in the area of the cavities; possible ruining your mould. Also, remember that should you accidentally drop your mould, it can be ruined. Storing mould blocks rubber-banded together is a good way to prevent much of this damage.

Venting. It is very difficult to cast a useable bullet from a mould that is inadequately vented. Some of the more common mass produced moulds usually come out of the box with vent lines that are partially blocked at the cavity. This can occur in most any mould made with vent lines. The partial blocking of the vent lines occurs in moulds that have the blocks vented before the cavities are cut with the cherry. Almost all machineable material leaves small burrs at the edges of the machined area. In moulds this occurs at the edges of the cavities. The burrs themselves are normally quite small, but can be enough to partially block the very thin vent lines. These burrs can be easily removed with the blade of a pocket knife, but is recommended that a 60° bent checkering file, fine cut, be used as it leaves no inside burrs and does a much cleaner job. Only remove the burr. Do not attempt to cut the vent lines deeper. After the burrs in the vent lines are removed, the edges of the cavity can be lightly rubbed with a piece of 0000 steel wool to ensure smoothness at the site of the vent.

Proper fit of mould blocks. For many years gun writers have written about their opinions as to how mould faces should fit together. Some say you should not be able to see any daylight between the halves when held up to a strong light. In reality, a small amount of light showing through the mould halves is good for venting the air from the cavities. Moulds fitted too tightly can be frustrating to use if not adequately vented. Frequently, a new mould has been made to cast more easily by getting the mould and the alloy at much higher than normal operating temperatures. While using the mould at this extreme temperature, the user notices that all of a sudden the mould starts casting perfect bullets with little effort. What has happened here is that the blocks became so hot that they warped just a little, but enough so that the mould became self-venting as light was then visible through the halves. Once the mould “opened up” it allowed the cavities to properly vent and the alloy could then fill into the cavities completely without fighting with the trapped air.

Picture showing how to properly tap out alignment pins. (Lyman Mould shown)

Misaligned Mould Blocks. If you find that a mould is throwing bullets that are significantly out of round, or if after sizing you notice that the bullets are heavily burnished on one side of the seam and untouched on the other, then the problem is likely to be that one (or more) of the alignment pins are not properly engaging . After the blocks have cooled down, remove them from the handles; when the two halves of the mould are brought together there should be little or no light visible at the interface, and there should be zero slippage of the blocks relative to one another. If you can see a significant line of light between the faces, the blocks could be warped, there might be small particles of metal holding them apart, or the alignment pins could be pushed too far out of their foundation holes and are preventing the blocks from closing fully. If there's any slippage between the blocks, then the alignment pins are seated too deeply into their holes and need to be adjusted. Take a piece of 2 x 4 with a ¼" groove routed in it. Place the mould block face down with the alignment pins in this groove and the blocks supported on both sides of the groove. Using a 3/16" drift punch and a hammer, gently tap the backside of the pin until it extends far enough out of its hole to engage the alignment hole in the opposite block. Check to make sure that there is no gap between the faces of the mould blocks caused by the pin protruding too far and holding the blocks apart (if so then gently tap it back in). Once the alignment pins are properly adjusted, then bullets should drop much closer to round and proper size.

Cleaning a Mold. Valuable tools for cleaning moulds include an old toothbrush, flat tooth-picks and Q-Tips, in conjunction with a good cleaning solvent like WD-40 or Ed's Red. For aluminum moulds, these are the only tools I use for cleaning. Using steel tools, or steel wool, to clean any mould can round off cavity edges, scratch the faces and otherwise do damage to your precious mould, making it a bad idea. For steel moulds, you can also use bronze wool, or a bronze brush for cleaning along with a suitable cleaning solvent. This is an excellent way to remove surface rust from a rusty old mould and do so without rounding the edges on the cavity or scratching the faces of the mould blocks. A bronze brush also is a great way to clean out those insidious little flakes of metal that like to get stuck in the vent lines and block them. For long-term storage of an iron/steel mould, I paint them liberally with Ed's Red using an old toothbrush. The carrier solvents help the Dexron III penetrate into the pores of the metal, and inhibit oxidation.

Mould release. Some folks get all wound up about how it's impossible to get a mould to drop bullets cleanly without spraying some kind of magic goop all over it. I've seen moulds that were so heavily coated that the blocks could not close completely, and all of the vent lines were filled. You will never get a quality bullet from such a mould. If you want to use a release agent, then fine, go ahead, but use it lightly. Just like smoking the mould, if a little doesn't do the trick, then clean the mould. In my opinion, there is no need for mould release, all is does is gunk up a mould and block vent lines. If your mould is not dropping bullets easily, then it probably needs to be cleaned (or lapped).

Cleaning Solvent. Ed Harris developed a formula for a cleaning solvent that he preferred for general all-round firearm cleaning that he called “Ed‘s Red“. It’s an excellent cleaning solvent. He had half a dozen ingredients that were included for various reasons, some well-founded, some a little questionable. Now that I’m well into my third decade as an experimental organic chemist, I have a pretty good feel for solvents, how they work, what they do, and how to best achieve the desired properties. I did some minor tweaking (and simplification) of Ed’s Red formula and have a cheap, simple and highly effective cleaning solvent that I use for almost everything gun related, particularly bullet moulds. Basically, I replaced the acetone with the less volatile MEK, and got rid of the lanolin and mineral spirits (which is a poor solvent for this application), and kicked up the xylene content (an excellent solvent for removing powder fouling, petrified greases, bullet lubes, etc). With no further ado:

Ed’s Red: Revisited

1 quart Dexron III automatic transmission fluid
1 quart methyl ethyl ketone (aka “MEK”)
1 quart xylene

Mix in a 1 gallon glass jug. This mixture is flammable, handle and store appropriately. As with any cleaning solvent, use with adequate ventilation.

Gravity segregation. Some folks like to think that if you don’t stir your lead pot, the components will separate according to their differing densities. Nope. They’re all soluble in the melt and Brownian motion insures that they stay well mixed. No gravity segregation will take place in your lead pot. A little test you can perform for yourself at home: dissolve a teaspoon of salt in a glass of water. Stir it thoroughly and set it aside overnight. Table salt is over twice as dense as water (just like lead is approximately twice as dense as either antimony or tin). If homogenous solutions spontaneously gravity segregated, then this one would do so just like the hypothetical segregating lead alloys. Let this salt-water stand undisturbed over night, then carefully remove a spoonful from the surface of the glass and taste it, is there still salt in that surface water?

Lapping a mould. It’s not uncommon for a mould cavity to be out of round, in some cases this can amount to several thousandths difference depending on where the diameter is measured. One way to clean this up is to lap the mould (check the alignment pins first!). Lapping can also be used to enlarge the diameter of the bullets if they are dropping out undersized, or smoothing out a rough cavity (either tooling marks or pitting). Keep in mind that this (like any lapping process) is a metal removal process and as such should be done slowly and carefully, stopping to check dimensions on a regular basis. The simplest way to lap a mould is by hand. One simple method for hand-lapping a mould cavity is to take a nail, hammer the tip flat and then bend the flattened portion in a right angle to form the lap handle. Remove the sprue plate from the mould. The flattened portion is then inserted into the center of the cavity and the mould cavity filled with bullet metal around the lap handle (make sure no part of the steel nail is “peaking out” of the lapping surface as this can scratch your mould). Allow the lap to cool, then wipe a drop of oil across the entire surface of the lap, followed by a coating of abrasive. I generally start with 400 grit silicon carbide. Valve grinding compound is generally either 180 or 220 grit alumina, either of which will remove a lot of mould metal fast, and should be avoided if you are just smoothing the cavity out. Mould metals (aluminum, brass, leaded steel, iron, etc.) are all pretty soft stuff, and all of the commercially available lapping compounds are considerably harder, so the identity of the lapping compound (i.e. alumina, silicon carbide, silicon nitride, etc.) isn’t as important as the particle size (grit). Once the lapping compound is in place, then the coated lap is inserted in to the mould, the blocks closed and the lap turned by hand, using the handle to rotate. There will be resistance, and in fact it’s not uncommon for the lap to only turn part way at first. Just keep working it until complete, free rotation is achieved, at which point the lap is spent. Clean the mould, heat it up, cast a bullet and measure it to see how close you are to the desired diameter and roundness. Repeat as necessary with a freshly poured lap (you can melt the old lap off of the handle by simply immersing it in the lead pot). This isn’t really as time-consuming as it sounds like, but it does take a while. Just look at it this way, you can spend the rest of your life shooting poor quality, out-of-round bullets, or you can invest an hour or two and spend the rest of your life shooting near-perfect bullets. Your call.

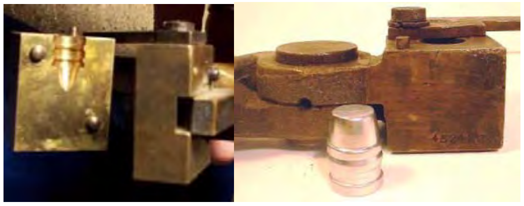
If you have access to the appropriate power tools, moulds can also be lapped under power. In this case one takes a bullet cast from the mould, wraps it in electrician's tape, chucks it up in a 3-jaw chuck on the lathe, center drills the base and taps it. The lap is then threaded onto an appropriate shank (e.g. bolt, all-thread, etc. -- do NOT use any kind of pointed or self-starting screw!). If a bolt is used, cut off the bolt head. The shank is then chucked up in a drill press, the lap coated as before, inserted into the mould cavity and the drill press started with the mould braced against the drill press table.

Pressure measurement -- psi vs. CUP. Questions often arise about these two methods of measuring pressure and whether or not they can be correlated to one another. In short, both scales measure pressure, they just go about doing it in different ways. Piezoelectric strain gauges have a very fast response time and give you pressure (in psi) as a function of time, and the peak chamber pressure is simply the top of the P vs. T curve. The older crusher method had a standardized metal pellet (typically either copper or lead, depending on the pressure range being monitored) inserted into a hole drilled into the side of the chamber, and was then backed by a monolithic anvil. When the cartridge was fired, the pressure generated distorted the pellet, and the amount of distortion was directly related to the peak pressure exerted on the pellet. The length of the pellet was then measured and the length looked up in a table of reference values to determine the peak pressure. These reference pressures were also in psi.

So why do we call these pressure determinations CUP (copper units of pressure)? Very simple. The table of reference values are in psi, but they are determined under static equilibrium conditions. For example, when a static load of 50,000 psi is applied to a copper crusher pellet, it will compress a specific amount, but when that same pellet is subjected to a .30-06 cartridge at 50,000 psi, it will compress somewhat less, leading to an apparent chamber pressure of somewhere around 40,000-42,000, so instead of calling it psi, it was decided to name these units CUP so this offset would be inherently included in the measured result. Why is there this discrepancy? Very simple, TIME. It takes time to move metal, so when a load is applied to the copper pellet it takes time for it to achieve its new equilibrium conformation. The millisecond or so that it experiences the peak chamber pressures of the fired cartridge may not be long enough to complete this rearrangement. How far is it off? That depends on the pressure being measured. For pressures below about 30,000 the two pressure scales are virtually identical (at these lower pressures, the pellet doesn't change much and it doesn't take very long for it to achieve its new conformation). Between 30,000 and 40,000, the CUP scale starts to lag behind the psi scale, and above 40,000 the two scales start to differ significantly (60,000 psi corresponds to roughly 50,000 CUP and 100,000 psi corresponds to about 70,000 CUP). There is a calibration curve correlating the psi and CUP pressure scales in "Firearms Pressure Factors" published by Wolfe Press (this is an excellent book, and is recommended for anyone who handloads ammunition).

Chapter 9. Moulds and Mould Design

What goes into making a bullet mould? What should you consider if you want to make your own design? What are the variables involved and what decisions will you have to make in the process?



Belding & Mull made made many of their moulds out of nickel. This one (for the Himmelwright wadcutter (left)) appears to be made out of brass. Yankee moulds were commonly machined out of bronze (like this 452423 mould (right)).

Mould making materials.

Traditionally, bullet moulds have been made out of iron or brass, and more recently aluminum has become popular as a result of its availability, ease of machining and high thermal conductivity. But do moulds have to be made from such stuff? Are there better materials out there? What else has been tried?

Iron isn't all that hard, so it machines fairly easily, but the iron carbide inclusions in cast or forged iron make it very abrasive and hard on the cutting edges of the cherries (this is why RCBS uses tungsten carbide cherries to cut their moulds). Brass cuts very smoothly and is very gentle on cherries. Aluminum also machines easily, but the cut faces are not as smooth as those on brass. Aluminum alloys are also more prone to warpage than brass (although this can be dealt with through appropriate stress relieving).

Bullet moulds can be made out of many materials. Popular materials include brass (Applegate 45 315 WFN mould, top), aluminum (Mountain Molds .40 caliber 200 grain Keith-style SWC, middle), and various ferrous alloys (RCBS 40 180 Cowboy mould, bottom).

Belding & Mull cut their mould blocks out of nickel. Meehanite (a cast iron alloy) has also been a popular mould making material, as has bronze. There are also a few experimental modern bullet moulds made from fired ceramic, with hardened steel alignment pins. There are a number of advantages to using ceramics to make mould blocks (excellent thermal stability, very smooth surfaces, ease of manufacture, lack of warpage, etc.), just don't drop it!

In the Field Museum of Natural History in Chicago there is an Inuit bullet mould that was hand-carved out of a single, split Walrus tusk. I stood staring at that display for quite some time, imagining the many long, cold, lonely nights spent carefully splitting, facing, hinging, and shaping that ivory in some remote igloo until the round balls that fell from it were just right for whatever musket that hardy soul used to feed himself with. I have also seen similar handmade Indian bullet moulds made from bone (buffalo, as I recall), and even bullet moulds in which the cavity was hollowed out from well-worn river-bottom stones (a stone mould with no handles has got to get HOT!).


Examples of an early Ideal single-cavity mould (the 3118 for the .32-20) and multi-cavity Armory moulds (an Ideal 7-cavity mould for the 360344 wadcutter).

Number of cavities. Historically bullet moulds were single cavity. After WWI, 2x and 4x moulds gradually started to appear, and after WWII became quite popular with individual casters. "Gang moulds" (6 or more cavities, also called "Arsenal moulds" or "Armory moulds") were traditionally used for the high volume, bulk casting needed by law enforcement groups and shooting clubs. These mammoth moulds take a long time to heat up and are of limited utility to a hobby caster who wants to cast only a few hundred bullets at a time (this is less of an issue with aluminum gang moulds due to their ability to heat up quickly).

Alignment pins. Early bullet moulds had no alignment pins, relying instead on the massive hinge pin to keep the mould blocks aligned. Later fixed handle moulds from Ideal incorporated alignment pins. Detachable mould blocks *must* have alignment pins as there is too much free play and too much variability in mass produced blocks; without this alignment mechanism to make sure the mould faces line up perfectly, your bullets would come out lop-sided.


Early moulds relied on the hinge to align the mould blocks (e.g. this early Ideal .38 wadcutter mould). Later on alignment pins were added (e.g. Ideal 429251).

Venting. Early Ideal moulds (i.e. fixed handle, single cavity) had no vent lines cut in the mould faces by the factory. The transition was made to interchangeable mould handles/blocks, but the mould faces remained unvented. In 1949 Lyman introduced 2-cavity mould blocks, and virtually all of the double cavity moulds I have seen have been vented, but there are a few exceptions (e.g. Himmelwright 2x), suggesting that factory cut vent lines came about after this date. Reviewing the Ideal Handbooks, moulds are not shown as being vented until Handbook number 43 (1964), but no mention is made of this in the text, or when the change was made. The purpose of these vent lines is to allow air to escape as the cavity is filled, allowing the mould to fill out properly and prevent voids in the finished bullet. Virtually all bullet moulds are vented in some way today.


Originally Lyman's double-cavity detachable mould blocks were unvented, just like all the early single-cavity moulds (e.g. the Ideal 360302 Himmelwright wadcutter mould shown). Later on the double-cavity mould blocks were vented by the factory (e.g. the Lyman 357443).

Aspects of cast bullet design

Every cast bullet design has the same set of variables that can be tweaked according to the desires of the designer. There is very little "new under the sun" it's really more of a question of refining what is already out there, and playing some subtly mix-n-match games to combine all of the desired features in one bullet (heck, even this sentiment is recycled -- Elmer Keith said the same thing about his Keith SWC's back when he started designing those back in 1928!). These variables include the bullet base design (PB, BB, GC, etc.), the amount of contact bearing surface employed, the shape, number and location of lube grooves, the location and configuration of the crimp groove, the diameter and thickness of the forward driving band, the length of the bullet's nose, the shape of the ogive and the diameter of the meplat. Sounds like a lot of fun, right?

Bearing surface. Traditionally, handgun bullets have had about half of their length used as bearing surface (rifle bullets generally use more). More recently, there has been a move towards heavier handgun bullets for deeper penetration, and this in turn has lead to longer handgun bullets with more bearing surface. Bearing surface is a good thing in that it makes sure that the bullet stays concentrically aligned within the throat and transitions smoothly from the throat to the forcing cone to become engraved in a symmetric and concentric fashion. The SSK designs are excellent examples of handgun bullets that take advantage of lots of bearing surface (60+%) and deliver excellent accuracy. The bottom line is more bearing surface makes for an accurate bullet since it helps to keep the bullet well-centered during engraving and as it travels down the bore (the Loverin rifle designs are another excellent example of how lots of bearing surface contributes to an accurate design).


Some of the early cast bullet designs had relatively little bearing surface (e.g. the Ideal 403168). Designs with more bearing surface (e.g. the SSK 44 320 TC) are generally easier to get to shoot accurately.

Lube grooves. All cast bullets need to be lubricated (see lube chapter), and this lube has to go somewhere. Way back when, 90 degree right-angled grooves were cut into mould designs for this purpose, and if you've ever cast with these moulds you know what a pain they can to deal with! As bullet metal shrinks, it shrinks towards the geometric center of the bullet, meaning that the driving bands end up "pinching" the mould at the 90 degree grooves, so the bullet holds fast and does not release from the mould readily. Two methods are commonly used to get around this problem: one is to cut these grooves with a slight bevel to them, and the second is to cut round lube grooves. Both approaches work just fine to provide "pinch-relief", but the rounded lube grooves generally hold less lube than a beveled flat-bottomed lube groove (what Elmer Keith liked to call a "square-cut" lube groove). Usually, this is of little concern since the rounded lube grooves are smaller and more of them can be used to decorate the bullet's bearing surface, resulting in the same overall quantity of lube. The important issue is how much lube is carried in the lube groove(s), and that they be capable of pumping the lube to the bullet/bore interface (see lube chapter).


The original Ideal 454424 (left, with "square-cut" grease groove) alongside the later Lyman 454424 with a rounded grease groove. Later Lyman would re-number this to 452424, and at different times has offered that design with both flat and round grease grooves (right hand photo).

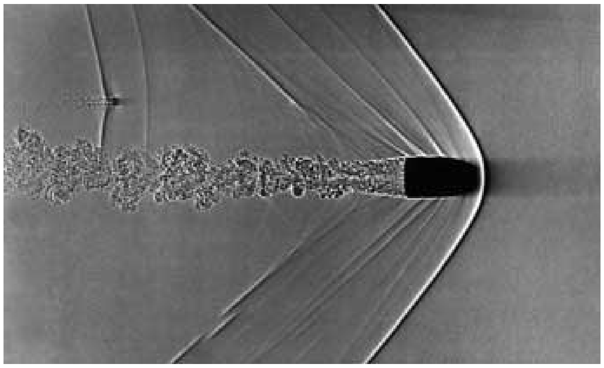
Crimp groove. Originally, handgun bullets had no provision for crimping, they were simply seated to a depth that allowed the case to be roll-crimped on the ogive. Heel bullets were simply crimped on the heel shank. A very few of the early (pre-1900) rifle bullets had crimp grooves, but most did not. It's important to remember that these plain-based bullets were designed for black powder, or light charges of smokeless powder ("gallery loads"). The recoil impulse of the gallery loads was light enough that bullets didn't move around in the case, and when these rifle bullets were seated on top of a case full of black powder, the compressed powder charge prevented them from being forced into the case when "waiting in line" in a tubular magazine. Thus, the only need for a crimp was to keep a revolver bullet from inching forward under recoil, and a roll-crimp over the ogive was usually sufficient for black powder level ballistics. Smokeless powder would change all this. Suddenly handgun cartridges cases had empty space in them, and velocities were no longer limited to about 900 fps. Beveled grooves dedicated to crimping had been introduced in rifle bullets with designs like the Ideal #3083 (for the Marlin .30-30), and were a natural next step in the evolution of handgun bullet design. As near as I can tell, the first handgun bullet to contain a beveled crimping groove was the Ideal 313226 (the 98 grain round-nose for the .32 S&W Long). This system worked so well that others soon followed (e.g. 313249, 358311, and 429251). Elmer Keith identified the 358311 as his inspiration and identified the beveled crimp groove as one of the more important design features of his SWC designs (his .38-44 Heavy Duty loads and heavy .44 Special loads generated significant recoil and required a strong crimp to keep the bullet from inching forward). Beveled crimp grooves have been standard fare on all revolver bullets ever since (although the angle, depth and length can vary considerably from one design to the next).

Early revolver bullet designs did not include a dedicated crimp groove (e.g. the Ideal 360271 and 360345 target bullets shown at left). Elmer Keith integrated a beveled crimp groove into the Ideal/Lyman 358429 (right) and most revolver bullets designed since then have followed suit.

Ogive/meplat. The ogive and meplat play a central role in determining how stably the bullet will fly and how efficiently it works upon impact. But these features also play a role in the internal ballistics of the load as well. How long is nose of the bullet? In other words, how much of the bullet is seated outside of the case? What is the resulting powder capacity? This will have a direct impact on how fast that bullet can be driven and still stay within sensible pressure limits.

The role of the meplat in crushing tissue and leaving a permanent crush cavity is well established; the larger the meplat, the larger the hole it leaves in its wake. This is why hunting bullets (e.g. Keith SWC's, SSK FP's or LBT WFN's) all have flat noses that are greater than half the bullet's diameter. Flat-nosed bullets are simply more effective and more humane killers. What is not commonly discussed is the role that ogive/meplat play in the aerodynamic/hydrodynamic stability of the bullet. The dynamics of how a bullet flies through the air, as well as how it flies through meat, is an important consideration when choosing a bullet to hunt with. Does a given design lead to deep, straight wound channels, or does it tend to tumble and veer off in unpredictable directions?

Aerodynamics. The meplat and ogive play a significant role in determining the aerodynamic stability (and hence accurate flight) of a given bullet design. When a bullet is traveling faster than the speed of sound, there is a high pressure bow wave that emanates from just in front of the meplat, and trails back behind the bullet. The bullet is basically acting as a piston, compressing the air in front of this cone, with somewhat rarified air (partial vacuum) behind the cone, along the bullet's body. (As an interesting aside, high power rifle competitors will commonly "de-tune" their spotting scopes to focus about halfway down to the target in order to be able to read mirage and dope the wind. This also allows them to "see" the bullet in flight and read the trajectory and wind drift in flight and see *where* the bullet is being blown of course. This conical pressure wave, and the change in the air's refractive index from the high/low pressure regimes, is what is being observed by these shooters.) Back to the story -- tests have shown that the ballistic coefficient is more heavily influenced by the ogive, than it is by the meplat. The reason for this is quite simple, the drag experienced by a bullet in supersonic flight is due to the size and shape of this conical bow wave. The surface area of the meplat is actually quite small relative to the surface area of this entire cone, and so the amount of drag actually due to the flat nose of a bullet (again, in supersonic flight) is fairly small. However the size and shape of this conical bow-wave are directly dependant on how easily it can "wrap itself around" the shape of the bullet, and with a shapely ogive the cone angle is smaller, and therefore the size of the conical bow-wave is smaller and the bullet experiences less drag going downrange. Likewise, when viewed from the side, the cross-sectional area of the cone is smaller, and since it is the "sail area" of this bow wave that dictates how susceptible the bullet is to wind drift, the more shapely bullet gets blown around in the wind less because it has a smaller sail. The combination of these two factors, less drag (hence greater retained velocity, and shorter time of flight) and smaller bow-wave cross-sectional area (a smaller sail for the wind to blow it off course with) are the reasons why boat-tailed bullets drift less in the wind than do flat-base bullets.



A shadowgraph of a supersonic bullet in flight. Note the bow wave -- how the ogive of the bullet interacts with this bow wave can have a significant impact on the stability of the bullet's flight. Note also the smaller pressure waves emanating from the grease grooves. Photo courtesy of: http://www.efluids.com/ efluids/gallery/gallery_pages/bullet shadowgraph.jsp

The forward portion of the ogive is thus a very important part of equation, as it plays a heavy role in shaping the bow-wave and determining how well the nose of the bullet "fits" inside of it. A sharp edge at the meplat/ogive juncture (such as one would get from a truncated cone, e.g. the Gordon Boser or Lee SWC designs) leads to a situation where the only stabilizing influence this bow wave can have on the bullet is through this perimeter around the edge of the meplat. By placing curvature at this juncture by making the ogive radiused, the bow-wave is able to wrap around the nose of the bullet, leading to a contact *surface* instead of just a contact *edge*. Why is this important? Well, this bow-wave acts as a dampening agent to damp out any yaw that the bullet might experience. Ever hear of a bullet "going to sleep"? That's just a reflection of how long it takes for any yaw inherent to the launching of a given bullet to be damped out by this mechanism (in combination with a couple of other factors). The efficiency of this damping mechanism is basically proportional to the amount of surface area that the pressure wave can act upon. In the case of the contact edge, there's relatively little that the bow wave can do to stabilize this yaw, but with a radiused contact surface this damping mechanism becomes much more efficient.

Hydrodynamics. Clearly, a large flat meplat results in greater ability to crush tissue upon impact, however, it is also well established that extremely large blunt meplats (e.g. wadcutters) are aerodynamically unstable and prone to tumbling upon perturbation. It is important to recognize that while the meplat determines the shape and nature of the wound channel when a bullet plows through meat, the ogive determines how stably the bullet "flies through meat". All of the arguments given above in the discussion of aerodynamics also apply here. It is interesting to note that J.D. Jones once noted that all of the cast bullets he recovered from big game animals all looked pretty much the same, and he used that shape as part of his inspiration for his SSK designs. He figured that if that's the equilibrium shape that a bullet achieved after punching through a critter, then starting it off in that shape should provide a reasonably smooth "flight" through more meat.

Optimum meplat diameter. OK, so we know that a big meplat is a good killer, but that too much meplat makes a bullet unstable in flight. How much meplat is too much meplat? Let's look at a few successful designs for some guidance here. Elmer Keith started off with a meplat diameter of 65% by borrowing Heath's ogive and meplat for the Ideal 429336. Keith then used 75% on his 452423, then settled on 68-70% for his 454424, 358429 and H&G #258 (.41 Magnum). J.D. Jones has used 70-75% meplats for his SSK designs. The LBT WFN is profiled by making the meplat .090" less than bullet diameter, so the relative diameter is not constant (75% for .358", 78% for .410", 79% for .429" and 80% for .452. The Keith SWCs and the SSK FPs are some of the most accurate handgun cast bullets that I've ever shot, and while the WFN bullets are superb hunting bullets, and are capable of fine accuracy, there are reports that they can be finicky about delivering their best accuracy, and can tumble upon impact (just like a wadcutter). In contrast, the big-bore LFN bullets are generally regarded as being inherently more accurate than their WFN brethren, with far better long-range stability than the WFN designs, and the LFN's have a reputation for penetrating nice and straight and deep. The LFN meplat is approximately .140" smaller than bullet diameter, or 67% for .429" and 69% for .452". Ignoring the contribution of the forward driving band for a moment, a purely empirical correlation suggests that the optimum compromise between stable aerodynamic flight and maximum tissue crushing capability occurs with a meplat of about 70-73% of bullet diameter.

The concepts outlined above for the ogive/meplat apply for supersonic flight, subsonic flight is a little different matter that we'll tackle shortly in our discussion of the driving bands and lube grooves. When the bullet is flying at subsonic velocities, then all of the arguments that you hear about shapely bullets really *do* apply, simply because in subsonic flight all of the features of the bullet's profile are in intimate contact with the slipstream, particularly below a Mach number of 0.85, or about 900 fps, where the slipstream is particularly conformal (at higher Mach numbers there are local pressure ridges along the projectile body, these grow into the bow wave and other pressure features at Mach 1). In subsonic flight, the primary source of drag is now that big, flat meplat since the conical bow-wave no longer exists. Again, in terms of influencing the aerodynamics of a handgunner's cast bullet, the ogive exerts the major influence in supersonic flight, while the meplat dominates in subsonic flight.

For competition (silhouette, bullseye, PPC, etc.) meplat diameter is immaterial, and the ogive is all important for optimum bullet performance. This is why cast bullets designed for silhouette competition tend to have smaller meplats and more curvaceous ogives.

Forward driving band. Elmer Keith felt very strongly about a full-sized forward driving band, both in terms of bullet diameter (to insure that the bullet was properly centered upon engraving) and in terms of width (to provide enough bullet metal for the lands to grip firmly and prevent slippage during engraving). The forward driving band probably doesn't do anything in terms of cutting the wound channel through yon deer since these forward driving bands have the tendency to get "wiped off" while traversing flesh, but they DO play a significant role in the flight behavior of cast bullets.

A full diameter forward driving band is very important to keep the bullet properly aligned, however if this is much longer than about .100" then it can cause problems with chambering the round unless the bullet is seated in a perfectly concentric fashion (a rarity) and is smaller in diameter than the throat (which is not always a good thing). Therefore, by keeping the forward driving band to .100" or so, it is readily accommodated by the taper of the leade from the chamber into the throat, and will chamber easily.

How tall should the forward driving band should be? In other words, when viewed from the side, how far should the driving band stand up over the base of the ogive? A shorter driving band means that the stresses associated with engraving are able to be distributed to the monolithic portion of the bullet, but if the base of the ogive is too small in diameter then this leaves the forward driving band to absorb the engraving forces all by itself, which can lead to slippage if the alloy isn't up to the task. By making this forward driving band as short as possible (i.e. by making the base of the ogive as large as possible) the forward driving band is provided the maximum amount of support. At this point, the bullet designer has a bore riding nose, which maintains the desirable turbulence of the driving band edge (vide infra), provides maximum bearing surface and provides positive engagement during engraving.

Aerodynamics. A very important consideration to long range high-power rifle shooters (e.g. 1000 yard) is the need to keep the bullet supersonic through the target. This is because as the bullet slows back down through the sound barrier and the supersonic bow-wave collapses, these long, sleek BTHP match bullets become destabilized and eventually start to tumble. Accurate flight is a thing of the past at that point. Therefore it is critical to these competitors that the bullet stay supersonic at least as far as the target distance.

Why was this not an issue for the 1000 yard shooters of the 1870s shooting the Trapdoor Springfield? Those loads started out supersonic, and transitioned to sub-sonic about halfway to the target and yet those bullets continued to fly in a stable and predictable manner for hundreds of yards. The BPCR silhouette shooters of today are able to pull off the same feat, but their compatriots shooting the bolt-guns and the BTHP jacketed match bullets suffer keyholing, tumbling and non-visible misses once their projectiles transition sub-sonic. Why? What do the BPCR shooters have working in their favor that the hi-power riflemen do not? The same questions apply to IHMSA shooters armed with .44 Magnum revolvers. There are many facets to the answer, but probably the most important is understanding HOW the bow-wave collapses during this transition, and recognizing the influence that certain cast bullet features have on that collapse.

The key is found in the nature of the airflow in the boundary layer, specifically whether this flow is laminar or turbulent. Allow me the indulgence of a historical caveat to introduce this concept. In the early days of aerial bomb design, engineers added fins to make the bombs fall "nose forward" and therefore in a predictable trajectory, giving them the best chance of hitting their target (kind of like the fletching on an arrow). As bombs got bigger and bigger, so did the fins. With really large bombs, it was found that even over-sized fins were just barely able to stabilize the flight attitude of the bomb, and that relatively minor perturbations would lead to loss of aerodynamic stability. Wind tunnel tests revealed that the large volume of air displaced by these huge bombs, coupled with a more or less smooth, laminar airflow, resulted in the slipstream basically "missing" much of the surface area of the fins (as well as generating destabilizing "eddies" back around the fins). A laminar airflow basically makes the bomb much larger in diameter, so most of the air basically has to go around what behaves like a much larger object. It was found that adding three small, radial ridges around the midsection of the bomb cured this problem. The thinking here is that the turbulence induced by these tiny ridges collapsed the large laminar airflow, and allowed a more conformal airflow that now flowed smoothly across the control surfaces of the fins. The take-home lesson here is that small amounts of controlled turbulence at the surface of a body leads to *smoother* airflow and more stable aerodynamic flight, just like the seams on a baseball allow for a predictable curve ball to be thrown by creating a small amount of turbulence at the surface which leads to smoother air-flow (somewhat counter-intuitively, a smooth ball would break even more and be difficult for the pitcher to control, see *The Physics of Baseball* by Robert K. Adair, Professor of Physics, Yale University).

In supersonic flight, the bow wave is typically a little ways in front of the nose of the bullet (roughly 1/8" to 1/4"). It is parabolic in shape. How the forward portion of the bullet's ogive "fits" inside this parabola is important to determine long-range stability. As the bow-wave collapses, the parabola starts to flatten out, and the nose of the projectile starts to penetrate the forward point of the bow wave, which then slips back over the projectile. The parabola continues to flatten due to the reduced pressure differential between the compressed air in front of the bow-wave and the rarified air behind it. This collapse/penetration leads to a cascade of events: first as the nose of the bullet penetrates and the pressure-wave slips farther back on the bullet. Sharp shoulders, or surface features, create secondary shock waves, due to the better ability of these surfaces to compress the air they encounter. Shadowgraph photography of supersonic cast bullets clearly shows shock waves emanating from the lube grooves and other structural features of the bullet's surface. As the bow wave slides back over these structural features, these shock waves serve to dissipate the energy of the bow wave in small pieces as the bullet slows back down through the sound barrier. The forward driving band is the first such structural feature that the dying bow wave encounters, and as such it has the biggest chunk of energy to dissipate since it's taking on the full brunt of the bow wave. The shock waves emanating from the crimp groove and lube groove(s) continue this break-up process as the fractured bow wave slides farther back, creating a turbulent boundary layer and dissipating the bow wave's energy in benign fashion. Bullets lacking the perpendicular face of the Keith SWC forward driving band can get a similar effect from lube grooves, although these are less efficient and more are required (a la the Loverin bullets).

It's important to recognize that this bow wave is in fact what the air "sees" in terms of the wind resistance and drag that the projectile experiences, so by slowing the departure of the pressure wave it serves to maintain drag on the rear portion of the bullet, helping to keep the bullet oriented nose forward. The boundary layer turbulence resulting from the forward driving band and lube grooves disrupts this pressure wave as it collapses towards the bullet base. As a result, the pressure wave is broken up over a period of time and dispersed in such a way that the airflow becomes turbulent conformal in a way conducive to stable flight (basically the energy is dissipated in small "packets" as turbulence/heat). For the smooth-surfaced jacketed BTHP, this penetration/collapse happens in much the same way, but the relative lack of surface features to break up the pressure wave, means that this wave collapses quite quickly, as a shock wave, and with a clap (quite literally a "sonic boom"). At the extended ranges that a high-powered rifle bullet is slowing through the sound barrier, it is traveling with a significant angle of incidence, which in turn means that this pressure wave moves backwards at different rates over the top of the bullet than it does over the bottom of the bullet. Therefore, these pressure waves leave the bullet's base at different times, resulting in an asymmetric force on the bullet's base as the shock wave ("sonic boom") collapses. This sonic "kick in the backside" can induce significant yaw (or amplify any yaw that is already present), and for a bullet spinning at well in excess of 100,000 rpm, that's all it takes to start tumbling. The important take-home message here is that this effect is transmitted through the bullet's base -- whether the bump comes a single, massive, axle-breaking pothole, or a series of several smaller "washboard" bumps. Which one is easier to steer through? It is interesting to realize that some of the very things that make a cast bullet ballistically inefficient overall, also make it aerodynamically MORE stable when slowing back through the sound barrier.

Specialized designs

Elmer Keith designed his SWC's to be general, all-purpose bullets so a shooter could buy one mould and use that one bullet for just about any task that he was likely to encounter. When we distill down all of the discussion above, it is readily apparent why these bullets work as well as they do. However, many cast bullet designs have been put together around very specialized features, for highly specific applications (especially in recent years). After all, bullet casting is affordable enough that a shooter can afford to have one mould specifically for one flavor of competition, another mould for a different form of competition, a third for hunting small game and yet another for hunting big game. Sometimes these specialized features amount to little more than passing fads, or reflections of shooting disciplines that came and went, but some of these specialized cast bullet designs stake a claim within the shooting community and take up permanent residence.

An example of a nose-pour mould (Hoch .41 caliber 210 grain mould).

Nose pour. By placing the sprue on the bullet's nose, the bullet's base can be made more rigorously square to the bullet body since it now being turned as a part of the cavity, and hence on the same axis. Since the bullet's base is it's "steering end" (i.e. the last part of the bullet to leave the muzzle, and the part most heavily influenced by the blast of gas escaping from behind as it leaves) having this feature perfectly square is a critical component to obtaining top accuracy. As a result, nose-pour moulds are popular with long-range rifle shooters and Schuetzen competition. Most commercially available base-pour moulds are pretty good in this regard, but if a mould has got a loose or bent sprue plate, or if the top edge of the cavity has gotten dinged, or the top face of the mould has been damaged, then the quality of bullets coming from that mould are suspect. The quality of bullets emerging from a nose-pour mould will not be seriously compromised by these injuries.

Dr. Franklin Mann's book (1909) *The Bullet's Flight from Powder to Target* stressed the importance of symmetrical and well-formed bullet bases.

Asymmetries, distortions, fins, defects will destroy the accuracy of a cast bullet, and Dr. Mann's detailed, systematic experiments revealed exactly how these deformations impacted accurate flight. By making a nose pour bullet the base will be perfect and will not be susceptible to asymmetries resulting from a bent or loose sprue plate or trapped air pockets, inclusions or voids. Note that by having the base at the bottom of the mould, since lead is much more dense than air or particulate impurities, that these detrimental defects are forced away from the all-important base simply by the force of gravity (a base pour mould can concentrate these defects at the bullet's base with dirty alloy or sloppy casting conditions).

Examples of the Harvey Prot-X Bore cast bullet designs (e.g. the .38 and .45 Harvey moulds shown). Some of the Harvey designs were even available in HP form (e.g. the .44 HP mould shown).

Harvey Prot-X-Bore. In the mid-1950s, Jim Harvey designed a series of moulds that were made to accommodate zinc washers so that bullet metal was cast through the hole in the center of the washer, thus permanently affixing the bullet to the washer. (Interestingly, these are seen in both base-pour and nose-pour configuration. Most of the Harvey moulds I've seen have been the nose-pour configuration. In base-pour format the molten alloy has to be poured through a cold zinc washer and I suspect wrinkled bullets were the norm with this style of mould. With a nose-pour mould the only lead that has to go through the washer is the rivet that holds it in place). The idea behind this design was to allow the use of pure lead (or very soft alloys) so that bullet expansion could be maximized at typical handgun velocities, and also to eliminate gas cutting and the need to size-lubricate the bullet after casting. The zinc washer was touted as being a bore scraper and removing lead fouling, as well as depositing a zinc layer on the bore, protecting it from oxidation and leading. These Harvey bullets were promoted as not needing to be lubricated, but that was pretty much limited to standard velocity loads and leading could get to be pretty severe at higher pressures/velocities.

An example of a 2-part bullet (Ideal 375296). The small mushroom-shaped tip would be cast out of a soft alloy (like pure lead), then that piece would be inserted into the regular cavity of the bullet mould and the remainder of the bullet would be cast of somewhat harder alloy.

Two part bullets. The idea of controlled expansion has been with us for a long time. The 1915 Marlin-Ideal catalog lists four 2-part bullet moulds -- the 308291 (165 grain GC-RN for the .30-30, .303 Savage and .30 Remington), the 319295 (a 175 grain GC-FP for the

.32-40), the 321297 (a 182 grain GC-FP for the .32 Winchester Special), and the 375296 (a 253 grain GC-FP for the .38-55). Note that these cherry numbers are all in the 290's, which would suggest that their introduction was right around 1902. Note also that these moulds all represent medium caliber arms. Apparently the thinking was that producing shootable 2-part bullets in smaller calibers would be too difficult, and that the larger bore weapons already made big enough holes. Anyway, the idea here was to cast the front quarter or so of the bullet with either pure lead or a very soft alloy, and then to place this soft "mushroom" (it had a "stem" to help bond the two halves) in the regular mould cavity and pour the back half with a harder alloy. The design concept is not unlike the Partition and H-mantle bullet designs (just a little bit older). These moulds are occasionally encountered on the used mould market today, but commonly command premium prices. Mountain Moulds of Pocatello, Idaho offers 2-piece moulds for a wide variety of mould designs (http://www.mountainmolds.com/).

A few years ago, Ross Seyfried wrote up a similar project (*Handloader*, April-May 2003) which could be pulled off with standard moulds and likely produce higher quality projectiles. The drawbacks of the 2-part bullet process as originally promoted by Ideal (outlined above) is that the bullet results from 2 separate casting operations; the nose is done first and then the base is poured later. This process schematic creates 2 significant roadblocks for the efficient production of high quality projectiles. First, it requires that the nose portion be handled and inserted into the hot mould (a good way to burn fingers! using tweezers prevents burned fingers, but significantly slows production); and second, the nose portion is cold when the base is being poured over it (which can cause voids and defects). Ross formulated a very clever strategy to get around all of these problems, and do it with standard moulds. His process involves the use of 2 separate lead pots, one filled with soft alloy (say 30-to-1), the other filled with hard (like wheelweight or 6-2 alloy). A special fixed-capacity ladle is made for the soft nose portion (I used a fired 9mm casing with a coat-hangar wire handle wrapped around it), this ladle is filled to the brim with soft alloy and poured into a hot mould. As soon as this pour is completed, the ladle is set aside and the mould is transferred to the bottom pour pot containing the hard alloy and the cavity topped off normally. This method obviates the need to handle the soft nose portion and the hard base is poured when the nose is still hot, so an effective soldering is achieved between the two portions. Yes, this process is somewhat slower than just plain casting, but there is no need to do this for garden variety plinking bullets, only those bullets that are going to be used for hunting.

More recently (around 1982), Lyman revived this idea with a series of 2-part revolver bullet mould designs that they called "composite bullets" (mould numbers 358624, 429625 and 452626) that were designed by Kenneth Ramage. These were variations on the SWC theme in which the soft nose was glued into a conical cup in the harder base. These moulds apparently didn't sell very well and were dropped from the Lyman line later in the 1980s.


The H&G #333, a stackable wadcutter for the .38 Special and .357 Magnum.

Multiple projectile loads. Shooters have been interesting in multiple projectile loads for centuries. Whether grapeshot from medieval cannon, or buckshot from a farm-boy's shotgun, the ability to land multiple projectiles on a target has always had both strategic importance, as well as functional appeal. The modern revolver shooter is no different. One of the early attempts to bring multiple projectile loads were the Remington.38 Special loads that contained a couple of buckshot pellets. Accuracy was marginal, but they were designed for close-range self-defense. Around 1980, Dean Grennell got H&G to make him a mould that cast a short, flat WC that contained a single grease groove and could be stacked inside a .38 Special or .357 Magnum case to allow the home caster to create similar home-brewed self-defense loads.

A few representative examples of the heavyweight truncated cone SSK designs.

JDJ. In the 1980s, J.D. Jones of SSK Industries brought out a new line of cast bullets that were specifically designed for the handgun hunter who wanted to take on the heaviest big game with a revolver. These bullets were typified by being heavy for caliber (e.g. 280 grains for .41, 320 grains for .44, and 350 grains for .45), having lots of bearing surface, multiple lube grooves and a healthy meplat (typically 70-75% of bullet diameter). These bullets were the first "heavier than normal" bullets designed for revolvers, and are designed for deep penetration, with a truncated cone design. Their meplats are typically a little larger than those found on Keith SWC's. The 320 grain .44 Magnum bullet has been used to kill pretty much everything, up to and including elephant. I have SSK moulds in number of different weights in .357, .41, .44, .45 and .475 diameters and they have all consistently delivered excellent accuracy. These moulds were available in PB, GC and BB form. Originally, these moulds were commissioned by SSK and manufactured by NEI (these moulds are stamped SSK), and later the rights to sell these moulds was sold to Peter Pi at Cor-Bon. The SSK designs are still cataloged by NEI, now located in El Paso, Texas.

Silhouette. IHMSA was a major form of competition in the 1970s and 1980s. To be competitive in silhouette shooting, one needed to shoot a lot. Cast bullets were a natural solution. Various mould-makers (like Saeco, RCBS, and others) unveiled a new line of mould designs specifically for silhouette competition. These moulds are typically gas-checked and feature a narrow truncated cone (similar to the SSK design, but with a smaller meplat and slightly radiused ogive, reminiscent of "Old Homely" 357443). In addition, they are usually of moderate weight (e.g. 180 grain for .357, 240 grain for .44), and are designed for maximum retained momentum at the 200 meter ram line. Cutting a wide, deep wound channel is not an issue here, the focus instead being on momentum in an aerodynamic package.


RCBS 35 Caliber 180 Gr. Silhouette


RCBS 44 Caliber 240 Gr. Silhouette

(No picture)
RCBS 30 Caliber 165 Gr. Silhouette


RCBS 7mm 145 Gr. Silhouette


A few representative examples of LBT cast bullet designs (the .357 180 FN loaded into .357 Magnum, the LBT .357 200 grain LFN-GC, the LBT .417 305 grain LFN, the LBT .432 320 grain WLN.

LBT. Veral Smith of Lead Bullet Technologies (aka "LBT") brought out his own line of hunting oriented cast bullet designs for the handgunner. While the SSK designs focused on weight first and meplat second, LBT took the opposite approach and focused on meplat first and weight second. In contrast to the SSK designs the WFN's and LFN's are generally a little closer to the "standard" weights for a given caliber, and are made to maximize wound channel diameter, not necessarily to maximize penetration depth. The WFN designs accomplish this with meplats that are 75-80% of the bullet diameter, while the deeper penetrating LFN's are typically 67-69% of the bullet's diameter. The WFN's have a well-established reputation to hit harder than virtually all cast bullet designs. The LFN's have a reputation to be a little more accurate, and for penetrating deeper and straighter. As with the other designs discussed, the LBT designs are available in a variety of weights and in PB, GC or BB versions.

This is just the tip of the iceberg, there are many other designs that could have been included, but this chapter has run on long enough! There are thousands of interesting cast bullet designs out there, and many more waiting to be cut into metal. All it takes is a desire, an active imagination and a good machinist who knows the subtleties of how to make a bullet mould. Everybody has their own vision as to what the perfect bullet looks like, so now you see why there are custom bullet mould makers!

Chapter 10

GC vs. PB Bullets: or "PB, or not PB, that is the question...."

"Whether 'tis nobler in the mind to suffer the slings and arrows from the phantoms of leading,
or to take arms against a sea of troubles, and by gas-checking end them..."

(with apologies to both Hamlet and The Bard, I just couldn't help myself...)

Stop me if you've heard this one before -- a handgunner walks into your neighborhood gun shop and says, "I'd like to start casting my own bullets, but I'm a bit confused about all the different choices that are out there. I don't have a lot of money to get started with and I don't want to buy moulds that aren't going to work well for me in the long run. Should I buy a gas-check (GC) mould design, or would plain-base (PB) work better? Are GC's expensive, or hard to find, or hard to put on? I read all this stuff about cast bullets, leading and bad accuracy, and I'm confused. Which bullet design is better?" Yeah, I thought you'd heard it before. Well, what do we tell our budding young bullet caster?

Let's look at why GC's were invented so we can gain some insight as to their best use. In August of 1902, Dr. Franklin Mann tested a new bullet for his .32 caliber muzzle loading rifle made by none other than Pope (described in his landmark treatise *The Bullet's Flight from Powder to Target*). These bullets were hollow-based and cast in a Zischang mould. They had a cavity on the base that was made to accept a brass machine screw, swaged into place in the cavity. The head is approximately bullet diameter. Dr. Mann's goal here was to create the perfect bullet base by preventing its distortion during the loading and firing process. These bullets were found to deliver approximately 1.5 MOA accuracy from the muzzle-loader. The ammunition was experimental and was created by custom, experimental loading tools and methods. Clearly, the concept of protecting a cast bullet's base with a harder, more durable metal was clearly taking form.

The gas-check proper was patented by John Barlow in 1906, and subsequently described later that year in his Ideal Handbook #17. The year this took place is particularly relevant. Many of the rifle shooters of the day had learned about shooting cast bullets in rifles like the .44-40, .40-82, .45-70 and .38-55, but ballistically speaking a new day was dawning at the turn of the century. The .30-30 Winchester and the .30 US Army (a.k.a. ".30-40 Krag") was less than a decade old, and was harbingers of things to come. The fact that shooters were getting more interested in skinnier bullets, higher pressures and more velocity was not lost on John Barlow. The older cartridges shot PB bullets just fine with full-throttle loads. The .30-30 and .30-40 Krag could be made to shoot PB bullets acceptably well at somewhat reduced pressures and velocities, Barlow realized that the new cartridge that the US Government adopted in 1903 (the short-lived .30-'03) would leave shooters wanting more than was realistically achievable from a standard PB bullet. He set about to design a cast bullet that would allow higher performance from the newer, higher pressure .30 caliber rounds. He refined his ideas during the same year that the Army refined theirs, 1906. It is fitting that the GC was unveiled in the same year that that .30-'06 was; this was neither coincidence nor accident. It is clear that the GC was well-received by rifle shooters of the day as a variety of other GC cast bullet designs were introduced over the next several years, both in .30 caliber and various other rifle calibers (e.g. 7mm, 8mm, .35, and .375).

Handgun shooters of that era by and large operated in a pressure/velocity regime served perfectly well by PB cast bullets, so GC handgun designs generated little interest in pre-WW I America. The exception was the 311316 GC .32-20 bullet. Although it was designed for high velocity rifle loads, it could be fired from both rifles and revolvers. Elmer Keith mentions GC bullets only in passing in his 1936 *Sixgun Cartridges and Loads* (on page 86), specifically addressing their use in high velocity loads in the .32-20 Colt Single Action Army (and similar loads for the .44-40, using the Ideal 429434 221 grain GC-RNFP). This is one of the few instances where he had anything good to say about GC's in revolvers. Hold that thought, we'll return to it a little later.

The Lyman 311316, the first GC bullet suitable for use in a handgun.

The introduction of the .357 Magnum in 1935 would change the landscape of handgunning. It introduced high-pressure, high-velocity loads to the mainstream revolver shooter. Factory .357 Magnum ammo was loaded with soft, swaged lead bullets, and lubed with some flavor of marginal mystery grease. Leading was reported to be hideous. As a result the .357 Magnum quickly developed a reputation for insidiously problematic leading, and that reputation scared people into thinking they should probably have GC's on bullets they cast at home for their .357 Magnums, or suffer a similar fate. It is important to realize that the bullets used by Phil Sharpe in the development of the .357 Magnum, as well as those used by Elmer Keith in his .38/44 load development, were virtually all PB bullets, and both of these expert handgunners obtained excellent results with them (see for example, the groups published in Sharpe's *Complete Guide to Handloading*). Indeed, the Ideal Handbook #34 (published in 1940) lists the PB Ideal 358446 as "the Standard Bullet for the .357 Magnum". Sharpe and Keith cast their .357 bullets with a BHN of 10-12, used quality bullet lubes, and had no problems with leading. The same is true today. But, the seeds of suspicion had been planted...

So, when did the first GC cast bullet designed specifically for a handgun come out? Cramer listed two GC handgun designs (#13 and #14) for the .357 Magnum in their 1939 catalog. These bullets are very similar to the 358156 HP/SWC, except with a somewhat shorter nose, and were designed by Ross Sernow of Los Angeles, CA. They were reported to perform equally well in the .38 Special and "the Magnum", and to be especially well adapted to hunting. It seems clear that these bullets were designed to prevent leading in high-performance field loads in the .357 Magnum. However, several of Cramer's other PB designs were listed identified as being specifically for "the Magnum", so Cramer recognized that a GC was not necessary in the .357.


The Lyman 358156 GC-SWC (designed by Ray Thompson in the early 1950s), and its plain-based progenitor, the 357446 ("the Standard Bullet for the .357 Magnum") shown for comparison.


The Cramer #14 GC-SWC design dates back to the 1930s.

Ideal Handbook #37 published in 1950 showed most of their rifle bullet designs as being gas checked. However, none of their handgun bullet designs were gas checked at that time. GC cast bullet designs specifically for handguns did not appear until about 1953 when Ray Thompson’s GC handgun designs were cataloged in the Lyman-Ideal Handbook #39. In that issue was cataloged for the first time the Thompson GC under #358156 and recommended for the .357 Magnum. This same issue also listed Thompson’s two .44 SWC-GC designs as #431215 and #431244. It is interesting to note that Lyman apparently reused some of their cherry numbers. For instance, the design originally carrying cherry #156 was actually #308156. It was used in the .32-40 Remington which was designed as a mid-range match cartridge for use in Remington’s single shot target rifles. Remington designed it as .32 caliber, but in fact, it was actually .308-.309 caliber. The cherry originally carrying #215 (429215) was a 205 gr. RN designed by Anderton for use in the .44 S&W Russian. The cherry originally assigned #244 (308244) was an 89 gr. RN for use in the .30 Luger. Ideal Handbook #39 only listed loading data for the 358156 (both SWC and HP) in both the .357 Magnum and .38 Special. No other GC bullets were listed in the handgun loading


Some of the GC revolver bullets that Ray Thompson designed in the 1950s (top photo, l-r: 429244, 429244HP, 429215, 429215 HP) (bottom photo, l-r: 358156, 358156 HP, 429244HP, 452491, 452491 HP, 452490).

data even though the .32-20 and the .44-40 have GC bullets listed in the rifle section of the loading data. Several new GC handgun designs were listed at the end of the loading section in Ideal Handbook #40 (1955) as New Bullet Designs available from Lyman. These designs included the 452484, a 225 grain GC-RN for the .45 ACP; the 452490, the 230 grain Thompson GC-SWC for the .45 Colt; and the 454485, a 250 grain GC-RNFP also for the .45 Colt, derived from the old 454190. The gas-checked cast bullet was clearly gaining acceptance amongst handgunners. In terms of their long-standing record of outstanding performance, the Thompson GC-SWC designs rank right along side the Keith SWC's; they are truly excellent bullets.

A GC allows one to shoot a somewhat softer bullet without leading, and this can be useful for getting cast bullets to expand at revolver velocities, and such was the motivation behind one of the more creative variations on the GC theme that's been tried. Introduced in 1953 (Ideal Handbook #39), and described in detail in *Handbook of Cast Bullets (*1958), were a series of moulds designed and developed by Jim Harvey that allowed the caster to insert a zinc (Zn) washer into the mould cavity and cast the bullet metal through a hole in the center of the washer, permanently joining the two when the bullet metal solidified. The bullets were ready to shoot as-cast, with no sizing or lubrication. Harvey's motivation for designing these bullets was to be able to shoot very soft pure lead bullets that would expand while hunting, without leading problems. These moulds were marketed under the "Harvey Prot-X-Bore" name and were made by Lyman. The mould numbers were in the 500 series, which Lyman had set aside for their experimental designs. The most commonly encountered of these moulds today is the 358500 SWC for the .38 Special (see Figure 11.3); note that this bullet had no provision for crimping or lubrication. The .44 Harvey SWC's, the 220 grain 429508, 170 grain 429509 and the 245 grain 429518, as well as the .45 Harvey SWC's 190 grain 452505 and the 454506 also lacked lube and crimp grooves. Interestingly, the .357" diameter 119 grain SWC (Lyman 358502) had a crimp groove and the Harvey 125 grain wadcutter (Lyman 358503) not only had a crimp groove, but 2 lube grooves as well. The absence of these features on the later, larger caliber Harvey designs indicates that Harvey felt they were not needed. In fact, wildly exaggerated claims were made about the "dry lubricating" ability of the zinc washer. *The Handbook of Cast Bullets* (an excellent reference published by Lyman in 1958) has a section on Jim Harvey and his bullets, and in it they admonish the shooter to seat and crimp his bullets in separate operations, as crimping during the seating step can distort the shoulder to the point of preventing the loaded round from chambering. The absence of a crimp groove means that the crimping operation must displace bullet metal and if this happens while the bullet is still going into the case a bulge is formed. The loading data for the Harvey Prot-X Bore bullets suggests that these lightweight bullets are capable of exceptional velocities in the 1600-1900 fps range. Although their accuracy at these speeds has been criticized by multiple sources, at modest velocity they seem to shoot fairly well.

The Harvey Prot-X-Bore mould for the .38 SWC (Lyman 358502).

For those of you that have Harvey moulds, and need a source of Zn washers, they are available from the following manufacturers:

Sport Flight Mfg., P.O. Box 1082, Bloomfield Hills MI 48303;
4-D Custom Die Co., 711 N. Sandusky, Mt Vernon Ohio
43050 740-397-7214 (http://www.ch4d.com/)

Back in 1990, in the first *Handloaders Bullet Making Annual*, Dave Scovill reported on the perforated GC developed by Edmund Wilk. The basic idea was to remove the center of a normal GC, and cast the bullet through the center, much like the Harvey Prot-X-Bore concept. The difference is that the bullet still needs lubrication and the GC can be placed on any of the driving bands of the mould, aimed at accomplishing different tasks. For example, Scovill found that placing the GC on the forward driving band of the Keith 454424 eliminated skidding on this band during engraving, whereas he reports evidence of skidding of the original SWC's that he cast. In other loads he found that the Wilk GC reduced or eliminated leading. In general, Scovill found that good loads were not improved upon, or surpassed, by bullets fitted with the Wilk GC, but that the accuracy of marginal loads was generally improved.

Now that we've seen where the GC came from, why they were invented, and some of the variations on the GC theme that have been toyed with, let's get back to our gunshop novice and his concerns. A very common misconception is that if you drive a PB cast bullet faster than about 1000 fps, horrendous leading will result, and the sixgunner won't be able to hit a barn from the inside. This just flat ain't true, folks! This "old-wives tale" is simply a hold-over from the reputation that the original .357 Magnum factory ammo had for leading (and remember, that was due to extremely soft bullets and poor lube quality). PB bullets can be driven considerably faster than 1000 fps with no leading whatsoever, all day long. Leading is a complex issue, and one that is addressed in a separate chapter. But, in a nutshell, the primary variables involved in leading and its prevention are alloy hardness and obturation, matching bullet diameter to throat/groove diameter, lubricant quality and quantity, powder selection and bore condition. Note the distinct lack of any mention of the presence or absence of that cute little copper diaper that we call a GC. For routine revolver shooting up to about 1500 fps, PB bullets can shoot just as cleanly and accurately as a GC bullet. They can at even faster speeds, but that requires that the shooter pay a little closer attention to a few very specific details.

As always, the new bullet caster wants to know, "Which bullet is better?"

Well, this requires that we ask the budding young caster-to-be what criteria are being applied to determine "better"? Usually, the answer is "Accuracy". Oh yeah, and he wants to avoid that mystical triple-horned demon of the netherworld, "leading". We've already touched on the issue of leading so let's focus on accuracy - which cast bullet design (GC or PB) is inherently more accurate? I'm going to let you in on a little secret here, known only to grizzled old alchemists, gun-hacks and other ne'er do wells. Lean over close so I can whisper, *neither* design is inherently more accurate than the other. Shhhh, don't tell....

When we think of cast bullet accuracy in revolvers, what is the most universal benchmark you can think of? My vote is for the classic .38 wadcutter target load. Have you ever seen a GC on a .38 wadcutter? Believe it or not, moulds have been made for GC wadcutters (and Terry Murbach tells me that these moulds were offered by more than one maker). Bottom line? This is an experiment that has been tried several times over the years, and it just didn't bear fruit. You never see them around because the results are simply not worth the effort. You can be sure that if the GC improved accuracy, bullseye shooters would burn them by the bucket-load. The take-home lesson here is that a GC does not make a cast bullet inherently more accurate. Inherent accuracy is more an issue of cast bullet quality, the care with which the ammo was assembled and the inherent "tastes" of a particular sixgun, than it is a question of whether or not the cast bullet is wearing a GC on its backside. To quote my respected friend John Taffin, "Every sixgun is a law unto itself."

As an example, I have a S&W 657 Classic Hunter .41 Magnum that is delightfully accurate with the plain-based Hensley & Gibbs #258 Keith SWC at full-throttle, and likewise does very well with most other PB bullets, like the RCBS 210 SWC. Feeding that gun cartridges loaded with GC SWC's will make groups open up considerably to the point of looking more like buckshot patterns. Why? I don't know. It just does. As a counterpoint, I have a stainless 4 5/8" Ruger Super Blackhawk .44 Magnum that is just plain mediocre with pretty much everything loaded with PB bullets, with groups generally running in the 2 1/2" range at 25 yards. Nothing great, nothing horrible, just, well, boring. But, feed that gun the Lyman 429244 GC-SWC, or its hollow-pointed kid brother, and groups become one ragged hole. Some guns like PB bullets, some guns like GC bullets, some guns like 'em both, but neither bullet design is inherently more accurate than the other overall.

That was about the level of my understanding of bullet casting operations back in the early days of my casting career -- just get a bunch of different moulds, cast a bunch of different kinds of bullets, shoot them all and see what cartridge does well with which bullet(s). Then I read Veral Smith's handbook ("Jacketed Performance from Cast" available from LBT). Among the numerous pearls of wisdom scattered therein is the observation that a GC becomes critical when a cast bullet load combines high velocity and high pressure (Veral was primarily addressing rifle loads here, but his conclusions are equally valid for revolvers). It's not just a question of velocity, or of pressure, but rather the combination of the two. Suddenly the clouds parted, the sunbeams came streaming through, the angelic choirs sprang into song and a small dose of enlightenment was bestowed upon this humble caster. Now, all of my scattered, independent observations started forming "The Big Picture"! A lead alloy bullet could handle things just fine up to a point, but beyond a certain pressure ***and*** velocity it needed that little copper crutch to perform its best.

For example, the LBT .358-200 grain LFN plain-based bullet loaded to about 1500 fps in a Ruger .357 Maximum resulted in severe leading and horrid accuracy. In contrast, the same bullets cast of the same alloy, loaded to similar pressures in the .357 Magnum at about 1200 fps were very accurate and clean-shooting (and in fact, is one of my favorite long-range plinking loads). The combination of roughly 35,000 psi and 1500 fps velocity resulted in leading, but 35,000 psi and 1200 fps didn't.

Shooters generally tend to first think in terms of velocity when addressing the PB/GC dichotomy. This is because we, as shooters, are obsessed with velocity. We pour over ballistics tables and reloading manuals, we chronograph load after load, we tailor loads for specific power levels based on velocity, and we create new cartridges in the pursuit of more (e.g. .44 Magnum), or less (e.g. .40 S&W) velocity. After all, it's velocity that allows bullets to do their job, and then dictates how well they do it. A bullet at 1000 fps is a lot more useful and interesting than the same bullet sitting on your desk next to your laptop. But leading is not simply the result of velocity. Look, for example, at the cast bullet loads for the .45-70. It's no trick at all to put together the low-pressure PB .45-70 loads at 1600-1700 fps that shoot very cleanly. Nor is leading simply the result of pressure. The SSK 350 grain FP can be shot at 1400 fps from a Freedom Arms 454 Casull with 26.0 grains of H110. Accuracy is very good and leading is not an issue, in spite of the fact that this is a 40,000+ psi load. No, a sixgunners cast bullet problems arise when one combines high velocity with high pressure, and that is precisely where the gas-check earns its keep.

What does a GC do? Quite a bit! But perhaps the most important is that it helps to seal the bullet's base to minimize gas leakage. This can also be accomplished with a PB bullet through the appropriate choice of alloy for the load, allowing plastic deformation (obturation) of the bullet so it can seal the bore. Factored in to all of this (and commonly overlooked) is the fact that bullet lube serves as a floating, fluid gasket that follows the bullet down the bore, also helping to seal the system. It has been recognized for many years that the flow characteristic of bullet lube is one of its most important properties. So with the right alloy and a good lube, we don't need a GC to seal the system for run-of-the-mill sixgun loads. But both of these sealing mechanisms can be overwhelmed at some point. Increased velocity results in increased abrasion defects along the engraved face of the bullet following the trailing edge of the lands. At high pressures, gas can and does, leak through these velocity induced defects.

For the sixgunner, where do pressure and velocity both rise to the point of making a GC important? Well, it depends on the alloy hardness, lube viscosity, etc.. Perhaps this starts to happen at the magnum revolver pressure/velocity level? Remember the horrible leading and accuracy that was obtained with the original .357 Magnum lead bullet loads? Please, recall that those were swaged lead bullets and therefore extremely soft, and the lube was marginal at best, thereby offering a clear demonstration of how these sealing mechanisms can be overwhelmed when substandard materials are used. Cast of a suitable alloy, e.g. BHN >11, PB bullets work just fine in all of the Magnum revolvers. These guns generally operate around 35,000 psi peak pressure, with velocities in the 1300-1400 fps range. With good alloys and good lubricants, PB bullets work just fine at this level.

When we start to ratchet pressure and velocity much beyond this level, a PB bullet can run into some serious problems. What does this mean for the sixgunner? Well, there are 3 factory cartridges that make me think of GC bullets as a "knee-jerk" first choice for standard weight bullets - the .30 Carbine, the .357 Maximum, and the .454 Casull. These are sixguns that routinely operate at pressures above 40,000 psi, and their bullets generally leave a revolver barrel in excess of 1500 fps. Now I'm not trying to say that PB bullets can't be made to shoot well out of these guns (they can), but rather when these cartridges are run at their normal, full-throttle level, they can make life very hard on a PB bullet. As an example, one of the loads my OM .30 Carbine Blackhawk just dotes on is 13.0 grains of W296 underneath the plain-based Lyman/Ideal 311008 HP (112 grains) for 1440 fps. This is not a maximum load pressure-wise (I would guess that it's only about 25,000 psi peak pressure), but it's about the limit of what I can squeeze out of this particular PB bullet before running into leading and accuracy problems. Don't get me wrong, this is an outstanding varmint load, it's just not loaded to the full potential of the cartridge and gun.


The .30 Carbine and Lyman 311316 GC-HP, an excellent varmint combination!

To run the peak pressures up to the 40,000+ psi range and velocities up to almost 1600 fps in this gun, I like to use the Lyman 311316 GC-SWC-hollow point cast of WW alloy with 2% added tin, air-cooled weight is 109 grains checked and lubed. 13.0 grains of Accurate Arms #9 give very good accuracy in the .30 Carbine Blackhawk, and generate 1570 fps. No two ways about it, this is a high performance varmint load!

.357 Maximum and the LBT 35-180-WFN-GC

The .357 Maximum is a kind of "red-headed step-child" of the cartridge world; it's gotten beat up for all kinds of things that weren't really its fault. The top-strap gas-cutting issues, forcing cone and barrel erosion problems can be mitigated through the proper choice of powder. My favorite loads are powered by 4227 and sparked by the CCI 450 primer. The .357 Maximum is a fine hunting round, and one that handles cast bullets just fine, but they had better have a GC on them if you're going to run this round at full-throttle. An excellent hunting bullet for the Maximum is the LBT 180 grain WFN-GC, cast with water quenched WW alloy and lubed with homemade molly lube. This bullet leaves very little room for clearance at the end of the Super Blackhawk cylinder. It must be fully seated and firmly crimped in place to avoid tying up the cylinder. Fortunately, the .357 Maximum doesn‘t have much recoil to jar this bullet loose. By putting as much of the bullet outside of the case as possible, it leaves significantly more case capacity than do other 180 grain bullets, which are generally seated much deeper. This helps to keep pressures down and allows the use of more powder for potentially higher velocities, than would be possible with other 180 grain bullets. For this bullet, I use 23.0 grains of 4227 and the CCI 450 primer for excellent accuracy and 1600 fps.

.454 Casull loaded with the RCBS 45-300-SWC-GC

An excellent all-round choice for the .454 Casull is the RCBS 45-300-SWC-GC (312 grains checked and lubed). I had a 7 ½” Ruger Super Redhawk that was partial to this bullet over 30.0 grains of H110, sparked with a CCI 400 primer, which generates 1650 fps. I generally cast these bullets fairly hard (BHN of 18 or so) using WW alloy, sweetened with a little linotype, cast hot and water quenched as they drop from the blocks. This is a 50,000+ psi load that leaves the barrel spotless, and shoots pretty dog-gone well. Ruger didn’t make the same mistake with this gun that they made with some of their .45 Colt Blackhawks. There have been several Blackhawks with .484” chambers and .450” throats that have passed through this writer’s hands. The excellent accuracy that this 454 Super Redhawk delivers is likely due to the tighter chambers and properly-sized throats that Ruger used on this gun. Cases come out of the cylinder at .478” and the throats are a snug .452”. In short, this is a very well-made revolver. I’ve had mis-informed blow-hards vociferously preach at me that they ***never*** shot cast bullets, ***only*** jacketed bullets, because they wanted “magnum performance” from their revolvers. Well Friend, I'm here to tell you that a 310 grain Keith-style SWC at 1650 fps with pin-point accuracy qualifies as "magnum performance" in my book!

One other place where a GC can make a real difference is in a ported or braked handgun. Here the difference between PB and GC depends on port pressure and how much base erosion takes place as the PB bullet crosses the port. As the bullet's base crosses over the port, the escaping gases can cut the unsupported and exposed portion of the bullet's base, creating small divots that can lead to instability when the bullet leaves the barrel and enters free flight. This was observed as far back as 1900 in Dr. Franklin Mann's ballistic research. The harder copper GC prevents this erosion, and leads to more stable bullet flight. I have never had a ported/braked barrel NOT shoot GC bullets well, while PB bullets have almost always given me poor accuracy in ported guns.


.405 Winchester loaded with the 300 grain Mountain Molds GC-FP

Presumably this could be countered by using some sort of felt or plastic wad or some such addition to protect the PB bullet's base, but I haven't tried this as a GC bullet gets me where I want to be quicker and easier. As an example of this, my .405 Winchester Contender is Magna-ported, and PB bullets don't shoot worth beans out of this gun, but GC bullets like the NEI .411-350-GC cast of linotype and lubed with home-made Moly lube shoots exceptionally well over 49.0 grains of H4895 at 1700 fps. (Yes, recoil is brisk).

Is there a time where the GC is a detriment? No, but they do add significantly to the expense of the cast bullet, they add an extra step to the loading process, and they aren't always readily available at your friendly local gun-shop if your supply runs out a few hours before you leave for the state championship, or a hunting trip. A while back, I went on a tour of all the major gun-shops in my community looking for a box of .45 caliber gas checks, and on that afternoon I found a grand total of 4 boxes of 6mm GC's, period. Elmer Keith didn't like GCs for these reasons for his revolver loads, and I tend to share that opinion (although, I do keep a supply on hand). Why add something if it isn't necessary? What's more, it almost seems sacrilege to load GC bullets into time-honored traditional (and relatively low pressure) cartridges like the .45 Colt, .38 Special .44 Special and .45 ACP. Loading a GC into one of these grand old rounds at 850 fps seems almost as silly as loading them with boat-tailed spitzer bullets. And while a GC is sometimes useful in higher pressure rounds, they just aren't necessary in cartridges like .357, .41 and .44 Magnums; useful sometimes, necessary no.

Annealing Gas Checks

Gas checks as they come from the factory, can benefit from being annealed. The stamping and forming process work hardens the copper and gives it a springy nature. The gas check lip when compressed in the sizing die can spring back and lose it’s grip once it leaves the confinement of the die. Since the gas check is harder than the bullet alloy, it may not obturate as one with the bullet when the assembled unit (bullet) is fired. The annealing process requires the use of heat. Preferably, the checks should be taken to faint red heated and quenched in water. A steel container will need to be acquired to contain the loose checks while heating. A discarded open mouth can will work well as a container. The container can be heated with a propane or acetylene torch. Red heat will render the checks fully softened. Ideally, this will give the best results. However, if it is not feasible to bring the checks to full softness, the checks can be placed in a steel container that will sit on the melt of the lead pot.

Your lead pot will generate sufficient heat to anneal the checks to a satisfactory level of softness. 750^o is sufficient to provide good performance of the check. At this heat, the checks can be air cooled. Now, this is not ideal, but it will suffice until you can acquire or devise a better method of annealing to bring the checks down to dead soft.

Occasionally a mould will be encountered that casts bullets with oversize gas check shanks. Needless to say, this is aggravating as it causes an extra step in the gas checking process. If you run into this condition with a mould, one solution is to expand the gas check enough so it can be pushed onto the bullet shank. This requires the use of a punch and a stripper so the expanded gas check can be removed from the punch.

So, getting back to our gun shop casting novice, "Which bullet design is better?" Neither one. We can't tell you which one of your pet .44 Magnum is going to shoot best, only your revolver and a little range time can tell you that. We *can* tell you that both will probably shoot just fine (assuming the gun and shooter are up to the task). PB cast bullets are simpler, cheaper, faster to produce and offer a more traditional approach to the handgunners art than do GC bullets. If the shooter understands how to assemble quality cast bullet ammunition, and is using a lubricant and alloy that are suitable to the ballistics of the load, then a GC provides no advantage for the majority of revolver applications. What a GC buys the sixgunner is the ability to be a little sloppy in the selection of alloy, lube or powder and still achieve good results. As a result of this flexibility, it may be a little easier to find an accurate load with a GC cast bullet. PB designs will also shoot very well in most guns, and significantly better in some. A GC is not a cure-all, and mis-application of GCs will result in poor accuracy. Quality control, both in terms of casting technique and loading technique, is what's really important for both GC and PB bullets, period. For a new caster, the most important thing is to start with a bullet design that has a well-established track record for accuracy, and I can't think of a better place to start than the Keith SWC’s. If the new caster decides to go with GCs, then the SWC’s designed by Ray Thompson are similarly excellent bullets. Where GCs really become necessary is when the shooter combines high pressure (>40,000 psi) and high velocity (>1500 fps), or is shooting a ported gun. While there are any number of custom wildcat cartridges in this pressure/velocity regime, the more common factory sixgun cartridges that really benefit from the use of GC cast bullets are the .30 Carbine, the .357 Maximum and the .454 Casull.

Chapter 11
The Wadcutter

OK, how many of you read the title and immediately thought, "Oh great, another re-hashing of the .38 Special..."? And your next thought was probably either "2.7 grains of Bullseye." or "3.0 grains of W231.", right? That's all well and good, but there's a whale of a lot more to the kindly old wadcutter than bullseye loads for your pet K-38 Masterpiece (you do have a pet K-38 Masterpiece, don't you?). There's a lot of fertile ground here, so let's go back and start at the beginning.

History of competitive pistol marksmanship and the role of the wadcutter

Competitive marksmanship has been around ever since that second caveman learned how to throw a rock. It's simple human nature that he take his newfound skill and challenge the first rock-throwing caveman to see who could throw their rock more accurately, or farther, or who could throw the bigger rock, or hit a moving target, or be the first to knock over yonder rotten stump (you know, the pretty much same games we play today with guns). As new technologies appeared, these primitive competitions evolved to keep pace, and assimilated weapon systems like slings, spears, atl-atl's, boomerangs, bolos, throwing knives and axes, short bows, long-bows, crossbows, handcannons, muskets, rifles, pistols and shotguns. It's entertaining to recognize that skeet, IPSC, basketball, hockey and golf all share this common origin -- all are manually directed competitive events with the goal of placing a projectile on a remote target. Even events like the javelin, discus and shot-put are related to archery flight shooting as a distance competition, and bowling and silhouette shooting are related by the need for accurate placement of the projectile with sufficient force to knock their targets down. Our history as warriors and hunter/gatherers is apparent from the games we devise today; whether Frisbee golf, lawn darts, Olympic archery, baseball or bullseye competition, we as a species are obsessed with the accurate placement of a projectile on a distant target.

Such marksmanship competitions undoubtedly started off as simple, informal affairs, much like current day plinking ("Betcha can't hit that pine cone!"). However, because of the vital importance of the hunter/warrior's marksmanship skills to early societies, these competitions soon became important affairs, with the pomp and pageantry befitting a hero, because these were public demonstrations of the skills that would *create* heroes, both on the battlefield and by providing protein to hungry families. Quite simply, the ability to shoot well was a commodity that was valued and respected by the surrounding community.

Human society has always valued marksmanship, and surrounded marksmanship skills with ceremony and respect. The Old Testament tells us the story of David and Goliath, in which the precise placement of a single projectile slew the fearsome giant. Formal archery training and competition is depicted in ancient Egyptian paintings, dating back to before 1500 BC. The Chinese philosopher Confucius (born in 551 BC) was schooled in the art of the bow and organized classes in archery for all of society, and has been quoted as saying, "By the drawing of the bow one can know the virtue and conduct of men." (think about that for a minute). Stone markers, ornately carved in marble still stand where arrows landed long ago in medieval flight shooting competitions outside of Istanbul (the Turks were highly regarded for their exceptional archery skills). In medieval England, obligatory marksmanship practice and regular competitions were royally decreed, and failure to participate was punished by imprisonment. In 1520, Henry VIII of England staged a magnificent show of arms called "The Field of Cloth of Gold" where he "cleft the mark in the middle and surpassed them all". These are just a few testimonials to the importance that each of these societies placed on the shooting skills of a man to hit a distant mark.

While the military significance of the longbow has decayed since the Middle Ages, the social importance of marksmanship has not. Through the 1800s toxophilites (archery enthusiasts) continued to organize large, formal archery contests "at the butts". About this time, other groups of shooters also started having gala social shooting events. Often these were ornate, formal dress, multi-day affairs, with engraved invitations, and focused on shooting skills with a variety of guns, particularly rifles and shotguns. Firearm technology evolved rapidly in the last half of the 19th century, transitioning from muzzle-loaders to cartridge loaded repeating arms. Handgun design went from cap-n-ball revolvers to double action revolvers and autoloading pistols. Once again, as technology evolved, so did the format of marksmanship competition. For the first time in history the skill of a shooter armed only with a handgun was viewed as more than the stuff of last ditch combat gallantry, and was now gaining recognition as grounds for serious (and socially valued) competition.

Smith & Wesson had been interested in manufacturing a large caliber, cartridge firing revolver throughout the 1860's, but the Civil War, as well as a variety of design problems and patent licensing issues, slowed their entry into this market. The S&W Model No. 3 (i.e. large frame break-top), patented in 1869 with production starting in 1870, would be a harbinger of the birth of bullseye pistol competition. In 1871, Russian General Alexander Gorloff ordered 20,000 Model No. 3's for the Russian Army, requesting a number of modifications to the standard design and that they be chambered for a new "inside lubricated" centerfire cartridge that was to become known as the ".44 S&W Russian". The pocket revolver had established S&W as a viable American manufacturing enterprise, but the large framed Model No. 3 cemented S&W's reputation as a major international arms producer. Over the next several years, various design changes were incorporated into these guns and additional production runs were sold to the Russian Army, eventually totaling over 130,000 guns. S&W was also selling variations of the Model No. 3 at a brisk pace here in the States. These guns were offered in a variety of chamberings, but the .44 caliber guns were the most popular (.44 Henry Rimfire, .44/100 centerfire and .44 S&W Russian). The New Model No. 3 .44 Single Action was unveiled in 1878 and made enough of a splash that its manufacture was featured on the cover of *Scientific American* (January 24, 1880). The first revolver designed and built specifically for competitive target shooting was the S&W New Model No. 3 Target developed in

1886, inspired by a group of pistol shooters who competed regularly in a 100-shot match. Bullseye pistol competition had been born. Chevalier Ira Paine set a record of 791 points (out of 1000 possible) on October 15, 1886 using a S&W New Model No. 3 in .44 S&W Russian, and then later bested his own mark with an 841 (March 17, 1887). Later, on November 4 of that same year, F. E. Bennett set a new record with a score of 857. Serious competition grew at these pistol matches, and public interest grew as well. The shooting industry was quick to take notice, and S&W quickly offered their Model No. 3 chambered in the inside lubricated .32-44 and .38-44 cartridges, specifically for such target competition. However, in the long run, the .44 S&W Russian chambering was by far the most popular with the competitive target shooters. As an aside, this new form of pistol competition was one-handed shooting since traditionally the handgun was an officer's weapon, and an officer (of course) was mounted, so he had to use his non-shooting hand to hold the reins of his horse! The one-handed pistol form was retained in military training since in combat the shooter might be wounded and only have one good hand. Thus, NRA bullseye pistol competition was born with its left thumb hooked under its belt.

Initially, the bullets used in these pistol matches were simply the standard 246 grain lead round nose .44 S&W Russian offered by the factories, or cast by the competitors. Unfortunately, these bullets, while superbly accurate, did not cut clean or full-diameter holes in the target, which made accurate scoring problematic and missed points a very real possibility. Competition grade guns and shooters had arrived, it was time for the bullets to catch up.

There were 146 mould designs listed in the Ideal Handbook #9 (1897) and not one of them was a wadcutter; all of the pistol bullets listed were either round-nosed, or round-nose flat-points. The original wadcutter made specifically for competitive target shooting was the Himmelwright wadcutter (Ideal #429220), which was unveiled in 1900 (and cataloged up through HB #39, 1953 and listed in the *Handbook of Cast Bullets*, 1958). This bizarrely shaped bullet was designed to cleanly cut full diameter holes in the target to make accurate scoring of target a snap, but also to have enough of an ogival nose to insure stable, aerodynamic bullet flight. This unique projectile was specifically designed for the S&W Model No. 3 chambered for the .44 S&W Russian (the .44 S&W American used an outside lubricated, heel-type bullet and the .44 S&W Special would not be introduced for another 7 years).

The next wadcutters on the scene were J. B. Crabtree's Ideal 360345 in 1903, B. F. Wilder's Ideal 360271 in 1904 and Himmelwright's Ideal 360302 in 1905, primarily designed for the .38 S&W, as well as the newly introduced .38 Special. Today, we would call the Crabtree and Wilder bullet "semi-wadcutters" to differentiate them from the cylindrical bullets we call wadcutters today, but the era of the wadcutter had just dawned and this distinction hadn't yet

The first bullet explicitly designed for target shooting was the Himmelwright wadcutter (Ideal 429220), designed for the S&W #3 .44 Russian. Loaded in the .44 Special.

been drawn in 1905 (these two bullets were still labeled as wadcutters in the Ideal Handbook #37, circa 1953; the term "semi-wadcutter" doesn't seem to have gained general usage until the mid-to-late 1950s, and was used in the *Handbook of Cast Bullets* in 1958 to describe the 358480, 452460 and a couple of other similar bullets, but interestingly enough, was not applied to either the Keith or Thompson bullets, those most commonly associated with the term today). Wadcutter experimentation continued, primarily focused on the effect of nose profile on bullet stability and accurate flight, with the dome-topped 454309 and square-nosed 360344 (150 grain), 429348 (180 grains) and M. L. Holman's 429352 (245 grains), all of which came out during this same timeframe.


The wadcutter Class of 1905/1906 (l-r: Ideal 360271, 360345, 360344, 429348, 429352 and 452309)


Classic wadcutter bullet moulds: the H&G #50 plain-based wadcutter.


Classic wadcutter bullet moulds: the Ideal 358395 hollow-based wadcutter.

The Peters Cartridge Company was the first to produce factory loaded wadcutter ammunition in or around 1914. In 1915, Ed McGivern designed an experimental hollow-based wadcutter mould that he commissioned Ideal (then owned by Marlin) to make. McGivern's bullet would eventually be known as the Ideal #358395. The incorporation of a hollow base into the wadcutter is not surprising since the wadcutter was designed explicitly as a target bullet and the hollow-base design was (mythically) believed to be inherently more accurate. In 1919, McGivern, along with Phineas Talcott (remember Phineas? was the owner of Ideal from about 1918-1925) and several Remington engineers tested this bullet extensively. It performed so well that Remington adopted is as part of its ammunition line, and Western Cartridge Company followed shortly thereafter in 1920. Bullseye pistol competition had definitely caught on and a great deal of work was put into the developmental of bullets and ammunition specifically designed for this pastime.

As an aside, it is interesting to note that in 1897 Ideal had 146 bullet designs, and in 1915 they were assigning cherry number 395. In less than 18 years, they had added approximately 250 bullet designs to their line, and most of these new numbers came about between about 1900 and 1905! Also, keep in mind that a number of the original cherry numbers (particularly those of the round ball moulds) were recycled, making the total number of new cherries even higher than this simple analysis would suggest. John Barlow, and Marlin, were clearly being aggressive in serving the needs of the shooting public during this timeframe.

After Lyman bought Ideal in 1925, the evolution of the wadcutter continued, first with the dainty 112 grain 358425 (1930), and the somewhat more robust 160 grain 358432 (1931?). The pinnacle of the target wadcutter design was achieved in the early-1930s with the now familiar design settled on by George Hensley as his classic #50 (which Lyman later emulated with their 358495 in 1955).

An example of a transitional wadcutter from around 1930 (Ideal 358425).

Obviously, one of the principal design features of the wadcutter is to cut full diameter holes in the target for easier and more precise scoring in bullseye competition. However, there are also several other aspects of the wadcutter that are commonly overlooked. Wadcutters are generally designed to be deeply seated in the cartridge case to eat up case capacity, to produce better uniformity with the light powder charges used for target loads. The wadcutter also generally has extensive bearing surface that provides better alignment in the throat and forcing cone of a revolver, thereby favoring concentric engraving, and better short range accuracy (before the lousy aerodynamics of the "flying trash can" destabilize the bullet and ruin flight stability).

Gil Sengel wrote up a nice little piece on wadcutters in the Jan/Feb 1990 issue of Handloader magazine (#143), and he coined a terminology to differentiate between different styles of wadcutter based on how deeply they we seated in the case (or more accurately how much was left sticking out of it).

Type I wadcutter. A Type I wadcutter has no crimp groove, only lube grooves, and is seated entirely within the case. If a crimp is to be applied on a Type I wadcutter, it is applied over the nose of the bullet. The primary application of this bullet is in semi-automatic bullseye guns like the S&W Model 52 and the Colt 1911 National Match .38 Special Gold Cup. These guns require the wadcutter to be fully seated within the case for reliable cycling of the action. Perhaps the best known example of a Type I wadcutter is the Lyman 358063, introduced in 1963 in response to demand from bullseye shooters competing with custom made 1911s chambered in .38 Special and .38 AMP, the S&W Model 52 (introduced in 1961), and the Colt 1911 National Match .38 Special Gold Cup Mid-Range. This bullet design was the direct result of the popularity of these guns and bullseye competition. (As an aside, cherry #63 is a recycled cherry number, the original being a round ball for the .32-44 S&W Gallery). Successful loading of these bullets requires that seating and crimping be performed in separate steps.

An example of a Type I wadcutter (H&G #280, .32 caliber wadcutter). Note the lack of "button-nose" and no crimp groove.

These same issues apply to the target pistols built for the .32 S&W Long. These semi-auto target guns made by Walther, Pardini-Fiocchi, Erma, and others are specifically chambered for the .32 S&W Long loaded with deeply seated Type I wadcutters.


An example of a Type II wadcutter (George Hensley #66, 98 grain .314" wadcutter). Note the "button-nose" and the crimp groove.

Type II wadcutter. It's easier to seat the bullet with one driving band outside of the case and to crimp using a traditional crimp groove, thereby allowing seating and crimping to be performed in a single stroke, and historically this is how wadcutters have been most often employed. This is the design that is most commonly encountered (and thought of) today when one mentions the terms "wadcutter". The classic example of a Type II wadcutter is H&G #50 or Lyman 358495. These bullets have 3 grease grooves, followed by a crimp groove, one driving band and a small "button nose". This design provides all of the advantages of the Type I (deep seating, wadcutting ogive, full-length bearing surface, etc.) but it also allows for easier and more uniform seating and crimping. For over 3/4 of a century, this bullet design has established itself as the definitive bullseye pistol competition bullet. Moulds for the Type II wadcutters have been made in virtually all of the common revolver calibers, and in a variety of bullet weights. Loaded to 900 fps or so, these bullets make excellent small game hunting loads. The Lyman 358495 over 4.5 grains of W231 for 950 fps is a personal favorite for such activities.

That cute little vestigial nose left on these Type II wadcutters is intended to provide additional aerodynamic stability by breaking up the air-flow and starting the slipstream. Since these are virtually always subsonic bullets (not only sub-sonic, but below 0.85 Mach, or roughly 900 fps), the airstream is roughly conformal to the bullet's profile, with turbulent flow in the boundary layer at these velocities. There is no super-sonic "bow-wave". A flat face with a sharp shoulder (e.g. Ideal 358348) can induce substantial turbulence just aft of the shoulder. This is because the slipstream is unable to flow smoothly around a sharp 90 degree corner, so there are turbulent "eddies" formed just aft of this shoulder, which can destabilize the spinning wadcutter and lead to tumbling. By putting a small nose just forward of the flat face, the airflow is more gradually redirected as a result of the eddies formed along the sides of the nose, resulting in somewhat greater stability in flight, and therefore longer accurate range before the wadcutter starts to tumble. This "aerodynamic re-direction concept" was most pronounced in the Himmelwright wadcutters, and tapered off with subsequent designs. Since virtually all bullseye shooting is done inside of 50 yards, that's all the accurate range that's needed from a wadcutter target load, so the extended proboscis of the Himmelwright wadcutter really isn't necessary. Because of the complexity this proboscis adds to the seating/crimping step, it was simplified (or dropped altogether) in subsequent wadcutter designs.

There were also a number of very lightweight Type II wadcutters that were made for the very light loads used in gallery (or "parlor") target shooting. An example of this kind of bullet would be the Ideal 358101 (this is another recycled cherry number, the original was a .424" RB). Looking at this bullet, I have to wonder if the conversation surrounding its genesis didn't start out something along the lines of, "Hey! Wouldn't it be neat if...." This 77 grain bullet was presumably originally designed for light gallery loads, but I suspect it may have also found application in discrete urban rodent control. Similar lightweight wadcutters, such as the H&G #239 (.44 caliber, 200 grains), and H&G #155 (.45 caliber, 200 grains) have also been produced.


Example of a lightweight Type II wadcutter (77 grain Lyman 358101).

Type III wadcutter. The Type III WC was intended to extend the WC's capabilities to the hunting fields by seating the bullet out of the case to more typical SWC seating depths. By seating it out of the case there is more capacity for powder and pressures of full-velocity loads are kept moderate. For this reason it is sometimes referred to as a "full-velocity wadcutter". Long range stability is still a problem with these bullets, but they can be very effective hunting bullets at modest ranges.


An example of a Type III wadcutter (250 grain Lyman 429352)

Ogival Wadcutters. In recent years, LBT and NEI have marketed moulds they have called "ogival wadcutters" which combine the Type III concept with a very small amount of curvature added to the ogive to improve the WC's flight characteristics without sacrificing too much meplat. This was a revision of an old idea that had been around for many decades, originally being captured in early Frankford Arsenal bullet designs (circa 1890). The Frankford Arsenal bullet was for police use, back in the days (in the words of one ballistic historian), "when the police actually shot bad guys with the hopes of killing them". For those PD's using service revolvers, the ogival wadcutter makes a great deal of sense in that close range lethality is great, while the bullets will generally start tumbling inside of 100 yards, rapidly losing velocity/energy in the event of an errant shot, thereby minimizing risk to innocents.


Frankfurt Arsenal gang mould for a bullet design similar to the ogival wadcutter or WFN profile

In any event, in more recent years the focus of the ogival wadcutter has been more on hunting applications, where these bullets serve admirably, although they have a limited effective range due to poor flight stability. While most handgun hunters are perfectly content to limit themselves to moderate ranges before they shoot, it's important to recognize the limited value of a bullet that can't be relied upon to finish off a rapidly departing wounded game animal before it gets out of range, should the first shot not prove quickly fatal. There are a number of excellent hunting designs


An example of an ogival wadcutter (the 365 gain NEI .44 OWC loaded in the .44 Magnum). This bullet gives fine accuracy for the first 40 yards or so, but at longer ranges accuracy can be pretty iffy.

(Keith, SSK, LBT, etc.) that allow a skilled handgunner precise bullet placement at extended revolver ranges, thereby allowing such a cripple to be finished off in a responsible and humane fashion. The ogival wadcutter, although a short-range sledgehammer, can't be relied on to finish off an outward bound cripple before it escapes, due to the ogival wadcutter's poor long range accuracy, leading to the possibility of a long, and perhaps fruitless tracking job. In heavy brush or black timber, such a follow up shot is unlikely anyway and shot opportunities will be at close range, allowing precise first shot placement. The ogival wadcutter would be right at home in "the thick stuff", like one encounters when hunting feral hogs, but could be a poor choice on the plains of Wyoming for hunting antelope.

Base design

Which is better, plain-based wadcutters or bevel-based? Are hollow-based wadcutters really more accurate than solid bullets, or not? Why doesn't anybody make gas-checked wadcutter moulds? Let's examine these issues, one at a time.

Originally, wadcutters were plain-based (PB). The reason some folks wanted to put a beveled base on their wadcutters was to facilitate the loading process. This is a significant concern if you're a junior officer on the local PD, stuck at the loading bench on a sunny Saturday and you can't leave until you have a couple thousand rounds loaded for your departments' qualification course next week. Bevel-based bullets also tend to drop more easily from the mould, expediting the casting process. As the bevel-based wadcutter gained acceptance, some shooters claimed that they were in fact more accurate than their plain-based cousins. Detailed testing (see for example John Zemanek's article in *Handloader* #161, Jan/Feb 1993, or E. H. Harrison's article on "Making Accurate .38 Handloads" in *NRA Handloading*) suggests that in certain guns the bevel-based wadcutters are indeed slightly more accurate than plain-based wadcutters. However, it is important to point out (as both authors do) that in certain other guns the reverse is true. In my own extensive testing on this subject I can find no significant difference between the two, both shoot very well out of my guns.

What's more, I have found no significant advantage to using cast hollow-based wadcutters over solid based wadcutters. I have hollow-based moulds for .38, .41, .44 and .45 caliber wadcutters, and while these bullets shoot just fine, there is nothing to recommend them over other target loads that I assemble using solid-based wadcutters (either plain-based or bevel based). Commercial hollow-based wadcutters are also quite accurate. This is only partly due to their being hollow-based (which makes sizing less important since they will swell to fit the bore when fired), but also due to the fact that they're formed under high pressure and therefore have no voids. It is important to remember that swaged hollow-based wadcutters must be limited to mild pressure loads to prevent "popping the cork" and leaving a lead sleeve in the bore of your revolver.

An example of a bevel-based wadcutter mould (Lyman 358091).

As for gas-checked wadcutters, this is an experiment that was tried many years ago and their virtually complete absence today makes it pretty obvious that the final conclusion was, “Why bother?”. If you have a GC wadcutter mould, you have a unique conversation piece, and quite likely a collector’s item. Target bullets need to be accurate and they need to be produced in large quantities; adding a gas-check didn’t help the accuracy and slowed down the production rate, leaving the project to die an ignoble death. May it rest in peace.

The bottom line is that there's nothing wrong with shooting bevel-based or hollow-based cast wadcutters, but there's no evidence to indicate that either is more universally accurate than the plain-based wadcutter. The hollow-based wadcutter is considerably slower to produce than the plain-based wadcutter, and both the bevel-based and hollow-based wadcutters are best limited to moderate pressure loads since the hollow-based wadcutter gives poor accuracy (and marginal safety) at higher pressures, and bevel-based bullets can lead to cylinder gap leading at higher pressures. The plain-based wadcutter is every bit as accurate as it hollow-based and bevel-based brethren, and more versatile than both since it's not limited to mid-range loads and can be loaded to full-velocity. For mid-range target loads all three are equally capable of fine accuracy at moderate ranges.

Ideal 429106

Ideal 429107

Ideal 452309

Ideal 452389

Wadcutters in the field

While I have used many, many .38 wadcutters for bullseye practice and competition, perhaps my favorite use of wadcutters is found in hunting small game with a .32 S&W Long. I have used all manner of .32 wadcutters in these guns (RCBS, NEI, H&G), and they all shoot remarkably well over 2.0 grains of Bullseye, but for use in the hunting fields I prefer the Lyman 313492 (Type III wadcutter), which weighs about 90 grains when cast of WW alloy. Seated on top of 2.5 grains of Red Dot, this little pill generates about 950 fps with excellent accuracy, and it hits small game hard at moderate ranges, but without excessive meat damage. This load is well suited for shooting bushytails in the treetops as the inherent instability of the flat-nosed wadcutter shape (as well as contact with leaves and branches) will have this little wadcutter tumbling, and rapidly losing velocity, in short order. A pleasant afternoon stroll, with a favorite .32 S&W Long revolver, in pursuit of small game is an excellent way to shake off the tensions of modern life.

The wadcutter is indeed the bullet of champions. The importance of the wadcutter to PPC and bullseye pistol competition is emphasized in the writings of champion pistol shooters like Jim Clark and Gil Hebard. To achieve master class proficiency, these shooters have sent literally tons of wadcutters downrange. The social ceremony of marksmanship continues to this day in the National Matches at Camp Perry, national PPC matches, Olympic competition and events like the Bianchi Cup, and for the pistol shooter the prestige of these matches is borne on the back of the workhorse wadcutter. The ability to shoot well is still a valuable commodity, to both the individual and to society. But the wadcutter is not merely a match bullet, it also finds application in very light gallery loads, vermin control, law enforcement, and as a short-range hunting bullet in the thick stuff. Surprising versatility for such a specialized bullet.

Chapter 12
The Keith Semiwadcutter (SWC)

The cast handgun bullet started out as a simple sphere, and stayed that way for centuries. Even after the introduction of the rifled barrel and revolving cylinder, the default form of the handgun projectile was still “ball”. It wasn’t until the middle part of the 19th century, after elongated projectiles had a firm foothold in long-guns, that conical projectiles started to gain a following in handguns. After all, handguns were viewed as last ditch, self-defense tools, adequate only for short range, so who cared if they weren’t all that accurate, or what their downrange trajectory was like? Manufacturing tolerances were loose (by today’s standards), cylinder gaps were generous, and the soft metals, simple lockwork and lack of a top-strap meant that barrel/cylinder alignment was often less than precise. The round ball was up to the accuracy potential of these early revolvers, and it was entirely adequate for the uses to which these early guns were put, so why bother with anything else?

That was to change with the introduction of the self-contained cartridge, the bored-through cylinder and the top-strap. The revolver underwent a series of wondrous transformations from the late 1850s through the early 1870s in which these design features were incorporated, and emerged a tool of vastly improved accuracy, range, and reliability. The elongated bullet figured strongly in these improvements.

Now, in the 1870s, these elongated bullets were pretty much limited to being either simple round-nosed bullets or primitive conical (pointed) projectiles, as the focus was improving the trajectory of the round by fine tuning the aerodynamics of the projectile (BP was limited in terms of pressure/velocity, so aerodynamics was the only real avenue open for improvement). The round-nosed lead bullets shot just fine, giving excellent accuracy and range. Unfortunately, they weren’t the most efficient of killers. This was viewed with little surprise and concern at the time because handguns had generally been viewed as under-powered, last ditch weapons. The fact that a trained pistolero could hit a man-sized target at 100 yards instead of 50 feet was real progress, and while the round-nosed bullet might not kill a ne’er-do-well outright, the impending septicemia surely would. This was of little solace to the western cowboy who found himself face to face with a grizzly, however; handgun killing power could definitely stand to be improved.

This was the 1870s, the heyday of the Winchester 1873 repeating rifle, often chambered for the .44 WCF. One of the things learned during this period was that blunt or flat-pointed bullets seemed to hit harder and kill faster than did similar round-nosed slugs. Autopsies revealed that the blunt or flat-pointed bullets did more tissue damage, left bigger holes and resulted in far more bleeding than the puncture wounds of the round-nosed projectiles (these wounds had a tendency to close over and bleed little). Such observations were not lost on the handgunners of the day, and soon flat-pointed bullets started finding their way into handgun cartridges. Initially, this took the form of dainty little meplats on top of the traditional round-nose ogive (for example the 454190, the traditional .45 Colt bullet), in an effort to maintain as much of the aerodynamic form as possible. While these RNFP bullets offered some improvement over the RNs, with the limitations that BP placed on velocities, the killing power of these bullets was still unremarkable (by today's standards).

The round-nose flat point (RNFP) was the state of the art in terms of handgun bullet design before the turn of the 20th century.

This led to a slow, but steady evolution of bullet shape throughout the remainder of the 19th century. Several of these antiquated designs look almost comical to us today, but were designed with a specific function in mind (e.g. Himmelwright wadcutters). Meplats got larger, specialized features started getting incorporated into bullet designs (crimp grooves, wadcutters, etc.), tolerances started getting tighter and handguns started becoming more accurate and were viewed as more of a general purpose tool, rather than just a last ditch defense weapon.

The Himmelwright wadcutter (Ideal 429220).

In 1904, B. F. Wilder put together a the first handgun bullet design that would today be called a semi-wadcutter (SWC), so named because it combined the wadcutting shoulder of the newly developed wadcutter with a more traditional round-nose, flat-pointed ogive. Wilder's design is now known as the Ideal 358271 (originally 360271). In 1905, Crabtree followed with his somewhat blockier 360345, and C. E. Heath of the Boston Pistol Club did likewise with his design, the 429336. These early designs are all notable in that they contain 2 small lube grooves and no crimp groove. This is presumably because these bullets were primarily intended for low impulse target loads and the bullets were held in place by neck tension, or were crimped lightly over the forward driving band. Other designs followed, but the standard revolver bullet was still either round-nosed or a RNFP.

Target bullets were evolving rapidly just after the turn of the 20th century (Ideal 360271 and 360345).

At first glance Heath's 429336 looks rather like the bullet that Elmer Keith would later draw up as the 429421, especially the ogive. The major difference is that Heath's bullet has 2 small lube grooves, and no crimp groove. If one of the grease grooves was used as a crimp groove, then there wasn't very much lube capacity in the remaining grease groove, and if both were used for lube then the bullet either wasn't crimped or it had to be seated deeply and crimped over the shoulder. Neither of these scenarios is conducive to heavy .44 Special loads; the recoil generated would have unseated an uncrimped bullet, and deep seating would have raised pressures tremendously. A better bullet design was needed.


The Heath target bullet (Ideal 429336, left) compared to the Keith SWC (Ideal 429421, right).

While this evolution of bullet shape was taking place, smokeless powder made its rather awkward entry onto the scene. The rules for loading one's own ammunition changed drastically, and more than one fine old revolver was blown to bits in the learning of these lessons. As a result, the acceptance of smokeless powder was gradual amongst handgunners. By the 1920s, the ground rules for loading smokeless powder were pretty well laid out, accepted and understood. Some of these new smokeless powders were delivering unprecedented velocities to the revolver shooters of the day, and there was a real need for bullet design whose performance would match these new velocities.

Enter Elmer Keith, stage west. He was a northwestern cowboy, with a love for guns and shooting. He understood guns, how they worked and how they killed. He studied the experimental cast bullet designs of the day, and put together a few experimental designs of his own. He took these first ideas to Belding & Mull, who cut the moulds for him. Elmer and his shooting partner Harold Croft spent the mid-1920s working up loads for these bullets, testing them at all sorts of ranges and evaluating their performance on all manner of critters from jack rabbits to elk. These early B&M designs were blunt, round-nosed flat-points, with large meplats, of various weights in .44 and .45 caliber. While there were a number of things that Elmer liked about these designs, they didn't provide the long-range accuracy that he was looking for, and so he went back to the drawing board.

He wanted an all-round bullet, one that was useful for target shooting, as well as hunting and self-defense. This would require a wadcutting shoulder, on a semi-wadcutter (SWC) frame. Others had made SWC's before, but the meplat was small, the crimp groove was little more than an empty grease groove, bullets were seated too deeply, and other details were not to Elmer's satisfaction. He took the features that he liked from his B&M designs and combined them with features of these other SWC designs and drew up what he felt was the perfect bullet for his pet .44 Special. The meplat was 65% of the bullet diameter (this meplat and ogive was taken directly from Heath's 429336, Keith would ultimately settle on approximately 70% for later designs in other calibers). The ogive had a double radius to insure stable long-range flight. The crimp groove was beveled to match the profile of the case when crimped, for a firmer grip. The crimp groove was located to seat as much of the bullet outside of the case as possible (in fact this turned out to be a problem in the case of the .357 Magnum when S&W started making those guns a few years later, as the cylinders were too short to accommodate the 358429, this was S&W's oversight, not Elmer Keith's -- Keith solved this problem by either using .38 Special cases or seating the 358429 deeply and crimping over the forward driving band). Keith's SWC had three equal width driving bands. A full-width, full-diameter forward driving band is a very important feature of the Keith SWC as that band is what aligns the bullet with the bore as it traverses the barrel/cylinder gap and what starts the engraving/rotation process. These three full-width driving bands insured that over half of the bullet length was bearing surface to ensure that the bullet was well-aligned within the bore. Another key feature of the Keith SWC was the "square-cut" grease groove (this is perhaps more accurately described as a "flat-bottomed" grease groove since the sides are beveled slightly to allow the bullet to release from the mould upon opening). And finally, Keith's bullet was plain-based. Elmer Keith felt that GC's were useless on revolver bullets.


In the late 1920s Elmer Keith modified the Heath target bullet to have a beveled crimp groove and a larger grease groove and the Ideal 429421 was born.

While Keith and Croft had been evaluating the initial B&M designs, the struggling Ideal Co. had been sold to Lyman and both the company and mould production were now in much better shape. Elmer took his revised design to the newly revamped Ideal/Lyman in 1928. The result was to become known as the Lyman/Ideal 429421, a 250 grain SWC that would change forever how shooters thought of handguns and handgun bullets. The 429421 provided match-grade accuracy, cut clean holes in target paper, delivered excellent long-range (e.g. half mile) accuracy, and crushed big, leaky holes in meat. In short, it did all the things Elmer wanted his sixguns to do, and it did them all superbly. It was truly a landmark in the evolution of handgun bullet design. He was well pleased.

The 3-point mulie buck stood about 50 yards distant, along the crest of a harvested wheat field. He knew that danger was near, but held his ground unsure of what to do next. An unknown hunter's errant shot had left him wounded across the top of his hams, unable to run away from the packs of coyotes that would be working the canyons after the sun set, so I resolved to end his suffering quickly. I shot him just behind his left shoulder. The bullet passed through both lungs and heart and shattered the far shoulder. The buck spun and went down hard, but adrenalin is a powerful drug (he had been wounded by an unknown hunter several hours before). He struggled to regain his feet, with no success. A second 429421 went through his neck and the life drained quickly from his eyes. That's pretty much how it generally goes with this bullet; put it where it counts and you have meat to pack out.

Shortly after designing the 429421, Elmer Keith followed up with a hollow-base version (Ideal 429422).

One of the concepts popular in the 1890s was to take a proven bullet design and increase the velocity by decreasing bullet weight. This was done by removing metal from the bullet by making either a hollow-base, or a hollow-point. Thus, the length of the bullet stayed the same and it wouldn't be necessary to re-think the rifling twist to make the lighter bullet perform its best. Given that manufacturing tolerances of the day weren't always overly precise, a revolver's cylinder throat and barrel groove diameters didn't always match-up as well as one might like. One solution to this problem was to use a HB bullet that would swell to fit the both diameters no matter how well they matched. Thus, Elmer's second design was simply the 429421 made with a hollow base. This design was numbered 429422.

In many circles HB bullets are revered as being inherently more accurate than other bullet designs. Is this reputation deserved and where does it come from? Well, in the middle part of the 19th century, when various methods of making a bullet spin were being evaluated with, experimental ballisticians were trying to find a bullet that would be easily loaded (from the muzzle, of course), but would also "take" the rifling and spin. A hollow cavity on the base of the bullet was found to be a very effective way to do this. Thus was born the Minie' ball, which delivered greater accuracy (and downrange punch) than the other projectiles of the day. Hollow-based bullets do indeed deliver greater accuracy *in muzzleloaders*. Note that this reputation was garnered in a low-pressure, long-barreled firearm, in which the muzzle-pressure would be quite low. For cartridge firing guns, loaded with groove diameter bullets, this inherent advantage is lost. In the shooting community however, we don't tend to let go of "proven concepts" easily...

In his landmark treatise, the “Complete Guide to Handloading” (first published in 1937, last reprinted in 1953), Phil Sharpe argued that hollow-base bullets were obsolete and had no legitimate place on the handloader's bench. The hollow base had originally been employed in revolver bullets to allow the gases from the burning black powder to expand the base and seal the base of the bullet as it jumped from the case, to the throat, to the forcing cone, to the bore, many of which had considerably different dimensions from one another back in the 19th century. This design also keeps the weight forward and therefore (some will claim) the bullet will act like a badminton birdie and stay nose forward for a more stable flight (and with low pressure black powder loads, this may be true). It also reduces bullet weight, thereby allowing higher velocities, while keeping a solid nose construction for better penetration. Sharpe goes on to report that, in spite of their reputation, hollow-base bullets are commonly *less* accurate than are solid base bullets, especially in higher pressure loads, because of distortion to the skirt as it leaves the muzzle due to high muzzle-pressure, leading to unstable flight. Personal experience reveals that hollow-based bullets, in light to moderate pressure loads (i.e. less than about 12,000 CUP) where the muzzle-pressure is lower, demonstrate fine accuracy (but not necessarily better than PB bullets), but at higher pressures, accuracy suffers notably. As usual, Sharpe's arguments are well thought-out, well organized and well explained. However, there is one issue that Sharpe probably didn't foresee back in 1953, and that is the impact that nostalgia has had on the shooting sports in the new millennium. Back in the 1950s, the rage was modernization and magnums; the shooting world was looking *forward*, not backwards. Black powder cartridges like the .38-40 and .44-40 were dead in the water, and the grand old .45 Colt wasn't doing too well itself. The focus was on higher pressures and velocities, stronger steels and slower powders. Today we have cowboy action shooters dressing in the styles of the 19th century and specifically seeking out old guns and old cartridges, just for the sense of style bestowed by these classic old pieces. The hollow base bullet fits in perfectly here, and indeed may well be a necessary accoutrement for complete period authenticity. Sharpe was right, hollow-based bullets *are* obsolete, but his thinking is outdated by being too modern!

OK, let's get back to the story of Elmer Keith and his SWC's. To review -- it's 1929, The Great War ended a decade ago, the '20s have been roaring for some time, flappers, big bands and jazz have taken the country by storm, the stock market is about to crash, prohibition is in effect and organized crime has moved in to supply the thirsty US of A with libations. The transition has been made from black powder, and the shooting public now has some understanding (and trust) for the new smokeless powders. But magnum handgun cartridges (and magnum pressure levels) are still unknown to the American handgunner. This is the Golden Age of the .45 ACP -- from the newly refined Colt 1911-A1 and the S&W 1917 revolver, to the Thompson sub-machine gun, the .45 ACP was definitely basking in the center stage spotlight. Military surplus ammo and components were widely available, as were revolvers, semi-autos and fully automatic firearms with which to fire it. The importance of this market was not lost on Elmer Keith. He was so pleased with how well his 429421 had worked out in the .44 Special that he


Elmer Keith designed the Ideal 452423 for the .45 Auto-Rim.

applied those same design concepts to the .45 ACP, and it's thick-headed younger brother the .45 Auto Rim. The result was the Lyman/Ideal 452423, a 238 grain Keith SWC that started off with 3 equal width driving bands, a "square-cut" grease groove, a beveled crimp groove (for use in the revolvers), a short nose (to keep OAL length down so that loaded rounds worked in the magazine guns), and a big, fat meplat (.340", or 75% of bullet diameter) to maximize their effectiveness in the hunting fields. The excellent performance of the 452423 in the .45 ACP was, in large part, overshadowed by the subsequent release of the .357 Magnum with its unprecedented velocities and kinetic energy figures, but that doesn't change the fact that Keith's first SWC in .45 caliber was, and is, both deadly and accurate. Standard loads for this bullet worked in the 800-900 fps range, and Keith worked up some +P loads that delivered 1100 fps from large frame revolvers. These old guns are best limited today to loads generating 900 fps or less (newer guns, with better steels and heat treatment, work just fine with Keith's +P loads).

As with their other designs, Lyman modified the 452423 at a later date to use a rounded grease groove. Virtually all of the 452423's you see nowadays are round groove moulds. (I have never seen a HB version of this bullet). As the .45 ACP and .45 AR were smokeless only cartridges, and the HB was feature commonly intended for BP cartridges, there was no need to incorporate the HB into this design. HP versions of this mould were made (picture shown in Sixguns) but came about at a later date and are hard to find today.

Mostly I shoot the 452423 in the .45 Schofield cartridge, where it makes a good all-round bullet. Loaded on top of 6.8 grains of Unique, it delivers 868 fps from a 7 1/2" Blackhawk, and makes a delightfully pleasant rodent round. I also like to shoot the 454423 HP (cast soft) in the .45 Colt over 9.0 grains of W231 for right at 1000 fps, which is really spectacular varmint medicine!


Elmer Keith's original design for the .45 Colt was the Ideal 454424 (on the left, flat-bottomed grease groove). Later, Lyman modified Keith's design to include a rounded grease groove (on right). Later on, Lyman modified this design and re-numbered it as the 452424, which has also been produced in both a flat-bottomed grease groove and rounded grease groove.

Elmer had two homeruns under his belt with the 429421 and the 452423, so he stepped into the batter's box once again, this time to apply his design concepts to the cartridge that gave birth to the modern sixgun, the .45 Colt. Staying within the baseball metaphor, he hit a Grand Slam with the 454424. The traditional weight for the .45 Colt was 250-255 grains, so that was his target weight (while Elmer experimented with heavyweight bullets, he generally aimed for standard weights to keep pressures moderate, remember this was in a day and age when most of the .45s in existence were made of soft steels and powders were still limited to pretty fast burning numbers, 2400 wouldn't be released until 1933, and he already knew from personal experience that heavyweight bullets in a first generation Colt SAA, even with black powder as the propellant, could wreck a gun). Like its predecessors, the original Lyman/Ideal 454424 had three equal width driving bands, a "square-cut" grease groove, a deeply cut beveled crimp groove, a double-radiused ogive and a hearty meplat (.320", or 70% of bullet diameter). The nose was longer than that of the 452423 since the .45 Colt cylinders allowed for more room than did a 1911 magazine (this longer nose may explain why the meplat is slightly smaller than that of the 452423). It was, of course, plain-based. Taken in summation, these attributes joined to create what is unquestionably one of the finest handgun bullets of all time.

Over the course of the years, Lyman has vacillated back and forth over whether or not this bullet has a square or rounded grease groove. First Lyman went to a rounded grease groove so that bullet would drop from the mould more easily. Later they reduced bullet diameter slightly and changed the number to 452424. With this later design change, they also changed the thickness of the various driving bands and simplified the ogive from a double-radius design to a single radius design. One does occasionally find Lyman 452424 moulds that have the square-cut grease groove, but they are unusual. If there has ever been a 454424 HB, I've never seen it, nor even heard any mention of one. This is rather curious as the hollow-base design was commonly a feature of black powder cartridges/bullets and the 454424 was designed explicitly for the .45 Colt, one of the original black powder cartridges. If the 429422 was such an obvious choice to make, and as we shall soon see, the .38 version was too, then why not the .45 Colt? Perhaps the explanation is found in the reputation of both the .44 Special and .38 Special as target rounds and the throw-back thinking (from muzzle loading days) that HB bullets were inherently more accurate, while the .45 Colt was thought of as more of a working man's gun. Or perhaps it was simply that the .45 Colt was seen as falling out of favor with the American shooter in the middle part of the 20th century.

Elmer Keith designed the 358429 173 grain SWC for the .38 Special.

In 1929, Elmer Keith also drew up the design that would become known as the 358429. Keith didn't send this design in to Lyman until about 1931 (well before the unveiling of the .357 Magnum in 1935 and the publication of Keith's book "Sixgun Cartridges and Loads" in 1936). This bullet was specifically designed for the so-called .38/44 loads (loads assembled in .38 Special cases, loaded to very high pressures for use in .44 frame guns). The .38 Special case leaves lots of room for the bullet to be seated long when housed in the N-frame cylinder of the S&W Heavy Duty or the Outdoorsman. Thus, the 358429 SWC was designed to have a long nose to leave as much room for powder as possible (crimp groove to meplat measures a full .385", whereas more recent .38 SWC designs generally measure .300-.330" in this dimension). When the .357 Magnum was unveiled in 1935, it was made with the same length cylinders as had the Outdoorsman (when one takes into account the difference of the recessed cylinder on the Magnum), and when crimped in the crimp groove in Magnum cases the 358429 was simply too long for these cylinders. This led to the practice of seating these bullets more deeply and crimping them over the forward driving band. The meplat measured .250" (or 70% of the bullet diameter). Keith tested his new bullet on all manner of critters (jack rabbits, grouse, porcupines, etc.) and the 359429 loaded into .38/44 loads at 1100-1200 fps was far more effective than any of the existing .38 Special loads of the day. The bar was raised even higher with this bullet was launched even faster from the .357 Magnum case.

Later .357 Magnum revolvers would take this OAL into account and were made with longer cylinders so that the 358429 could be seated and crimped in the crimp groove, but the N-frame .357 Magnums (and Colt Pythons) were made with the shorter cylinders, forcing the deeper seating. 'Tis a shame, if there ever was a gun made for the 358429 it's the Model 27, smaller guns are better served by lighter bullets and lower pressures.

This bullet is one of the classics in terms of long range plinking. My favorite load with this bullet is 14.5 grains of IMR 4227 for about 1250 fps, and very good accuracy. For whatever reason, softer loads don't seem to shoot as well for me with this bullet. The 358429 is also very good at boring *through* things to get at critters on the other side. I've given more than one rodent a rude surprise as he hid on the backside of a fallen log, just peaking out over the top. Jack rabbits, cottontails, rattlesnakes have all been handled with authority by the 358429 from my sixguns.

The Lyman 358431 hollow-base SWC.

As with the 429421, the hollow-based version of the 358429 soon followed. In this case it was given the designation of Lyman/Ideal 358431. The profile and the crimp groove are the same as the original, so this bullet still required deep seating in the .357 Magnum revolvers, but the concave base left more room for powder. It weighed 160 grains and as a result gave somewhat higher velocity than did the parent 173 grain SWC. Keith promoted this bullet for its higher velocity when loaded in Magnum loads, but (as discussed above) experience with hollow-base bullets has taught that accuracy generally suffers with high pressure loads. HB bullets deliver their best accuracy in moderate loads, and the 358431 can deliver exceptional accuracy from standard .38 Special loads (if higher velocity is desired from a

.357 SWC load, move to a lighter bullet like the H&G #51, or the Lyman 358156 or 358477). Keith ultimately decided that 160 grain bullets was probably best for the .38 Special, although he favored his 173 grain SWC for .38/44 and .357 Magnum loads.

Elmer Keith's first hollow-point, the Ideal 358439 (154 grain .38 HP).

Keith had suggested in his writings that if a shooter wanted even more shock than was afford by his SWC designs, they could get it by adding a HP cavity to his bullets. Capt. Frank Frisbie and Harold Croft ordered the first such a mould from Lyman for their .38 Specials (cavity size of .150" was determined through their discussions with one Mr. Pickering, of the Lyman Co.). The result was to ultimately receive its own design number around 1933-4, becoming known as the 358439, and one of the finest varmint bullets ever dropped into a revolver cylinder. The 358439 delivered devastating expansion in the .38/44 loads, and was nothing short of explosive when later loaded into .357 Magnum cases and launched at 1400+ fps.

I will confess right up front that I am highly biased; this is one of my all-time favorite bullets. In .38 Special cases over 8.5 grains of HS-7 (1000 fps), it provides the shooter with an truly remarkable performance, particularly if cast moderately soft (BHN of 8-9). Tough, stringy Montana jack rabbits fold up right now when hit with this load. When I'm loading the 358439 into .357 Magnum brass, I prefer to use 14.0 grains of 2400 for 1350 fps. This is one very flat-shooting, hard-hitting and explosive varmint combo. I would like to officially go on record as "tipping my cap" to Mr. Keith, the 358439 is truly a great bullet design.

Keith designed the 429421 HP and 454424 HP for the .44 Special and .45 Colt (respectively).

The popularity of the 358439 proved to be so great that Elmer went back and designed HP versions of his 429421 and 454424 SWC's in the mid-1930s. Both of these bullets weighed a nominal 235 grains when cast of his pet 16-1 alloy and expanded readily when driven to the higher velocities that his loads generated (1200 fps in the .44 Special and 1100 fps in the .45 Colt). In *Sixguns* Keith reported that both of these HP's tore "unbelievably large holes in game" and proved to be excellent hunting bullets for medium-sized game (e.g. porcupines, coyotes, antelope and deer). All of these HP cast bullets were described in Keith's *Sixguns Cartridges and Loads,* which was first published in 1936.

The HP cavity of the 429421 HP was slightly smaller (.140") than that for the 358439, which leaves notably thicker walls surrounding the cavity, leading to slower, more controlled expansion (in contrast to the violent explosion of the 358439). The HP cavity on the 454424 HP is somewhat larger (.170") than the 429421 HP, but the walls are still quite thick, and expansion is still controlled. The bottom line is the 358439 is a varmint bullet, while the 429421 HP and 454424 HP are also well suited to deer and antelope sized game. The violent fragmentation of the 358439 may have influenced Ray Thompson later on in the design of his .357 HP (the 358156 HP), which has a smaller cavity diameter of only .125 ” at the mouth. The 358156 HP expands in a somewhat more subdued fashion than does the Keith bullet. The Thompson HP is also an excellent varmint bullet, it’s just that it mushrooms more slowly than does the fragmentary 358439.

When shooting the 429421 HP in the .44 Special, I generally cast it to a BHN of about 8 or so using either range scrap or 1:1 WW/pure lead, and load it over 10.0 grains of HS-6. This load delivers between 900 and 1000 fps depending barrel length, and gives controlled expansion upon impact. For .44 Magnum loads I just cast them from WW alloy sweetened with 2% tin and load them over 23.0 grains of W296 and a CCI 350 primer for 1400 fps from a favorite 7 1/2" Ruger Super Blackhawk Liberty Model. This is one of my all-time favorite hunting loads.

The 235 grain 454424 HP also gets cast soft (i.e. range scrap or 1:1 WW/lead, BHN 8) if I'm going to use it below 1000 fps. I particularly like these softer bullets loaded on top of 9.0 grains of W231 (1000 fps), which is particularly consistent shot to shot, and very accurate. When I'm taking this bullet deer hunting, I cast them from sweetened WW alloy and load them on top of 26.0 grains of W296 with s CCI 350 primer (1350 fps from a 7 1/2" Blackhawk; this is a "Ruger only" load). This is an exceptionally accurate hunting load.


The Ideal 452423 HP came along a little later, after the other Keith HPs.

At some later point, Keith also followed suit with a HP version of the 452423, which weighed 225 grains and was pictured later on in *Sixguns* (1956). However in *Sixguns Cartridges and Loads* (1936) he specifically discussed how the 454424 HP was designed to be used in both the .45 Colt and the .45 AR, thereby bracketing the timeframe of the introduction of the 452423 HP as sometime between 1936 and 1956. With the resurging interest in .45 ACP/.45AR revolvers in the 1950s with S&W introducing the Model of 1950 and Model of 1955 revolvers, it wouldn’t be too surprising if the introduction of the 454423 HP coincided with the production of S&W's new revolvers. Mostly I shoot the 452423 HP in the .45 Colt and .45 Schofield cartridges. The 452423 HP weighs about 232 grains when cast of range scrap (soft, basically .22 lead, about BHN of ~8). In the .45 Colt, a pet load is 9.0 grains of W231, which delivers over 1000 fps comfortably, making an excellent varmint load, that would also serve just fine for larger game like Javelina, coyote, antelope and deer.

It is interesting to note that HP cavities had been originally used to increase velocity of rifle bullets by reducing bullet weight without changing length, here Keith was intentionally incorporating them into handgun bullets to enhance handgun lethality as a result of their superior expansion properties. We take such thinking (and expansion) for granted today, but in the early days of the Great Depression, with handgun ballistics generally being defined by lead round-nosed bullets at around 850 fps, these were some pretty advanced theories that Elmer reduced to practice. The sun had risen on high-performance handgun ammunition. Between the deeply penetrating Keith SWC's and the violent expansion of the Keith HP's, the handgunner could pick-n-choose a wound channel suitable for virtually any species he wanted to hunt. His SWC's were a first major step forward in terms of optimizing handgun performance, and his HP's were the second (and remember, all this was happening before there *were* any magnum handguns!). Trying to envision the modern handgunning landscape without these landmarks is an unpleasant thought indeed.

Over the years, Lyman has altered Elmer Keith's SWC designs. They shortened the forward driving band and made it smaller in diameter, they changed the "square-cut" grease groove to a rounded groove that simplified cherry production and allowed bullets to drop a little more easily from the mould blocks. They also changed the ogive slightly. Elmer was not happy. The new rounded grease groove held significantly less grease than his original design, and Elmer liked lots of grease (and for good reason). The new bullets still shot just fine, but they were NOT what Elmer had designed and put his name on. He did not care for the alterations made to his bullets.

In 1963-64, the .41 Magnum made its appearance (as a result of Keith's lobbying) and shortly thereafter Lyman released a new "Keith SWC" for this newest Magnum, the 410459. This announcement surprised Elmer because he had neither designed the bullet, nor had he even been consulted about what it should look like. Lyman had simply taken what they were then currently producing as "Keith SWC's", distilled some of those features into a .41 caliber form, and started making moulds, completely unbeknownst to Elmer. Keith was miffed because there were a number of things he didn't like about the "Keith that wasn't really a Keith" -- the grease groove was rounded, the forward driving band was too narrow, and the meplat was too small (.235", 57% of the bullet diameter, in fact it was smaller than the meplat he had designed into his .38 SWC some 30 years earlier!). This would not do! Hensley & Gibbs had been making moulds that had faithfully incorporated Keith's design features into their .38 SWC's (design #43, their 173 grain SWC, and design #51, their 160 grain

SWC) for many years, so Keith turned to H&G for his new bullet. He asked James Gibbs to make a *proper* .41 Keith SWC, and the two men settled down to draw up exactly what that bullet should look like. The result was H&G design #258 which produces a 220 grain SWC, and has a full-width and full-diameter forward driving band, a "square-cut" lube groove and a meplat that measures a full .275" (67% of the bullet diameter). This was to be the final Keith SWC, unveiled in 1964. He also asked H&G to re-create his original SWC designs in .44 and .45 caliber (they were already making the .357). This they did (and H&G added some nice subtleties like radiused filets in the lube grooves) and now not only were Elmer's original designs now once again available, they were now available in H&G quality gang moulds! These moulds were #501 (.45 Colt), and #503 (.44 Special/Magnum). It's interesting to note that Elmer's ideas about bullet proportions evolved over time, with the meplat diameter starting out at 65% of bullet diameter (429421), then 75% (452423) then he settled on 67-70% for his last three designs (454424, 358429 and H&G #258). As a result, his .41 SWC actually has the same size meplat as his original .44 SWC!


In 1964 Elmer Keith designed the H&G #258 for the .41 Magnum.


Tools to gladden a sixgunner's heart! H&G gang moulds, cut to Elmer Keith's specs for the Keith SWCs.

The moniker "Keith SWC" gets slapped on all sorts of bullets that Elmer Keith never even SAW much less designed. While they commonly capture many (if not all) of his ideas, it's really only fair to limit use of the term "Keith SWC" to those bullets that he actually designed, shot, and promoted, and refer to the more recent variations on his theme as "Keith-style" SWC's (Elmer Keith DID have style after all!). As to those designs with bevel bases, gas-checks, straight ogives, undersized forward driving bands, or itty-bitty grease grooves, well, there are other names for those…

In the decade from 1925 to 1935, handgun bullets and handgun performance changed dramatically. In part this was due to experimental high-pressure loads worked up by men like Sharpe, Wesson and Keith; in part this was due to the invention and release of 2400 powder by Hercules; and in part this was due to better steels and heat treatment processes used to make the guns stronger. But those facets only tell the beginning of the story, the launching of the bullet. It is the bullet that must fly true, it is the bullet that carries the energy, and it is the bullet that performs the work upon impact. In short, it is the bullet's design and construction that dictate how effectively the gun and the shooter are able to accomplish their goal. Elmer Keith understood how a revolver bullet started its journey from the cartridge case into the throat, across the cylinder gap into the forcing cone and down the barrel, how it flew, how it carried its burden downrange and how it delivered its promise upon impact. His insights resulted in his landmark SWC and HP designs that changed forever how the world viewed handgun bullets and handgun performance.

Chapter 13

Casting Hollow Pointed Bullets

The Gould bullet (Ideal 457122), a 330 grain cast HP for the .45-70.

In the original Ideal Handbook (published in 1888), John Barlow summarized his results using cast hollow-pointed bullets for hunting and how the HP cavity enhanced the bullet's killing effect (showcased with the 330 grain Gould HP for the .45-70). In the low pressure loads of the black powder era, one of the primary goals of the HP cavity was to reduce the bullet's weight, and hence increase muzzle velocity, without changing bullet length. Since the rotational stabilization required for stable bullet flight is (to a first approximation) a function of bullet length, this meant that the twist rate of the barrel didn't need to be modified to accommodate the lighter faster load ("express load"). This increase in muzzle velocity undoubtedly contributed to the greater killing power of these early HP loads, but the facile expansion behavior of these bullets was clearly an important factor. Bullets of this era were generally quite soft, commonly cast of 30-to-1 alloy (BHN of 7-8) which expands somewhat at typical black powder rifle velocities (1300-1400 fps) anyway, so the expansion of these early rifle HP's was nothing new (perhaps somewhat more dramatic than what those shooters were used to, but nothing they hadn't seen before). As the HP cavities got wider and deeper, the expansion became more pronounced and became a property that shooters sought out and exploited (even augmented with percussion caps and .22 blanks, like the Maynard exploding bullet of 1885).

While bullet expansion was nothing new to these riflemen, the pistoleros of the day were generally limited to far more pedestrian velocities (typically 700-900 fps) and even 30-to-1 alloy doesn't expand much at these speeds with typical RN pistol bullets. Thus, the handgunner of the 1890s generally thought basically in terms of bullet diameter, and not so much about bullet expansion. Early experimenters incorporated HP cavities into traditional revolver/lever-gun rounds like the .44-40 (Ideal #42499), and these “express” bullets developed a reputation for “increasing the killing capacity of their rifles by 50%“ (so stated the Ideal Handbook #9, published in 1897). The concept of increasing handgun lethality through enhanced *bullet performance* (as opposed to just dumping in more powder, or going to a bigger round-nosed bullet) was just starting to take root.

The next major step in terms of handgun bullet performance was the invention of the Keith SWC in 1928. Shortly thereafter, these two enhancements (HP's and the Keith SWC) were united in Keith's cast HP designs, first with the 359439 (no, that's not a typo, this HP was given a separate numerical designation from its parent SWC, the 358429) in or around 1932-3, then the 429421 HP and 454424 HP shortly thereafter, and ultimately the 452423 HP. The first three bullets were described in Keith’s 1936 “Sixguns Cartridges and Loads”, and then all four were covered in more detail in his 1956 epic “Sixguns”. Harold Croft and Capt. Frank Frisbie ordered the first 358439, and had it made with a .150” diameter HP cavity (with a 5 degree taper). This bullet proved to be an explosive bullet at .38/44 and .357 Magnum velocities, ideally suited to vermin control (reliable controlled expansion at .38 Special velocities). When Elmer Keith went back to the drawing board for the 429421 HP and 454424 HP, he incorporated .140” and .170” HP cavities (respectively), for thicker walls around the cavities and expansion would be more controlled for hunting larger animals (deer, black bear, elk, etc.) in his +P loads at 1200 and 1100 fps (respectively). A subtle, but nonetheless important feature of the Keith HP’s is that they all have a tapered cavity (approximately a 5 degree taper), usually with a rounded bottom. This allows the molten alloy to flow smoothly around the HP pin and avoids trapped air pockets. In addition, as expansion progresses towards the bottom of the cavity, this design avoids the formation of stress risers at the bottom of the cavity (no sharp corners), thereby helping the bullet stay intact. The broad meplat of the Keith SWC's bludgeons its way through meat, leaving a deep wound channel with a permanent hole through the middle of the crushed tissue (round nosed bullets crush far less tissue and fail to leave this permanent hole, leaving instead a sphincter-like wound channel that closes up on itself, severely limiting blood loss). The expansion of the Keith HP’s leads to significantly more shredded tissue than does the SWC‘s, leaving a wider wound channel (although they don’t penetrate as deeply as Keith SWC‘s). In my experience, the Keith SWC’s tend to leave a wound channel with 2-3” of bloodshot tissue, with a permanent hole about ½” across. The Keith HP’s leave as much as 6” of tattered, bloodshot tissue and a permanent hole about an inch across.


The first HP moulds suitable for use in handguns. These bullets were designed as "express bullets" for use in rifles, but also could be fired in revolvers (all were listed in the Ideal Handbook #9, circa 1897); the Ideal 31133 HP for the .32-20; Ideal 40090 HP for the .38-40, and the Ideal 42499 HP for the .44-40.


The hollow-points of Elmer Keith (l-r: 358439, 429421 HP, 452423 HP, and 454424 HP)

Sadly the Keith HP moulds are no longer available from Lyman, but they can be found on the used mould market, often commanding premium prices.

The original .357 Magnum HP (the "Sharpe HP"), a George Hensley #51 HP.

As a result of his development of the .357 Magnum cartridge in the 1930s, Phil Sharpe designed his own HP in which he took his inspiration from Keith's 358439, but with 5/6 the bearing surface (for higher velocities) and a shorter ogive (so as to fit within the short cylinder of the brand new N-frame .357 Magnum). The mould was made by George Hensley and produced a 146 grain HP (Hensley's #51). Accuracy was found to be excellent and expansion violent at 1500+ fps. The Sharpe HP had straight-walled .100" diameter cavity, with a flat, square-edged bottom. A flat-tipped HP pin can create turbulence when the molten alloy is poured, trapping air bubbles in the bullet, so it is important to cast fast and hot with such a mould. In addition, the flat bottomed HP cavity of the Sharpe HP focuses stress at the corners of the cavity during expansion, leading to shear at this juncture, making this HP design more prone to fragmentation (which may explain why Sharpe went with a smaller cavity diameter).

The original Lyman/Ideal HP's were standard mould blocks simply drilled to allow entry of the HP pin, with no provision for holding the pin in place other than friction, nor was there any way to be sure that the pin would be held at the same depth for each pour. George Hensley solved this problem by devising a cleverly milled collar that addressed both issues very effectively and he used this design for all the HP moulds made in his shop. In 1941 Lyman modified their design to include the pin/set screw design they used for years. In the latter part of the 20th century, Lyman went to using a simple snap ring to hold the HP spud in place.

The Sorenson HP (Ideal 40388 HP), originally designed for the .38-40.

After WW II, Douglas Sorenson designed the 40388 HP for the .38-40 (this bullet was also available in solid form). The Sorenson HP was first listed Ideal Handbook #37, published in 1950 (This is another example of a re-issued cherry number, the original #88 was the famous 330 grain 38-55 paper patched target bullet designed by Rabbeth). The .38-40 had a reputation for "hitting hard", and the Sorenson HP was designed in this spirit, but in post-war America the .38-40 cartridge was waning in terms of both popularity and sales. The mould design quickly and quietly faded away, as did the cartridge. It's a shame because this bullet is nothing short of amazing in the Herter's .401 Powermag. 20.0 grains of Accurate Arms #9 produces over 1600 fps and excellent accuracy. This bullet is explosive at 1600 fps!

The hollow-points of Ray Thompson (l-r: Lyman 358156 HP, 429215 HP, 429244 HP and 452491 HP).

Ray Thompson also designed a series of HP's right World War II. The Thompson HP's (and SWC's) were protected by GC's on their bases, and also had narrower lube grooves to accommodate the GC. The .38/.357 designs also came with two crimping grooves so the shooter could load these bullets to .357 OAL's in cheaper and more plentiful (at that time) .38 Special cases. The Thompson GC-SWC designs 358156, 429215, 429244 and 452490 are mainstays in the Lyman product line to this day. An interesting historical sidebar: the Lyman mould numbering scheme identifies the nominal bullet diameter with the first three digits, followed by a sequential design number (or "cherry number"). The Thompson design numbers of 156, 215 and 244 would suggest that they pre-date the Keith designs (421, 423, 424, etc.), when in fact they clearly did not and came along over two decades later. This is an example of cherry numbers that had been dropped from the Lyman/Ideal line that were “recycled” (for example, the original cherry #156 was a 150 grain .32-40 FN bullet, #215 was a 205 grain .44 RN and #244 was an 89 grain RN for the .30 Luger). Rumor has it that Ray Thompson requested these previously dropped design numbers since they were approximately the weight of his .38 and .44 designs (actually, the larger .44 bullet is closer to 260 grains). His 452490 was obviously numbered sequentially. In any event, each of Thompson's GC-SWC designs was also made in HP form -- 358156 HP, 429244 HP, 429215 HP and 452490 HP (these moulds are encountered today in roughly that order of frequency).

Ray Thompson stuck with the same HP pin diameter and design (i.e. tapered and rounded) that Elmer Keith used in the .44 bullet (.140”), but went with a somewhat smaller pin diameter for his .357 HP (.125”), about halfway in between the Keith HP and the Sharpe HP. This leads to a more moderate, controlled expansion of the bullet relative to the 358439. The 358156 HP is still an excellent varmint bullet, but just not as explosive as the 358439 in its expansion behavior. It could easily be argued that the 358156 HP is the most versatile, all-round bullet for the .357 Magnum. While I prefer larger calibers for hunting deer, if I were to use a .357 Magnum for deer, the 358156 HP would be, far and away, my first choice of projectile, jacketed or cast, it's that good. The 429215 HP is an explosive, high velocity varmint bullet out of either the .44 Magnum or .44 Special. The 429244 HP has very similar expansion characteristics to the Keith version (429421 HP), it simply carries a little more weight, and a gas-check. The 452490 was also available in HP form, but can be very hard to find. Both the Thompson and Keith HP's are excellent hunting bullets. Like the Keith HP's, the Thompson HP's have also been dropped by Lyman, but can be found on the used mould market (gun shows, mail order businesses, online auction houses, etc.)

In the past, Lyman offered the service of custom cutting HP versions of virtually any mould they offered at the customer's request (sadly this is no longer true). As a result, one can encounter a little bit of everything when perusing used moulds at gun shows, online, etc. Some of these designs leave you scratching your head, and some are clearly very useful designs. This unexpected joy of discovery is one of the things that makes collecting bullet moulds so much fun!

Occasionally one runs across some rather odd-ball HP moulds, in this case the Lyman 313445 HP.

For example, there is a rather unusually proportioned SWC for .32 caliber revolvers (the 313445) that was a popular target bullet back in the middle part of the 20th century. I stumbled across a HP version of this mould several years ago and gave it a home for no other reason than, well, it was *different*. The HP cavity is quite narrow (only .078" at its widest point) and shallow (only .270" deep), and as a result expansion is minimal when fired from the .32 S&W Long that it was designed for. Even the higher velocity of the .32 H&R Magnum doesn't induce much expansion. However things can get very interesting with this bullet in the .30 Carbine Blackhawk!

Other examples of HP variations of traditional Lyman designs include moulds like their .25-20 bullet (the #257420 HP), and the .32-20 HP mould like the 313316 HP. As a historical aside, it is interesting to note that the 257420, the younger of these two designs, was the cherry number immediately preceding Elmer Keith's 1928 landmark design for the .44 Special. Small caliber HP's like these commonly benefit from being force-fed (see casting discussion below).

The Lyman 257420 HP, a dandy varmint bullet in the .25 Hornet or .25-20 Winchester.

Cast HPs can extend the effectiveness of the Thompson-Center Contender with rounds like the 6.5 TCU, .30-30 Winchester and .270 Ren.

The advent of the Thompson-Center Contender brought certain bore diameters traditionally thought of as being rifle calibers into the Handgunners realm. Some of these old Lyman/Ideal HP moulds serve this branch of the hunting community quite well indeed. For example, the Lyman 266455 HP makes a very nice coyote bullet in the 6.5 TCU wildcat cartridge when sized .266"; 28.0 grains of H4895 generates 1850 fps from a 10" Contender and expansion is violent. A 10” .45 Colt Contender is extremely well-served by the 330 grain Gould HP (#457122) sized .454", and is capable of launching this bullet at 1250 fps. In fact, the cast HP can make a given cartridge a legitimate hunter in the Contender when it might not be such when loaded with jacketed bullets. For example, none of the .270 jacketed bullets will expand at .270 Ren velocities, but when loaded with the 280412 HP over 9.0 grains of H110 (1425 fps) the .270 Ren makes a very effective coyote load, and expansion is positive. Another example would be the .30-30 Winchester in a 10” T/C; this gun is something of a fish out of water since the case has too much capacity for good ballistic uniformity with light bullets (hence the advent of the .30 Herrett), but the heavier, more accurate jacketed bullets are going too slow to expand. However the 10“ .30-30 Winchester T/C is an excellent cast bullet gun and a hunting weight cast HP can easily be tailored to expand at the velocities attainable with this gun through judicious choice of alloy, making an excellent load for deer-sized game. The 157 grain 311466 HP loaded over 32.0 grains of H4895 generates right at 1790 fps from a 10" T/C and expansion is violent. Similarly, the .357 Hartley (kind of a .35/.30-30 Ackley Improved, if you will) makes a fine hunting round for deer and black bear sized game in a 10" T/C with the 288 grain Lyman 358009 HP. 32.0 grains of H4895 pushes this behemoth out of short-barreled Contender 1460 fps. Once again, expansion is positive. In each of these cases, the cast HP very nicely "fills in the middle ground" between the velocities that can be reasonably achieved in these short-barreled guns and those needed to make typical jacketed rifle bullets expand, making for very portable and hard-hitting hunting arms.

Back in the days that Elmer Keith, Phil Sharpe and Ray Thompson were designing their HP moulds, most bullet casters used binary alloys composed of lead and tin. These malleable alloys were well-suited for HP’s in that they expanded smoothly, and were not prone to brittle fracture. As a result, these bullets were designed with a fairly narrow HP cavity (since the alloys were fairly soft), that extended fairly deeply into the bullet (since they didn’t tend to break up, and a deep cavity led to more expansion). In more recent years, the most common source of bullet metal is wheelweight alloy, which tends to vary somewhat in composition, but generally has 3-4% antimony and roughly 1/2% tin (among other “stuff”). This alloy is of similar hardness to the previously preferred 16-to-1 HP alloy, but is more brittle than it 16-to-1 meaning that when HP’s cast of straight WW alloy expand, they may be more prone to fragmentation (depending on impact velocity). Perfectly usable bullets (SWC’s, RNFP’s, TC’s, etc.) can be cast from straight WW alloy, but trying to cast high quality HP’s from straight WW alloy can be an exercise in frustration (depending on how cantankerous your particular mould is). Adding a small amount of tin to the mix does wonders in terms of casting high quality HP bullets, as well as improving their expansion behavior (see chapter on Alloy Selection). However, there is another strategy that also works very effectively -- change the nature of the HP cavity. By making the HP cavity wider and more conical, the bullet will still expand when cast with antimony containing alloys (like straight WW), and by making the cavity shallower, if the expanded "petals" of the bullet should break off, there is still adequate bullet mass left behind the cavity to punch through the other side of yon critter (much like the concepts behind the Nosler Partition bullet design). This is precisely the tact taken by Lyman when they rejuvenated the concept of the cast HP by introducing their line of Devastator HP's back in the 1990's. This next generation of HP moulds reflects the changing tastes of the American handgunner, and is aimed largely towards semi-auto cartridges; the 9mm, the .40 S&W and 10mm Auto, the .45 ACP, as well as the perennial hunter the .44 Magnum. The HP "spuds" on these moulds are conical, and start off with a "mouth" diameter of .200-250"! In addition, they extend less than .290" into the bullet (as compared with over .410" for the 429421 and 429244 HP pins). As a result, these designs expand very readily when cast of WW alloy, and if the "petals" do break off, so what? There's still plenty of bullet metal left. In a nutshell, the old Keith and Thompson HP designs were built around malleable alloys of lead and tin. The Devastator HP's were designed specifically with WW alloy in mind. Times change and Lyman has changed to keep pace.


The Lyman Devastator HPs, shown loaded in (l-r) 10mm, .44 Magnum and .45 ACP.

The 9mm Devastator (Lyman #358637 HP) is simply a 125 grain HP version of their excellent 147 grain RNFP for the 9mm Parabellum, and this HP is clearly a varmint bullet. Note that 22 grains of bullet metal have been removed to generate the HP cavity -- folks, that's a big hole! For the sake of comparison the Keith and Thompson HP's removed about 12-14 grains of alloy to make their HP's. Running jack rabbits are a real challenge for the handgunner, and a double-stack magazine 9mm loaded with these bullets is just about ideal for such pursuits. This bullet also serves well in .38 Special varmint loads at 1000 fps.


Browning Hi-Power paired up with the Devastator HP.

The 10mm Devastator (Lyman #401638 HP) is also a derivative of their standard mould line, this time a 155 grain HP of their 175 grain


The S&W 610 shoots the 10mm Devastator HP quite well.

TC design (again, 20 grains of bullet metal removed for the cavity). This is an excellent varmint bullet launched from a 6 ½" S&W 610 at 1374 fps by 11.5 grains of HS-7 (1220 fps from a 3"). Expansion at this velocity is positive and early. This load would be adequate for coyotes, feral dogs, badgers, porcupines, javelina, etc.


The .45 Devastator HP shoots (and feeds) quite nicely in the 1911.

The classic .45 ACP 230 grain RN (Lyman #452374) was modified with a similar flat-nosed HP plug to create the Devastator .45 HP. This HP is listed at 180 grains but they drop from my mould at about 186 grains (44 grains of metal removed!). When launched with 7.5 grains of Unique they deliver right at 1100 fps and very good accuracy from a full-sized Kimber 1911. This bullet feeds quite nicely too. Once again, expansion is positive and early. I also limit use of this big-mouthed bullet to game no larger than 110-120 lbs. Loaded into .45 Schofield cases on top of 7.5 grains of Unique this HP makes a vintage varmint load extraordinaire!

The lighter semi-auto Devastator HP's can be something of a challenge to get a "good mouth" on as a result of the relatively small amount of hot bullet metal going into the cavity to warm up the rather large HP pin. Turning up the pot temperature somewhat helps to counter this, and I have had good success casting at about 750° F or so. The caster can also dunk the pin into the lead pot to pre-heat it. This problem seems to be less of an issue with the much heavier 429640 HP.


The Devastator HP in the .44 Magnum makes a powerful hunting combination.

The .44 Magnum Devastator is the real hunter of the new generation of HP's. The 429640 HP is a HP version of their now discontinued RNFP design (an excellent bullet that should have never been dropped). When cast with sweetened WW alloy, these HP's drop from the blocks at 260 grains (the parent GC-FP drops from my mould at 284 grains when cast of a similar alloy, revealing the removal of 24 grains of bullet metal to create the cavity; again, these are big holes!). Excellent accuracy is obtained with this HP when loaded over 22.5 grains of W296 and a CCI 350 primer in .44 Magnum cases, developing over 1400 fps from a 7 ½" Ruger Super Blackhawk. Expansion on mule deer is positive, and as a result of the greater bullet weight of this HP (relative to the lighter semi-auto Devastators) penetration is very good. Deer, black bear, and even elk are fair game for this bullet. This is arguably the single most useful cast bullet on the market today for the American handgun hunter.

Lee also makes a line of HP moulds. On the Lee HP's the HP spud is physically attached to the mould so it can never be lost. Due to the mechanics of how these moulds operate, the HP cavity is by necessity fairly shallow and slightly conical, so the bullets will release readily. For the handgunner, they make various HP moulds in .38, .44 (both GC and PB versions of their SWC designs) and .45 ACP (a PB RN design). Because of their shallow cavities, expansion of the Lee HP's is rather limited and not as dramatic, but as a result weight retention is good, leading to deeper penetration. Thus, the Lee HP's offer the handgunner a somewhat different "flavor" of cast HP performance. The Lee HP moulds are not as solidly built as the Lyman moulds, but they are nonetheless moderately serviceable and offer the caster an affordable entry into casting HP's.

&G #45 HP mould for the .44 Special and Magnum.

Hensley & Gibbs also offered HP versions of their mould designs. As with all H&G moulds, these were beautifully made. Today, HP H&G moulds are not often encountered and when you do happen across one, it's usually wearing a steep price tag.

Casting High Quality HP's

In order to cast high quality HP bullets, it's important to remember to do four things; first make sure to use an alloy with at least 2% tin (see chapter on Alloy Selection), secondly, turn the pot temperature up about 50 degrees hotter than normal (750° F or more), thirdly, fill the cavity quickly, and fourthly cast as quickly as is you can comfortably and safely do so. There is a common sentiment that HP moulds are demonically possessed, and that it's difficult to cast high quality HP bullets. Not true! It IS true that casting HP's is a slower process than casting SWC's from a gang mould since the HP mould is a single cavity mould, and requires manual manipulation of the pin with each cast, however if one pays attention to these four points then making high quality HP's is no more difficult than any other cast bullet. It all comes down to making sure that the molten alloy can fill in around the HP pin completely before solidifying, so let's go through these issues, point by point.

The tin content of the alloy is important to keep viscosity down so the alloy flows quickly and easily around the HP pin (it also lowers the melting point of the alloy so it stays liquid longer). Two percent tin is all that's really needed to accomplish this, certainly more won't hurt, but with the cost of tin, why bother? Tin also helps to keep the alloy malleable so the resulting HP mushrooms smoothly instead of fragmenting. Keep the antimony content low, preferably 3% or below to prevent brittleness of the cast HP. Starting with WW alloy and diluting it down with lead-tin alloy, is a good way to do this.

Casting a little hotter than normal helps to keep the blocks and pin up to temperature. I normally cast at about 650-700° ^{F}, and turn the pot up to about 750° F or so for HP's. HP moulds are commonly single cavity moulds, so there's only one "bullet's worth" of hot metal going into the block with each cast. In addition, a HP mould requires extra processing steps (i.e. removing the pin and laying it down, and putting it back in again), so the time between each pour may be a little longer than for a typical 2-cavitymould. Heating the alloy up a little hotter than normal helps to counteract this. This is particularly true for the new Devastator HP's with their much thicker pins (I cast these at 750-800° ^{F}).

Fill the mould quickly so the "mouth" of the HP doesn't get a chance to solidify prematurely (this will create wrinkles and voids in the HP walls and make for an inaccurate bullet). Many HP moulds, but certainly not all, "prefer" to be force-fed (i.e. held in direct contact with the bottom pour spout or ladle). Smaller bullets in particular tend to respond well to force-feeding as it allows for a faster casting pace and helps to keep the mould and pin up to temperature. Whether a given mould prefers to be force-fed or not, the faster the cavity is filled, the higher your percentage of quality HP's will be.

Cast fast! By running as much metal as possible through the mould keeps both the mould blocks and the HP pin hot, and minimizes the amount of time that the HP pin is outside of the mould. The HP pin starts to cool down as soon as it's removed from the blocks, so a fast casting pace keeps it out of the blocks the shortest amount of time, and exposes it to the most amount of hot bullet metal. A cool HP pin is an unhappy HP pin (you will *never* get high quality HP's from a cool HP pin). ***Do not inspect your HP bullets as you cast!*** This will only slow down your casting pace, and increase the number of defective bullets. As with any casting session, there will be rejects. Ignore them! Just cast fast! There will be plenty of time at the end of your casting session to sort through your bullets, cull the rejects and dump them back into the lead pot for next time.

Cast HP Performance

The performance of a cast HP depends on the alloy that the bullet is cast from, cavity diameter, cavity depth, and cavity taper. Thus the caster has the ability of fine-tuning the expansion properties of his load by changing the alloy that the cast are cast with, or (if the caster is a machinist) by making alternate HP pins to change the depth or taper of the cavity.

How a HP expands depends on the amount of hydraulic fluid that fills the cavity, and the forces applied by that fluid. So the key variables involved are the diameter and depth of the cavity, and the impact velocity. As the cast HP enters an animal, the body fluids are forced into the HP cavity. The hydraulic pressure acts upon the internal surface area of the cavity, pushing it outward. The more surface area, the more force gets applied. A smaller cavity allows less hydraulic fluid in, and has less surface area for it to press against. A smaller cavity also gives rise to thicker walls in the bullet's nose (for a given bullet diameter), resisting this force more effectively. Therefore, smaller cavities result in slower expansion than do larger cavities.

For those HP designs with a relatively large cavity relative to bullet diameter (e.g. the 358439 and the Devastator HP's), an alloy with a BHN of 11 (e.g. WW alloy sweetened with 2 % tin) provides controlled expansion at 900 fps, and rapid expansion above 1200 fps. Alloys with a BHN of 8 (e.g. 50/50 WW/Pb or 25-to-1) allow smooth expansion down to about 800 fps with these big mouth bullets.

For the rest of the Keith and Thompson HP's, alloys with a BHN of 11 give controlled expansion at 1200 fps, and rapid expansion at 1400. Alloys with a BHN of 8 will provide modest expansion down to about 900 fps.

Selected Cast HP Loads

Starting with the smaller bores and working up, the .30 Carbine Blackhawk is at its best with the Lyman 313316 HP, a GC-SWC that drops from the blocks at 105 grains when cast with sweetened WW alloy. Loaded over 13.0 grains of AA #9, this bullet leaves a 7 ½" Blackhawk at almost 1600 fps. This makes for a flat-shooting, hard-hitting varmint load, with violent expansion. Staying with the .32's, the .32 H&R does very nicely with the 108 grain Ideal 31133 (the hollow point version of the timeless 3118). This PB HP is very accurate when loaded over 6.5 grains of AA #7 for 1100 fps. Peeling rodents off of their mounds from 75 yards is no problem for this load in a 6" S&W Model 16. Once again, expansion is positive when cast to a BHN of about 11 or lower.

The 358477 HP is an excellent varmint bullet in the .38 Special

Moving to the mid-bores, the .38 Special could fill volumes with accurate cast bullet loads, and it's equally well-served by cast HP's. There are three combinations for the .38 Special that have served with distinction. The first, and quite possible the most versatile .38 Special load in existence, would be Elmer Keith's first HP, the 154 grain Ideal 358439, over 8.5 grains of HS-7 for 1050 fps from a 6" S&W Model 14 (this is a +P load at about 20,000 psi). This is a very accurate load, somewhat similar to the highly regarded "FBI Load", and it just flattens vermin, even wiry Arizona jack rabbits, *right now*. Expansion is positive, but not violent or explosive when cast to a BHN of 11 or less. This is simply as good as the .38 Special gets. I have shot many thousands of these rounds and can think of no way to improve it. My second pet load for cast HP's in .38 Special involves the 358480 HP, a 128 grain SWC-HP. This HP is a little more stoutly constructed than is the 358439 (it has a shallower cavity, surrounded by thicker walls) and must be cast pretty soft in order to expand at .38 Special velocities, so I generally cast it using 25-to-1 alloy. Loading this PB bullet over 4.5 grains of Bullseye generates 1025 fps and makes an excellent small game and varmint load. It’s not terribly destructive, but it’s a clean and efficient killer. The last of my favorite .38 Special loads is the “Johnny come lately” of the group. The old Lyman #358477 (150 grain SWC) has always been a personal favorite, as has Elmer Keith’s HP (#358439), so it should be no surprise that a HP version of the 358477 was a long sought after goal. This can be thought of as revisiting the 146 grain Sharpe HP that was used in the original development of the .357 Magnum (the old 358477 has a very similar profile to the original Sharpe HP, made by George Hensley). Recently, I sat down and did a little lathe work and made just such a mould (after years of fruitless searching, then I found a 358477 HP a couple of months later!). Since this was envisioned as principally being a varmint bullet, the channel was cut at .160” and the pin turned to .158”. The cavity was taken down to the bottom of the crimp groove, terminated with a 5 degree taper, and rounded. One way to think of this bullet is the Sharpe bullet, with a Keith HP pin design. Bullets drop from the mould at 140 grains, and are exceptionally accurate when launched with 4.4 grains of Bullseye (956 fps from a 6" S&W K-38 Masterpiece). At this velocity, expansion is modest when cast of WW alloy, but when cast at BHN of 8 these HP's expand very nicely.


Both the Keith HP (Ideal 358439)and Sharpe HP (H&G #51 HP) are truly explosive when loaded to .357 Magnum velocities.

For the .357 Magnum, my list has 4 entries. The time-honored, old stand-by's are either the 358439 or the 358156 HP over 14.0 grains of 2400 for about 1350 out of a 6” S&W 686, or a little over 1400 fps from an 8 3/8” S&W 586. The third entry is more recent, and once again involves the 358477 HP, this time over 15.0 grains of 2400 (for 1571 fps from an 8 3/8", 1502 fps from a 6"). This bullet has the advantage of providing the same kind of explosive performance as the 358439, but it also functions in all .357 Magnum revolvers (the long nose on the 358439 makes it too long for the N-frame .357s and the Colt Python, and requires that it be seated deeply and crimped over the forward driving band and not in the crimp groove). The 358477 HP is very similar to the bullet that was specifically designed for the .357 Magnum at it's birth, and defined a completely new level of handgun performance at 1500 fps in 1935. The fourth entry would be the first magnum HP, the 146 grain H&G #51 HP over 15.0 grains of 2400 for about 1500 fps. This is Phil Sharpe's bullet that started it all back in 1935. The 358439 pre-dates the .357 Magnum, and provided inspiration for the first Magnum in the form of the .38/44 Heavy Duty loads, but the Sharpe HP was designed specifically for the S&W's N-frame cylinders. The Keith and Sharpe HP's ushered in the Era of the Magnum Handgun. All four of these loads are exceptionally accurate, and allow the shooter to pick what level of expansion is desired. The Thompson HP provides a good mix of controlled expansion and penetration. The Keith HP (359439) provides more violent expansion and somewhat less penetration, as does the H&G #51 HP (the Sharpe HP). The 358477 HP just flat explodes at 1500+ fps. To my way of thinking, these bullets *define* .357 Magnum performance.

The .44 Special and the Lyman 429421 are an excellent, time-tested combination.

The .44 Special is one of my favorite cartridges, and for general plinking there is no finer bullet for the .44 Special than the 429421. For hunting, the 429421 HP is an excellent compliment to its SWC parent. I generally load the .44 Special to “Skeeter Skelton levels” (i.e. about 950 fps and 20,000 psi, as opposed to Elmer Keith’s loads at 1200 fps and 34,000 psi) using either Skeeter’s load of 7.5 grain of Unique, or 10.0 grains of HS-6. Either of these powder charges will deliver about 925 fps from a 4” S&W 624, and will crowd 1000 fps from longer barrels. At these velocities the 429421 HP must be cast pretty soft to expand, generally a BHN of 8 or so. I generally cast these with recovered range scrap (BHN of about 7.5 or 8), but one can get similar results using either range scrap, 1:1 WW/Pb, or 25-to-1 lead/tin. This is usually the load that accompanies me in the mountains during my summer firewood cutting chores.

Both the Lyman 429421 HP (L) and Ohlen-modified RCBS 300 grain HP (R) are excellent hunting bullets in the .44 Magnum.

Ah yes! The .44 Magnum! The huntsman of the handgun clan. From a 7 ½” Super Blackhawk the 429421 HP can be comfortably launched the at 1400+ fps and 1350 fps or so from a 6” S&W 629 Classic Hunter using 23.5 grains of W296. This is a hard-hitting hunting load that I have used with complete satisfaction on critters ranging from prairie dogs to mule deer. The new Devastator HP (the Lyman 429640 HP) shoots extremely well using 22.0 grains of W296 with a CCI 350 primer for 1400+ fps from a 7 ½” Super Blackhawk, and does a fine job on deer-sized game. Ray Thompson’s HP (the 429244 HP) does very nicely indeed over 23.5 grains of W296 (again, the CCI 350) for about 1300 fps from a 6” S&W 629 (about 1400 fps from a 7 ½” SBH, and 1750 fps from a 20” Marlin 1894). This is a good bullet in the Marlin lever-gun since it cycles so smoothly, shoots so well and hits like a sledgehammer (the Lyman 429640 certainly has the right ogive for the lever-guns, but the fragile mouth of the HP version gets dented and tends to hang up when cycling the action of my rifle, whereas the 429244 HP feeds much more smoothly). I have a 300 grain HP mould (made from a modified

RCBS 44 300 GC-SWC mould) that is my personal favorite in the .44 Mag; it is an excellent hunting bullet and kills hogs very quickly. Any one of these loads would make a fine companion for the handgun hunter in the Lower 48 (assuming the shooter is up to the task).


The Ohlen-modified 452374 HP shoots, cycles and expands very well in the 1911.

The .45 ACP is traditionally thought of in terms of a 230 grain RN at around 850 fps, or bullseye loads built around a 200 grain cast SWC at about 750 fps. Nice, but, so what? In more recent years, a number of more sprightly loads have come on the market pushing 185 grain JHP's to 1100 fps for defensive and law enforcement applications. I wanted to mimic some of these loads using a cast HP for coyote, badger, porcupine, skunks, etc. In my experience, one of the more accurate and reliable bullets in the .45 ACP has been the Lyman 452460, 200 grain SWC. A single cavity 452460 mould was converted to drop HP bullets that weighed 186 grains (see "How to Make HP Moulds" for details). When loaded on top of 7.5 grains of Unique this bullet generates 1121 fps and groups well from an 5" Colt Government Model. When fired into water bottles and ballistic gelatin at this speed, expansion was positive. The 452374 HP also weighs about 185 grains and can be pushed the same speed. It expands easily and cycles smoothly in my 1911's. My personal favorite is a 452374 2-cavity mould that I had modified by Erik Ohlen, that now drops 210 grain HPs that shoot, cycle and expand perfectly when cast of 25-1 alloy and shot at 965 fps.


The beautiful work of Miha Prevac (45-270-SAA HP mould) makes bullets that shoot and expand very well indeed.

For the .45 Colt, the list is once again short and sweet, I like to load the 454424 HP, cast to a BHN of about 8 using recovered range scrap over 14.0 grains of HS-7 sparked with a CCI 350 primer for 1050 fps and excellent accuracy. This is my preferred hunting load for my N-frame .45's. When a little more horsepower is called for, I cast these bullets out of sweetened WW alloy and load them over 26.0 grains of W296 (once again with a CCI 350) for my .45 Colt Blackhawks for about 1400 fps. This load gives 1732 fps and excellent accuracy from .45 Colt Marlin 1894 lever-gun.

Many of the top handgun hunters (like John Taffin, J. D. Jones, Hal

Swiggett, Mark Hampton and others) have gone on record recommending an expanding bullet as the best choice for the handgun hunter when hunting game animals under 400 lbs. We read all these wonderful stories about hard-working handgunners hunting exotic corners of the globe and smashing massive beasts with iron-sighted revolvers launching hardcast heavyweight slugs at tobacco-spitting distances, and we figure, “Well, if that bullet will hammer a 2000 lb Cape buffalo, it’ll handle a 150 lb deer with no problem, and I’ll feel like a big-league stud hunting with such beast-smasher load.” The only problem is, those hardcast heavyweights don’t get a chance to do much damage to a dainty little 150 lb deer before they exit the far side, and so that deer may run a long, long ways before it finally falls to it’s modest wounds. Heavyweight hardcast bullets are best suited to thick-skinned, heavy-boned game, weighing thousands of pounds, that require wound channels 4-6 feet deep to die in a forthright manner. Typical American hunters spend most of their time hunting deer-sized game (and maybe elk), and for these lighter thin-skinned animals an expanding bullet is generally a better choice. The cast HP allows the independent handgunner to make his own expanding bullets and feel the satisfaction of slaying big game animals with ammo that he crafted from its raw materials. Cast HP’s are in no way suited to hunting dangerous game like Asiatic water buffalo, elephant or the big bears, but for thin-skinned game from rodents up through elk there is a cast HP handgun load that will flat do the job, and do it well.

Chapter 14
How to make a HP mould

Some hollow-point (HP) moulds can be pretty hard to find, other worthy designs may have never been offered commercially. The ability to convert a regular bullet mould to drop a HP version of that bullet offers the caster ready access to hard-to-find HP designs, or allows the caster to experiment with novel HP designs that may have never previously seen the light of day.

When you get right down to it, there isn't really a whole lot involved in converting a regular bullet mould to cast HP bullets: drill a hole for the HP pin, make a HP pin and install some means of holding the pin in place while you pour the bullet metal. The kicker is, that hole has to be exactly centered on the bullet's axis. OK, so you just chuck your mould up in a 4-jaw chuck, dial indicate off of the cavity to get things centered and then center-bore with a bit of the desired size, right? Maybe, maybe not… virtually nothing about a typical mass produced bullet mould will be square with anything else, much less have any trueness in its relationship with the cavity (it might be close, but it's doubtful that it will be truly square). Yes, it's easy to center the mouth of the cavity using a 4-jaw chuck, but since the faces of the mould blocks aren't parallel or square with the cavity's axis, the posture of the blocks in the chuck results in the cavity's axis not being parallel to the lathe's axis, so the hole might *start* in the right location, but it wanders farther and farther off axis the deeper you drill (unless you invest significant time and effort into shimming the blocks and dial indicating off of several portions of the cavity).

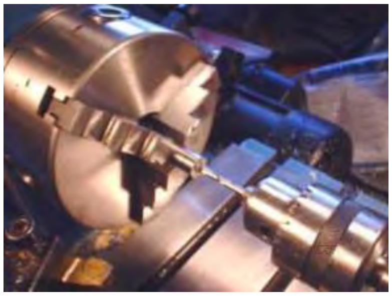
So, how do we drill a simple hole that is indeed concentric with the bullet so we'll make a stable bullet that flies true? Easy, we ignore all external surfaces and index off of the cavity itself. This requires that we turn a dummy bullet that snugly fits the mould cavity in question, and use this to guide our work. This can be done 2 different ways: we can make a center-bored pilot that we use to guide our drill bit, or we can use a mandrel to turn the mould on the lathe and center-bore the mould blocks from the tailstock. Examples of each are discussed below.

First, buy the parent mould for whatever bullet design you want a HP for. Single cavity moulds are ideally suited to this conversion and are usually pretty cheap and widely available since most bullet casters want to make lots of bullets in a hurry and sell off their single-cavities to buy gang moulds. The external condition of the mould doesn't matter, just make sure that the cavity is crisp and sharp. I have always wanted HP moulds for the Lyman 410459 for the .41 Magnum and the Lyman 452460 for the .45 ACP. Both parent SWC's have proven themselves to be exceptionally accurate, and I was hoping to combine that heritage with an expanding HP for hunting small and medium game (coyote, antelope, etc.). I looked for both of these moulds in HP form for years, and wasn't able to find either one (although I did find a 410459 HP about a year after I made this one). Therefore, I was forced to convert SWC moulds to HP form to scratch this particular itch.


410459 PBHP

Method A:

The conversion of the 410459 started off with a piece of ½" drill rod (W-1) and a #27 (.144") drill bit. The drill rod was chucked up in a 3-jaw chuck and center-bored to a depth of about 1". This piece was then turned to about .416", or slightly greater than final finished diameter (.410-.412" depending on the mould). Next, the features of the bullet's profile were turned (crimp groove, lube groove, ogive, etc.). The important parts of this step are fitting the bearing surfaces of the driving bands and the meplat of the bullet to the cavity, matching the exact ogive isn't as critical. Fitting, de-burring and polishing were continued until a snug fit of the pilot inside the cavity was achieved. At this point, the pilot was cut from the drill-rod with a parting tool, and flame hardened with a propane torch (heated to a bright red and water quenched). The pilot was then placed in the mould cavity, the mould clamped in a vice, the pilot hole filled with cutting oil and the hole drilled through the bottom of the mould blocks using the same #27 bit with a hand-held electric drill.


Center boring


Turning the 410459 pilot
(rough pilot profile)

The HP pin was turned from ¼" mild steel round stock to .142", so that it would extend to the top of the first driving band when in place. The exposed portion of the pin was tapered slightly (5 degree taper), the tip rounded, and the whole unit polished. The knob was cut from a piece of oak scrap using a 1 1/4" hole saw, and the profile cleaned up on the lathe. The bottom of the mould blocks were drilled and tapped for 6-32 x 3/8" pan-head screw to serve as a keeper. A groove was turned in the pin to hold the retaining clip such that it was a snug fit just inside of the retaining screw when the pin was in place. The knob was installed and oiled with teak oil, completing the HP spud.


The finished pilot and Lyman 410459 mould; the pilot in place.

Bullets cast from the new HP mould weighed 207 grains when cast with WW alloy sweetened with 2% tin. The bullets dropped very easily from the mould and were visually beautiful, with perfectly centered cavities (better than several of my factory HP moulds in fact). These bullets shot reasonably well, but not to the level of accuracy that I had hoped for. A micrometer revealed the reason why -- the bullets were undersized and nowhere near round, with diameters varying from .408” to .412”.


The 410459 blocks after being drilled


Mould blocks after HP channel has been drilled out, and the roughed out HP pin and knob.

The mould cavity was lapped to a more uniform and better fitting .411-.412” with 120, 280 and 400 grit silicon carbide. Bullets cast from the larger, rounder cavity shot much better. Opening morning on the Snake River had a mulie doe wander within 50 yards of my position hidden in a basalt outcrop. I launched the 410459 HP using 21.0 grains of W296 over a CCI 350 primer (1320 fps from a 6 ½” S&W 657 Classic Hunter). Her lunge told me she was heart-shot, and then she circled tightly to her left to come back around to her original position and collapsed. The 410459 HP entered the middle of her left shoulder, just behind the leg, and ranged forward and down, exiting low on the forward edge of the right shoulder. Expansion was positive, with the forward third of both lungs shredded and the heart center-punched. In short, the bullet performed exactly has hoped, expanding smoothly and punching all the way through.


The .41 Magnum loaded with the Lyman 410459 HP makes an excellent deer load.


.41 Magnum loaded with the 410459 HP

After I completed the mould described above, I proudly described the process and results to my good friend (and pistolsmith extraordinaire) Dave Ewer. He looked at me with that comical expression he gets (all too frequently) when I do something in a more convoluted or round-about way than was needed. When he finished chortling at all the extra work of parting, hardening, hand-drilling, etc., he congratulated me on my success and suggested a simpler and more straightforward method, and one that allows even more precise alignment of the hole with the bullet‘s axis. Hence was born

Method B, to be forever more known in my shop as “Dave’s Method for a Hole in the Head” (the “hole in the head” in this name refers to the hollow-point cavity, or at least that's what he told me...).


452460 mandrel and dog

Method B:

In this case, work started with a ½” piece of aluminum roundstock, which was turned to match the profile of the 452460 mould (similar to that described above, except no center bore, oh and by the way, turning aluminum goes MUCH faster than drill rod). Once the fitting was completed, the mould blocks were clamped firmly in place on the mandrel with an automotive hose clamp. A “dog” was made out of scrap aluminum flat-stock and clamped onto the mandrel’s shaft to anchor the sprue plate stop pin and prevent the mould from slipping on the mandrel (this could also be done with a hose clamp). A 5/32” end-mill (.156”) was used to make a plunge cut from the tailstock to start the HP pin channel (a drill bit can wander when starting a hole, so the end mill chosen for the initial cut to insure that the hole was maintained on center). After the initial hole was made, it was reamed to the desired final diameter using a #18 bit (.169”). The pin was turned from ¼” mild steel round stock to a diameter of .167”, set to penetrate to the middle of the top grease groove. The tip was given a 5 degree taper, rounded off, and polished. The bottom face of the mould was drilled and tapped for the retaining screw and the keeper clip and knob were fabricated as described above.


452460 mould clamped onto mandrel and held in place with dog.


Taking the plunge cut with an end-mill to cut the HP pin channel.


The drilled 452460 blocks, and the drilled mould with the rough cut pin and knob.

Bullets cast from this mould weighed 186 grains using WW alloy, sweetened with 2% tin. Bullets dropped easily from the mould and cavities were well-centered. Initial .45 ACP test loads were assembled using 5.0 grains of Bullseye and CCI 300 primers. From a full-size (un-tuned) Kimber 1911, these bullets produced a 10-shot group at 50 feet that could have been completely covered by a silver dollar. Yes, this is an accurate bullet.

452460 with the block drilled

From a full-sized Colt Government Model 1911, these bullets deliver 1121 fps when loaded on top of 7.5 grains of Unique. Impromptu expansion testing on 2 liter plastic bottles filled with water revealed that these HP's indeed expand readily. More formal testing with ballistic gelatin confirmed this. The first shot fired into a 16" block of ballistic gelatin expanded fully and stopped less than an inch from the end of the block. Based on the "wound channel" left behind, the second shot also expanded, but it exited the block and impacted the backstop, 100 yards downrange. The final 3 shots all expanded nicely and stopped after penetrating 12-14" into the gelatin. The four recovered bullets weighed 186, 183, 171 and 150 grains. In short, expansion is positive, weight retention is good and the design flat works.

Advantages/disadvantages of each method:

Fired with a muzzle velocity of 1100 fps, the 452460 HP demonstrated positive expansion in ballistic gelatin (bullets were cast of WW alloy)

Method B is faster if the gunsmith is only converting a single mould, and arguably results in a more precisely centered HP pin as the cavity itself is turning on the lathe's axis. If multiple moulds are going to be converted, it would be advantageous to turn the mandrel out of steel for greater durability. Method A takes a little longer, but if the gunsmith is going to convert more than one mould of a given design, once the pilot is made, then subsequent jobs are very quick and easy, requiring only a vice and an electric hand-drill (no lathe work), and can be handed off to an assistant to perform. If this conversion is being contemplated on a fixed handle mould, or on one (or more) cavities of a gang mould, then Method A would avoid having to swing the mould in a highly eccentric fashion.

The 452460 HP loaded into the .45 ACP cartridge

Method B also allows the channel to be cut over a much wider range of dimensions. The advantage of a wider channel (and pin) is that a wide variety of cavity diameters, profiles, etc. can be made to fit a single set of mould blocks, allowing the caster to experiment widely with a minimum of investment. The thicker pin also has a larger thermal mass and won't cool down as quickly (conversely, it will take longer to heat up).

The traditional pin design (.150-.170"), while simpler to make and fit, can also be varied as to cavity depth and taper, but is more limited in terms of cavity diameter. With proven HP designs (e.g. the Keith and Thompson HP's) this is of little consequence however.

For those that don't have access to a lathe, these HP mould conversions can be performed by Hollow Point Bullet Mold Service (http://www.hollowpointmold.com/, erik@hollowpointmold.com , (541) 738-2479). Erik has converted a number of moulds to HP configuration for me and I have been very pleased with the quality of his work in every case. What's more, Erik offers a variety of different conversions, including multiple cavity HP conversions (Cramer-style and inset-bar style), that allow the caster to make a bunch of HP bullets very quickly. He did a 4-cavity 429421 HP conversion for me and I can routinely cast 10 HPs a minute with this amazing mould. The 2-cavity Cramer-style HP moulds that he's done for me can produce 5-6 HPs a minute with no problem.

Cast HP bullets provide the handgunner with excellent expansion properties for hunting medium and small game. Some HP mould designs can be found on the used mould market, some are difficult or impossible to find (or very expensive), others only exist in someone's imagination. Conversion of a standard mould to drop HP bullets allows the caster to have access to these designs. A small investment (of either time or money) can provide a lifetime supply of high performance hunting bullets.

Chapter 15
Handgun Hunting with Cast Bullets

I stood atop the basalt rimrock, 2000 feet above the mighty Snake River, but I could have been standing behind a barn in an Indiana cornfield for all I could tell. The fog was patchy and blowing, and the canyons below me looked as though they had been cast to the brim with a milky white alabaster. It was, mid-November, a little after sunrise, cold and damp. I knew that there were 8 or 9 mule deer in the canyon below me, with 3 good bucks in the group (I had been following them for almost an hour), but where were they? They could have been 20 yards away and I would have no way of knowing. I pondered my options as the fog condensed onto and dripped from the brim of my favorite hunting hat. As though delivered by some divine nostril, a blast of crisp, cold air swept the fog from below me, revealing the carefree band of mulies only 35-40 yards down canyon. My scoped Contender came to bear on my chosen target, and I swore silently as the heavy condensation ran from both lenses of the scope, obscuring all hope of making a shot. A dry bandana was quickly extracted, and the lenses blotted to some vague semblance of dryness, but my movements were too much for the deer's comfort and the window in the fog too short-lived. The fog closed in and the now spooked bucks disappeared into it, not to be seen again for the rest of the season. My opportunity had been presented and I had failed to make good on it. An iron-sighted revolver has been my preferred damp weather hunting tool ever since. These revolvers are invariably loaded with cast bullets.

What are the best cast bullets for handgun hunting? What issues are important, and which designs are best suited for what classes of game? To answer these questions, let's look at the physics and physiology of the bullet's impact.

How Does a Bullet Kill?

Big guns kill big critters, so a big gun is going to absolutely disintegrate a smaller species, right? A common misconception is that if a gun/load/bullet is well-suited for quickly and cleanly killing a charging 1000-lb grizzly, then it will kill a 150-lb whitetail even faster and more dramatically. Sure, it'll kill the deer eventually, but that little whitetail may run a whole lot farther than the grizzly, and may very well be lost. Does that mean the dainty Southern whitetail is that much tougher than a huge coastal grizzly bear? Not hardly. It just means that the wrong bullet was sent to do the job.

In the ads for specialty hunting bullets we see terms like "rapid expansion", "controlled expansion", "deep penetration". What's best? What do we want for hunting? How do we cast our bullets to deliver optimum hunting performance? Well, that depends on what we're hunting.

A bullet kills by crushing soft tissue, rupturing blood vessels, inducing hemorrhage, ultimately reducing the blood pressure to zero, thereby denying the brain of oxygen. Unconsciousness and death quickly follow. How quickly the blood pressure drops to zero depends on how much tissue is crushed and how quickly blood flows out of that tissue (which is directly related to how much blood flows *into* that particular organ). The key concept here is that of *wound volume* -- the total number of cubic inches of soft tissue that are left crushed and bleeding by the passage of the bullet. Blood has to leak out of the cardiovascular system *from* somewhere, and it has to have somewhere to *go*. The larger the volume of the wound the more tattered tissue is left along the periphery for the blood to leak out of, and the greater the wound volume the more space the blood has to flow into. An exit wound also helps to drain the blood, by giving it somewhere to go.

Hydrostatic shock

Let’s deal with a couple ill-defined and over-used buzz-words. “Hydrostatic shock” is held in almost mystical regard by some shooters. What is hydrostatic shock? High velocity bullets tend to have a larger diameter wound channel than just the tissue crushed by the bow wave of the bullet as it passes through (the bullet is generally less than 1” in diameter and the bow wave that sets up in front of the bullet will usually crush 2-3” of tissue, hydrostatic shock can rupture blood vessels in a foot or more of soft tissue). The British military performed extensive ballistic and forensic studies after World War I (back in the days when "high velocity" was all new and shiny and exciting and different) and found that “hydrostatic shock” became a significant issue when the bullet's impact velocity was greater than about 2600 fps.

OK, let’s do some simple analysis. The speed of sound in air is roughly 1000 fps, the speed of sound in water is roughly 4000 fps. If we assume that the vital zone of a typical game animal is approximately equal parts air (the volume of the lungs) and water (the primary component of the surrounding soft tissue), and further approximate that the speed of sound in mixed media is simply a weighted average of that of its components, then the prediction is that the “speed of sound” in the vital zone of yon critter is going to be roughly 2500 fps, quite similar to the point that the Brits started to note the presence of this mysterious phenomenon they called “hydrostatic shock”. Hydrostatic shock is the result of a high speed pressure wave that ruptures blood vessels, greatly increasing the amount of hemorrhaging in the wound channel. In a nutshell, it’s a sonic boom traveling through living tissue. As the bullet passes through the vitals of an animal going faster than the speed of sound (that is, the speed of sound *in that particular tissue*), the “sonic boom” helps to rupture blood vessels and crush tissue. As the bullet slows down to below the speed of sound (again, the speed of sound in that particular tissue) this pressure wave collapses, and the wound channel beyond this point becomes the traditional (sub-sonic) wound channel. This behavior is obvious when one observes wound channels in homogenous media like ballistic gelatin, especially with rapidly expanding bullets (i.e. those that tend to slow down rapidly) that retain significant mass, like the Nosler Partition. Inspecting the ballistic gelatin wound channels of these bullets, one sees a large cantaloupe-sized cavity just beneath the surface, which later collapses to a long, narrow channel. This collapse takes place when the bullet slows down below the speed of sound *in that particular medium*. It is important to recognize that ballistic gelatin has a different density (and hence a different speed of sound) than does the vital zone of your typical buck, so the size of each of these features and the point where the bullet slows to below the speed of sound will be very different in the buck's vital tissues than in the denser ballistic gelatin.

It is also important to recognize that hydrostatic shock is only delivered very early in the bullet's impact, while it is still moving very fast. This mode of tissue destruction drops off very quickly as the bullet slows down. So, if you have a large muscular beast with lots of hide, muscle and bone between the entry point and the vitals (e.g. Cape buffalo, grizzly bear), hydrostatic shock isn't likely to play any role at all because the bullet has slowed down to below the speed of sound (in soft tissue) by the time it reaches the vital organs. But a smaller animal with relatively little meat between the outer skin and the vitals (e.g. pronghorn antelope) is more prone to fall over as if electrocuted when shot with the latest hyper-velocity Eargesplittenloudgeboomer. The reason is simple, the bullet is still traveling at supersonic (*soft tissue supersonic*) speeds as it traverses the vital organs.

A point that is commonly ignored is that hydrostatic shock causes bloodshot meat (although it's not the only mechanism that causes meat to become bloodshot), which helps to explain why moderate velocity rounds like the .30-30 Winchester, .35 Remington, .444 Marlin and .45-70 are so popular with "meat hunters".

Since the focus of this book is on cast bullets and since cast bullets are almost always used at velocities below 2600 fps, hydrostatic shock can be largely ignored. This 2600 fps is not a fixed number because each species is built differently, and each animal has a different amount of breath in its lungs when the bullet hits, and each shot presentation involves different tissues of different densities. This number undoubtedly varies several hundred fps, depending on the prey species, shot presentation, elevation, etc. However, the concept of supersonic impact and its relationship to the nature of the wound channel is nonetheless important for higher velocity jacketed bullet loads. The bottom line is that hydrostatic shock can play a significant role in how the .25-06 kills, it's probably not much of a contributor for the .44 Magnum.

Penetration vs. Expansion

For a given power level (e.g. .44 Magnum), changing the cast bullet's hardness or bullet design will have a direct impact on the bullet's ability to penetrate. The softer a cast bullet is, the more it can expand, leading to broader wound channels and less penetration since part of the kinetic energy is being used to deform the bullet metal, and the bullet is crushing a wider path through the meat. The harder a cast bullet is, the less it will deform and the deeper it will penetrate. As penetration depth increases, wound channel diameter tends to decrease. Said another way, any given bullet is capable of crushing only so much tissue (i.e. converting it's kinetic energy into the work of crushing/displacing tissue), and it can expand quickly and make a short, wide wound channel, or it can expand not at all and make a long narrow wound channel. The vital zone on each animal is of different size and the hunter needs to take this into consideration when choosing a bullet design, alloy and load. The nature of the wound channel needs to be matched up with the vital zone dimensions and shape of the animal being hunted. It is up to the hunter to make sure the bullet's construction is appropriate for the prey species, and to then place that wound channel where it can be most lethal and humane.

Tailoring the bullet to the quarry. The obvious issues involved in matching the bullet to the quarry are bullet weight and diameter, but the caster also has the advantage of being able to specifically tailor his bullets by varying alloy hardness and HP cavity diameter and depth.

OK, so what sort of wound channel works best for big game? For any game animal, it's important that the wound channel not only reach the vitals but go all the way through them (again, it's good if the blood has somewhere to go). As a result, penetration depth is critical for large and dangerous game. This means that the bullet can't waste its energy distorting the bullet metal and slowing down too early (i.e. expanding). All the work must be used to crush tissue, none to deform the bullet. Thus, the blunt-nosed non-expanding solid bullet that is favored for this type of hunting produces a long wound channel that tends to be fairly narrow, but added up over its total length of many feet, this creates a significant amount of wound volume.

However, if this same load is used on a pronghorn antelope, the bullet punches through from side-to-side with the same narrow wound channel (assuming no major bone is hit), but since the antelope is a much smaller animal, this shorter wound channel results in significantly less tissue damage than it does on larger game, and the antelope may run quite a distance before eventually succumbing to it's modest wounds. Smaller animals don't generally need 4-8 feet of penetration, 18-24" is usually adequate, and therefore an expanding bullet generally results in a much quicker kill than does a non-expanding solid, as a result of the larger wound diameter (and hence wound volume) produced by the expanding bullet. When hunting with a handgun, this becomes particularly important. Notable handgun hunters like J. D. Jones, Hal Swiggett, John Taffin, Mark Hampton, and others, agree that while heavyweight solid flat-pointed bullets are desirable when pursuing large, dangerous game, that some sort of expanding bullet is usually a better killer when pursuing lighter-bodied, thin-skinned game like deer and antelope.

Rapid expansion. Hunting medium and small game is precisely where the cast HP comes into its own. It provides all the advantages of the cast bullet (longer barrel life, lower pressures, higher velocities, the pride of making your own hunting projectiles, etc.), along with the enhanced lethality of the expanding JHP, as well as the weight retention of the specialty high performance bullets (e.g. partition). The lighter, more frangible cast HP's (e.g. those for the .30 Carbine, .357 Magnum, etc.) are superbly suited for sixgunning varmint hunter, while the heavier, larger caliber cast HP's (e.g. those for the .44 Magnum, .45 Colt, etc.) are excellent for deer and antelope sized game.

Controlled expansion. Larger animals, like elk and moose, call for a heavier, more stoutly constructed bullet, like the .300+ grain designs available for the .44 Magnum, 454 Casull and .480 Ruger. Expansion of the cast bullet is fine in these cases, but it needs to be a more moderate, controlled expansion than a hollow point delivers to insure that the bullet digs deep. Controlled expansion can be attained by using one of the fine hunting moulds (e.g. Keith SWC, SSK FP, LBT WFN/LFN, etc.) and casting the bullets with a soft enough alloy to allow for modest expansion at the expected impact velocity (e.g. BHN of about 12 for typical .44 Magnum velocities). This approach sacrifices very little in the way of penetration depth, and can provide the hunter with a slightly wider wound channel. This level of penetration is far more than needed for deer, but it can be useful for "Texas heart shot" presentations. For loads in this category, I normally cast these bullets using air-cooled wheelweight alloy (or something similar), and they are very well-suited for elk.

Non-expanding solids. Large, dangerous game animals (e.g. Cape buffalo, the big bears, etc.) have their vital organs shielded by thick layers of dense muscle and heavy bone. A cast bullet must be hard and heavy (300 grains at a minimum, and preferably more) to reliably make it through this obstacle course to perforate the vitals. Bullet impact on these heavy bones can cause deformation that may lead the bullet to veer off track and miss the vitals completely. In this case, the bullet needs to be both hard and tough. One common method used to address this need is to cast the bullets from straight linotype (BHN = 22), but this approach suffers from the drawback of increased brittleness and possible fragmentation. While I have never hunted Africa (I hope to someday...), extensive research by a number of handgun hunters who have suggests that the best bullet metal for large and dangerous game is water-quenched (or heat treated) wheelweight alloy. This bullet metal is not only hard enough to resist expanding at handgun velocities (BHN of 16-18), but the modest antimony content (ca. 4%) also means that this alloy is tough, and resists fragmentation. Excellent penetration is obtained, and bullet deformation is negligible. For those who want their bullet a little harder, this alloy can be "sweetened" with as much as 20% linotype before any brittleness problems arise (again, these bullets are water quenched from the mould).


The Keith HP (Ideal 358439) at 1000 fps makes an excellent jack rabbit load.

Cast bullets in the hunting fields

Varmints. I have burned countless thousands of rounds of ammo all over the western US in pursuit of various "flavors" of vermin over the years. Sometimes the weather is hot and dusty, sometimes cold and foggy, but the guns I'm carrying are almost always loaded with cast bullets. For example, several years ago I was in southeastern Arizona hunting Javelina. As the trip wound to a close, I was able to spend a memorable afternoon hunting jack rabbits with a favorite 5-screw K-38 Masterpiece, loaded with Elmer Keith's 358439 at 1000 fps. It was mid-February and the afternoon was cool and cloudy, and the scent of sage flavored what little breeze there was. I kicked up the first jack shortly after leaving the truck, and he ducked and dodged his way through the sagebrush as only a jack rabbit can. He came to a stop about 35 yards out, tucked into the shadows behind this one clump of sage, and sat there to watch me to see if I amounted to any kind of threat. Classic bunny stance, broadside, facing my left. The Patridge front sight of the K-38 Masterpiece slid under the "armpit" of the rabbit as I mentally pictured a 6 o'clock hold on an imaginary bullseye on his shoulder. Just as I dropped the hammer, I remembered that the gun was sighted in for a 6 o'clock hold....but only when using wadcutter target loads. When loaded with these +P cast HP's it was sighted in for a center hold! Aarrgh! The results downrange confirmed my fears -- white fluff erupted everywhere, in a 6-8 foot explosion. The rabbit ran off, absolutely terrified, but clearly in excellent physical shape. I inspected the scene thoroughly and found only tufts of white fur, no sign of any meat or blood. I pursued the rabbit, and saw him several more times (with his shaved armpits he was easy to identify), but was never able to get a second shot at him. We parted ways, him fashionably coifed, me chastising myself. A few minutes later, I kicked up a second jack (this one larger, and medium brown), he ran about 40 yards and hid behind a clump of sage. There just so happened to be a small window through the scrubbrush and I threaded one of Elmer's finest through that narrow window into the center of the rabbit's shoulder. It landed with an audible "thump!", and punched though leaving a gaping exit wound in its wake.

Mr. Keith certainly designed good bullets.


The Lyman 452460 and 4.0 grains of Bullseye makes this old warhorse a good jack rabbit gun.

There was another jack rabbit that was memorable, this one in central Montana. A group of us had spent a hot July day out shooting prairie dogs, and we were headed back to town to get a hot meal and a cold beverage (or two). We were a good 20 miles from the nearest paved road, in the middle of nowhere, when a very large jack skeedaddled across the road, right in front of the car. I asked Reo to stop the car, and I got out, loading my 1918 vintage Model 1911 as I went. The jack had stopped to hide in a thick clump of sage, but when I dropped the slide home, he took of running again, cutting a wide arc across the Montana plains. I swung the old warhorse 1911 to lead him, and at each window in the sage, 4.0 grains of Bullseye launched an Ideal 452460 200 grain SWC off in the direction that long-eared pin-ball. I guess this rabbit thought that I was shooting a revolver, because after missing him 6 times, he stopped about 100 yards out to catch his breath and look me over. I knew from previous experience with the fine battlefield sights on this WWI 1911 that it was spot on point of aim at 25 yards or so, and with this load when the base of the front sight was held on the top of the rear sight, that it was spot on at 100 yards. With the sight picture so configured, and my last round in the chamber, I centered that needle-fine front sight on this husky jack and let fly. With a hollow “thwock!” (and no dust cloud to indicate a miss) the jack slowly and stiffly fell over backwards, as though he were a silhouette cut from 1/4” steel plate, and then disappeared from sight! I reloaded and went to investigate. Turns out he was standing next to a truly monstrous prairie dog hole (almost 2 feet in diameter) and when he fell, he fell directly into the hole. There were several splashes of bright red blood, indicating a solid upper body hit. A small patch of rabbit fur was visible about 5 feet down into the dark recesses of the hole, but not wanting to tangle with any possible rattlesnakes, I didn’t investigate further.

Several years ago, I was on my way back from some technical meetings and was able to stop off and spend a few days prairie doggin’ in south-central Wyoming. On one afternoon, my 629 Classic Hunter was loaded with Elmer’s 429421 HP at 1350 fps. In one area the landscape undulated like a giant washboard, and I could sneak up out of one gully and peak into the next, getting several shots in the 50-100 yard range. As soon as the critters in that gully got to spooked for me to get any more shots, I’d sneak over and peak into the next gully. That revolver spent most of that afternoon quite warm. Elmer Keith sure did design some fine bullets -- the 429421 HP expands well and it just flat hammers rodents.

One of my favorite ways to spend a sunny summer afternoon is hiking around the mountains of the Pacific Northwest with a favorite revolver, in pursuit of ground squirrels. A few summers ago, we had a group of sixgunners getting together for a mountain rendezvous, varmint shoot and campfire gabfest. I got there early, to prep the campsite and to cut a weekend supply of firewood. As the early arrivals started to dribble in, I was describing the area to them and showing off the 400-500 yard stumpfield that we would be using as our plinking range. A rather portly ground squirrel (aka "greydigger") chose that moment to hop up onto a stump, about 40-45 yards in front of us. Now when I'm cutting firewood, I wear my 3" S&W 624 Lew Horton .44 Special on my belt; this occasion was no exception, and it was loaded with 429421 HPs (cast soft, BHN about 8) over 7.5 grains of Unique for about 900 fps. As though on cue, one of the early arrivals asked, "What exactly do these greydiggers look like?". I pointed over towards the rodent and said, "Well, there's one right over there." and as he was trying to pick it out from the stumps, the 624 came out and spoke its piece. The soft HP flipped the rodent and turned him inside out. "Nice shot." came the drawn out response. That's one of the reasons I like that revolver so much, it makes nice shots.

The first time I encountered a Ruger Blackhawk in .30 Carbine, my only thought was "Why?". This was back in the days before I started handloading, and all I was thinking of was shooting milsurp FMJ though it, and if you want to plink, why not just do it with a .22 or .38? They're cheaper, quieter and more versatile. Well, now that I'm a handloader and bullet caster, I view the cartridge and the gun in a whole 'nother light! Loaded with GC cast HP's, the .30 Carbine Blackhawk can generate 1600 fps with superb accuracy, with a remarkably flat trajectory and some truly impressive terminal performance. This just may be the perfect varmint sixgun. I have a 3-screw Blackhawk in .30 Carbine that has made some very satisfying shots on ground squirrels. One afternoon Rob and I were hiking through the mountains. As we crested one ridge, we found a rather large digger sitting up on his stump, surveying his kingdom. A stiff charge of Accurate Arms #9 launched a 311316 HP down the hill, across the 80 yards between us. The impact was clearly audible, and expansion obvious, as he was launched several feet into the air, spinning in a triple back flip. "Wow, I gotta get me one a those...." was all Rob could say. The cast HP turns the .30 Carbine Blackhawk into a whole different gun.

Medium Game. For deer-sized game, I like the added wound-channel width delivered by an expanding bullet, so I commonly hunt using cast HPs, generally weighing 200 grains or more. For revolvers, these cast HPs are generally 40 caliber or larger. It's tough to beat the good ol' .44 Magnum as a cast bullet hunting round, but there are other fine rounds for game in this class, like the .401 Powermag, .41 Magnum, .44 Special and .45 Colt; they all do well with Keith-style SWCs and cast HPs on deer sized game. When I'm hunting with a Contender, these cast HPs are generally .33 caliber or larger. I'm partial to my own wildcat (the .338 GEF) for obvious reasons, but there are any number of other good rounds for game in this size range, including the .35 Remington, the .375 Winchester, .375 JDJ that also do well with suitable cast bullets. When hunting deer-sized game with rifles, I commonly just hunt using solids cast soft enough to expand at whatever velocity I'm shooting them at (or HPs at 1600-1700 fps). In this case, my preferred round is the .35 Remington or .35 Whelen.


The .44 Magnum loaded with the Lyman Devastator HP (429640 HP) makes a very effective deer load.

One such memorable morning started off crisp and cold, with a heavy frost on the ground, and the eaerly morning colors slowly leaking into the gray rocky canyons of the Snake River. Shortly after sunrise, a mulie doe snuck into the basalt-lined canyon below me with a large yearling. I followed her with my revolver's sights as she moved across the hillside she heard the metallic "Snick" as I eased the hammer back to full-cock, and she skidded to a stop. She quickly turned back and led her yearling back across the hill, uneasy about her surroundings. About 35 yards in front of me, she stopped and was looking down canyon, straight away from me. The front sight blade settled on her spine, a little below her ear, and the .44 Magnum roared. The Lyman 429640 HP (at 1350 fps) went exactly where it was told and the doe folded on the spot. In the timeless words of one of my long-time hunting partners, "She bounced three times on the way to the bottom of the canyon.". By mid-afternoon, I had the venison packed up and out of those rocky Snake River canyons and was back at camp enjoying a hot cup of coffee. I like the .44 Magnum, and the .44 Magnum likes cast bullets.

I also like the .44 Special. On another hunt, I had already filled my bag and was just along for the ride while a friend of mine was looking to shoot a nice sized feral boar with his .45-70. We were working over a muddy hillside when we heard a deep grunt come from up the creek channel in the drainage below us. Steve made a nice stalk on this boar, and hit him with his .45-70, loaded with the 330 grain Lyman 457122 (the Gould HP) at about 1500 fps. He placed the shot well, breaking the left should and just missing the heart, but this was one tough old boar, and he wasn't go to go down easy (the bullet expanded well and exited, and it just missed the heart by a little bit). The boar got into some thick stuff and Steve wasn't able to get into position to shoot


The 429251 HP recovered from a huge old boar.

again. The boar wandered my way and came out of the brush about 10 feet in front of me. I had my 7 1/2" stainless Ruger New Model Blackhawk .44 Special that my good friend Dave Ewer built for me. It was loaded with the Lyman 429251 HP (BHN = 8) loaded over 17.0 grains of 2400 for 1235 fps. When the black-n-white boar stepped out of the brush, I put two quick shots into his ribs and though his lungs, knocking him off his feet. Steve then came up and finished him off with his .45. One of my two shots exited, the other was found under the hide on the farside. Both had expanded nicely, and done significant damage to the lungs. The recovered 429251 HP had expanded to approximately .60 caliber and weighed 194 grains. Steve's boar weighed a little over 700 lbs on the hoof, and the skinned and gutted carcass weighed over 350 lbs.


The 33889 HP is a fine deer bullet.

Back in 1993, along with the help and guidance of the good folks at SSK Industries, I designed my own wildcat cartridge for the Contender, the .338 GEF. It’s based on the .356 Winchester case, necked down to .338 with the body taper blown out and a 40 degree shoulder. More recently, I converted a single cavity Lyman 33889 to drop HP bullets specifically for this wildcat. It weighs 245 grains when checked and lubed (WW alloy). The first load I tried put 3 shots into 1” at 50 yards. A late season doe tag was burning a hole in my pocket, so I took off for the breaks of the Snake River, outside of Pullman, WA. Dawn broke cold and gray over the basalt encrusted canyons of the Snake the next morning. I had worked my way down into one of my favorite canyons, and had nestled myself into a rock outcropping to break up my outline and get out of the biting wind by the time the sun came up. It was a beautiful morning, but there was relatively little deer activity. Around 10 am, a nice 3x3 mulie buck (I wish I had seen him during buck season!) and a large muscular doe slipped in quietly below me, side-hilling their way around the ridge I was on, trying to quietly sneak into the thick brush 100 yards below me. They hadn’t spotted me, but they may have scented me as the were clearly antsy about something (I was the only hunter in this group of canyons). As they milled about below me, it was clear that they were getting uncomfortable and ready to leave. The doe was not giving me very good presentations, so I tracked her in the scope, and when she stopped, angled strongly away from me, I lined up a raking shot and fired. The 33889 HP entered at the rear of the right ribs, angling through the lungs, passing just behind the heart and exiting through the middle of the left shoulder. Expansion was moderate and controlled (velocity of this load was only about 1250 fps), and it penetrated about 2 1/2 feet of deer and exited. She ran about 50 yards side-hill and died in the middle of a thicket that Br’er Rabbit would have been proud to call home. This rocky roost is one of my favorite spots as I have taken half a dozen deer from this very spot; the last three in three consecutive years, all using cast HP's.

Occasionally, I also hunt with a rifle, and when I do it is virtually always loaded with cast bullets. One recent trip that comes to mind had me hunting with an early Marlin 336 in .35 Remington (one of my favorite rifle cartridges). Once again we were hunting for feral hogs. On this trip, the load I was using was the RCBS 35-200 GC-FP over 38.0 grains of H335 for 2100 fps and very good accuracy. I was looking for a good eatin' pig on this trip, and so I was hoping to take something less than 300 lbs. Bill and I worked out way up to an area where we could hear hogs working in the bushes around the creek, but we were having a hard time seeing them. Eventually, a 150-lb hog wandered out into the open sunshine, about 30 yards in front of me and I hit him just behind the shoulder with a 200 grain RCBS cast bullet. He went down so hard he kicked up a cloud of dust. I guess that's why I like the .35 Remington so much; it works, and it works particularly well with cast bullets.


The .35 Remington loaded with the RCBS 200 grain GC-FP is a fine recipe for making pork!

Certain special cast bullets can also play a role in how you remember certain special hunting trips. A group of us were in south central Wyoming, hunting antelope. We had spilt up into two groups to scout out the country; Dale and Wayne had gone one direction, and Jeff and I had gone another. We were going to just cover as much country as possible and then meet back at central rendezvous point for supper. Jeff and I had seen a whole bunch of wide open Wyoming, but not a trace of any antelope, when we came to a bend in the deeply rutted road and saw a small band of antelope off to the left about 150 yards. The road-cut was deep, and the sage even deeper, so the profile of the truck, and my exit from it, was largely hidden from view. As I crawled up the embankment and into the sage with my Contender, I noticed that the antelope were getting skittish, but their attention was focused on something off to my right. I tried to work myself into position for a Creedmore shot, but my movements were spotted by the sharp-eyed antelope and they spooked. It was at this point that I spotted the cab of Dale's pick-up, beyond a similar hillock a quarter mile off to my right. As I stood up to walk back to the truck, so did Wayne, who had belly-crawled 150-200 yards through the sage to try to set up a shot for his .40-90 Sharps (loaded with a 385 grain paper-patched bullet and Pyrodex). He and Dale had been following this group of antelope for a while now, and he had spent the last 20 minutes snaking his way through the sagebrush, prickly pear and rocks, only to have all of his efforts laid waste by some goofball spooking his quarry. His displeasure was palpable, but unspoken. However, he soon got over the frustration of our little comedy/tragedy, as he was able to unleash his .40-90 Sharps at an antelope doe from 90 yards away. It was a quartering shot, that raked her from the front left shoulder to the front of the right ham. That great big gob of soft lead dropped her as though she had been struck by lightning. My indiscretions were now forgiven (although I am periodically reminded of them around a campfire). Every time I see a .40-90 Sharps loaded with a cast bullet, I think of Wayne and Wyoming.

Big game. For big game (i.e. anything over 500 lbs), a recipe that I like to follow, and it has worked well for me, is large (.40+) caliber, 300 grains or more, and a good flat-nosed meplat. For revolvers, this recipe gets combined with my favorite hunting guns chambered in .44 Magnum, .45 Colt, 454 Casull and the .480 Ruger. In Contenders and rifles, we're both fond of the .405 Winchester, .444 Marlin, .45-70, and cartridges of that ilk. All of these guns serve the big-game hunter very well when loaded with flat-nosed cast bullets of 300 grains of more.

For example, several years ago I used this recipe on a feral hog hunt. I was hunting with a Ruger Super Blackhawk that I had converted to .45 Colt. It was loaded with a 325 grain cast FP bullet that I had drawn up using the online bullet design program at Mountain Molds (www.mountainmolds.com). A stiff charge of H110 had this bullet running a little over 1200 fps from the 7 1/2" sixgun. Bill and I had found a large, old, golden-bristled boar, who was sporting an impressive set of tusks, snoozing away above his favorite pond. Given the fact that he was asleep, the stalk wasn't overly difficult, I simply swung around downwind of him and quietly walked up. I had to get close because he was bedded down next to a fallen log, and it was shielding his vital organs. From 15 feet away, I fired the 325 grain Mountain Molds cast FP through his chest, and I instantly knew that it had exited due to the large dust cloud kicked up on the far side of the hog. One shot was all it took. He weighed between 500 and 600 lbs.

This grizzled old boar fell to a 325 grain Mountain Molds cast bullet from a custom .45 Colt Super Blackhawk.

I used a similar strategy when I was hunting buffalo. This time, I was hunting with the masterpiece in stainless steel known as the Freedom Arms Model 83, chambered in the 454 Casull. It was loaded with the Lyman 454629 300 grain GC-FP that Lyman had made specifically for the Freedom Arms 454 (they even went so far as to stamp FREEDOM ARMS in the mould blocks). The load I had settled on was 30.0 grains of H110, which produced 1650 fps from this 7 1/2" five-shooter. The bullets were cast of water-quenched WW alloy and had a BHN of about 18. It was February and the buffalo hides were in their prime. The weather was cold, dipping down into the mid-20s overnight, but was clear and sunny, warming into the 40s during the days. I was hunting for a young "meat bull" on this trip, but my two hunting partners were each looking for hogs. We had covered a lot of ground that day, and seen a lot of animals, but no shots had been fired. Bob decided that he wanted to go back down the hill and go after one of the black-n-white boars we had seen earlier in the day. As we worked our way through the woods looking for bedded down hogs, we stumbled across a herd of buffalo, bedded down in an out of the way spot, back in the thick stuff. I dropped onto the backside of a line of trees to stalk the herd and managed to get within about 35 yards. The herd stood up and was staring at me, and there were several "meat bulls" of the size I was looking for, but all the animals were bunched up tightly, thereby preventing me from shooting. Eventually, the lead cow started to drift off into the thick stuff to my left, and the herd started to follow. The last one to move was a 3 1/2 year old meat bull, about 800 lbs, just the size I was looking for. The front sight blade settled in low on his shoulder and I fired. The 300 grain cast bullet smashed through his shoulder, clipped the heart and lungs and exited through the ribs on the far side. He reared up on his hind legs like a stallion and lunged forward to catch up with the slowly departing herd. They bunched around him to help out their stricken comrade, but it was clear he wasn't going to go far, so they soon wandered off, and a second shot through the lungs put him down for keeps. Neither bullet expanded, and both shots exited.

Buffalo bull taken with Freedom Arms 454 Casull and the Lyman 452629.

Rob with his buffalo.

It just wouldn't be right to talk about cast bullets and buffalo and not talk about the .45-70, right? Rob used this combination, in the form of his Winchester 1886, to take a fine young meat bull a few years ago. His .45-70 loads were composed of the Lyman 457124 (an older version with a small flat meplat, so it's safe to use in tubular magazines), cast of air-cooled WW alloy (BHN of about 10-11), loaded over 50.0 grains of 4895, to produce a muzzle velocity of 1650 fps. We had seen several groups of buffalo that day, and he had decided to take a meat bull. We found a group of three buffalo out in the open which had a fine young meat bull in it. Rob approached to within about 75-80 yards of the group and shot the young bull though the lungs using this load. The cast bullet's impact resonated across the meadow like distant thunder. A second shot produced similar results, and still the stricken bull just stood there. Rob's third shot knocked the bull of his feet with finality.


Bullet recovered from Rob's buffalo.

During the skinning process, one of Rob's cast bullets was found under the hide on the far side (the others passed through and exited). The recovered bullet weighed 386 grains (starting weight of 393 grains), so it basically lost its lube weight and virtually no bullet metal. It was one of the most beautiful lead mushrooms that you'll ever see. Generally speaking, 1600 fps will not be enough to get most jacketed rifle bullets to expand, and as a result they tend to produce poor wound channels. However, 1600 fps can be a very effective muzzle velocity with cast bullets because they can be tailored to expand very nicely indeed, and hence produce far superior wound channels at moderate velocities.

Cast bullets won’t make you a better hunter, but they may allow you to extract more pleasure from your hunting by allowing you to put more of yourself into your hunting. That little bit of extra work, that little bit of personal tailoring, that little bit of extra preparation that makes the moment of truth that much more satisfying because you’ve earned that trophy, and that venison, a little bit more completely than if you’d done things with generic factory stuff. You know the load, you know the bullet, you know the alloy, giving you confidence when you align the sights and drop the hammer. That’s what bullet casting offers the hunter. Good luck, good casting and good hunting! And remember -- cast smart and hunt ethically!

Chapter 16
A Few of Our Favorites...

Now that we've seen a little bit of the history of cast bullets, understand something about the metallurgy of bullet metals, the hows and whys of fluxing, what lube does, what leading is and how to avoid it, where some of the cast bullet designs come from, and how to best exploit cast bullets in hunting loads, we decided to wrap things up with a laid back discussion of a few of our favorite cast bullets and loads. Since handguns get used for a lot of different things, we decided to break this down in terms of application -- plinking, competition, and hunting. So, let's talk guns, bullets and loads -- the fun stuff!


For plinking it just doesn't get much better than a K-38!

Plinking Bullets and Loads

Plinking is a wonderful pastime, and one that is amenable to just about anything that goes "Bang!". That being said, I have probably burnt as many rounds of .38 Special ammo plinking as I have all other centerfire handgun cartridges combined. In many ways, the .38 Special is the perfect plinking round -- cheap to reload, accurate, sufficient power to make tin cans and pine cones dance merrily, low recoil and muzzle blast (so large volume shooting doesn't have a tendency to cause bad habits), and highly amenable to being loaded with cast bullets. In the .38 Special, I have assembled plinking ammo with dozens and dozens of different cast bullets, from a wide variety of mould makers and historical periods, and the vast majority of them have served their intended purpose admirably. For the .38 Special, I have many favorites from Cramer, H&G, RCBS, Lee, etc., but if I were forced to choose my all-time favorite plinking bullet for the .38 Special, it would have to be the old 150 grain version of the Lyman/Ideal 358477. This bullet is very accurate and is the right weight to extract optimum performance from the .38 Special loaded to standard pressures (about 950 fps when loaded to 16,000 CUP). I generally use 5.4 grains of Unique with this bullet to achieve this velocity, but also occasionally use 4.5 grains of Bullseye. Both loads are very accurate, and make excellent plinking loads. Years ago, I made a believer out of a friend of mine by using this load to put 5 out of 5 shots into a basketball-sized burnt log end at about 150-175 yards, using the 3" S&W Model 60 that I was carrying that day. Not bad for a snubby!

Another personal favorite for plinking is the classic .44 Special. There is no finer plinking bullet in .44 caliber than the legendary Lyman/Ideal 429421, Elmer Keith's first SWC design. The 429421 is a very accurate bullet, even out at extended ranges. Perhaps the two most famous .44 Special loads were those championed by Elmer Keith and Skeeter Skelton, and both were built around the 429421. Elmer used stiff charges of 2400 (ultimately settling on 17.0 grains in solid head cases) to achieve 1200+ fps with this bullet from a 7 1/2" sixgun. Skeeter's pet load was 7.5 grains of Unique for a little over 900 fps from his 4" Model 1950 Target. Elmer was a rancher/hunter/trapper who had occasion to use his ever-present sixgun to kill mountain lions, renegade livestock (bulls, broncs, etc.), or targets of opportunity (mule deer or elk) for the Keith family freezer. As a result, he tailored his pet load for the penetration required by these tasks. Skeeter was also a hunter, but his primary use for the .44 Special was in his duties as a law enforcement officer. If he was in a gunfight with some ne'er-do-well, he needed to have adequate punch, pin-point accuracy and moderate enough recoil for quick recovery in case a follow-up shot was needed. So he tailored his .44 Special load to emulate the time-honored .45 Colt -- a 250 grain bullet at 900 fps, except this time it was from a 4" S&W N-frame, instead of a 7 1/2" Colt Single-Action Army. Better sights and tighter tolerances allowed him to place his shots quickly and with precision, and this load provided enough "thump!" to take the fight out of a felon. Each load served its intended purpose very well indeed (and they still do).

My general purpose load for the .44 Special also involves Keith's 429421, although it is more akin to Skeeter's load than to Elmer's. I load the 429421 over 10.0 grains of HS-6 for about 950 fps. I originally developed this load using Winchester 540, and used 540 for several years with complete satisfaction, but when that powder was dropped from the market, I switched over to HS-6 and I've stuck with HS-6 ever since. This is an excellent plinking load.

The .44 Special is indeed special, and this USFA Flat-top Target is VERY special.

The historical aspects of guns, bullets, and cartridges are a fascinating part of the shooting sports. So I guess it's no surprise that special guns, that were owned by special men, also have a special place in my heart. One such example would a 1930s vintage S&W Military & Police that I own. It is chambered for the .32-20 cartridge, has a 5" barrel, and is in excellent shape. I bought this gun from the late Hal Swiggett several years ago, when he started selling off his collection. Hal has always been one of my favorite gun-writers, and I figured this would be a way for me to preserve a little piece of his legacy in my gun safe, as well as add a special something to my plinking for years to come. This gun is very particular about what it wants to shoot well. It wants .314" bullets (not .312"

Hal Swiggett's .32-20 M&P.

and not .315"); it wants velocities between 900 fps and 1000 fps (not 800 fps and not 1050 fps), and it wants its bullets loaded over HS-6 (not Unique, 231, Red Dot or HS-7). But with the Cramer #52D 93 grain SWC (this bullet is very similar to the Saeco #325), sized .314" and lubed with homemade Moly lube, loaded over 6.5 grains of HS-6 and sparked with a CCI 550 primer for 1000 fps, it shoots very nicely indeed! Hal once told a story about how he had been asked what his favorite trophy was (a jeweler wanted to make Hal a silver pendant of his favorite trophy, and had envisioned some exotic game animal like a mountain goat, Cape buffalo, or kudu, or some such). Hal put a lot of thought into and finally decided that "favorite" had to mean the one that he had derived the most pleasure from, and spent the most time pursuing. His conclusion? The lowly tin can. He told the jeweler this, and apparently his first reaction was disbelief, but eventually he came to recognize that Hal was serious and this was a genuine sentiment. He made Hal a silver pendant of a shot-up tin can, which Hal wore with great pleasure. Every time I shoot this M&P, I think of Hal and his unique style (and unique jewelry!).


Plinking with the old I-frame .32s is great fun!

Guns and cartridges that might not otherwise get shot very much are right at home in the plinker's gravel pit. Sometimes a quieter, gentler form of plinking is called for, one that harkens back to the simpler, more refined times of days gone by. On these occasions, I break out an old S&W I-frame chambered for .32 S&W Long(Model 1903). These dainty little pre-World War I guns are capable of exquisite accuracy, but they are not strong and must be loaded gently. I assemble special, easily identified loads for these guns, using full wadcutter bullets. I have .32 wadcutter moulds from RCBS, H&G, NEI and Lyman, and for this activity I probably use the H&G bullet the most (but all of them are excellent bullets). The H&G is a 98 grain "button-nose" (i.e. Type II) wadcutter, and for this load I use 2.0 grains of Bullseye. This load runs about 650-700 fps. It is quite accurate, and makes an excellent "stopping load" for those occasions when a renegade tin can decides to charge...


The traditional RNFP for the .45 Colt.

Speaking of the historical aspects of sixgunnery, perhaps the most significant sixgun landmark was the introduction of the .45 Colt cartridge, back in 1873. And there is no finer plinking bullet for the .45 Colt than the traditional RN-FP, like the Lyman/Ideal 454190. I don't like this bullet for formal target shooting (because it doesn't cut clean, full-caliber holes in paper) and I don't like it for hunting (because the meplat is too small, so it doesn’t kill as quickly as a SWC or HP), but it is a very accurate bullet, it carries very well at long range, and it does a dandy job of hammering inanimate impromptu targets of opportunity (tin cans, pine cones, rocks, etc.). While I do have a mould for the old Ideal 454190, it is an old single cavity, and so production can be a little slow with it. I have a 3-cavity Lachmiller mould for an identical bullet, and this mould turns out a pile of bullets in a hurry! I load this bullet over 6.5 grains of Red Dot, for about 800 fps (depending on barrel length). These plinking loads are easily identified because this is the only load I assemble using this bullet.


The Keith SWC (Lyman 358429) is an accurate long range revolver bullet.

Sometimes plinking is done at close range (i.e. pop cans or pine cones) and sometimes it's done at hundreds of yards, using rocks or stumps on yonder hillside as targets. I have spent many a sunny summer afternoon up in the mountains, flingin' lead at yonder stump, across a draw to a clear-cut on the far slope. The hillside makes an excellent backstop, and on a hot dusty summer day, it is easy to spot your shots from the dust cloud. Ranges can be anything from 100-600 yards, and are commonly 300+. The previously mentioned .44 Special and .45 Colt plinking loads are excellent for these afternoon blast sessions. Another fine load for this is the .357 Magnum loaded with the Lyman/Ideal 358429 173 grain Keith SWC over 14.5 grains of 4227 for about 1250 fps. This 4227 load is not the fastest load out there for this bullet, but in my guns it's the most accurate load I've shot with this bullet. The Keith bullet is very stable and flies well over long distances, making it an excellent choice for long range plinking. One afternoon, I was out at our local shooting range while a friend of mine had RO duty. This was his first shift as RO and he had asked me to come out and shoot so he could have an experienced RO on hand just in case things got busy. I had finished up with the load development work that I had planned for the day, so I was just lazing the afternoon away, plinking at the gongs. At that time, this range had gas cylinders cut in half, stuck up on t-posts for plinking gongs -- cheap, durable and they ring like a church bell when they get hit with a gob of lead. I had a large coffee can full of ammo and was burning it up plinking away at the 300 yard gong using a favorite S&W 686. I use the method that Elmer Keith taught for years about holding up a little extra front sight and "walking the shots in to the target". Once the proper amount of front sight is determined, then the fun begins! Well, I had the sight picture figured out for the 300 yard gong and was just blazing away, having a great time. Offhand I was having no trouble hitting the gong on a regular basis (roughly 40% of the time), and when I missed, it generally was left or right by less than a foot (with the elevation right on). I was having fun, and had a lot of ammo to burn up (I wanted to free up the brass for a loading project I had planned), so I was just loading and shooting, loading and shooting, with my attention focused on the gun and the gong. Suddenly I realized that I was the only one shooting, so I looked around to see if the other shooters were waiting on me, so that they could go downrange and change their targets. That's when I found out that all of the other shooting benches were unoccupied, and the other 5-6 shooters (and the RO) were all standing directly behind me watching me ring the gong! I felt bad because I was holding them up and keeping them from their shooting, but the other shooters said it was no problem, they were enjoying the show! (plinking as a spectator sport...) The RO called a cease-fire and sent people downrange to change their targets, and as he walked past my bench he quietly said, "Remind me to *never* piss you off!". The Keith bullet is accurate.

Cast bullets in the .44 Magnum make a fine recipe for plinking happiness!

Some days plinking is not so much about distance as much as it is about making an impact. Some days the plinker just wants to see his shooting *make something happen*; take some inanimate object and knock it over, spin it around, or just flat pulverize it. On these days, one of my favorite plinking rounds is the venerable .44 Magnum. Makin' small rocks out of large rocks is one of the .44 Magnum's many talents. Once again, I have used many different cast bullets in these plinking sessions, but looking back over the years, I have undoubtedly shot more 429421s over 23.5 grains of 296 (1350-1400 fps) than anything else. For many years I had a gravel pit about 5 minutes drive from my house, and it was an excellent place to shoot (in the intervening years civilization has encroached and residential neighborhoods now surround this gravel pit, and shooting is not allowed there anymore). There was an excellent backstop and a large population of indigenous targets (i.e. rocks). After the paper-punching was done, we would line up suitably sized rocks (at a safe distance) and reduce them to rubble. The 429421 is an excellent projectile for this work; with a hearty "thwap!" and a puff of dust, another chunk of basalt would go tumbling across the dusty hard-pan. Chunks of cinder blocks were always favorite targets, and this load would just flat pulverize them in a cloud of dust.

We had a fun variation on this theme that turned into something of a tradition in one of the hunting camps I've been a part of over the years. One of the guys in camp had a large apple orchard (and his wife made the best apple pies!). Every year, Terry would come to camp with a large box of "rejects" (along with a couple of homemade pies), and inform us that he was not allowed to take any of these home. Most of these apples were as good as you commonly find in the grocery stores, so the rest of us would go through the box and pick out a bunch to take home to our families. Eventually, we would get down to about 15-20 lbs of apples that were bruised, wormy or otherwise blemished. On the last day, we would fix a big breakfast and break camp, giving ourselves lots of time for the drive home. We had to dispose of these bruised apples somehow, so we would set them up in the gravel pit we camped in and have a blast session right before leaving. Apples make excellent plinking targets! As far as cleanup goes, the local deer population was more than happy to help with that chore.


400 grain cast bullets in the .480 Ruger carry a lot of thump!

As long as we're on the subject of favorites and rock bustin', a personal favorite for rock crushing is Ruger's big .480 -- nothin' busts basalt like the .480 Ruger! When you get 400 grains of motivated bullet metal flying along, momentum gets transferred and small rocks result from big rocks. Lee makes an excellent 400 grain FP for the .480 Ruger, and for plinking loads I like to size this bullet .476", lube it with homemade Moly lube, and load it over 22.0 grains of 4227. This load is very accurate, gives right at 1000 fps, leaves no leading whatsoever in my Super Redhawk, and hits like a ton of bricks. I also like the Lee 6-cavity 400 grain Keith-style SWC (from a Group Buy) for the .480 Ruger for these activities.

Competition Bullets and Loads

For as long as Mankind has recorded history (and probably much longer), the ability of an individual to place a projectile on a distant target with great precision has been revered. The value that human society places on marksmanship skills dates back through antiquity, and isn't likely to go away anytime soon. The tools of marksmanship, and the concept of "precision" in this context are constantly evolving, but that doesn't change the underlying value we place on the ability of the individual to honorably use these skills to defend innocent life and depose tyrants. Thus, the motivation behind marksmanship competitions. Over the years, these have taken every imaginable form, but in the context of this book (cast bullets in handguns) we will focus on only a few -- bullseye, silhouette, bowling pins and PPC (for those of you wanting to read about cowboy action shooting, let me recommend my good friend John Taffin's book "Action Shooting: Cowboy Style").

Bullseye

The basic bullseye course of fire involves .22, centerfire and .45 caliber sidearm's. The full course of fire is a 2700 point match, with 900 points possible for each of the 3 guns, each of which contains slow fire, timed fire and rapid fire stages. There is a great deal of flexibility in the centerfire and .45 stages, but most people shoot their 1911s for both stages. A common misconception is that one *must* shoot a 1911 for the .45 stage. This is not true -- the rules stipulate that a competitor must shoot a .45 caliber sidearm, with a sight radius of not longer than 10" (hence S&W making revolvers with 8 3/8” barrels), and a trigger weight of not less than 2 1/2 lbs. It not only doesn’t have to be a 1911, it doesn't even have to be a .45 ACP! Just .45 caliber. I have shot a .45 Colt Ruger

Blackhawk in state championship bullseye matches and did just fine with it (yes, a single action revolver can be competitive, even in a rapid fire string). For the revolver aficionado, the centerfire stage is most commonly shot with a .38 Special, and the .45 stage with a .45 ACP.

The .38 wadcutter is almost synonymous with bullseye competition. The “standard” loads are 2.7 grains of Bullseye or 3.0 grains of Winchester 231 underneath a 148 grain wadcutter. I have always gotten slightly better accuracy using 3.0 grains of Bullseye, and so that’s the load I use. I don’t recall ever chronographing this load, but I would imagine that it’s doing a little over 700 fps. For this load I use both the H&G #50 and the Lyman 358495 more or less interchangeably, depending on whichever I have on hand at the time, and both shoot very accurately (as does the Cramer #16H).

I have shot a variety of different .38 revolvers in bullseye competition over the years, but I eventually settled on a 6” K-frame gun, and then ultimately a full-lugged K-frame to make it a little muzzle heavy and “hang” on target a little better. S&W did make a run of Model 14s in the 1990s that were full-lugged, but this gun is actually a 60s vintage gun that was fitted with one of the 90s vintage barrels. The action has been slicked up, and the gun shoots quite nicely. There’s a funny story behind this gun -- I found it at an out-of-town gunshow. I had forgotten my checkbook out in the car and as I walked out to get it, Lyle (who had driven over with our group, and had watched me ogle the gun) bought the revolver. I walked back into the show just in time to see him tear the check out of his checkbook and hand it to the dealer. Thinking that he might have bought it for me to prevent anybody else from buying it, I asked him how much I owed him. His response was simply, “Nah, I’ve decided to take up bullseye shooting” (he‘s a rifle shooter). I knew he was pulling my leg, but he kept up the charade for the rest of the show. When the group of us made it back to the car to drive home, we managed to come up with a ruse to get Lyle out of the car for a couple of minutes and we stashed this revolver in some of my stuff (a 50-cal ammo can with some 10mm brass in it). On the way home, we stopped off for a quick burger. Later, as were we dropping Lyle off, he made a big spectacle about not being able to find his revolver. The rest of us kept a straight face and eventually started to tease him about paying the man and then leaving the gun behind at the gun show. Each of us drove home chuckling to ourselves about how we had pulled a quick one over on Lyle (a practical jokester whose quick wit usually zinged *us*). When I got home, I opened the 50-cal ammo can of 10mm brass that I had used to stash the K-38 in, and the gun was gone. There was a message waiting on my answering machine admonishing me not to mess with the Master. I still haven’t figured out how he got that K-38 out of my ammo can and stashed away without any of us seeing him, but he did. He traded it to me a week later, and we both got a hearty laugh out of the whole deal.

The Master's .38 Special sixgun.

Nor do the bullseye rules require the centerfire gun to be a .38 Special, just that it fire a centerfire cartridge, .30 caliber or larger, have a sight radius of less than 10" (again the motivation behind S&W making 8 3/8" barreled revolvers), and have a trigger weight 2 lbs or more. An elegant and very accurate way to fulfill the criteria is with a revolver chambered for the .32 S&W Long, shooting wadcutter loads. Years ago, with this in mind, I commissioned the construction of a tight .32 wadcutter gun, for bullseye competition and small game hunting. I started off with a centerfire K-frame (a Model 15) and bought a 6" full-lugged barrel that S&W had made for the .32 H&R Mag guns of the early 1990s. I also bought a K-22 cylinder and a set of chambering reamers for a tight .32 S&W Long (.0015" clearances) and .3125" throats (the groove diameter of the S&W barrel is .312"). As I dropped the parts off with my good friend and master pistolsmith Dave Ewer to perform the conversion, he told me that this project would really work better if I was using a Model 19 instead of a Model 15. He pointed out that a Model 15, being built for a narrow-ribbed barrel, has the front end of the top-strap scalloped, and that wouldn't look right with the wide lug of the .32 Magnum barrel. He also pointed out that the front edge of the frame and yoke are shaped differently for the non-magnum and magnum K-frames, and the bottom of the full-lugged barrel would join the frame just slightly below the flat face milled to receive it. I had been looking for a .32 S&W Long K-frame revolver for many years and was hot-n-lathered up to get going on the project, so I told him to go ahead and do it with the parts I had on hand. As a result of my choices, this revolver has a couple of cosmetic flaws (Dave was right, it would have been better to start off with a Model 19), but the bottom line is that Dave built a work of art with this gun, and it shoots extremely well! When paper-punching is on the agenda, I load this gun with the H&G #66 98 grain wadcutter, sized .312" and lubed with homemade moly lube, over 2.0 grains of Bullseye. I don't recall ever chronographing this load (Why bother for a bullseye load? It's going fast enough to punch its way through paper!), but I would guess that it's going somewhere around 700 fps. This is a very accurate load, and does a good job on small game and small vermin as well.

Custom K-32 is very accurate with wadcutters.

Another line of reasoning holds that larger caliber bullets cut larger holes in the target and therefore, for the same shot placement, have a greater chance of cutting a higher scoring ring and getting the shooter a few extra points over the course of a match. This line of thinking assumes that the shooter is capable of shooting the large caliber sidearm just as accurately as the smaller caliber (as a general statement, most shooters shoot higher scores with the smaller guns). However, that being said, it's not at all unusual for a match to be decided by a 1 or 2 points (or 1 or 2 X's), and many times I have seen how one or two shots on the losing target could have made up the difference if they had just been made by a larger caliber bullet, so you have to wonder...

Model 1950 Target .44 Specials.

When I'm in this mindset and want to shoot a larger caliber for the centerfire stage (and I'm not trying to rattle somebody's cage by shooting a "cowboy gun"), I pull out a very special revolver, and one that was literally made for the bullseye game -- a 6 1/2" S&W Model 1950 Target in .44 Special, fitted with thumb-rest target stocks. For bullseye shooting, with the .44 Special, my favorite load is the Lyman/Ideal 429421 loaded over 6.5 grains of Unique for right around 750 fps. This mild load is extremely accurate.

The .45 Colt in full target dress.

While the 1911 is a fine gun, and one of my personal favorites, I am at heart a revolver man. And let's please keep in mind that the game of bullseye was invented for the revolver, before there were any semi-automatic handguns to compete with! Given the admirable track record that the .38 wadcutter has amassed over the years I felt that it only made sense to try shooting a .45 Colt N-frame loaded with full wadcutters for the .45 stage. Dave Ewer built one for me by re-chambering and re-barreling a Model 29, to have tight .480" chambers and tight .452" throats. It was fitted with a Partridge front sight and a wide target trigger and target hammer. I have moulds for several .45 caliber wadcutters, but the load that I have used for such activities is NEI 225 grain wadcutter, sized .452" and loaded over modest charge of Winchester 231 for around 700 fps.

Of course you can't talk about bullseye competition with talking about the venerable 1911! Perhaps the all-time favorite cast bullet for bullseye shooting in the 1911 is the H&G #68, a 200 grain SWC with a long nose for smooth feeding. I have shot a number of bullseye matches with the H&G #68, and it is a fine, accurate bullet. But this chapter is about favorites, and if I were forced to pick a favorite it would be the Lyman 452460, also a 200 grain SWC. Some people report having problems with the shorter nose of the 452460 leading to feeding problems, but I've never had any such problems in any of my 1911s. My favorite bullseye load is the 452460 over 4.0 grains of Bullseye for about 725 fps. This is a very accurate load, and one that will cycle every 1911 I've tried it in; yes, even the ones with the GI recoil springs.


The Argentine 1927 bullseye gun.

Years ago, I wanted to build up a 1911 specifically for bullseye competition. Because I was working on a limited budget, I started off with an affordable Model 1927 Argentine, one of the guns that Colt made under contract with the Argentine government. I tightened the frame/slide fit, and fit a Bar-Sto National Match barrel and NM bushing. I replaced the trigger, hammer, sear, mainspring and mainspring housing. Dave Ewer milled the slide down and mounted a Bo-Mar rear sight, along with a Partridge blade of suitable height. Everything came together quite nicely, and this gun is both highly reliable and very accurate. When it was all said and done, putting this gun together was a really fun project, as well as surprisingly affordable (compared to what competition 1911s *can* run). This gun gets fed a steady diet of the 452460 over 4.0 grains of Bullseye.

Silhouette

Dynamic targets are always fun, and if you get a target that not only moves around or falls down, but also rings like a church bell, what more can you ask for?! Such is the allure of silhouetting. The standard IHMSA course of fire is two banks of 5 each of chickens, pigs, turkeys and rams at 50, 100, 150 and 200 meters, respectively. Scoring is simple, if it falls down it counts, if it doesn't fall down, it doesn't. For an iron-sighted sixgun, it takes a pretty flat trajectory and lots of downrange momentum to knock those rams down at 200 meters. The .357 Magnum was accurate enough and flat-shooting enough, but just didn't have the gumption to knock over the full-footed rams that were used in the early days of silhouette competition ("full-footed" meaning the entire "foot" of the steel target was on the railroad tie base; later on other conventions were adopted in terms of target placement). This led to the development of new wildcat cartridges (e.g. the .357 Maximum) and the use of larger magnum handguns (like the .41 and .44 Magnums). Being a student of other people's experimentation, I have followed their lead.

The .357 Maximum is a fine cast bullet load for IHMSA.

The .357 Maximum was originally developed by Elgin Gates with the specific goal of knocking down stubborn steel rams. Guns were made by Ruger, Dan Wesson and others, and the cartridge was immensely successful at achieving its intended goals. Paranoia surrounding the issue of top-strap cutting ultimately deflated the surge in popularity that the

.357 Maximum briefly enjoyed, and the cartridge has been left for dead. ‘Tis a pity, because for hammerin’ steel the .357 Max is a real peach. When distant steel targets are on the agenda, my favorite load is the Saeco #395 200 grain GC truncated cone bullet over 19.5 grains of 4227. I use the CCI 450 Small Rifle Magnum primer for this load because it gives me better uniformity and accuracy (small rifle primers are recommended for the .357 Max due to the pressures the cartridge develops). This load delivers 1570 fps from my 7 1/2” Ruger SBH and excellent accuracy. It is remarkably flat-shooting, and delivers a solid punch at 200 yards. Just like it was designed to do.


150 meter 1/2 scale turkey silhouette 5 shot group. Freedom Arms 41 Mag scoped from the bench.

Another favorite of mine for ringin’ steel is the .41 Magnum. I have a S&W Model 657 Classic Hunter that absolutely dotes on the Lyman 410459 SWC over 21.0 grains of Winchester 296 (almost 1400 fps). It is very accurate, and the skinny nose of the 410459 makes for a nice, flat-shooting load.

Bowling pins

Bowling pins are fun to shoot! But they can be stubborn about leaving the table if hit around the edges, or hit with insufficient momentum, so an accurate handgun, with good sights and a certain amount of thump is required to play this game (.38 Special and 9mm are generally considered too light; .40 S&W and .357 Magnum are rounds that start to get a bowling pin's attention). Too much power can mean that recoil recovery time starts to eat up precious tenths of second, so cartridge selection is worth giving some careful consideration to (a .44 Magnum is very effective at sweeping pins off the table, but the heavy recoil tends to slow down follow up shots). A shooter's time is very important in pin-shooting, and since stages are commonly set up to require a reload in the middle, being able to recharge one's handgun quickly is obviously a significant advantage. The .45 ACP is popular for pin-shooting, both in 1911 form and in the S&W N-frame, where the full-moon clips amount to built in speed-loaders. The .45 ACP provides adequate power to sweep the pin off the table, yet has moderate enough recoil to be controllable for fast recoil recovery. A variety of accouterments (ports, muzzle-brakes, full-lugs, etc.) were devised to help with recoil recovery and facilitate faster follow-up shots on "pin guns". Around 1990, a new revolver came on the scene that was destined to pound pins. It was the S&W 610, a stainless steel 10mm revolver. As a result of being built for a rimless semi-auto cartridge, it was loaded with full-moon clips. It had a non-fluted cylinder and a full-lugged barrel to keep weight up, and make the modest recoil of the 10mm cartridge even more controllable. The chambers and throats of the 610 were cut with great precision, and held to tighter than usual tolerances, making them exceptionally accurate revolvers. And it had the fine sights and action of the S&W N-frame. The 610 was born to bowl!


S&W 610 makes a good bowling pin gun when loaded with the Lee 175 grain truncated cone.

Flat-nosed bullets are thought to be better for pin shooting as they "grab" the slick, rounded surface of the pin for better momentum transfer. Round nosed bullets, even though they facilitate speed-loading, glance off to the side too easily and tend to knock pins over, but just leave them spinning on the table (and remember, if the pin doesn't leave the table, it doesn't count!). As a result, the truncated cone bullet design tends to be popular in this form of competition (smooth ogive for speed-loading, flat meplat for momentum transfer). The gun that I own that is best-suited for bowling pins these days is a 4" S&W 610. It has a wide, smooth trigger for fast double action work, and a black Baughman front ramp to stand out nicely against the white enamel coat of the bowling pin. My favorite load for this kind of shooting is the Lee 175 grain truncated cone, cast of WW alloy and sized .401", loaded over 10.0 grains of HS-7 for right at 1100 fps. The Lee 6-cavity mould makes a pile of bullets in a hurry, and the simple form of the truncated cone design allows the bullets to drop free of the mould with ease.

PPC

I don't shoot formal PPC competition because I'm not a law enforcement officer, but I have a number of friends who do, and do quite well at it (so I hear about their matches all the time). On occasion I have set up some impromptu courses just to run through the paces and see what it's like. Several years ago I got lucky and was able to pick up a first-class PPC revolver for a very friendly price when a dealer was clearancing his remaining inventory. This gun was made by Spokhandguns, and is based on the S&W 681. It is a switch barrel gun (like a Dan Wesson) with a heavy shroud and a full-length rib. The barrel that it currently wears is a 6" Douglas Air-gauge barrel. The full-length rib was made by Aristocrat, and is topped off with some excellent target sights. Dave Ewer (the honcho behind Spokhandguns) worked this action over with his usual golden touch, and both double and single action are light and smooth. This gun is pure joy to shoot!

Mostly I just plink with this gun, and occasionally shoot a few varmints. On these occasions, it generally gets loaded with various .38 Special SWC and HP loads, whatever I'm playing with at the moment. But when I break this gun out in a "PPC frame of mind", this gun gets loaded with .38 Special ammo loaded with the Lee 38-158RF cowboy bullet over 4.2 grains of Bullseye for about 900 fps. I use this bullet for several reasons. Firstly, the rounded ogive of this bullet allows for smooth reloads using speed-loaders (the SWC shoulder gets hung up entering the chambers and slows things down). Secondly, it's a very accurate bullet, so I know if I miss, it's my fault. Thirdly, this is a 6-cavity mould, so I can cast a lot of bullets in short order, making this practice easy to prepare for. And lastly, this is the only load I use this bullet for in .38 Special, making the ammo easy to identify.

Hunting Bullets and Loads

Edible small game

If there is a finer way to hunt small game than with a .32 caliber revolver, I don't know what it is. The .32s have adequate power to cleanly dispatch rabbits and squirrels, but they are not so powerful that they destroy lots of meat (and you're not starting off with all that much to begin with!). The .32s tend to be very accurate, and easy to shoot. They are cheap to reload, and they are highly amenable to shooting cast bullets.

Wadcutter loads in the .32 S&W Long make a great combination for small game.

When shooting up into the treetops for bushytails, my favorite is to use a .32 caliber revolver shooting Type III wadcutter loads (i.e. where the bullet is seated out of the case to standard SWC seating depth). This allows the bullet to be launched at reasonable hunting velocities, while still keeping pressures modest. The bullet I use for these loads is the Lyman 313492 88 grain wadcutter over 2.6 grains of Red Dot for 965 fps. This load kills squirrels cleanly, doesn't tear up a lot of meat, and if you miss the bullet quickly starts to tumble, and loses velocity quickly. This is a very accurate load, and one that anchors small game very effectively at moderate ranges.

The RCBS 32 caliber 90 grain cowboy mould is another personal favorite for small game. I also load this one up over 2.6 grains of Red Dot for a little over 950 fps. This is a flat-shooting load and one that will reach out nicely to 50 yards or so. An excellent first ingredient for Brunswick stew. If I want to reach out farther than that, then I favor the RCBS .32 caliber 98 grain SWC in the .32 H&R Magnum. My favorite load for this combination is 6.5 grains of Accurate Arms #7 for 1100 fps out of a 6" S&W Model 16. This load will anchor small game with authority out to at least 85 yards. It is starting to get a little destructive for edible small game, but not too bad.

There's more to hunting than just seeing and shooting critters. Some days I want to go back in time and reminisce -- think about old friends, old memories, simpler and more innocent times. There is no reason to give up performance just for nostalgia's sake though! In times like these, my favorite small game gun is Hal Swiggett's 1930s vintage 5" M&P chambered in .32-20. I load this gun with

Old school small game revolver, the 5" M&P .32-20.

the Cramer #52D 93 grain SWC cast of WW alloy, sized .314” and lubed with homemade Moly lube and loaded over 6.5 grains of HS-6, sparked with a CCI 550 primer for right at 1000 fps. This is a very accurate load, and one that does a fine job on small game (and does it with a lot of “old school” charm!).

Varmints

For varmint shooting we’re not concerned with limiting meat damage, and in fact dramatic expansion is desirable to ensure humane results from any “hits around edges”. As a result, for varmint loads I strongly favor cast HPs, most often at fairly high velocity. The enhanced performance provided by the cast HP also allows these loads to be used effectively for somewhat larger vermin (skunks, coyotes, jack rabbits, rock chucks, etc.).

The .25 Hornet loaded with the Lyman 257420 HP makes a fine varminter.

A few years back I built a .25 Hornet on an Old Model Ruger Blackhawk. My dear friend Rob Applegate had given me a take-off barrel from a Ruger 77 .25-06 (with a 1 in 10” twist), and I had taken a chunk of this barrel and turned it down to fit an OMBH that I bought for the project. One of Hamilton Bowen’s cylinders was rechambered with a reamer from Dave Manson. Bullets are sized .258” and the gun is capable of excellent accuracy. My favorite varmint load is the 257420 GC-HP over 6.0 grains of HS-6 for right at 1600 fps, and this load will put 5 shots into less than an inch at 25 yards. This load produces very little recoil, and shoots amazingly flat. This dainty little bullet expands very well at this speed. All in all, an excellent (and economical) varmint load.

The .30 Carbine Ruger Blackhawk, when loaded with cast HP bullets, is an amazing varmint gun!

When the .30 Carbine Ruger Blackhawk came out, my first response was basically, “Why?”. It was being sold as a plinker for those guys that wanted to shoot milsurp ammo. Well, if somebody wanted to play “roll the can” with cheap ammo, why not .22, or .38 Special? Why go with a cartridge that is going to generate belligerent muzzle blast and extreme velocity that basically offers no advantage to the plinker? It just didn’t make sense to me (still doesn’t, in fact). Then I started casting bullets, and more importantly, I started casting hollow-pointed bullets. The .30 Carbine Ruger Blackhawk loaded with cast HPs is a whole ‘nother beast! The velocity, accuracy and muzzle blast are still there, but now instead of a .30 caliber FMJ round nose sneaking its way through the ribs of yonder ground squirrel, there is an explosion of flesh and lead that has to be seen to be believed. My favorite bullet for the .30 Carbine is the Lyman .311316 GC-HP, sized .311" (I have polished out the throats on my revolver to .310") and loaded over 12.5 grains of either Accurate Arms #9 or 2400, either of which produces around 1500 fps and excellent accuracy. Since this gun headspaces on the case mouth, it is important to taper crimp these loads lightly (a roll crimp or a severe taper crimp will cause misfires). .30 Carbine brass is very strong and will provide many years of service with these loads.

When the .357 Magnum is loaded with cast HPs, like the Keith HP, varmints beware!

When varmint hunting with a handgun, can it really get any better than with a .357 Magnum? After many years of researching the answer to that question, I have come to the conclusion that it is highly doubtful (but I'm always willing to do more research!). There are many excellent bullets for varmint hunting in the .357 Magnum, but my favorite is the Lyman/Ideal 357439. This is the HP version for the 358429 SWC that Elmer Keith designed back in 1928. He suggested that its shocking power could be greatly enhanced by adding a HP cavity, and a couple of his friends thought this sounded like a good idea and had Lyman/Ideal make mould for this new design. It was given its own number designation of 358439, and became a very popular bullet. For use in the .357 Magnum, I generally cast this bullet to a BHN of about 12 or 13, where it weighs about 154 grains. I size it .358" and load it over 14.0 grains of 2400, which generates 1350-1400 fps (depending on the gun). At this speed, this bullet is violently explosive, even out at 100 yards or more. The biggest critter I've personally shot with this bullet has been a big Montana jack rabbit, but I would have no qualms about using this load on coyotes, or badgers. My fondness for this bullet is due to two factors. The first factor is it's performance -- the ease with which accurate loads can be assembled and the violent expansion it delivers when it gets to where it's going. The second factor is its history -- the fact the Elmer Keith designed it and it was one of the bullets he used in his .38/44 loads (the mere mention of which conjures images of Lemhi Valley jack rabbits...). These two factors are also reflected in another .357 Magnum favorite, the H&G #51 HP. After many years of searching, I finally was able to buy a bullet mould for the H&G #51. This is the 146 grain HP that Phil Sharpe designed for his work developing the original load data for the .357 Magnum (along with the corresponding SWC). He commissioned George Hensley to make the moulds, and both were found to deliver superlative performance in the first magnum handgun. I generally load the 146 grain Sharpe HP over 15.0 grains of 2400 for 1600 fps (from an 8 3/8" barrel) and expansion is truly explosive at this speed!

The Keith bullet is too long to fit in a some .357 cylinders (like the N-frame), but it fits just fine in the newer K-and L-frame 357s. The H&G #51 fits in all .357 cylinders. It is much easier to find a Lyman 358439 than it is to find a H&G #51 HP, but both are outstanding varmint bullets, and both are important landmarks in the history of handgun performance.


Long-barreled S&W Model 14 makes a fine varminter with the Lyman 358477 HP.

The .38 Special is another of my favorite varmint cartridges. Once again there are many excellent bullets for the .38 special, and many of them are favorites in one way or another, but overall I would say that my favorite varmint bullet for the .38 Special would be the 140 grain Lyman 358477 HP. For the .38 Special, I cast these bullets fairly soft, out of range scrap that has a BHN of about 7.5 to 8, and load them over 4.5 grain of Bullseye for about 950-1000 fps (depending on barrel length). Cast this soft, these bullets expand nicely at this speed; not explosively, but they do mushroom well. An excellent load for ground squirrels, prairie dogs and the like.

A sentimental favorite of mine in .38 Special is Elmer Keith's 154 grain Lyman/Ideal 358439, also cast from range scrap to a BHN of about 8, and loaded over 8.5 grains of HS-7. This is a +P load (the data in the Hodgdon manual suggests that this load generates around 19,000 CUP peak pressure), and delivers about 1050 fps from a 6" revolver, and is very accurate. This load was inspired by the so-called "FBI Load" and has proven itself to my time and time again on all manner of vermin. This is one of my all-time favorite jackrabbit loads.


5-screw K38 Masterpiece loaded with the Keith HP (Ideal 358439) performs superbly.


S&W Model 16 .32 H&R Magnum loaded with the Ideal 31133 HP is excellent rodent medicine.

Little guns make good verminators too! The .32 H&R is a fine little varmint load, especially when loaded with the Lyman/Ideal 31133, the HP version of the timeless 3118, originally developed for the .32-20. This bullet drops from the blocks at about 108 grains when cast soft. Sized .312" and loaded over 6.5 grains of Accurate Arms #7 (1100 fps), I can shoot this little varminter all day long and get no leading at all. Performance? Outstanding! This load has made dramatic impacts on vermin out to 85 yards, and more (too destructive for edible small game though).

The Herters .401 Powermag loaded with the Ideal 40388 at 1600 fps makes an explosive varmint package.

The Herter's .401 Powermag is a little-known and under appreciated cartridge. It's basically the same cartridge as the wildcats put together by "Pop" Eimer and Gordon Boser (in the 1920s and 1930s, respectively). It was brought out by Herter's in the early 1960s in their large framed single-action revolver (made under contract by Sauer and Sohne in Germany). It is basically a .40 caliber version of the .41 Magnum, and as such, it is an excellent round for the handgun hunter. I have been working with the .401 Powermag for several years now, and my favorite varmint load for it is the old Lyman/Ideal 40388 HP (originally designed by Douglas Sorenson back in 1950 for the .38-40) loaded over 20.0 grains of Accurate Arms #9 for 1610 fps. This load is very accurate (5 shots into about 1 1/8" at 25 yards) and leaves no leading behind (I know, I was surprised too). What this 165 grain HP does at 1600 fps has to be seen to be believed!

I am very fond of the .44 Special cartridge. It is a very well-balanced cartridge, that delivers a very useful level of power in a classy and controllable package. Friend John Taffin even went so far as to label it as being the Cartridge of the Century (that would be the 20th century), and I must admit that I tend to agree with him. The .44 Special is an excellent round for varmint hunting on sunny summer afternoons, and I have burnt much powder in such pursuits. Generally speaking, my favorite load for these strolls through the mountains in search of ground squirrels is the Lyman 429421 SWC over 10.0 grains of HS-6 for about 950 fps (depending on barrel length). Sometimes a rodent will hide behind a log or stump and just peer out over the top to watch the hunter make his approach. The 429421 at 950-1000 fps has the gumption to just punch right through these sun-bleached logs and nail the varmint hiding behind them. I also use this powder charge when shooting the 429421 HP. For the HP loads, I cast them soft (BHN of around 8, using either range scrap or 1:1 WW to lead) and they expand moderately well at 950-1000 fps.

.44 Special with 429421 HP and 4" Model 1950 Target and ground squirrels.

The .45 Colt is a grand old varmint cartridge! I have shot many, many different bullet out of various .45 Colt sidearms, and for varmint hunting the wide flat meplat of the Keith SWC cannot be improved upon in my estimation. I am partial to Elmer Keith's original SWC design for both sentimental and practical reasons. While I do have an early Lyman/Ideal 454424 that drops of bullet to Elmer's original specifications, it is a single cavity mould and production is slow (I do break it out and cast with it every so often though, when the mood strikes me to shoot "the real thing"). Mr. Keith wasn't happy with the changes that Lyman made to his mould designs, and so in the early 1960s he went to H&G and had them re-create his original SWC designs, with a few added refinements (like increasing the bevel on the grease grooves, and adding filets to the bottoms of the grease grooves, etc.). The original design criteria were still there -- the three equal width driving bands, the flat-bottomed grease grooves, the beveled crimp groove, the radiused ogive and big flat meplat -- the H&G bullets were Keith SWCs through and through. Years ago, I was able to pick up an 8-cavity H&G #501, and once this behemoth gets warmed up it generates a mountain of Keith bullets in hurry! My favorite load for varminting is 9.0 grains of Universal Clays for a little over 900 fps (again, depending on barrel length).


The Keith SWC (Lyman 454424) makes an excellent varmint load in the .45 Colt.

Generally speaking, I don't care to go chasing my brass through the weeds, but every so often I just get a hankerin' to go varmint hunting with the grand old 1911. The .45 ACP makes a dandy varmint round, especially when loaded with cast HPs. Lyman's 452374 HP (the .45 Devastator HP) cycles through my 1911s very nicely and shoots quite well. I generally cast these 185 grain bullets to a BHN of about 8 with range scrap and load them over 7.5 grains of Unique. This load delivers right at 1100 fps, and gives very good accuracy. I use a similar load assembled using the 452460 HP that was described in an earlier chapter. For both of these loads expansion is excellent! These bullets hammer ground squirrels and jack rabbits, and would be just the ticket for javelina, and similar sized game.


The Lyman 452460 HP makes a dandy varmint bullet in the .45 ACP.

Medium Game

These are some my favorite loads that I've hunted deer and hogs with over the years, and enjoyed. My philosophy here is simple -- medium to large caliber cast HPs or Keith SWCs at decent velocity (1100-1600 fps), with a bullet weight generally in the range of 200-250 grains. Since most serious hunting loads will shoot through a deer, one of my primary interests here is getting good expansion to make the wound channel wider.

This tasty little meat hog fell to a Lyman 33889 HP at 1600 fps.

I'm going to start off with a personal favorite, the .338 GEF, a wildcat that I put together with the help of J. D. Jones back in 1993, based on the .356 Winchester case. From a 12" Contender, it will comfortably shoot 200 grain jacketed bullets (most notably the Nosler Ballistic Tip) at 2100 fps and 250 grain Partitions at 1900+ fps. I've shot hogs, antelope, whitetail and mule deer, and a Corsican ram with the .338 GEF Contender, as well as a whole pile of vermin (varminting is a great way to fireform brass!), and I've been completely satisfied with its performance. This cartridge was originally envisioned as a jacketed bullet wildcat, but in more recent years, I've been more interested in shooting cast bullets, so the transition was quite natural. After playing around with a variety of cast bullets in the .338 GEF, I have settled on my favorite, the Lyman 33889 HP. I have gotten my best cast bullet accuracy in this cartridge using very slow powders. For the 238 grain Lyman 33889 HP, I use 46.5 grains of H4831 to generate right at 1600 fps, a very useful velocity for a cast HP. Expansion is excellent at this speed and it punches right on through the other side, even on thick-skinned hogs. This is an excellent bullet!

The 429421 SWC has a been a standard by which other handgun bullets have been judged against for many years, and it was among the first handgun bullets I ever cast. It was several years later that I cast my first 429421 HP, but I had been fascinated with that bullet ever since I first saw *that picture* (in "Sixguns", on page 240) of that perfect mushroom that Elmer Keith recovered from under the far-side hide of a mule deer. Both the 429421 SWC and HP have been personal favorites of mine for many years. Over the years, I have shot (and seen shot) a large number of animals of all different sizes, shapes and varieties, that were shot with the Lyman/Ideal 429421 SWC and HP. From prairie dogs, up through mule deer, big hogs and elk, Elmer Keith's design has made short work of them all. But instead of telling one of my hunting stories here, I'm going to share one of my friend's hunting stories because it showcases what this remarkable bullet is really capable of. Years ago, I sent a batch of 429421 HPs to my respected friend John Taffin, as a way of saying "Thank you.". You see, several years earlier he had dug through his extensive archive of handloading articles and dug out some early references on casting HP bullets that dated back to the 1930s and 1940s and sent them to me. These references really helped me to understand the important role that tin plays in the malleability of bullet metal, and why tin is important to cast HPs. These references also laid a solid foundation for which alloys were suitable for which velocity ranges, so I was very quickly able to improve upon the very good bullet performance that I was already getting from cast HPs. John is a very gracious man. In any event, I sent him some 429421 HPs as a token of gratitude. I know how much John loves to hunt with his .44 Specials, so I cast these bullets with 20-to-1 alloy, tailoring them for excellent expansion at 1200 fps (the approximate velocity of “the Keith Load“). I sent them to him unsized, so that he could size and lube them to his preference. A little while later I got a polite note in return, thanking me for the bullets. Some time later, I got an e-mail from John extolling the virtues of the 429421 HP and telling me what a remarkable killer it was. He had just gotten back from a hunting trip where he had had the opportunity to take two very large wild boars (650 and 550 lbs). He had shot them with a Texas Longhorn Arms 7 1/2” .44 Special, loaded with the 20-to-1 429421 HPs over 17.0 grains of 2400 (1200+ fps). He had “double-tapped” each of these boars (John is fast with a single-action!), and both of the animals had dropped quickly. All of his shots were in the heart/lung area, and in each case one of the shots had exited, and one had remained inside the hog. John said that the recovered bullets were beautiful little mushrooms, and that the bullets had lost very little weight. The wound channels of all of the shots made it obvious why the big boars went down so quickly. Pictures of John with these two monster boars can be found on page 69 of his excellent book “Single Action Sixguns” (highly recommended reading!). Pigskin on hogs of this size is very thick, and to be honest with you, I’m surprised that any of his shots exited after traveling through thick-muscled boars of this size. But they did! You just can’t argue with the facts. It’s results like this that cause me to scratch my head when somebody tells me that they need to hunt with some “Uber-magnum” loaded with 300+ grain hard-cast bullets loaded to 1500 fps to make sure that they get “enough penetration” to kill a deer. If the .44 Special, loaded with a soft 429421 HP at 1200 fps is capable of penetrating completely through a 650 lb boar hog, then you can rest assured that penetration will be more than adequate to kill a thin-skinned deer weighing 1/3 of that (or less). In my experience, the Keith HPs (and obviously the SWC's too) will reliably exit deer on broadside shots when fired at 1200-1400 fps, and the HP expansion makes for a wider wound channel that kills quickly. In the .44 Special, my favorite hunting load for medium game is the same one that John was using -- the 429421 HP cast to a BHN of about 8, loaded over 17.0 grains of 2400 for a little over 1200 fps. This is a very accurate load, that hits hard and penetrates well. I have a very special revolver built up by Dave Ewer, with this load in mind -- the starting gun was a stainless steel New Model Blackhawk .357 Magnum, that he rechambered the cylinder to .44 Special and fitted a 7 1/2” barrel. This gun is exquisitely accurate, and being a large-framed Ruger, it handles the pressures of the Keith load (which has been measured at 34,000 CUP) without any problems at all. I also like this load with the Lyman 429251 round-nosed HP, and have gotten similar performance on large hogs as Taffin did with the 429421 HP.

The .44 Magnum occupies the same niche in the handgun hunters battery that the .30-06 does in the rifleman’s battery -- that of the tried and true workhorse that delivers the goods with a reliability that borders on the monotonous. It may not be flashy, but it's effective. I like the .44 Magnum. One of my favorite loads for the .44 Magnum is 23.5 grains of Winchester 296 and a CCI 350 primer underneath the Lyman /Ideal 429421, in either SWC or HP form. This load delivers about 1400 fps and very good accuracy. Like Elmer, I prefer the original version of his bullet, with the full-width forward driving band and the flat-bottomed grease groove. Lyman's newer version, with the smaller forward driving band and the rounded grease groove, shoots just fine and will kill deer just as dead, it's just that Elmer's original version appeals to my sense of aesthetics and nostalgia more directly. The .44 Magnum round loaded with an original Keith SWC just looks *right*. For the 429421 SWC, I generally cast these up a little harder than WW alloy, to a BHN of maybe 13-14, or sometimes just use WW alloy and water quench them from the mould (which for my WW alloy gives me about BHN of about 16 or so). Prepared thusly, this ammunition provides outstanding penetration (I have yet to recover one from an animal). When deer-sized game is on the agenda, I really like to hunt with the 429421 HP. When loading for the .44 Magnum, I generally cast this up to a BHN of about 12-13. WW alloy will work just fine for this bullet at this speed, but will lead to some fragmentation at full-throttle Magnum velocities (not that this is really a problem with deer-sized game as the bullet's base will generally still penetrate and exit). I like to add a little tin to offset this behavior and to help the cast HP to mushroom more smoothly. My other favorite load for the .44 Magnum is the 300 grain HP from the RCBS 44-300-SWC mould I had Erik Ohlen modify for me. I load this bullet over 21.0 grains of W296 and spark it with a CCI 350 primer, to give 1300-1400 fps (depending on the barrel length). I generally cast these bullets to a BHN of about 12-13, and they have proven themselves to be very effective at killing hogs very quickly.


Excellent expansion and penetration from the 429251 HP at 1200 fps.


The .44 Special loaded with the Keith SWC (Lyman 429421) at 1000 fps makes an excellent all-round field load.


The 429421 HP is a fine hunting bullet in the .44 Magnum.


The S&W 657 .41 Magnum loaded with the Lyman 410459 HP is a fine combination for deer.

The .41 Magnum is kind if the "red-headed step-child" of the handgun hunting clan, but it is nonetheless an excellent round for hunting deer and hogs. Hands down, my favorite deer-hunting bullet for the .41 Magnum is the 410459 HP that was described in an earlier chapter. I really like how quickly this bullet kills deer, as well as the relative lack of bloodshot meat. I load it over 21.0 grains of Winchester 296 and a CCI 350 primer for 1350-1400 fps. This load is flat-shooting and does a fine job with deer.


The Ruger Bisley Blackhawk .45 Colt is an outstanding hunting revolver.

The .45 Colt loaded with the Keith SWC is an excellent hunting combination no matter how you look at it. Elmer's concepts were originally captured in the Lyman/Ideal 454424, but as discussed earlier in this chapter, I most often cast this bullet using the H&G #501 gang-mould these days. There are a large number of capable hunting loads employing this bullet in the .45 Colt cartridge, assembled with a whole host of different powders. In this case, picking a personal favorite is tough to do, because so many of these combinations offer such top-notch performance. I have hunted with this bullet loaded over Red Dot, Winchester 231, Unique, Universal Clays, HS-6, HS-7, 2400, H110 and Winchester 296 (and probably a few others that slip my memory at the moment). If forced to pick a single favorite for hunting deer, I would probably have to go with a "Blackhawk only" load of 26.0 grains of Winchester 296 with a CCI 350 primer. This load produces 1400 fps from a 7 1/2" Ruger Blackhawk, and is exceptionally accurate. I size the bullets .452" and lube them with homemade Moly lube. This load hits hard, and kills quickly.


The S&W 25-5 is a fine deer gun when loaded with the Keith HP (Lyman 454424 HP).

Another favorite in the .45 Colt is the 454424 HP, cast soft (BHN about 8), loaded over 14.0 grains of HS-7, once gain sparked with the CCI 350 primer (standard primers work just fine with this load, it's just that I've found that the magnum primer provides much better uniformity in cold weather, and since this is a hunting load, and hunting season can be cold, I use the magnum primer). This load generates 1050-1100 fps (depending on barrel length), at surprisingly modest pressures. This is my favorite hunting load for my S&W .45 Colt revolvers, in particular my 8 3/8" Model 25-5. From the longer barrel, this load gives right at 1100 fps and very good accuracy, and the soft HP expands nicely at this speed. I am also fond of this powder charge underneath the Lyman 454190 HP, cast soft and assembled similarly. I also like the "Keith load" of 18.5 grains of 2400 with the 454424 HP. This combination generates around 1100 fps and exquisite accuracy.

Big Game

When the critters get large (like elk and buffalo), heavy cast bullet loads can inspire real confidence. Once again, my philosophy is simple -- large caliber, heavy cast flat-pointed bullets and good velocity (1100-1900 fps). For these loads I generally prefer bullets .40 caliber and larger, and bullet weights of 300 grains and up. My primary motivation here is to get bullet weight/momentum up to maximize penetration, making the deepest possible wound channel and increasing the probability of the bullet exiting the far side of the animal.

The Keith SWC (Lyman/Ideal 429421) at 1400 fps is a dandy elk load, but generally speaking when I'm going out after anything over about 400 lbs, I reach for a bullet that is somewhat heavier. A landmark in terms of handgun hunting heavy bullet designs is the SSK 320 grain designed by J. D. Jones of SSK Industries for the .44 Mangum. These moulds were made by NEI, and J. D. went on to design a whole series of bullet designs for the handgun hunter. The 320 grain SSK bullet has been used to kill all manner of big game, including Cape buffalo, the big bears and elephant, all out of .44 Magnum revolvers. J. D. likes to test guns, cartridges and bullets, particularly by traveling to exotic locations and shooting big critters. It's tough, hard, nasty work, but he somehow manages to suffer through it. The story goes that J.D. was testing a bunch of different cast bullet designs (including the Keith SWC) and found that when he recovered these bullets from large thick-skinned carcasses that they all tended to look pretty much the same -- more or less the profile of a truncated cone, with the shoulders, etc. all "wiped off" from the impact. He figured that if that's the way they're going to end up, why not start them out that way too? He had previous experience with the 9mm truncated cone bullets and had a high opinion of them, and so that's how he drew up his first design. The 320 grain SSK has lots of bearing surface and lots of lube, and has been very accurate in all of the guns I've shot it in. I generally cast this bullet with water-quenched WW alloy (BHN of around 16-18), size it .430", and lube it with homemade Moly lube. I load the 320 grain SSK bullet over 21.0 grains of Winchester 296 and a CCI 350 primer for 1345 fps and excellent accuracy (this load also works well with a number of other fine 300 grain cast bullets, like the NEI RNFP, Saeco RNFP, RCBS and Lyman SWCs, etc.). I have a 7 1/2" stainless Ruger Super Blackhawk that is my "heavy bullet gun", with the sights zeroed for heavy bullet loads, and the SSK bullet is the "go-to" bullet for this gun. This bullet has a well-established reputation for deep penetration, and killing well.

My personal favorite for the .45 Colt? Several years ago, I commissioned Dan Lynch of Mountain Molds to make a mould for me to make a .45 caliber RN-FP (plain-based) that weighed 325 grains and had a 73% meplat. The mould he

The Mountain Molds .45 caliber 325 grain FP used to kill a 500+ lb boar (45 Colt).

made for me was exactly what I had hoped for. When loaded in to .45 Colt cases over 21.0 grains of Winchester 296, and sparked with a CCI 350 primer, this bullet leaves the muzzle at 1235 fps and delivers good accuracy from a 7 1/2" Ruger Super Blackhawk that I converted to a tight-chambered, tight-throated .45 Colt. I used this load to kill a large boar that weighted over 500 lbs. One shot through the heart/lung region was all that it took. The 325 Mountain Molds bullet went completely through the grizzled old boar, slammed into the dusty slope behind him and whined off into the distance. He was a tough ol' boar, but slow-cooked in a crock pot with some of my wife's homemade tomatillo salsa he was rather tasty!

The Freedom Arms 454 Casull loaded with the Lyman 452629 can handle pretty much anything.

The 454 Casull is arguably one of the best all-round hunting handguns for big game animals, especially when they are 500 lbs and up. The quality of Freedom Arms revolvers is well known, and the 7 1/2" Premier grade 454 that I have lives up to this reputation. This revolver is exquisitely accurate, and it is easily capable of shooting sub-inch groups at 25 yards (on those days that I am up to it). My favorite bullet for the 454 is the Lyman 452629 300 grain FP-GC cast to a BHN of about 16-18 by water quenching either a 2:1 mixture of range scrap and linotype, or WW alloy. It is important to use a fairly hard alloy with the 454 Casull as the pressures in this cartridge are enough to upset the bullet's base while the ogive is starting to get engraved, and when this oversized base hits the forcing cone it has to get swaged back down to size. This stresses the forcing cone, and can ultimately cause damage to the gun. Hard bullets avoid this problem. My favorite load is 30.0 grains of H110 over the CCI 450 small rifle magnum primer for 1650 fps and excellent accuracy. This is the load that I used to take a buffalo from about 30 yards. I shot him twice (broadside -- shoulder, heart and lungs) and both shots penetrated fully and exited. He went down quickly after the second shot. I don't know that you can ask much more than that of a revolver.

The .480 Ruger is another "Hammer of Thor" type handgun cartridge that is very well-suited to the pursuit of big game. It is also very well served by cast bullets, very heavy cast bullets, and therein lies its appeal to me. Having a standard-sized revolver that comfortably launches 400 grains of bullet metal at useful velocities is something that is very interesting to me. Factory ammo for the .480 Ruger has a 325 grain jacketed bullet traveling along at 1350 fps. For 400 grain cast bullet handloads for hunting, I generally aim for 1100-1150 fps, even though higher velocities are possible within SAAMI pressure specs. John Linebaugh has showed in his extensive penetration testing, that a 400 grain bullet from his .475 Linebaugh at 1100 fps will out-penetrate everything up to the 400 grain .475 load at full throttle (1450 fps), including the 300 grain 454 Casull at 1650 fps (which, as we have already seen, will shoot through a buffalo). The cylinder walls between the chambers of the .480 Ruger are awfully thin, and now that the .480 Ruger Super Redhawk has been dropped from production, I see no reason to stress a limited edition handgun with "red-line" type loads. 400 grains of bullet metal at 1100 fps will shoot through anything I'm going to point it at, and will do so without stressing the gun. There are several good .475" bullets suitable for the .480 Ruger, but if pressed to pick a favorite at this point it would either be the RCBS 400 grain SWC, or the Lee 400 grain FP, both of which are superbly accurate over 21.0 grains of Winchester 296 (1100 fps).

Cast bullets get loaded into my big bore single-shot handguns as well. Take, for example, my Contender .405 Winchester. This barrel started off life as a 14" .41 Magnum barrel. It has a .411" groove diameter and a 1 in 20" twist. A quick visit with a .405 Winchester chambering reamer converted this barrel into a very interesting, and very accurate big game gun. A few years ago, I had Mountain Molds make a 300 grain FP-GC mould for me to fit this gun. I size them .412" and use Hornady .416" crimp-on GCs. These bullets get loaded over 55.0 grains of H4895, which delivers right at 1900 fps from the 14" Magnaported barrel. This is an accurate, and flat-shooting load, and one that is capable of reaching out and hammering yon beast.

The Mountain Molds 300 grain GC-FP in the .405 Winchester is a capable hunting combination.

The Mountain Molds 300 grain GC-FP designed for the .444 Marlin shoots very well in both the Marlin levergun and the T/C Contender.

The .405 Winchester has a certain panache to it (it was Theodore Roosevelt's "Big Medicine" after all), but I must confess that my personal favorite big bore Contender is my .444 Marlin. Part of this sentiment comes from the fact that the .444 Marlin was my first serious big-bore Contender, part of it comes from the fact that I learned a great deal about how to load high-performance cartridges in the Contender, and part of it comes from the fact that I have burned up literally thousands of rounds in load development working with the .444 Marlin Contender, and so I have a very good feel for what the gun and cartridge are capable of. It is an old friend. I am also very fond of the .444 Marlin the levergun. A few years ago, I had Mountain Molds make a mould for me that would drop a 300 grain GC-FP designed specifically to cycle in the levergun, and to fit the .444 Marlin factory throat. It shoots quite well in both the Contender and the levergun. Well, my current .444 Marlin Contender barrel started off life as a 14” stainless .44 Magnum Hunter barrel. It was rechambered using a minimum tolerance chambering reamer, and cut with a short throat, similar to (but not identical with) the SAMMI throat. My favorite load for the Mountain Molds 300 grain GC-FP in the Contender is 49.0 grains of H322, sparked with a Federal 215 primer. This gives 1900 fps, and hits like a ton of bricks.

The RCBS .45 405 GCFP is a very accurate bullet in the .45-70 ("While visions of Cape Buffalo dance in their heads...").

The last entry on this Favorites list is also one of the oldest -- the timeless .45-70. This Contender is a 12” Hunter model, and was a gift from a dear friend of mine. He told me that recoil was brutal with this gun and he was right, but there is something special about shooting a .45-70, even in a handgun. I’ve done a fair amount of load development for this gun, and none of it has involved jacketed bullets. If forced to pick a favorite load for this gun, the powder charge would be easy -- 40.0 grains of Reloader 7, with a Fed 215 primer; the bullet would be a little tougher. It would be toss up between the RCBS 45-405-GC and the Lyman 457193 (the 405 grain plain-based analog to the RCBS bullet). I size these bullets .459” (bullets sized .458” keyhole), and lube them with homemade Moly lube. This combination delivers about 1475 fps, and will keep 5 shots within about 1 1/2” at 50 yards (in the absence of flinching). I have absolute confidence in this load to kill anything that I will ever point it at (and I genuinely hope to point it at Cape buffalo at some point in the future).

Elmer Keith's #5, "The Last Word" in sixguns.

So, as you can see from the fore-going discussion, casting your own bullets can generate a whole new world of adventures for you and your favorite handguns. It has certainly been an adventure for us!

The Last Word

A long time ago, Elmer Keith wrote an article entitled "The Last Word" in which he described the design and construction of a very special .44 Special sixgun that he called "#5". He called this gun "The Last Word" because it captured all the features that he felt a sixgun should have. #5 fit the hand well, balanced and pointed well, had throats that matched the groove diameter, had excellent sights, was chambered in his favored (at that time) .44 Special cartridge, would handle Keith's powerful loads, was very accurate even at long range, was stylishly engraved, and was finished off with a classic pair of carved ivory stocks. In short, it was both functional and elegant. I have had the opportunity to inspect Keith's #5 closely, and I can understand why he felt this way about it; it is a very special sixgun. Was it the perfect gun for bullseye competition? Nope. Was it the perfect law enforcement sidearm? No way. Was it the perfect concealed-carry handgun? Not a chance. Elmer Keith designed #5 to be an outdoorsman's tool that would be on the belt when needed and would reliably and precisely deliver a powerful blow when called upon. He designed it to reflect the style and character of it's owner -- an outdoorsman’s tool that was powerful, portable and elegant.

While Keith never called it "The Last Word" in cast bullets, the concept applies to his first SWC design, the Ideal 429421, just as succinctly. The Ideal 429421 is both functional and elegant. It is a very accurate bullet that is clearly capable of delivering the goods when called upon, and it reflects the style and character of its designer. From plinking, to competition, to hunting, the 429421 can do it all. In my book, “The Last Word” in cast bullets is the Ideal 429421.

Appendix A
How old is your mould?

The Original Ideal Handbook (originally published in 1888) lists both single cavity and Armory moulds (as well as a multitude of loading tools). Obviously, an Ideal mould cannot be older than its cherry design, so that's the starting point for determining the age of any given mould (see attached plot of cherry number vs. year). There have been a handful of recycled cherry numbers (usually from old round ball numbers, but also from a few phased out designs, like paper patched bullets), making it appear that a cherry number is much older than it really is. As a result, one must be careful using this mode of analysis, and perform various "reality checks". For example, the 31141 appears to be a very old mould design, but GC's were not invented until 1906, after cherry number were well into the 300s, indicating that cherry #41 got recycled (the original #41 was the 30841, an adjustable cylindrical mould for making paper patched bullets). One must also ask if there were suitable guns around at the time from which to shoot the design in question; for example the 41028 and 41032 are clearly .41 caliber pistol bullets, suitable for use in the .41 Magnum. These cherry numbers would suggest adoption well before the turn of the 20th century! Recall that the only reloadable .41 caliber handguns in the early days were the .41 Long Colt and the .41 Short Colt, both of which took heel-type bullets, or seriously undersized hollow-base bullets. The .41 Magnum wasn't introduced until 1964 and Lyman was well over cherry number 500 by that point (the original #28 was the 25728, a .25 caliber round ball for gallery shooting; the original #32 was the 31032, a heel-type bullet for the .32 Swiss Ordinance, "For those who have any use for this bullet, we can furnish mould for same." states the Ideal Handbook #9, 1897). *Most* of the cherry numbers assigned by Lyman/Ideal were done sequentially, making this a useful exercise, but there are exceptions that one must look out for.

The 41028 is an example of a recycled cherry number.

Another complication is the presence of gaps and discontinuities in the sequential assignment of cherry numbers. An example is found with the enigmatic Lyman 410459. The Lyman 452460, 200 grain SWC for the .45 ACP, was released in the early 1950s (cataloged in Ideal Handbook #39, 1953), and since the 410459 is the cherry number right in front of #460, one might suppose that it too came out in this timeframe. The only problem is no one was manufacturing a .41 caliber revolver suitable to shoot a .410" diameter SWC from at the time. I have not been able to find any other bullet design that was listed with cherry #459, but the 410459 was not released until 1964, concurrent with the introduction of the .41 Magnum. If one surveys the cherries in this range, most of them were rifle designs drawn up by Guy Loverin (#'s 454, 455, 457, 462-471). Gordon Boser had cherry numbers 452 and 453. These bullets had all been issued by the mid-1950s, well before the .41 Magnum. Given the tendency of bullet designers to get "chunks" of cherry numbers (since they would commonly come in with multiple designs), it is possible that perhaps one of these gentlemen may have also had the first #459, which for whatever reason didn't make it into production. Or maybe Lyman just skipped that number for whatever reason, and then went back and used it. Cherry numbers #456 and #458 and #461 are likewise still missing...

Ideal single-cavity 3118 mould for the .32-20 (integral handles).

The 500 series cherry numbers were set aside for experimental designs. The most notable of these are the Harvey Prot-X-Bore zinc washer designs, but there were others, like Harvey's experimental designs using conventional GC's whose only bearing surface was the forward driving band and the GC, everything in between was lube reservoir (357511 and 357512). After perhaps as many as a couple dozen cherries in this series, Lyman then skipped to cherry numbers in the 600's (e.g the 410610 GC-SWC for the .41 Magnum, listed in the Lyman Handbook #44, 1967). As of this writing Lyman is currently producing cherry numbers approaching 680.

Early Ideal HP moulds had no "keepers" to hold the HP pin in (e.g. the old Ideal 25727 mould shown (top)). After 1940, Lyman HP moulds had keeper pins to hold the HP pin in place (e.g. the 454424 HP mould shown (bottom)), and after about 1990 they used a snap-ring to hold the pin in place (e.g. the 429244 HP mould shown (center)).

Initially all Ideal moulds were available in single cavity form, with fixed handles from the 1880s up through the late 1920s. Exchangeable mould blocks were first advertised in the *American Rifleman* in 1927, and first cataloged by Lyman/Ideal in 1931. So, if you have a fixed handle single cavity mould, these are the dates that likely bracket its production. For example, if it's for mould number 3118 (cherry #8) then that's one of the original Ideal designs and that mould could have been made as far back as the 1880s, or as recently as about 1930.

Originally, the single cavity detachable mould block made by Lyman/Ideal were smooth and unvented. This practice was continued from their introduction up through the introduction of double cavity mould blocks in 1949. Vented mould blocks were introduced shortly thereafter.

Originally Ideal HP moulds had no hardware for pin retention other than friction, and Lyman didn't add the keeper pin until 1940, so all fixed handle HP mould had no keepers, and detachable block HP moulds without keepers were made between 1931 and 1940. HP blocks made with keepers and no vent lines were made during the 1940s, while vented HP mould blocks made with keepers were made after that. The move was made to using snap-rings as HP keepers in somewhere around 1990.

Ideal Armory moulds were multiple cavity gang-moulds (5, 6, 7-cavities, etc.). Rugged moulds for high production casting.

An example of a 4-cavity Ideal mould (Ideal 358477).

Armory moulds were listed in the original Ideal Handbook (1888) and were still cataloged up through Ideal Handbook #39, indicating that Armory moulds were produced from the 1880s up until the early 1950s.

Double cavity mould blocks were first cataloged in 1949, and continue to be a mainstay in the Lyman product line today. In some ways, one can think of the popular double cavity moulds displacing the Armory moulds from Lyman's product line. Initially these double cavity moulds were stamped "Ideal", but in the late 1950s this was changed over to "Lyman".

An example of an Ideal 2-cavity mould (308291).

Detachable 4 cavity mould blocks were introduced in 1958 first listed on the poster that came with the *Handbook of Cast Bullets*. The switch-over from stamping moulds "Ideal" to stamping them "Lyman" is thought to have occurred in the 1957-8 timeframe (when they changed the stamping on the tong tools). This suggests that 4 cavity mould blocks were stamped "Ideal" for only a short period of time, while double cavity moulds were stamped "Ideal" for about a decade. 4-cavity moulds continue to be produced today.

A Hensley #51, made in the 1930s.

George Hensley started making moulds in 1932, then later teamed up with James Gibbs in 1937. So a mould stamped "Geo. Hensley" was made between 1932 and 1937. Hensley & Gibbs continued production from San Diego until 1964, so H&G moulds stamped with that location were made between 1937 and 1964. After that time, they were made in

Oregon. After the company was sold in the mid-1990s, the H&G mould designs were subsequently available through Cast Performance in Riverton, WY.

So, how old is your mould?