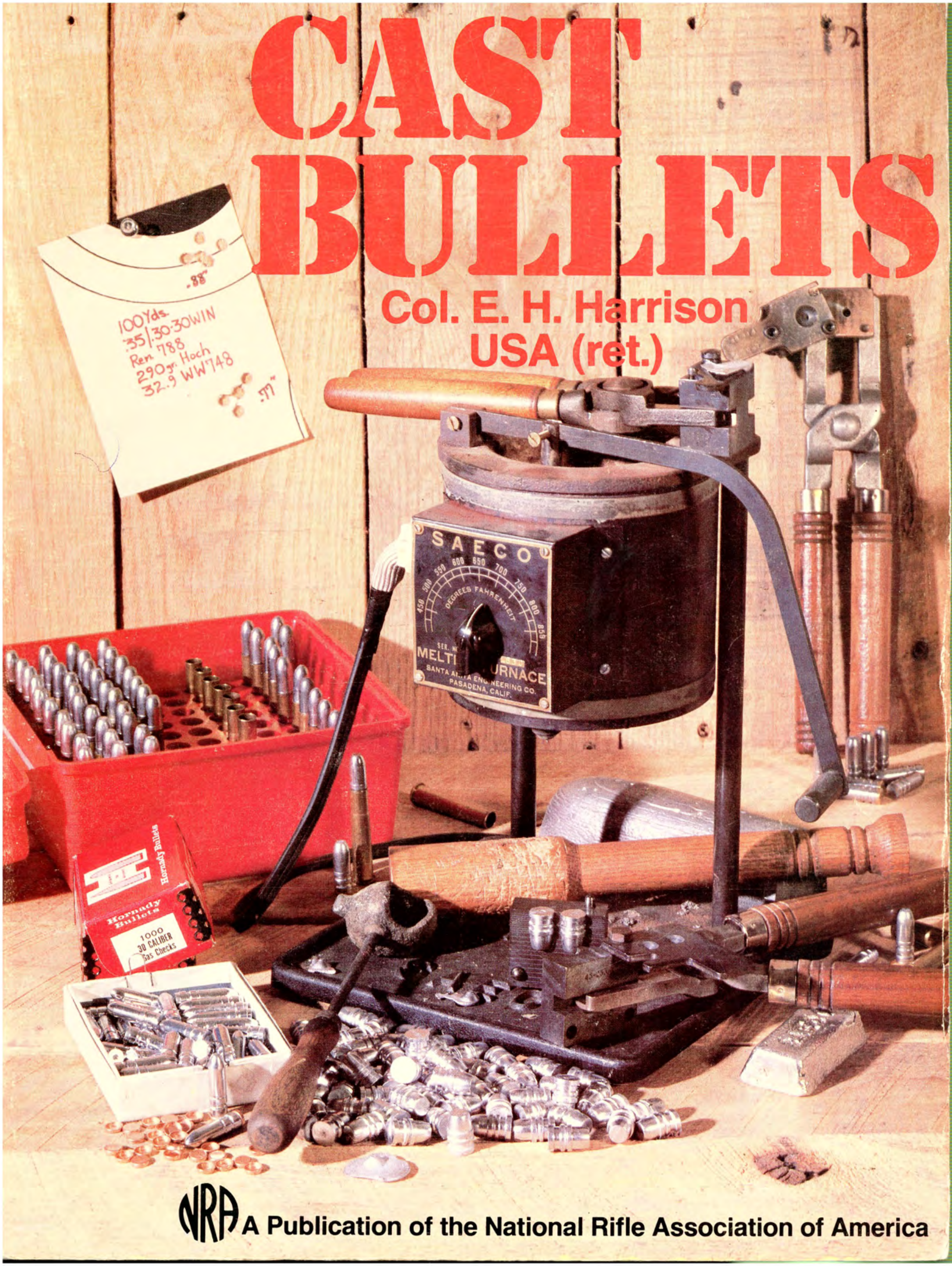
CAST BULLETS

Col. E. H. Harrison USA (ret.)



A Publication of the National Rifle Association of America

CAST BULLETS

WARNING

This book includes handloading data which are believed to be safe and satisfactory when properly assembled and fired in sound firearms of the appropriate types and in good mechanical condition.

All technical data conveyed in this book reflect the experience of individuals using specific equipment and components under specific conditions.

Because of unavoidable variations in handloading components used in various combinations, and the firearms in which the handloaded ammunition may be fired, neither the National Rifle Association of America or any of the manufacturers whose products are listed can assume any responsibility for any consequence of using the information in the following pages or data tables. The data are furnished for the information and use of readers, entirely at the user's own risk, initiative and responsibility.

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Col. E. H. Harrison
USA (ret.)

Published by
the National Rifle Association
of America
Washington, D.C.

NRA BOOK SERVICE

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For information, address the National Rifle Association,
1600 Rhode Island Avenue, N.W., Washington, D.C. 20036

ISBN 0-935998-49-7
Library of Congress Catalog Card Number 79-89301
Printed in the United States

Published 1979
Second Printing, April 1980
Third Printing, October 1982
Fourth Printing, May 1988
Fifth Printing, February 1990

Cover photograph by John R. Lamson, Jr.

Published by the
National Rifle Association of America
1600 Rhode Island Avenue, N.W.
Washington, D.C. 20036

George Martin, Executive Director, NRA Publications
Frank A. Engelhardt, Dep. Director & Book Service Manager
Michael A. Fay, Manufacturing Director
Harry L. Jaecks, Art Director

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Introduction

This Handbook collects the most significant findings on cast bullets in smokeless powder rifles and handguns, principally obtained in a systematic investigation of the subject, and published by the *American Rifleman* beginning in December 1957. Some minor corrections and footnotes have been added. The date in the subject index identifies the issue of the *American Rifleman* in which the article originally appeared.

A great deal of this material as well as its final form in this handbook, is due to Robert N. Sears and C. E. Harris, Associate Editors of the *American Rifleman.*

The Investigation determined the factors necessary for success with cast bullets. Performance now can be obtained which formerly was considered impossible.

Col. E. H Harrison
U.S. Army (ret.)

Foreword

Despite the ever increasing popularity of reloading one's own rifle, pistol and shotgun ammunition, the casting of lead alloy bullets has been, until now, the great undiscovered branch of the handloading arts.

This has not always been the case because during the later years of the 19th Century and early part of this Century, accuracy buffs used hand-cast lead alloy bullets in the achievement of a level of accuracy equaled only by today's finest equipment and components.

Despite these achievements the art of casting and loading alloy bullets languished during the years following the First World War and by the 1950's was almost forgotten. This is not to say that shooters no longer were casting bullets because in truth probably more shooters than ever, especially pistol shooters, were taking advantage of the *economy* of cast bullets but without realizing their real potential. Poor accuracy was considered the handmaiden of low cost.

This unfortunate trend was reversed almost single handedly by a series of cast bullet articles written by Colonel E. H. Harrison and published in the *American Rifleman* during 1957-58. Until that time nearly all cast bullet shooters had been experiencing uniformly poor results simply because there was very little workable information on the subject.

Harrison's articles banished a host of misconceptions surrounding bullet casting and presented in clear, logical manner specific guidelines for casting and loading truly accurate rifle and pistol bullets.

Building on these guidelines the shooting of hand-cast lead alloy bullets has become not only a reasonable alternative to expensive jacketed bullets but a totally fascinating field of handloading in its own right. In my opinion it is the single most absorbing area of handloading and the one which offers the greatest personal satisfaction.

Cast bullet shooting is *the* modern handloading sport, an exciting new field for shooters who have become weary of merely assembling their ammo. The opportunities for exciting new discoveries in cast bullet performance still abound and this book is the first great step into a whole new world of shooting pleasure and excitement.

JIM CARMICHEL
Shooting Editor
OUTDOOR LIFE MAGAZINE

Cast Bullets in Rifles

General Considerations

Part 1 of 4

An examination of factors affecting accuracy and power

By Col. E. H. Harrison, USA (Ret'd)
NRA Technical Staff

CAST-bullet handloads offer the following advantages:

1. Low cost. The cost of bullets, which in jacketed-bullet handloads is the greater part of the ammunition costs, is brought very low, and becomes almost nothing when scrap metal is used.

2. Independence. The cast-bullet handloader is the only one who really makes any of his ammunition. Others merely assemble it.

3. Controlled power. The power of cast-bullet handloads is adjustable between wide limits. The user can make his loads fit his environment, and also the preferences which he will develop.

4. Unlimited barrel life. While non-erosive powders are now available, and it is also possible to select certain jacketed-bullet handloads to minimize erosion, these are not in widest use. With cast bullets, a fine barrel will not wear out.

The author acknowledges invaluable help received from R. H. Dorian, B. E. Hodgdon, Lysle D. Kilbourn and the Lyman Gun Sight Corp., H. H. Kimball, W. M. Stuart, F. W. Whitlock.—E.H.H.

Against these great advantages must be set the following disadvantages:

1. Velocity limitation. Full power can be obtained in low- and medium-velocity cartridges. In high-velocity cartridges, cast bullets must be loaded materially below full velocity.

2. Accuracy limitation. Some handloaders have been unable to obtain satisfactory accuracy with cast bullets.

Pistol and revolver ammunition does not suffer materially from these disadvantages. The advantages are so important that .38 and .45 handgun practice and competition, on their present scale, depend on cast-bullet handloading for their existence.

Problem in .30-'06

The Lyman Gun Sight Corp. and others had by 1957 developed excellent cast-bullet loads at velocities of 2400 feet per second (f.p.s.) or more in the .22 Hornet and certain other .22 centerfire cartridges. The problem in the .30-'06 cartridge has proved more difficult. Hitherto, successful .30-'06 cast-bullet loads have generally been limited to about 1650 f.p.s. This excluded them from the field of powerful loads and high-speed varmint loads. However, they have been successfully used for target shooting up to 600 yds.

Investigations for this article brought the velocities of heavy cast bullets in the .30-'06 cartridge up to 2100 f.p.s., with excellent accuracy. This is above the power of the original .30-40 Krag cartridge, which gave a 220-gr. bullet a muzzle velocity of about 2000 f.p.s. This was thoroughly demonstrated to be adequate for use on all North American big game, and for very good target shooting at 1000 yds. It is no more necessary to use a rifle always at full power than any other machine. For the target and other shooting done by many handloaders, cast bullets can be more than powerful enough.

The accuracy difficulty has been a greater limitation. This article is devoted to the results of a systematic investigation into cast-bullet accuracy, and incidentally power. After the factors decisive for accuracy had been found, the results were very favorable.

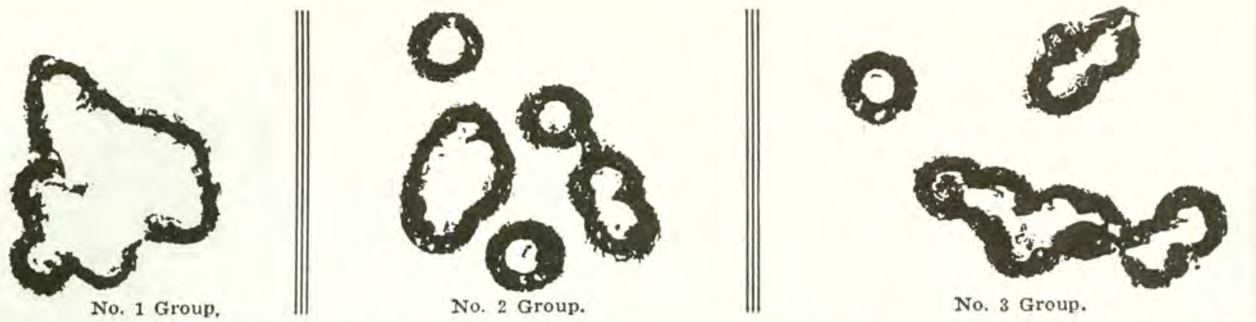


Fig. 1: 30 consecutive shots at 200 yds. by John D. Kelley, Williamsport, Pa., Nov. 24, 1905. Stevens-Pope .38-72 rifle held in machine rest, 69 grs. Hazard Fg blackpowder, 3 grs. duPont No. 1 Rifle Smokeless, UMC 7½ primers

Cast-bullet accuracy

Groups shot at 200 yds. with cast bullets were not beaten by modern bench-rest shooters until after World War II. Modern bench-rest shooting, though of fantastic accuracy, is done mostly with rifles of small bore, and most of its records are made with rifles designed for the one purpose of bench-rest shooting and not usable for anything else. On the other hand, the classic cast-bullet group shooting was done in rifles which, while of heavy single-shot type, were good for offhand target shooting as well. Equaling the 30 consecutive shots in Fig. 1 would be a test for the best .30 cal. target rifle.

These results were obtained with blackpowder target rifles, in which suitable smokeless powders were ultimately used. No comparable results were attained with cast bullets in early smokeless powder rifles. However, the shooters of that day did learn to use cast bullets in such rifles with very good success.

When the .30-40 Krag rifle came into wide use for target shooting in the early 1900's, shooters soon felt the need for target ammunition more suitable under many conditions than the full-power military ammunition. Its power was not needed for target shooting up to at least 200 yds., some of the ranges used for Schuetzen target shooting were not considered safe with military ammunition, and the owner of a fine Krag did not like to see its barrel worn out with the frequent shooting necessary for proficiency. There was, therefore, a considerable effort to use in the Krag rifle the cast bullets with which everyone was familiar. This development was reported by Dr. W. H. Hudson in *Shooting and Fishing*, predecessor of THE AMERICAN RIFLEMAN. His reports were based on such solid foundations and were written with such clearness and good judgement, that I found them a pleasure to read half a century later.

Early efforts in bullet design

The first efforts were directed toward a bullet design to provide good sealing of the hot smokeless powder gases, and adequate lubrication. Some of these bullets are shown in Fig. 2. They were used with 14 to 15 grs. of Marksman powder, a 'bulk' rifle smokeless powder of that day, made up of irregular and porous pellets somewhat similar to DuPont bulk shotgun powder. These bullets so loaded were successfully used for target shooting at 200 yds.

Various wads and fillers were tried in the endeavor to keep the hot powder gases off the bullet. In 1905, J. H. Keough loaded dry Cream of Wheat cereal to fill the air space between the powder charge and the bullet base. While it did protect the bullet, the filler caused undesirably high powder pressures with the powders then used, though not so high as some later but vague statements have implied. The experimenters of that day did something which later experimenters have too often omitted—they had questionable loads laboratory-tested for velocity and pressure. With bullets of this kind in the Krag rifle, 20 grs. of Lightning powder with Cream of Wheat filler gave 1643 f.p.s. muzzle velocity, with mean pressure of 38,600 pounds per square inch (p.s.i.) and individual maximum of 44,700 p.s.i. Lightning was a double-based powder, then and for some time later considered standard for such smokeless cartridges as the 7 mm. and .30-30. These loads were used successfully for target shooting at 500 and 600 yds.

In August 1905, J. H. Barlow, founder of the Ideal Manufacturing Co., first reported use of a copper disk or cup on the bullet base with such smokeless loads. With the same charge of powder, the Cream of Wheat filler being replaced by the copper cup, tests gave 1555 f.p.s. velocity and 21,340 p.s.i. pressure.

Satisfactory loads are safe

This first established a fact important to the user of cast bullets. In modern rifles their moderate pressures make loading and experimentation practicable without the precautionary laboratory measurement of pressure. As we shall see, accurate shooting with cast bullets can be done only with moderate powder charges. All charges giving even reasonably satisfactory results are automatically safe ones.

Barlow mentioned that others had experimented with a copper cup for this purpose. Dr. Hudson stated that the British had for some years been using bullets with copper cups on the base, but that this should not detract from credit due Barlow for making it available to us.

It was first intended that the gas check drop off the bullet as it left the rifle muzzle. It was soon found better that the gas check stay on the bullet,

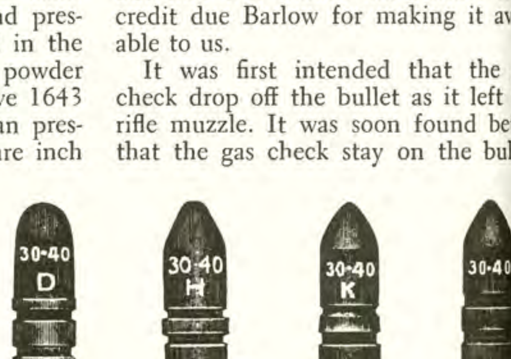


Fig. 2: The most successful .30 cal. Ideal cast bullets of 1905, just before introduction of the gas-check cup. They all share the characteristic of a long body filling the rifle bore to the bottom of the grooves, with a short bore-size bearing in front. The groove before the forward band on 3 of these bullets was intended to receive fouling scraped up by the band, and was also filled with grease before shooting so the first band would be lubricated. The oversize forward band on the second bullet was intended to fill the excessively large Krag throat, to improve sealing of the hot smokeless powder gases which was a major problem before the gas check was used. (This has long been a feature of bullets for the 8.15 x 46R and other German lead-bullet target rifles)

and it was made so as to do so. There has been no fundamental change since.

In the very next month, September 1905, appeared the announcement of the first Ideal bullet designed for the gas-check cup. This was Ideal No. 308284, now called No. 311284. In that month scores up to 46 were made at Sea Girt in re-entry matches at 600 yds., and later up to 47. The load was 23 grs. Lightning powder and this bullet. Among those making these scores was Lt. Townsend Whelen.

The 20" bullseye of the military B target, used then as now, while it is a little over 3 minutes of angle in diameter at 600 yds., is not especially easy as even many modern riflemen know. This cast-bullet development had therefore been crowned with remarkable success.

At the end of 1905, the Ideal Manufacturing Co. advertised a number of new gas-check bullets for smokeless cartridges—Nos. 308291 for .30-30, 319295 for .32-40, 321297 for .32 Winchester Special, and 375296 for .38-55—which are so good they are still in use.

Barlow was granted a patent for the gas check on Apr. 5, 1906.

The astonishing thing is that the decisive part of this recorded development in .30 cal. cast bullets took place within less than one year (though based on work at a slower pace going back to about 1900).

No progress for many years

Next followed something almost equally astonishing—an almost complete lack of further progress for many years. After the standardization of the M1903 Springfield rifle modified for M1906 ammunition, Ideal bullet No. 308334 (now 311334) and others were produced for it. But there was little if any improvement on the results already obtained. Probably this condition was connected with the onset of World War I, and the deaths of both Dr. Hudson and Barlow.

After difficult times during and following the first World War, the bullet mold and loading tool business of the Ideal Manufacturing Co. was, fortunately for shooters, taken over by the Lyman Gun Sight Corp. For many years, however, .30 cal. cast bullets continued to give about the same results. The same loads of Lightning powder were recommended in writings on the subject long after that powder had ceased to be available.

Then there began a slow improvement in results. With many reports of failures, and the work of each successful experimenter confined usually to but a single type of load, still some of the

Fig. 3: The mechanism of cast-bullet success and failure. Left-hand bullet was fired with 10 grs. Unique. It passed through the rifle bore truly point-forward and concentric. (These bullets were fired with gas checks, which came off in the recovery medium.) Right-hand bullet was fired with 18 grs. Unique. While there is no sign of rifling failure, and the load is quite safe, the bullet is badly cocked by the force of the powder gas applied to it. A bullet in this condition is unbalanced and also will yaw badly on leaving the bore, resulting in wild shooting. *Completely successful cast-bullet ammunition can be loaded with any rifle powder whatever, but the charge must be comparatively light for the powder chosen.* There are some other factors important to cast-bullet loading, but this is the critical one

results reported were striking. The purpose of this article is to show the factors responsible for success and failure, and to outline what is possible.

The first step is computation of the rifling pressure on the bullet, to judge the likelihood of the bullet 'jumping the rifling'. The continued popularity of this ancient supposition is difficult to understand, especially since the famous Dr. F. W. Mann made a point of showing that it could hardly occur. The computation (on page 28) shows that it is indeed unlikely. Except under one very special condition, I have never found it in thorough testing, and I do not believe it occurs in practice.

What does occur is a cocking and deformation of the lead-alloy bullet in the rifle bore, with severe unbalancing of the bullet and resultant large yaws and wild shooting. This is the mechanism of cast-bullet inaccuracy. The purpose of cast-bullet experiments therefore must be to deliver the bullet at the muzzle undeformed and straight.

In my opinion, the limited progress in cast-bullet loading has been due first to lack of clear understanding of the problem, and second to the unmanageable number of variables involved.

Many variables involved

Fig. 3 shows what the problem is.

For an appreciation of the variables, consider for example some factors which influence ammunition performance. It is not difficult to imagine say 10 of these, such as powder type, powder charge, bullet design, bullet hardness, etc. Each of these could take several values, say for example 6. These factors are in general not independent; that is, a change in one may affect results obtained from the others. There will then be in our example 60 variables in all. Ten of them (one of each of the 10 factors) must appear once in each load. How many combinations are there of 60 things taken 10 at a time? By well-known algebraic means it is found there are about 75,395,000,000 (seventy-five billion, three hundred ninety-five million). These result from only certain intended values. In practice there must be chance variations in them, since no operation or thing can be completely uniform; and these variations will affect the results. In addition, the design and dimensions of rifles in which the loads are fired constitute a further superimposed system of variables. In any case, regardless of the exact number of factors taken and the degree to which they may be interdependent, it is clear that

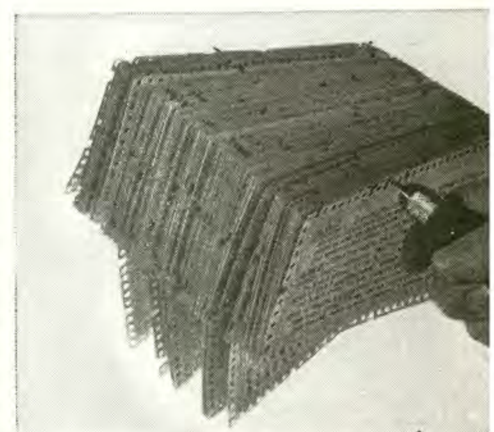


Fig. 4: Results of experiment were entered on Royal McBee Corp.'s KS371N Keysort cards. Each card has 78 available holes on its edge, and to each of these a meaning can be assigned. This offers the means of sorting data in very many different ways. With a special hand-operated punch, each card is notched through the holes pertaining to data on that card. To sort, a selector rod is passed through all the cards at the hole standing for the kind of information desired, which for this investigation included both loading particulars and results. Lifting the selector raises the cards and allows those notched at that hole to drop. These can then be sorted with respect to other points, or they can be returned to the whole and a new sorting made. Thus all the data can be rapidly examined, over and over, with respect to any combination of factors and while following any train of thought, and all very rapidly since each sorting is done in a few seconds. Punched-card systems are employed for many purposes and in almost countless ways. Keysort cards are used by the Editor of The American Rifleman for management of extensive editorial material and records

Is 'Jumping The Rifling' Likely?

When a cartridge is fired, the powder gas pressure rises to a peak and then dies away. It applies to the bullet a force which is the unit gas pressure times the area of the bullet base:

$$f = p \cdot \text{area} = p \cdot \pi r^2.$$

This force will at each instant give to an unhindered bullet a forward acceleration proportional to the force and inversely to the bullet's mass:

$$a = \frac{f}{m} = \frac{\pi p r^2}{m},$$ with properly chosen units.

The rifling enforces a corresponding angular acceleration, which is the longitudinal acceleration divided by the barrel length in which the rifling makes 1 turn, times the angle in 1 turn, namely 2π radians:

$$\alpha = \frac{a \cdot 2\pi}{l} = \frac{2\pi^2 p r^2}{lm}.$$

The torque necessary for angular acceleration is the product of that acceleration with the moment of inertia of the bullet about its axis:

$$T = I\alpha.$$

The torque is made up of a force applied to the bullet's surface at the end of a lever arm which is its radius, so

$$Fr = I\alpha = I\left\{\frac{2\pi^2 p r^2}{lm}\right\}.$$

Then the tangential force at the bullet's surface to spin it is

$$F = \frac{2\pi^2 p r I}{lm}.$$

As a simplifying approximation consider the bullet made up of a cylinder and a cone, corresponding to the body and point. The moments of inertia of these solids about their longitudinal axes are respectively .5 and .3 their masses times the square of their base radius:

$$I_{bullet} = I_{cylinder} + I_{cone}$$
$$= .5 m_{cyl} r^2 + .3_{cone} r^2$$
$$= r^2(.5 m_{cyl} + .3 m_{cone}),$$

and therefore

$$F = \frac{2\pi^2 p r^3}{lm}(.5 m_{cyl} + .3 m_{cone}).$$

Body and nose masses are some fractions x and y of the bullet mass, so

$$F = \frac{2\pi^2 p r^3}{lm}(.5xm + .3\ ym)$$
$$= \frac{\pi^2 p r^3 (x + .6y)}{l}.$$

The tangential force is divided among the several lands of the rifling. On each land, it is spread over the projected area of the length and depth of the rifling engraved in the bullet. The unit pressure on the land sides is therefore the total tangential force divided by the number of lands and the projected area of each:

$$P = \frac{F}{N(LD)} = \frac{\pi^2 p r^3 (x + .6y)}{lNLD}.$$

Knowledge of these factors governing land pressure obviously opens the possibility of manipulating them so as to minimize it. For an indication as to whether this is likely to become necessary, the conditions in the usual cast-bullet load can be noted. For example, Lyman bullet No. 311413 has a shorter body than a number of other bullet designs, hence will have a shorter engraved length and present a less favorable condition. Its body can be taken as a cylinder of 120 grs. and its nose a cone of 50 grs., which will make

$$x = \frac{12}{17} \text{ and } y = \frac{5}{17}$$

In a 4-groove bore of usual dimensions, its engraved length including the gas check and excluding the grease grooves is about .328", depth of engraving .004", radius of the bullet .154", and rifling twist 1 turn in 10". A peak pressure of 30,000 p.s.i. will rarely be exceeded in cast-bullet loads in rifles. Putting these values into the above expression for P gives

$$P = \frac{\pi^2 (30000)\,.154^3 \left(\frac{12}{17} + \frac{3}{17}\right)}{10(4)\,.328\,(.004)}$$

$= 18{,}200$ p.s.i., the unit pressure on the sides of the lands.

This value is within the compressive strength of even moderately alloyed lead. It is true that lead alloys rapidly lose strength at raised temperatures, to which the bullet surface may be exposed. On the other hand, the above peak pressure is applied only very briefly, and the material to which it is applied is confined laterally by the rifle bore and longitudinally by the gas pressure behind it. There is therefore *a priori* reason to expect the cast bullet to withstand well the twist of the rifling.—E.H.H.

no lifetime would be long enough to solve the problem by the usual cut-and-try methods.

Investigation of this article was therefore done with the aid of mechanical data sorting. Since the precise results of decades of testing by hundreds of individuals are not available, being in general lost as soon as obtained, it was necessary to obtain the basic data by three years of test firings. The results were used as described under Fig. 4.

Removing non-decisive factors

The essential feature of the analysis was removal of non-decisive factors. Every factor has some effect. However, these effects are very uneven. Much the greater part of the task consisted in locating the factors which decide the success or failure of the load. These proved to be comparatively few.

It is not possible to develop successful cast-bullet handloads by the familiar process of simply making every component and loading operation as uniform as possible. This is done successfully in jacketed-bullet ammunition, because ammunition of that type long ago reached the stage of fundamental correctness in its components. Cast-bullet ammunition has not hitherto been in that condition.

The following factors are not decisive:

- Cartridge case make
- Primer make
- Primer seating punch shape
- Primer vent diameter
- Precise powder charge weight
- Precise bullet weight
- Precise bullet diameter, most loads
- Bullet seating depth
- Bullet pull-out force
- Bullet grease, most loads

The most assiduous attention to the above factors will not make a cast-bullet load perform well. They can even be systematically ignored without making a cast-bullet load perform very badly.

The following factors are decisive:

- Bullet hardness, some loads
- Bullet grease, some loads
- Bullet design
- Rifling design
- Powder charge

The remaining three parts of this article are devoted to the effects of these decisive factors.

Footnotes for this article on page 144.

Cast Bullets in Rifles

Cast Bullet Alloys

PART 2 OF 4

By Col. E. H. Harrison, USA (Ret'd)

NRA Technical Staff

SINCE the practicable limit on power with cast bullets is set by their hardness and strength (almost synonymous terms), the characteristics of bullet alloys are fundamental to performance.

Pure lead is too soft and weak for most bullets. It has long been hardened by the addition of tin or antimony. Despite this practice, its full effects have not been rationally used in the making of bullets, or even become known to handloaders.

There is an impression among handloaders that tin is the more important alloying metal, and that hardness of cast bullets can be expressed as the equivalent of a given fraction of tin in the alloy. Neither of these impressions is correct at the hardness levels required for most rifle bullets. However, we can examine the effect of tin first.

Effects of alloying with tin

The hardness of lead-tin alloys is shown by the lower of the two curves in Fig. 5. The first addition of tin causes a rather steep rise in the hardness. Then the curve tends to level out, so additional tin has less effect. It is evidently of little use to put in more than 8% or 10% tin. Since the hardness of pure lead is between 4½ and 5 Brinell, we also perceive that the lead-tin alloy can practicably be made only about 2½ times as hard as pure lead.

Hardness is not the only important characteristic of bullet alloys. They must be melted and cast into bullets, and their behavior during that operation is of practical importance.

How an alloy melts and freezes is shown by what is called its equilibrium, constitutional, or phase diagram. Fig. 6 shows in simplified form the lead end of the lead-tin equilibrium diagram. It makes clear there is no such thing as a 'melting point' for such an alloy. Depending on its composition, it begins to melt at a certain temperature but will not all melt until that temperature is raised considerably. In the making and shooting of cast bullets, this characteristic works unfavorably in both directions.

When the alloy is melted for casting, it begins to melt at the temperature shown by the solidus. It cannot be cast in that condition, however, and the temperature must be raised above the liquidus, with the accompanying inconvenience of higher temperature, more slagging, and loss of the alloying metal. When the alloy cools in the mold, it begins to freeze at the temperature shown by the liquidus; nevertheless it cannot be cut off and dropped in that condition, and the temperature must be further lowered to the solidus. This is far from ideal behavior in an alloy intended for casting.

On firing, the high temperature for complete liquefaction as shown by the liquidus is of no benefit. The alloy loses all strength as soon as its temperature reaches the solidus.

These unfavorable factors become unimportant only at very low percentages of tin, where the liquidus and solidus are almost together. The cost of tin is also not to be ignored. Everything considered, it is inadvisable to use more than a very small percentage of tin alone, say 3%.

Greater effect of antimony

The hardening effect of antimony is greater than that of tin. Its hardness curve (Fig. 5) is seen to be much higher, with less tendency to level off. The lead-antimony alloy can readily be made about 4 times as hard as pure lead.

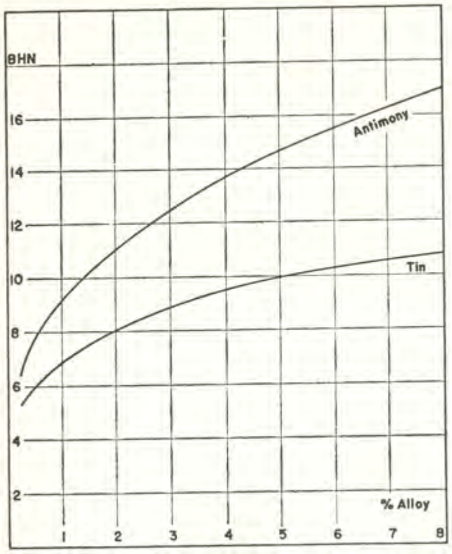


Fig. 5: Hardening effect of tin and antimony used separately. Brinell hardness numbers (BHN) express compressive strength in kilograms per square millimeter (each number then corresponds to about 1420 p.s.i.) or the numbers can be used simply for hardness comparison. It is evident that lead can be made much harder with antimony than with tin

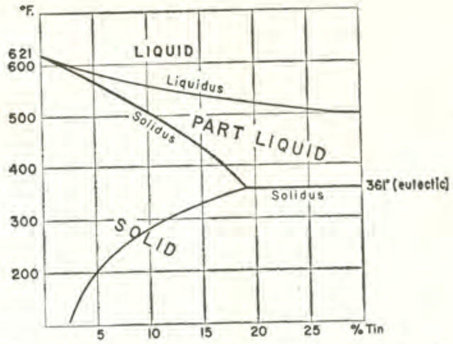


Fig. 6: Equilibrium diagram of lead-tin alloys, at the lead end. Pure lead melts and freezes at the definite temperature 621° F. When tin is added, the resultant alloy melts or freezes over a range of temperature. Above the line marked *liquidus* the alloy is all liquid, and below the *solidus* it is all solid. Between, it is a mush. For example, an alloy of 10% tin, 90% lead, begins to melt at about 510° F., but will not all melt until the temperature is raised to 560°. Meaning of the eutectic is more easily seen in Fig. 7

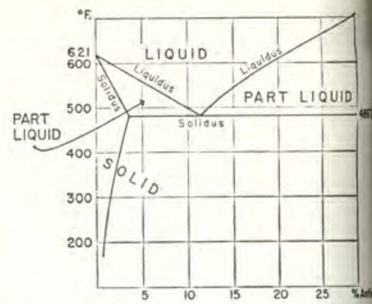


Fig. 7: Equilibrium diagram of lead-antimony alloys at the lead end. The liquidus intersects the solidus at the composition 12.7% antimony. There being here no spread between liquidus and solidus, the alloy all melts and freezes at one temperature like a single metal. This is advantageous in both casting and shooting bullets. Such an alloy is called the *eutectic*. The curved line extending left and downward from the solidus on both lead-tin and lead-antimony diagrams signifies further change of state after freezing, which is explained in the text

The equilibrium diagram of lead-antimony alloys (Fig. 7) is of the same general form as the lead-tin, but its proportions are quite different. For our purposes, its most striking characteristic is that the liquidus intersects the solidus within the lead end of the diagram. At this eutectic composition of about 12.7% antimony, the alloy melts and freezes at a single temperature of about 486° F., and the disadvantages of the usual liquidus-solidus separation entirely fall away. The eutectic alloy is also of very good hardness. I have used approximately this eutectic of lead and antimony for rifle bullets with very good results.

It has been stated that antimony should not be used alone to harden bullets, since that would leave free lead in the alloy in a condition to rub off on the bore surface and 'lead' it. It is true that the solid solubility of antimony in lead is very small, only about ½ of 1% at ordinary temperatures, and that of tin is greater. However, the latter is still only about 2%. Where both are so small, it is hard to see how the difference between them can be very important. Possibly it might be in revolver and other soft bullets with very low percentage of alloy; but in those the problem of using antimony alone does not arise, since some tin should always be used for satisfactory casting qualities.

In rifles, leading is uncalled for in any case. With correct loads (which will be described in Part 4) *leading will be completely absent.*[1] Use of tin and antimony in rifle bullets rests on the other consideration here described.

In hardening, more can be accomplished with tin and antimony together than with either alone.

Credit for the use of tin and antimony together to alloy bullet metals appears to be due to Dr. W. H. Hudson and the old Ideal Manufacturing Co. The hard alloy usually recommended is 1 part tin, 1 part antimony, 10 parts lead.[2] This, however, has little rational basis in the properties of lead-tin-antimony alloys, and is not even very hard (only about 15 Brinell). It is, however, some 30% harder than a 1 to 10 alloy of tin and lead.

Type metals are well developed

Type metal alloys are required to have much the same properties as bullet alloys—a sharply defined melting and freezing point, fluidity when melted, resistance to crushing, and resistance to wear. To gain these qualities, alloys of lead, tin, and antimony have been used in type metals for centuries. During most of that time they were formulated by cut-and-try, and consequently type metals of the past have been of almost every possible proportion among these three metals. However, beginning in Germany before World War I, and later in Japan and England, fundamental research mapped the characteristics of these alloys and located those compositions which for specific reasons are better than any other.

There is no such thing as 'type metal', though sometimes certain compromise compositions are used as general-purpose type alloys. In most cases the requirements of the different printing processes have called for alloys appropriate to each. There is therefore little meaning in the words 'type metal' alone; it is necessary to say what kind of type metal is meant.

Following are the alloys used for type casting and plate making by a large printing company in Washington, D. C.:

Type Metal	*% Tin*	*% Antimony*	*% Lead*
Electrotype	3.0	2.5	94.5
Linotype	4.0	12.0	84.0
Stereotype	6.0	14.0	80.0
Monotype	9.0	19.0	72.0

A fifth kind, called foundry metal, is made up of about 13% tin, 25% antimony, and 62% lead, often with up to 2% of copper added. It is used for permanent type set by hand. For that reason it is formulated to be as hard as possible, 35 Brinell or more. It must be cast by a type founder who has the necessary equipment for melting it and controlling its composition.

The structure of these alloys is complex, and their hardness is not in any simple relation to the proportions of tin and antimony in them. Fig. 8 shows the hardness of all proportions of lead-tin-antimony alloys up to tin 14%, antimony 24%. That composition has a Brinell hardness above 32, or about 7 times the hardness of pure lead, and it is evident that further increase in the tin and antimony content would make the alloy still harder.

We have already seen, however, that the usefulness of a cast-bullet alloy depends not only on its hardness but also on its melting and freezing characteristics. It is not practicable to diagram here these characteristics for ternary (3-part) alloys since to do so requires a 3-dimensional portrayal. However, it has been done and we can make use of the information obtained.

There are 2 eutectic proportions of lead-tin-antimony. One has the composition 4% tin, 12% antimony, 84% lead, with melting point 462° F. The other is 10% tin, 10% antimony, 80% lead, with melting point 476° F. (It is interesting that this latter composition was advocated for a bullet alloy by Dr. Hudson in 1906, before this eutectic was known.) The first of these alloys has a Brinell hardness of about 22, and the second about 24.

The second of these alloys thus shows a slight advantage over the first in both melting point and hardness. The advantage is so limited as not to repay its much greater use of costly tin.

Suitability of linotype metal

The composition of the linotype metal in the above table is exactly the same as the first eutectic, which of course is no accident. This linotype metal, the culmination of both long experience and scientific investigation, combines the advantages of very good hardness, sharp melting point, fluidity when melted, and inexpensive ingredients. It is the best all-round hard bullet metal I have been able to find. Its casting qualities are superior, it is very easy to get good bullets from it, and it is hard enough for most requirements in rifle bullets. It has the great merit of availability, since it is usually possible even in outlying districts to buy it from the local newspaper.[3]

For an alloy harder than linotype, a thorough trial was made of the monotype metal in the table. This also is easy to cast, and its hardness (28 Brinell) makes it the best alloy for heavy cast-bullet loads.

There is no good way of making lead-alloy bullets any harder than that. The foundry metal given above is much harder than the other alloys. However, it is too difficult to cast in home equipment. Before World War I a somewhat similar alloy for hardest bullets was sold by the Ideal Manufacturing Co., but it was dropped.

In my opinion, if the extreme in hardness is desired it would be better to use a zinc diecasting alloy such as Zamak or Kirksite, which has proved reasonably practical for making cast bullets. Bullets made of it are hard enough to shoot well with any safe charge of powder.

The hard lead alloys are required for medium and heavy cast-bullet loads. Some handloaders wish to use salvaged metal, reducing their ammunition costs to the very minimum. Like loaders of handgun ammunition, they will cast bullets of anything they can melt. With light loads (and those only) it makes little difference what bullet alloy is used. Alloys from very hard to very soft perform about the same, and such loads can give the very finest grouping. The handloader whose environment or whose purposes call for light loads is therefore quite right in using whatever scrap is available.

Be cautious with scrap metals

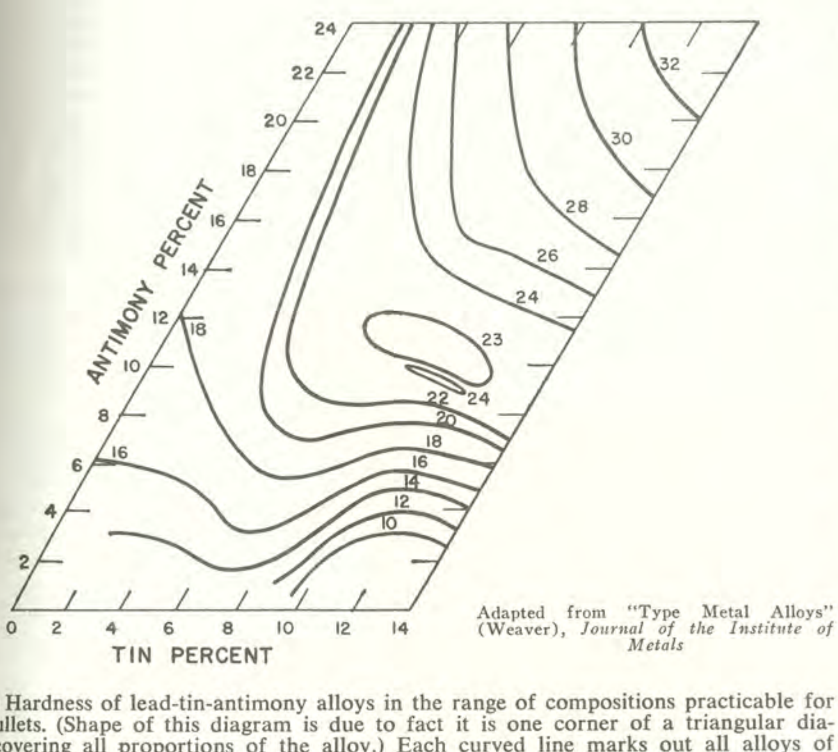
Since it will be quite impossible to tell what is in such scrap metal, the user can take only certain precautions to get satisfactory casting. The most important precaution is to avoid certain types of contamination of the alloy. The most harmful of these contaminants from his standpoint are zinc and aluminum. Both have the property of markedly increasing the surface tension of lead alloy, even when they are present in only very small amounts. This makes it practically impossible to cast sharply filled out bullets. The principal source of these two contaminants is diecasting metals among the scrap. While such metals can be used to make very hard, high-speed bullets, as mentioned above, the melting pot and dipper must then be very thoroughly cleaned before being used with lead alloys. Great care must be taken to differentiate between lead and diecasting scrap. In addition, the soldered ends of certain types of lead cable sheathing have a similar contaminating effect.

If there is any doubt as to the quality of lead scrap, it should be melted separately and tested for casting behavior before being added to metal which is known to be good. Neglect of this precaution can ruin a whole supply.[4]

These low alloys are the only ones in which the proportion of tin should equal that of antimony (note the electrotype metal above). About 3% tin is necessary for fluidity and good casting qualities. Prolonged or excessive heating oxidizes the tin and antimony out of lead alloy, especially the tin. Also scrap lead can be counted on to contain much less tin than antimony. For these reasons it is always necessary to add tin to scrap lead to make it cast well into bullets.

Tips on casting bullets

During casting, the melt must be hotter than the bullet mold if the bullets are to drop well from the mold. Alloys of known composition should be kept at about 100° F. above the liquidus during casting. Alloys of unknown composition will have to be controlled by trial. Take great care not to overheat the metal since that burns out its constituents unequally. A bullet mold which is never oiled or greased will make good bullets with maximum ease, and



Adapted from "Type Metal Alloys" (Weaver), *Journal of the Institute of Metals*

Fig. 8: Hardness of lead-tin-antimony alloys in the range of compositions practicable for cast bullets. (Shape of this diagram is due to fact it is one corner of a triangular diagram covering all proportions of the alloy.) Each curved line marks out all alloys of the Brinell hardness number indicated. To read the diagram, select % tin on bottom edge and % antimony on left edge, and at coordinate intersection note nearest hardness line. For example, intersection for 8% tin and 8% antimony falls near line labeled 20, indicating a BHN of 20 for a alloy of 8% tin, 8% antimony, balance lead

Fig. 9: Carrying lead pot outdoors for fluxing can be done with a suitable sling. This one is based on a strip of ¾" plywood. 3½" wide. A hole at its midpoint fits over the spout on bottom of pot, preventing slipping. The long eyebolts bring the points of attachment of the bail above the pot's center of gravity, so it is stable when carried

will permit lowering the casting temperature materially. Store the mold with VPI to prevent rusting.

'Fluxing' the melt will throw down solid metal entrained in the slag, and also improve fluidity. Fluxing before skimming will prevent taking out the alloying metals. The usual flux is a small piece of wax or fat (it is not necessary to use a piece larger than a .32 revolver bullet) dropped onto the surface of the metal, which is then stirred, allowing the flux to decompose and reduce the slag. The resulting smoke can be minimized by lighting the gas given off. I have found oilsoaked sawdust the most convenient flux, leaving minimum deposit on the pot to continue smoking.[5]

The modern electric melting pots, especially when thermostatically controlled, have by their quietness, convenience, and close control done much to decrease the labor and improve the results of bullet casting. Since they are almost always used indoors, they tempt one to omit the fluxing operation. The greasy smoke from fluxing is damaging to house interiors. The remedy is to carry the pot outdoors for fluxing, which should be done at least occasionally. Some pots have no provision for carrying while hot, but a carrying bail such as that shown in the photograph can readily be made. ■

• HEAT-TREATED BULLETS

Bedford, Ohio

Editor:

It has long been known that lead-antimony alloys in the range 2% to 8% antimony are susceptible to heat-treatment, with a notable increase in hardness and strength. However, this appears not to have come to the attention of handloaders.

The American Society For Metals granted permission to reproduce, from its *Metals Handbook*, the table below. It shows the approximate tripling of hardness by heat-treatment, and the slow decline of hardness with age. These samples were heat-treated at 235°C. (456°F.), quenched in cold water, and aged at room temperature. **Sb** is the chemical symbol for antimony, and H. T. is the abbreviation for heat-treated and heat-treatment.

Length of aging period at room temperature	*Brinell Hardness (1/16" ball, 9.85 kg., load for 30 seconds)*				
	1 day	*4 days*	*14 days*	*104 days*	*7¾ years*
4% Sb aged w'out H.T.	8.1			8.6	8.3
4% Sb H.T. and aged	24.3	24.3	22.0	22.8	18.4
6% Sb aged w'out H.T.	8.6			9.0	9.0
6% Sb H.T. and aged	23.5	26.0	23.1	21.2	17.4
8% Sb aged w'out H.T.	9.5			10.1	10.0
8% Sb H.T. and aged	26.5	26.5	25.3	24.0	19.9

The alloy is quite soft immediately after quenching. The slight decline of hardness with age may be retarded by storing in a cool place.

The handloader does not ordinarily possess heat-treating equipment, but he can drop the cast bullet straight from the mold into cold water, and that is what I did. The bullet hardness produced was tested with an indentation apparatus, in comparison with bullets cast of linotype metal. Following are the results:

Test	*Alloy*	*Bullets dropped from the mold onto soft cloth*	*into cold water and aged several days*
1	½ scrap lead ½ scrap typemetal	soft	app'x hard as linotype metal, BHN 22
2	5% antimony 95% lead	soft	slightly softer than linotype metal
3	5% antimony 1% tin 94% lead	soft	app'x hard as linotype metal
4	5% antimony 2% tin 93% lead	soft	app'x hard as linotype metal
5	3% antimony 3% tin 94% lead	soft	app'x hard as linotype metal
6	12% antimony 3% tin 85% lead	hard	no further hardening

Tests 2, 3, 4, and 5 were made partly to determine the effect of tin on hardening. It increases hardenability with this quenching method, but good hardness can be attained without it.

The level of hardness achieved seems reasonably independent of the exact composition. Almost any witch's brew of scrap should harden satisfactorily if it contains a few percent of antimony and perhaps a dash of tin. Storage battery scrap contains considerable antimony. Cal. .22 bullet scrap has been checked and contains no antimony.

Note, however, that when the antimony content is high (Test 6) the bullets are hard even when cooled slowly, and quenching them in cold water gives no additional hardness.

The bullet is dropped immediately from the mold held about 2 ft. above a cloth-lined tub of cold water. If you get down close, a teaspoonful of splash will catch that open mold every time. For safety, place the tub so that no drop of splash can ever reach the melting pot to spatter hot lead. As an added precaution stand between the tub and the pot while dropping bullets. A bucket is not large enough—too many bullets miss it, or are damaged by striking the sides. Above all, do not use any heat for drying the bullets as that would soften them again. Sizing will be easier if you do it before the bullets have a chance to harden.

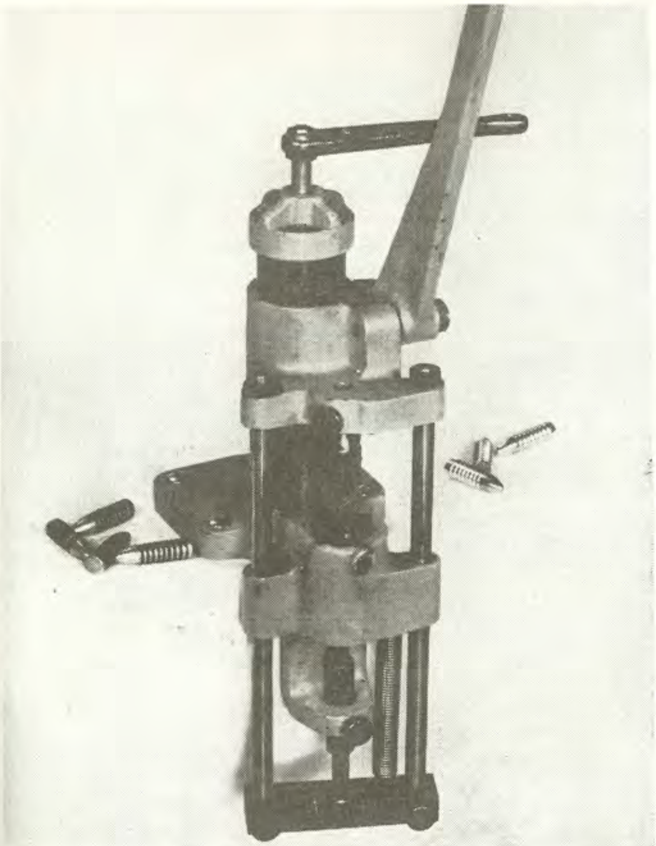
This method of heat-treating is called precipitation hardening, and is the method used to harden beryllium-copper and the heat-treatable aluminum alloys. There are some similarities between the treatment of the lead-antimony alloys and the high-carbon steels, with which most of us are more familiar. In steel carbon is the hardening agent, and only 0.82% is needed for full hardening. In our bullet alloys antimony is the agent and less than 3% enters the hardening reaction. More antimony adds but little to the hardness, but 7% to 8% is desirable for better casting properties, and also a little tin for the same reason.

Quenching must be drastic. We must not allow time for the constituents which exist at the higher temperature to change into unwanted soft products before the metal reaches the safe cold state. A range of hardness from very soft to very hard can be had merely by varying the thermal treatment, without varying the composition of the metals at all.

But I guess the joke is on me after all. For 35 years I have been casting bullets of that lowly ½ scrap lead, ½ scrap typemetal mixture of Test 1 without ever once suspecting its true worth. I just followed ancient instructions, dropped the bullets from the mold onto the traditional soft cloth where they annealed into mere shiny shadows of their proper hard selves. And ready to hand, in a volume consulted literally hundreds of times, were all the metallurgical data needed to produce heat-treated cast bullets.

The increase in hardness of the few samples tested was spectacular, and justifies a belief that the process may be valuable to many shooters, especially those who must depend mostly on scrap metal. I have not determined whether the heat of powder gases and bore friction may soften the surface of these heat-treated cast bullets, and that must be determined.

James V. King



Cast Bullets in Rifles

Cast Bullet Lubricants

PART 3 OF 4

Footnotes for this article on page 144.

By Col. E. H. Harrison, USA (Ret'd)

NRA Technical Staff

BARE lead bullets must be greased, as otherwise the lead rubs and tears off the bullets and sticks to the rifle bore, making satisfactory shooting impossible.

Some experimenters have believed the kind of bullet lubricant used had a great effect. On that basis my own investigations were concentrated on bullet lubricants for some time. I was forced to conclude that choice among all available lubricants can do no more than improve results, being decisive to success or failure in only a few special cases if at all.[1]

Nevertheless, the handloader must choose a lubricant. Application of the lubricant is connected with the question of sizing bullets, and that turns out to have a bearing on bullet design, which most certainly is a decisive factor. So consideration of bullet lubricants is necessary.

Lubricant action not known

The action of cast-bullet lubricants is not known. Those which have been most used are not even very good lubricants as lubricants go, yet changing to materials which are good lubricants has not generally appeared to make much difference.

The first bullet lubricant was tallow. It obviously was used because it was available, and it turned out to have the additional good points of convenient consistency, ready application, and reasonably good performance. It had the disadvantage of decomposing in time.

Tallow was therefore replaced by certain waxes which are more stable. Some of these are vegetable, such as carnauba and Japan waxes. Others are of 'mineral' or petroleum origin. Under various names, such as montan, ozocerite, and so forth, these are merely paraffin waxes of varying hardnesses and melting points.

Concoctions of waxes, often with addition of oil and graphite, were devised for bullet lubrication by the principal rifle shots of the 1880's and 1890's. Unique virtues were ascribed to these, but they were all intended to form a material of convenient consistency, readily applied to the bullet, and leaving a more or less favorable deposit in the bore. The widely-used Ideal bullet lubricant, supplied by Lyman, appears to be made of waxy materials.

Bullet lubricants of this kind give good results with most correct cast-bullet loads. The handloader can make up serviceable ones for himself. One which was long used by the NRA Technical Staff is composed of equal parts beeswax and paraffin wax, melted together and ¼ their volume of cup grease added, plus graphite if desired. The proportion of cup grease is adjusted by trial to make the lubricant suitably flexible and plastic at the temperature at which firing will be done.

Another, which I used for years, is made of equal parts by volume of beeswax, castor oil, and powdered graphite. The proportion of oil is adjusted to make the mix plastic and not brittle. Castor oil has had a bad name for gathering in drops when mixed with a wax. Perhaps it does so in a paraffin wax. However, it has never shown any tendency of this kind in the above mixture, and I kept one lump of it under observation for 8 years.

All the bullet lubricants mentioned up to this point can be applied with a mechanical lubricator, or by dipping the bullets in the melted lubricant, or by

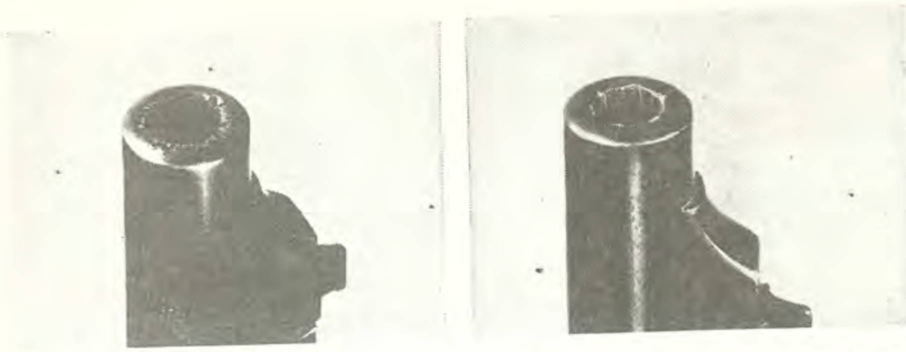


Fig. 9: Best cast-bullet loads leave a distinct ring of bullet grease on the muzzle face, as shown in photograph on left. As the powder charge is increased, the grease ring lessens and disappears. Still further charge increases result in appearance of a thin, lightly-attached ring of lead on the muzzle face, heaviest opposite the lands, as shown in photograph on right. With slow-burning rifle powders there will be no leading but the charge will be found too heavy for good grouping. With reduced-load rifle powders, appearance of the lead ring indicates the satisfactory charge has already been overstepped, and bad leading will be found in the bore. For satisfactory shooting and freedom from leading with such powders, charges must be kept down to levels to be recommended in Part 4

standing them in a pan of melted lubricant which is allowed to solidify and the bullets then removed with a cylindrical cutter. For the latter two methods, it should be remembered that the graphite will tend to settle out while the melted lubricant is kept standing.

Very little cast-bullet lubricant development has gone beyond this point.

Waxes unfavorable

While waxes are convenient to handle, they have other characteristics which at least appear to be unfavorable. Their standing as lubricants is poor, and they are never used industrially for lubrication tasks of any severity. Their melting point and flash point are both low. They are undesirably hard when cold and soft when warm.

It is obvious that the bullet and rifle bore are subjected to great heat and pressure. It appears to have escaped general attention that smokeless powder gases are also oxygen-deficient, so it is impossible to obtain a clean burn-off of the lubricant in any event.

Graphite has a good deal of immunity to such conditions. In a chemically reducing atmosphere, it is sufficiently stable to be used even for crucibles. For a radical solution, an attempt was made during this investigation to use graphite alone, in the form of a water paste which was allowed to dry on the bullet, though this required a good deal of care and trouble. While there were a few striking successes, this was in most cases a failure. About the same results were obtained with powdered molybdenum disulphide used in the same way. Dry lubricants used alone appear to be for some reason unsuited to bullet lubrication.

It therefore was necessary to return to a lubricant of more nearly conventional type. This forced the choice into some form of the fixed lubricating greases, which differ fundamentally from waxes.

Lubricating greases

Lubricating grease appears to have been invented in Germany about 1867. It consists 85% to 95% of oil, usually petroleum oil, held in a gel by a chemical soap, usually of sodium, calcium, or lithium base. It is a much better lubricant than wax, and it is also far less sensitive to temperature changes. Lubricating greases have a comparatively high melting point, and it is generally not practicable for the user to melt and cast them.

The most familiar type is automobile chassis grease. The various brands, while differing in appearance, are practically all of good quality. However, they are necessarily made soft for application through pressure fittings, and are much too soft for convenient use on bullets. A slightly stiffer lithium-base grease is made for use in all pressure fittings on the automobile, hence is called multipurpose or "MP" grease. True waterpump grease is a little stiffer still, but is not always obtainable.

As bullet lubricants, the above three types of automobile grease perform about the same.[2] They permit very accurate shooting with light cast-bullet loads, apparently because of the soft fouling left in the rifle bore. With medium and heavy cast-bullet loads I have not found them to do so well, possibly for some reason connected with their softness. They are all three too soft for convenient application to bullets or handling the bullets afterward.

It was found quite practical to incorporate large proportions of graphite or molybdenum disulphide in chassis grease. This cannot be done successfully by hand, but is easy with power mixing. The mixer is a short piece of heavy wire, with one end bent into a loop and the other end held in the chuck of a drill press, electric drill, or geared breast drill. This will incorporate the grease in a few minutes.

A good basic formula

A good basic formula was found to be equal parts by volume of chassis grease and powdered graphite or molybdenum disulphide. A stiffer grease can be used for the base, but then the proportion of graphite or molybdenum disulphide must be decreased. If graphite or molybdenum disulphide of special fine particle size is used, its proportion in the mixture must be decreased. This also must be done when the residue left in the rifle bore is stiff or dry. The mixture behaves as though each particle of solid lubricant must be surrounded by the carrier grease.

Such grease mixtures gave very accurate shooting when properly adjusted. These good results seemed to be due to the favorable residue left in the rifle bore. However, the proportions of the mix had to be adjusted for different loads (in contrast with wax lubricants, which are not very sensitive to the amount of graphite used). While the solid lubricant stiffens the grease somewhat, it is still very inconveniently soft for application to the bullet and for handling the bullet afterward. This inconvenience extends to the complete ammunition when it is of a kind leaving grease grooves exposed in the loaded cartridge. The performance gain over wax lubricants such as Ideal was still

Fig. 10: Sizing does not remove most defects, since they are not limited to tops of the bullet bands. Sized bullets shown here have defects (see arrows) which are not removed by sizing but only made inconspicuous under a smoothed coat of grease. Out-of-roundness, being all over the bullet, is still less removed by sizing

small, and was considered not worth the inconveniences. Ideal was the better in some heavy loads.

For practicable improvement, then, we are left with lubricating greases manufactured so as to be stiff. Such greases do exist, for example the very stiff and sticky sodium grease used on the side rods of steam locomotives. This has been used on revolver bullets by a few handloaders, but is not generally available. However, a grease of rather similar characteristics was brought on the market in 1957 by the firm of Cooper-Woodward, Riverside, California, under the name Perfect-Lube. While this bullet lubricant does not give performance markedly different from that of wax lubricants under temperature conditions favorable to the latter, it is much less sensitive to heat and cold than wax lubricants.

Synthetic lubricants offer possibilities

The remarkable synthetic lubricating materials which have become available offer interesting possibilities. In 1957 the investigation was extended to two such lubricants made up into greases by a laboratory familiar with the problem. They had striking physical properties, including remarkably high melting and flash points. Nevertheless they gave little performance improvement, and one of them, a silicone (siloxane), left a deposit in the bore more difficult to remove than leading. It is quite possible that some markedly superior bullet lubricant eventually will be developed. It would extend the usefulness of light loads fired without the gas check. At the other extreme, it might also raise the practicable velocity of cast bullets with heavy charges of slow-burning powder, the failure of which, as some evidence has shown, sometimes occurs from softening of the bullet surface by friction on the bore.

Fig. 11: Sizing tends to damage bullets. Photograph shows result of sizing from .317" to .308" in 3 steps. (To make effect visible, bullets were cast of soft alloy in a point-cutoff mold which left bases free of any sprue mark.) This sizing is little more than that regularly required on bullets as cast by some molds. Bullet on left is unsized. Other bullets show bulges in base from the stresses produced by sizing. The bullet metal has to go somewhere

In any case, all lubricating greases must be applied to the bullet either by rubbing on by hand (obviously appropriate in only small quantities) or with a mechanical lubricator, since they cannot conveniently be melted.

The mechanical lubricator is already an old device. It was developed first as a convenience, and from that standpoint its value can hardly be over-estimated by the reloader preparing many cast bullets. But it is also used to 'size' or reduce the diameter of the cast bullet, and that we must now consider.

Poor bullets not improved by sizing

Bullets as cast are not round, though from a good mold they are nearly so. If the greased bullet is forced through a die smaller than itself, it is made round and the grease is smoothed flush with the bullet bands, giving a good appearance.

It has often been stated that the condition of the bullet is improved by this operation. This may be true to a limited extent in the case of bullets from a mold in bad condition, or bullets badly cast. The die, however, touches only the tops of the bullet bands, but out-of-roundness and most casting defects extend to the rest of the bullet and are not removed by sizing (see Fig. 10). A poor bullet is made to look well when greased and sized, but not shoot well.

Sizing a material amount, in dies generally available to the handloader, is in fact likely to be damaging (see Fig. 11).[3]

The above facts were well known to the highly proficient users of black-powder Schuetzen and bench-rest rifles. They never sized bullets for these rifles, often using tapered or 2-diameter bullets which could not be sized, and their cast-bullet shooting was the best that has ever been done. Dr. Mann pointed out that sizing bullets must damage them. Incidentally, he concluded on the basis of exhaustive tests that the body of a bullet should be of only bore (not groove) diameter. My own experience (which also includes some with Schuetzen rifles) and that of successful cast-bullet experimenters made known to me, confirms that the best shooting is done with bullets as they come from a good mold.

Application is limited

The practical application of this, however, is limited by existing molds for .30 cal. bullets. Many of them cast bullets so grossly large that they must be reduced by sizing, sometimes two

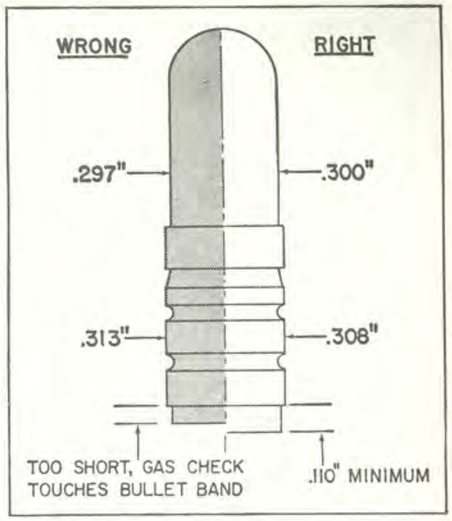


Fig. 12: Wrong and right dimensions to which the bullet should be cast. Body should be not greater than rifle groove diameter. Forepart must be not smaller than rifle bore diameter[4]

sizings at the cost of extra labor. When only such a mold is available, sizing is necessary.

Molds are now offered on special order for some .30 cal. bullets which are less oversize, and this reduces or eliminates the necessity for sizing. However, the bullets from some of these molds are smaller not only in the body, but all over. Since this affects bullet design, a decisive factor in the success of cast-bullet loads, it must be considered.

Most cast bullets for .30 cal. rifles are made of a body plus a forward part to ride on the rifling lands in the bore. The design is obviously plausible, but sufficient attention has not been given to its application. It is defeated when its dimensions are unsuitable.[5]

Under what appears to be a desire to make certain the body will fill the grooves and the forepart will go easily into the bore, most molds are made so as to produce the bullet body materially larger than the rifle grooves and the forward part materially smaller than the rifle bore. This has got the thing backward. A cast bullet body of .308" will fill the grooves as successfully as any larger size whatever. A forepart of full .300" diameter will go into the bore of a new barrel and will be no more than large enough. When even slightly under bore diameter it cannot be kept from bending and slumping with any but a very light charge (see Fig. 3, Part 1). Its eccentric mass then gives rise to a whipping action as the bullet spins, and computation shows the resultant centrifugal force to be above the compressive strength of the lead bearing on the tops of the lands. A rotating bullet in

Leading destroys cast bullet accuracy. It can be caused by poor lubrication, gas cutting, soft alloy or too high velocity.

the rifle bore is in unstable equilibrium, any displacement from its axis causing forces which tend to increase the displacement. When this process is allowed to begin, the necessary consequence is wild shooting.

Correct bullet dimensions important

It is useless to attempt accurate shooting with a wrongly-dimensioned bullet. This matter is so important that the wrong and right dimensions are shown in detail (Fig. 12).

From that figure it is seen there is little point in the usual question as to whether the cast bullet should be of groove diameter or larger. Both parts of the bullet must be specified. The bullet body should be of groove diameter; with a somewhat larger body, good shooting can be done but not the best. The bullet forepart must fit the bore closely.

Accordingly, the usual cast bullet with oversized body and undersized forepart cannot shoot well. A special mold casting the bullet with body less oversized than usual is advantageous as to the body, but if the forward part of the bullet should at the same time be reduced from its usual diameter which is already too small, the loss is greater than the gain. Much better results will be obtained by buying a mold for the largest bullet available and sizing it heavily to bring the body down to a reasonable oversize, accepting the damage to the bullet in order to get the necessary diameter in its forepart.

It will be obvious that at best the above procedures are only expedients. The only way to get best shooting from cast bullets is to cast them in a mold which makes them the right size to begin with.

Plain-base bullets are a special case. They should be paid some attention, since while their power must remain quite limited, they afford the cheapest shooting possible. (Gas check bullets can be fired without the gas check in such loadings, making a special bullet unnecessary.) While as stated above an oversized bullet can be shot with reasonable accuracy, an oversized .30 cal. plain-base bullet is impracticable because of leading. Even with correct powder charges, lead is deposited on the rifling lands. Reducing the bullet to groove diameter corrects this, and correctly-loaded plain-base bullets not larger than groove diameter can be shot quite accurately and with great satisfaction.

Before going on to the other governing features of bullet design, it is advisable to consider the matter of leading.

Troublesome leading

Leading is a very serious trouble. It makes the shooting wild until the lead is removed. Removing it can be very difficult. The brass wire bore brush does little more than burnish heavy leading over which succeeding bullets have passed. Softening the lead by amalgamating it with mercury has often been recommended, but is tedious and the mercury is not always obtainable.[6]

The only cleaning material I have found effective in removing leading is medium steel wool (fine is ineffective). Wrapped on a brass bore brush, it can scrub the lead out. One rifle used in this investigation was intentionally leaded many times in tests of bullet lubricants, and the leading removed in this way. Examination with a Zeiss-Kollmorgen borescope shows little damage attributable to the method of cleaning, but of course it does some harm.

Firing jacketed bullets takes out leading, and I believe that is by far the best way. For safety, first remove the bulk of heavy leading with steel wool, then two full-charge rounds suffice. These will leave their own metal fouling which must be wire-brushed out before firing cast bullets again—it may not be visible to inspection from the ends of the barrel, but it is there. Reduced loads minimize the fouling from jacketed bullets, and may be advisable in some environments. Three shots with jacketed bullets loaded to about 2000 f.p.s. clear leading out excellently, and their fouling is brushed out with ease.

It would be of little use to remove leading only to have it reappear. Fortunately, it is completely preventable. It occurs only through lack of knowledge of prevention.

Leading results from excessive charges of reduced-load powders (4759, 2400, IMR 4198, etc.). Medium and slow-burning powders beginning with IMR 4064 do not leave leading in any charge. Leading is positively prevented by limiting the charges of reduced-load powders to those that will be given in Part 4. Medium and slow-burning powders can be used in any charge which shoots well.

This prevention of leading is so positive that even pitted barrels can be used with cast bullets without trouble. The long-standing belief that pitted barrels must lead reflects the fact that cast-bullet loads, including also .22 rimfire, have been marginal in this respect and poor bore condition was sufficient to make them unsatisfactory. Correct loading makes cast bullets practicable in any barrel properly serviceable for jacketed bullets. ■

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Footnotes for this article on page 144.

Cast Bullets in Rifles

Bullets, loads, accuracy

PART 4 OF 4

By Col. E. H. Harrison, USA (Ret'd)

NRA Technical Staff

IN addition to possessing the correct diameters in its body and forepart, the bullet must be of a form adapted to the rifling.

Rifling can be variously designed. After long experience, it has been concluded generally that the various rifling forms give only limited differences in performance with jacketed bullets. It developed in this investigation, however, that the form of rifling affects materially the performance of cast bullets.

Rifling forms commonly encountered in .30-'06 rifles are shown on page 25.

Almost all cast bullets for rifles are made up of a forward bore-size segment and a rear groove-size segment. Fig. 13 illustrates the 3 proportions in which this can be done.

The vital feature is length of bearing. Failures are due to the bearing not being long enough, or to its being divided unsuitably between the 2 parts.

It might appear at first sight that the bullet with long bore-size forward part is best, since that permits most of the bullet to lie ready aligned in the bore before discharge. An artillery shell is so designed. Its steel body lies almost entirely in the bore on loading, and its forward shoulder or bourrelet rides on the lands and so guides the shell at its forward end, while a narrow driving band seals and guides the aft end.

In general, such a design fails in a cast bullet. The reason is that most barrels are rifled with a few narrow lands, and the bullet body is not steel but only alloyed lead. The body is then too easily pressed down over the lands on one side or another by the forces of discharge, tilting the bullet in the bore. From that condition, it will yaw excessively in flight, and successive bullets will not fly the same.

For this reason, reliable cast bullets generally must have a long body like that of the right-hand bullet in Fig. 13; or a body of good length with a forward bore-riding part of moderate length, as in the middle bullet of that figure.

There is an important exception. Model 1903A3 Springfield rifles are for the most part rifled with only 2 grooves, leaving 2 extremely wide lands. These positively guide the long forepart of bullets like the left-hand one in Fig. 13. Such bullets are best in these 2-groove barrels, though others can often be made to group very well.

There is ample variety to meet the above requirements among the many bullet designs available. This variety is one of the most attractive features of cast bullets.

The 10 bullets which were found most valuable are shown on page 26. Accompanying remarks tell something of how they should be used and what can be expected of them.

Powder charge determines success

The most important factor of all in the success of cast bullets is the powder charge. It must get the bullet out of the barrel without deforming it.

It is on precisely this point that most cast-bullet failures have been made. The fact that loads must be reduced from those used with jacketed bullets has led to the employment of reduced-load powders predominantly. They have been loaded at what seemed a reasonable level (usually indeed quite a safe one), the bullet was deformed by the pressure of the quick powder, and the handloader never knew what happened to the accurate shooting he expected.

The error is in using mainly the fast-burning powders. They are correct for very light loads only. If anything more is wanted, it is necessary to go to

Fig. 13: The 3 basic forms of cast bullets: (l. to r.) No. 311334, short body and long bore-riding forward part; No. 311284, body and forward part both of good length; and No. 311467, long body and very little forward part

medium- and slow-burning types. The very slowest can be used, and for heavy cast-bullet loads they must be. To the first class belong Unique, 4759, 4227, 2400, the .30 carbine powders, and (for our purposes) 4198. To the second belong 3031, 4895, Hodgdon B. L. "C" Ball-Powder, 4320, 4064, and HiVel 2. To the third or slow-burning belong for example HiVel 2 again, 4350, 4831, and .50 machine-gun powder. Within the first 2 classes, the charge must be much lighter than commonly used for those powders. Velocity increase is obtained by going to the next class. In the last class comparatively heavy charges may be used, with some powders even the cartridge case full.

Taking a gross view, it is clear that a too-heavy charge deforms the bullet beyond the point at which it will group well. However, it appeared at least possible that ignition and burning characteristics of the propellant might also affect results. Some investigation therefore was made on this point, and some of the examples obtained are shown in Fig. 14. These give a rather strong indication that fundamentally the height of the peak pressure decides success or failure with cast bullets.

Maximum performance level

From this and many other indications, I believe that with presently available means, the maximum performance level attainable with lead-alloy bullets in the .30-'06 with reliably accurate shooting is represented by about 2200 f.p.s. velocity and 30,000 p.s.i. pressure.

I have never seen any good indication that one kind of powder will shoot smaller cast-bullet groups than another, presupposing correct loading. There are, however, a few kinds which for certain reasons are especially suitable or unsuitable.

The only one which I believe has any clearly unfavorable characteristic is Unique. Though excellent in many ways, it tends to leave small deposits of half-burnt lead near the chamber, and no way of loading could be found which completely prevented it. This powder, the only one which behaved in this way, should, I believe, not be used with cast bullets in the .30-'06.

HiVel 2, remarkable as the only powder which can be loaded in a wide range of charge weights behind cast bullets, sometimes leaves a little round drop or two of lead in the rifle bore. This, however, can be corrected by a slight reduction of the charge or with a soft wad over the powder as explained below.

At the other extreme, Ball-Powder has the favorable property of a low flame temperature especially at the start of burning. There proved to be no special need for this distinctive characteristic in cast-bullet loading, except with

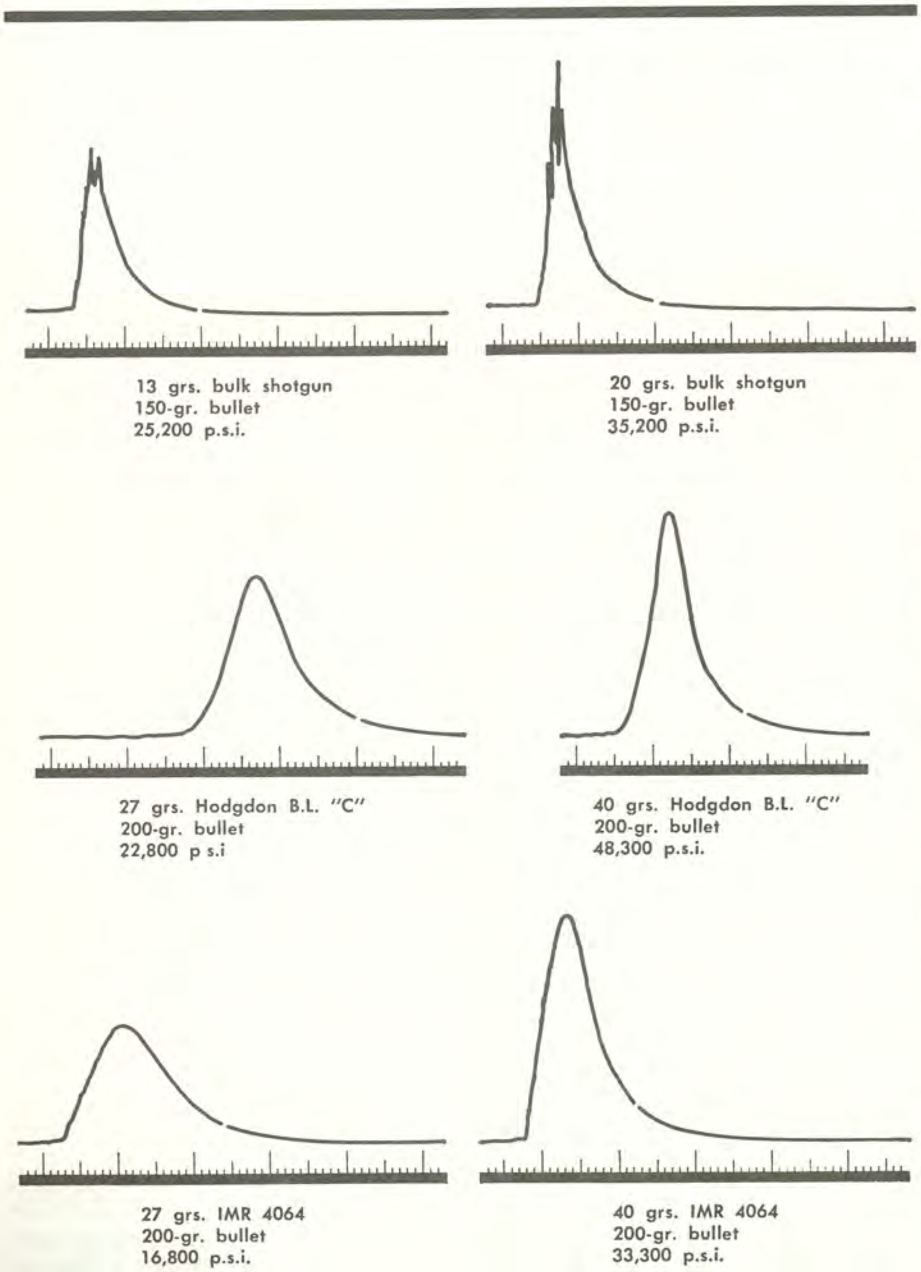


Fig. 14: Pressures vs. time developed by some powders suitable for cast bullets. Horizontal scale of time (l. to r.) is marked in tenths of milliseconds; peak pressure is noted in pounds per square inch crusher gauge, which is usual measure of powder pressures. The left-hand charge of each pair shoots good groups with cast bullets, the right-hand charge shoots poor groups. The powders differ in smoothness and general form of pressure curve, slope of its rising branch, and ignition time; but in all the powders, the characteristic difference between good-grouping and poor-grouping loads is height of the pressure peak. Each powder can be used very successfully with cast bullets, the one essential being use of a limited charge for that powder

plain-base bullets. These require rather careful adjustment of the powder charge to prevent leading, and .30 carbine Ball-Powder is very convenient because it is less critical in this requirement.

Delivering bullet straight into barrel

Since a successful load must deliver the bullet straight into the barrel, an investigation was made of special loading methods, calculated to accomplish this, which can be followed with the usual loading tools.

One of these is the old practice of seating the bullet shallow in the case neck, so it is pressed against or into the rifling when the rifle is closed. This has been beneficial in the .22 rimfire, and agrees in principle with the practice of pre-seating the bullet in the rifling which was followed in blackpowder target rifles. (Loading in this way may cause an undesirable pressure rise in full-charge ammunition with jacketed bullets, but in .30 cast-bullet loads this has no importance.) In light loads this procedure makes very little performance difference. In medium and heavy loads it results in some improvement in both alignment and sealing of the bullet, but the effect is small.

It appeared there is no benefit possible from unconventional ways of sizing and expanding the case neck. The least harmful of these proved to be use of a neck-expanding plug .001" or .002" smaller than the bullet, as with jacketed bullets. Bullets not above groove diameter can be loaded in the same die equipment as that for jacketed bullets. However, an expanding plug of full bullet size is better. It is true that care must be taken to keep cases trimmed to the .30-'06 allowable overall length of 2.494", and to segregate or reject cases into which the bullet seats too easily in assembly. Here the ammunition manufacturer has an advantage in obtaining uniform results since he uses only new cartridge cases.

It might be expected that wads would be useful to protect the bullet from the hot powder gases. The experience during this investigation was that most wads do little to protect the bullet, and grease wads have very little lubricating effect. Wads generally appeared to have a slightly unfavorable effect on grouping. There is little case neck below the seated bullet (sometimes none at all) to hold a wad. With a powder which is suitably slow-burning for the load, eventual failure of the bullet occurs not from powder gas heat but from plastic

2-groove rifling—To speed production, most M1903A3 rifle barrels were rifled with only 2 grooves. The rifling form and dimensions are the same as in the usual Springfield 4-groove rifling described below, but one pair of grooves is omitted. The lands cover ⅝ of the bore. Barrels so rifled are not popularly esteemed, but in fact give very reliable results with Service ammunition. Cast bullets with short groove-diameter body, the rest of the bullet bore-size, are guided positively by the abnormally broad lands, and shoot excellently in these barrels. Ideal No. 311334 is such a bullet, and is best even for light loads

4-groove rifling—M1903 and M1 rifle barrels have 4 broad grooves, and lands only 1/3 as wide as the grooves. The lands therefore occupy ¼ the circumference. They give this rifling a performance characteristic opposite to that of 2-groove rifling, with cast bullets. The lands are too narrow to guide firmly anything riding on them, and the bullet must have a groove-size body of good length. Ideal bullets Nos. 311467, 311284, and 311291 are among the best for 4-groove rifling, because of their long bodies

5-groove rifling—Of British origin, this is seen in M1917 "Enfield" rifles and British-made .30-'06 sporting rifles, as well as in .303 Lee-Enfield rifles. Essential characteristic is not the number of grooves, but the equal width of lands and grooves. Lands therefore occupy half the bore. Cast bullets should be chosen as for use in barrels with 2-groove rifling

6-groove rifling—Most sporting and target rifle barrels have been rifled with 6 grooves, with usual .300"-.308" diameters. As in the 4-groove Springfield, lands cover only ¼ the bore. These 6-groove barrels require the same cast-bullet forms as 4-groove barrels, and appear to handle cast bullets somewhat better

8-groove rifling—Much shooting was done in one heavy target barrel so rifled, diameters .300"-.308", lands covering ¼ the bore. It required bullets of same form as for 4- and 6-groove barrels. Performance was unusually good

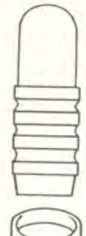
Multi-groove rifling—Many lands and grooves serve to spread the engraving and torque stresses favorably over the bullet. The Marlin Firearms Co. has adopted their Micro-Groove rifling for all their rifled arms. Cast-bullet test firing was done in an experimental heavy barrel with Micro-Groove rifling, in this case having 16 grooves, lands half as wide as the grooves, bore .3067", grooves .3082" diameter. Groove depth therefore was only ¾ of .001". Light and medium cast-bullet loads fired from this barrel, using bullets with long groove-size bodies, gave very fine accuracy. Heavy cast-bullet loads gave wild shooting, and it was obvious the bullets did not receive sufficient rotation. This is the only such case with .30 cal. cast bullets that I have ever experienced or reliably heard of. A Watts 24-groove barrel gave excellent results with cast-bullet loads. Obviously any bullet used in shallow rifling must depend on a long groove-size body, since no current cast bullet has a forepart large enough to fill the bore diameter

311359, 115 grs.—There is some need for a very light, short-range bullet. This design, though modern-looking, is quite old. I believe its best performance is about 1" at 50 yds., with very light charges. Recovered bullets show the reason, which is large yaw in the rifle bore. Nevertheless it can be reliable within its field, and it can be seated with all grease grooves inside the case neck so cartridges can be carried in the pocket.

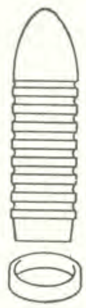
311465, 120 grs.—Lightest of the family of multi-banded .30 bullets. Practically all body, making the most of its short length. Has same practical disadvantages as No. 311467 at right, and its best reliable grouping appears to be about 1½ minutes of angle. However, about 2100 f.p.s. velocity is readily attained, making a light, comparatively fast load. This bullet also can be fired without gas check with very light charges, making the lightest and least expensive of practicable loads.

311413, 165 grs.—Has been more used than any other .30 cal. cast bullet. Gives minute-of-angle groups and smaller in the hands of skilled experimenters using carefully-adjusted light charges. I have never obtained good shooting with medium or heavy charges from this bullet in lead alloy and have never learned of anyone doing so. The long point, though desirable from the standpoint of exterior ballistics, is obtained by cutting away the sides of the forepart leaving it without support. The unavoidable result, with all charges but the lightest, is deformation and yaw of the bullet in the rifle bore (confirmed from recovered bullets) and consequent poor grouping. Repeated failures with this widely-used bullet have had an unfortunate effect on popularity of cast bullets in rifles generally.

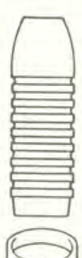
311403, 170 grs.—Designed by no less a person than H. M. Pope for light-load target shooting in .30-'06. Tapered from bore size at leading band, to oversize base band which is intended to be only started by hand in unsized case mouth. However, the base band oversize is carried much too far. The mold tested cast the base band .317", which even lightly started in case mouth made cartridge too large to enter chamber. When loading was accomplished by reaming case necks, it proved impossible to completely prevent leading on top of rifle lands. If base band were not over .309", and last grease groove correspondingly deepened, the bullet could be expected to perform well with appropriate light charges.



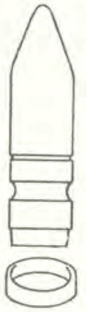
311291 (originally 308291), 170 grs.—One of the original 1905 gas-check designs, and successful like all that group. For best results, its forepart must be full .300" diameter and body should be not above .308". With these dimensions, it groups excellently both with and without gas check, with correct charges. Has the additional practical advantages of being easy to cast and inspect, and of exposing no grease in the loaded round. The best medium-weight bullet when the above qualities are required.



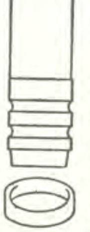
311467, 175 grs.—Essentially same as some of the very first Ideal .30 cast bullets, with gas check added. Long groove-size body, with first 2 bands a little smaller. Has inconveniences of somewhat difficult casting and inspection, and exposure of grease in the loaded cartridge. But accurate and consistent performer in medium and heavy loads in all narrow-land rifling, and because of narrow bands will adapt to broad-land rifling. I have not tried the shorter No. 311466 (150 grs.) but others have reported good results with it and these would be expected.



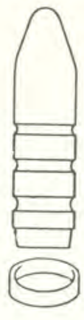
311407, 180 grs.—Like 311467 but blunt point, which improves stability at low velocities. Performs well at low and medium velocities, and in .308" diameter is excellent without gas check with suitably light charges.



311334 (originally 308334), 190 grs.—Designed for the Springfield 1903 rifle soon after the latter was standardized in 1906 form. However, with medium and heavy charges it is unreliable in the M1903 and others with narrow rifling lands. Its long bore-size forepart is guided positively by the broad lands of the 2-groove M1903A3 rifle, in which it shoots excellently and is the best bullet.



311299, 210 grs.—Another of the original 1905 gas-check bullets. Intended for the .303 British cartridge, it is usually cast with .314" body and .303" forepart. When body is sized to .310" (which must be done in 2 steps except with strong sizing machine) this bullet makes best practicable fit at point of greatest wear in a worn barrel. Very slight erosion of lands before chamber, determinable only with breech bore gauge or by recording number of jacketed bullets fired, is sufficient to admit this bullet. Sized as above, it is in that situation the best bullet and gives results comparable to those of No. 311284 in a new barrel.



311284 (originally 308284), 2 **grs.**—The first gas-check bul and still the best heavy bullet unworn narrow-land barrel Groove before first band meant to be filled with lubric as well as act as dirt catch With modern powders, groove can be left dry and bullet seated to expose no grea Long body, and forepart moderate length; for best res these must be .308" and .30 respectively. Groups excellen with all medium and heavy ca bullet charges, and is the b available for heaviest loads, cept in worn barrels (see 311299). Also groups excellen without gas check, with suitab light charges, but for that use 311291 is of more appropri weight and requires less m

deformation of the bullet under p sure, for which no wad of practica thickness gives any help.

Worthwhile wad uses

There are, however, two worthwh uses for wads with cast bullets. One is the lightest loads, in which the powd charges occupy but a small part of t .30-'06 case. These small charges shou be at the primer end of the case firing. This is especially true with m reduced loads of Ball-Powder, whi without this precaution are likely show a long ignition time (see Fig. which also may be irregular. Where is not convenient to raise the rifle mu zle before firing, the charge may be he back against the primer with a ball 2 grs. weight of tissue paper tamp lightly down on it in loading. The oth use is with HiVel 2 powder, to he prevent deposit of small lead drops the rifle bore as already mentioned. ball of tissue paper of 3 grs. weig loaded in the same way proved valuab for this purpose.

Very light and very heavy loads ha special requirements.

Very light loads can dispense wi the gas check. Their special requir ments are:

(1) The bullet should have not l than 3 bands, and it must not be larg than groove diameter of the rifle barr

(2) The powder charge must be ligh ½ to 1 gr. below the lightest ones the table of charges on next page.

(3) The lubricant may have to b changed or adjusted until the bore left in good condition, the test bein easy wiping with a dry patch. Contra to all correct gas-check loads, corre loads without gas check leave a f

small flakes of lead in the fouling, but these remain unattached and do no harm.

Very heavy loads, exceeding the power of any in the table below, require extraordinary means to prevent deformation of the bullet by powder pressure. I found no satisfactory means. The basic effort was on charges of unusually slow-burning powders, intended to give the required thrust without rising above the pressure which deforms the cast bullet. These all were practical failures, partly because powders slow enough to be effective left very undesirable quantities of unconsumed grains, and most of all because their grouping was uncertain. The whole purpose of this investigation was the removal of uncertainty from .30 cal. cast-bullet performance. Supported by all the facts which have been given, the loads which accomplish this are outlined in the following table.

The charges in the table are not very flexible. Materially increasing them destroys accuracy of shooting, though the experimenter may think at first he has succeeded. Materially decreasing them results in poor burning (except with HiVel No. 2, which can be loaded in materially lighter charges than those shown). For the light loads any bullet alloy can be used. For the medium and heavy ones, the alloy must be at least as hard and strong as linotype metal. Powders shown are the ones which were thoroughly tested. Others can be interpolated on the basis of their general performance characteristics which are well known to handloaders. The non-canister powders are available from B. E. Hodgdon, Inc., Merriam, Kan. Because of its light weight, bullet No. 311465 gives velocities materially higher than the typical ones noted at the head of each column.

Factors determining success

I hope this article has given some appreciation of the real factors determining success with cast bullets in the .30-'06 rifle.

They are now summarized as follows:

(1) Advantages of cast bullets are low cost, independence from supplies of ready-made bullets, adjustable power within wide limits, and unlimited barrel life. Disadvantages are an inevitable limitation in velocity, and an accuracy limitation which has been experienced hitherto.

(2) Mere uniformity of components and loading procedures provides no remedy for inaccurate shooting, so long as the components and procedures remain wrong.

(3) The decisively important factors are bullet hardness, bullet design (including bullet dimensions and relation to rifling form), and powder charge.

(4) Traditional bullet alloys are inadequate for medium and heavy loads, for which at least linotype metal or equivalent is required. All alloys perform well in light loads.

(5) Choice of bullet lubricant is rarely decisive to success. The handloader can, however, gain some limited improvement by experiment, starting with the reliable Ideal lubricant and using quality of bore fouling as the test.

(6) Bullet diameter is decisive. Any forward part of the bullet with the function of riding on tops of the lands must be at least .300" diameter. The body of a gas-check bullet should be not above .308". The body of a bullet fired without gas check must be not above .308".

(7) Sizing does not remove most defects, and always tends to damage bullets. Best results are obtained only when the bullet is cast to the approximately correct dimensions. The lubricating and sizing machine is a great convenience in greasing bullets, for which use the die should be as large as the cast bullet. When sizing is necessary because bullets are oversize, it should be done in a die with a sloping shoulder designed to squeeze the bullet, not a die with square cutting shoulder since in the general case that fails to center the bullet and takes more off one side than the other.

(8) Bore leading is absolutely fatal to accurate shooting. Severe leading is very hard to remove. The most practical method is to fire two or three jacketed bullets, for safety first scrubbing most of the leading out with steel wool. It is useful to lead the bore once, since after that the user will be willing to adopt the necessary prevention. This consists in keeping charges of reduced-load powders very low. Medium- and slow-burning powders will not lead in any charge.

(9) Rifling type affects performance of cast bullets. For best results, broad-land rifling requires a short bullet body and long bore-riding forward part; narrow-land rifling the opposite.

(10) The fundamental requirement is to get the cast bullet out the muzzle undeformed. The deforming agent is powder gas pressure, and the only way to prevent deformation is to keep the pressure down. The levels to which powder charges must be restricted for that purpose, so far as repeatedly confirmed experiment has led me to believe, are given in the table of loads.

The matter of accuracy

The accuracy obtainable from cast bullets, the object of this whole investigation, must depend in the first place on the rifle and shooter. What it takes to make a precisely-shooting bolt-action rifle is reasonably well known. When cast bullets are to be fired, it is only necessary also that the bore be well wire-brushed to take out the fouling from jacketed bullets, and that the barrel not be heated in firing. Only heavy-barreled target rifles of high quality can reliably deliver best shooting. I believe it is less appreciated that by no means every user can shoot the .30 cal. rifle well enough to establish the performance of really good ammunition, even from a bench. The requirements of let-off without the almost undetectable

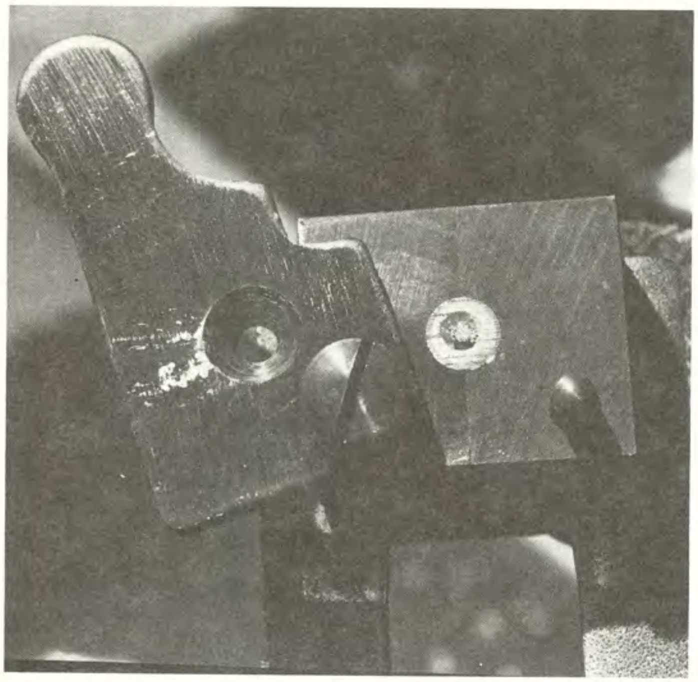
Ideal Bullet and Nominal Weight	4759, H-240,[1] Carbine Ball—P. (1300 fps)	Herc. 2400 (1300 fps)	IMR 4227 (1300 fps)	IMR 4198 (1600 fps)	B.L. "C"[1] Ball—P. (1700 fps)	IMR 4895 (1850 fps)	IMR 4064 (1950 fps)	HiVel[1] No. 2 (2000 fps)	IMR 4831 (2100 fps)
2- and 5-groove rifling									
311465—120	13	14	15	21	30	34	36	34	—
311334—190	12½	13½	14½	20	28	32	34	33	44
4-groove rifling									
311465—120	13	14	15	21	30	34	36	34	—
311413—165	12½	13½	14½	—	—	—	—	—	—
311291—170	12½	13½	14½	20	28	31	34	31	42
311467—175	—	—	—	20	28	31	34	31	42
311407—180	12½	13½	14½	20	28	31	—	—	—
311284—210	—	—	—	—	27	30	32	30	42
6-groove rifling									
311465—120	13	14	15	21	30	35	36	34	—
311413—165	12½	13½	14½	—	—	—	—	—	—
311291—170	12½	13½	14½	20	30	33	35	33	44
311467—175	—	—	—	20	30	33	35	33	44
311407—180	12½	13½	14½	20	30	33	—	—	—
311284—210	—	—	—	—	30	32	34	33	44
8-groove rifling									
311465—120	13	14	15	21	33	35	36	34	—
311413—165	12½	13½	14½	—	—	—	—	—	—
311291—170	12½	13½	14½	20	32	33	35	33	45
311467—175	—	—	—	20	32	33	35	33	45
311407—180	12½	13½	14½	20	32	33	—	—	—
311284—210	—	—	—	—	32	32	34	33	45
Marlin Micro-Groove rifling									
311465—120	13	14	15	21	29	32	34	32	—
311467—175	—	—	—	20	27	30	—	—	—
311407—180	12½	13½	14½	20	27	30	—	—	—

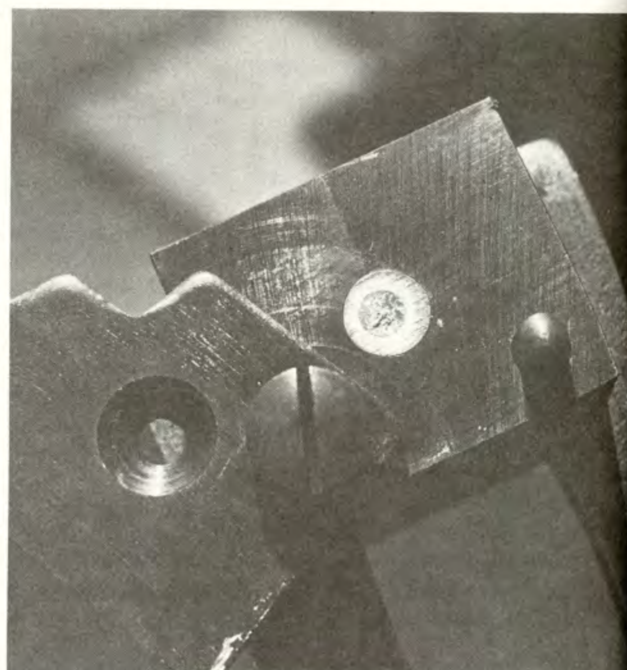
flinch that, I believe, affects most shooters, and of holding the rifle so uniformly that it recoils at every shot almost exactly the same, are very severe.

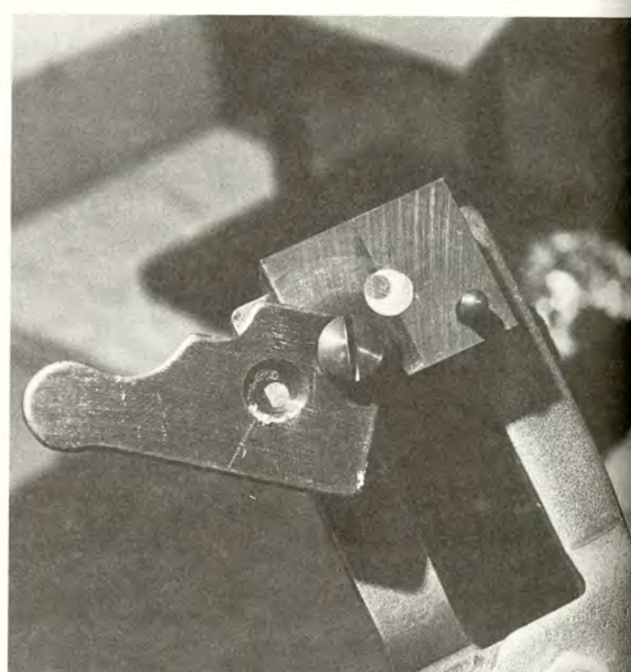
With these requirements fulfilled, the gentlemen who assisted in the investigation demonstrated that with correct .30-'06 cast-bullet loads, 5-shot groups of 1½" diameter at 100 yds. are readily obtained. Some of them consider such groups a failure. They shoot half or more of their 5-shot groups under 1". This is equal to the grouping of any .30-'06 jacketed bullets except possibly the very best. There is little difference among the loads of the table in accuracy obtainable, but the heavier loads are harder to shoot well.

I think it is important to note that good results were in each instance obtained with correct loads immediately on trying them. This may appear remarkable, since the lead-alloy cast bullet is much softer and more vulnerable than any jacketed bullet. The explanation, which I hope has become clear, is that the cast bullet must be fired in a load which does not deform it. Within that limitation, to which it will always be subject, it has even a certain advantage over the jacketed bullet which is valuable to the user. Making best jacketed bullets is partly an art. The only reliable indicator of their quality is their shooting. Cast bullets which pass a close visual examination and a check weighing can, however, be relied on to be good.

It remains to consider how the inherent power limitation on .30-'06 cast bullets should be regarded. The limitation is comparative, not absolute. Beside the attainments of modern technology, all shoulder rifle bullets are slow, short-ranged, and weak. A judgment is appropriate only in light of what the bullet must do. Much of the shooting most enjoyable to many shooters, in some cases most of it, is within the power of cast bullets. Whether the shooter will wish to use them must depend on the importance to him of the advantages of cast bullets which have been mentioned.







Above

Holes in the bullet base indicate shrinkage voids caused by not pouring a large enough sprue, or not maintaining long enough contact with the pouring spout or dipper. Such bullets will have a tear drop shaped cavity near the base. Any bullets with obvious holes, regardless of size, should be rejected and remelted, since their accuracy can never be better than mediocre.

Upper Right

If the sprue is cut before it is completely hardened, semi-molten metal may be smeared across the blocks and bottom of the sprue plate. That can cause out of square bases. Another defect, shown here, is fracturing of the sprue cut, tearing metal from the base. Pistol bullets with such defects may be acceptable, but match rifle or pistol loads should only have perfect bases.

Right

A perfectly sharp, square base with a clean cut-off is the objective of the careful bullet caster. The offset sprue here is intentional, as it is used to orient the bullet in the rifle chamber, after marking it with a felt tip pen. This can be used as an alternative to permanently marking the mould with a punch or file, and is a help to moulds giving an off-center cut.

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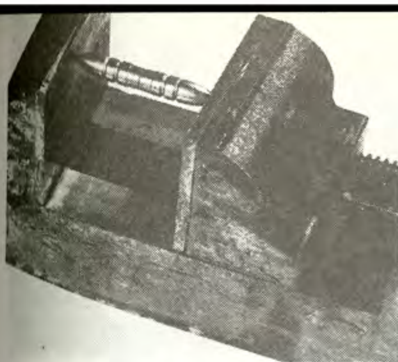

Fig. 1: A simple hardness comparison is given by pointed bullets of same shape cast of the compositions it is desired to compare, and lightly compressed as shown. The nose crush-up is an indication of comparative hardness, but not on a quantitative scale

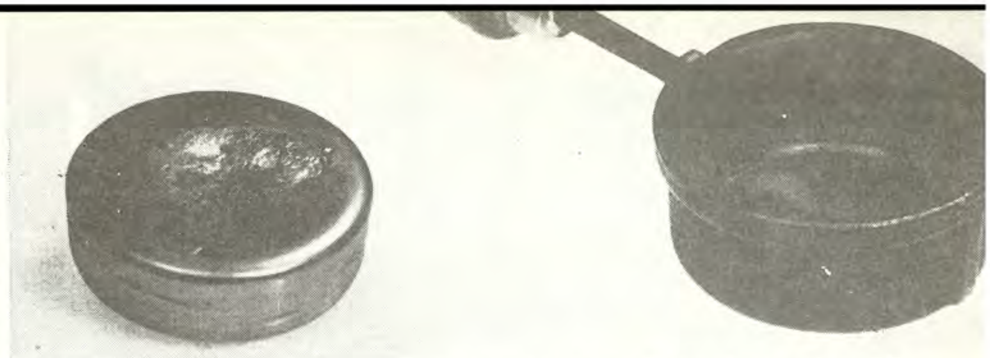

Fig. 2: Sample pieces can if desired be cast in shape offering large work surface. Mold is iron pipe cap with threads bored out on slight taper. Bottom must be faced very smooth, to leave suitably smooth work surface on cast piece

Measuring the Hardness of Cast Bullets

By Col. E. H. Harrison, USA (Ret'd)

NRA Technical Staff

All lead-alloy bullets are much softer than jacketed bullets. Such hardness and strength as they do possess are often important to their performance.

Alloys of desired characteristics can be assured by using new metals in the required proportions, or by buying alloys. The cost of even new metals for 180-gr. cast bullets is under 1¢ per bullet, at 1959 prices, which is less than one-fifth the cost of jacketed bullets.

Scrap metal often 'unknown'

For the very minimum cost, however, most handloaders make their cast bullets of scrap or salvaged metal.

The user of such metal ordinarily must accept the fact he has very little idea of its composition and qualities.

Especially for medium and heavy cast-bullet rifle loads, the hardness of the metal can make a great deal of difference.

A lead-alloy hardness tester for the handloader was on the market for some years, but is no longer listed. It measured hardness on its own scale, which was not related to the recognized scales of hardness used in the metals industry.

An ingenious and simple method of hardness comparison, due to F. W. Whitlock, uses equipment that many handloaders already possess. A pointed bullet of the alloy to be tested, and a like one cast of pure lead, are placed base to base in a vise, and compressed until the nose of each is partly crushed (Fig. 1). Obviously the nose of the soft lead bullet will be crushed in more than that of the alloy bullet, and the difference is a measure of their relative hardness. It is, however, not related to any standard hardness scale, nor does twice as much compression, for example, mean a corresponding hardness ratio.

If blocks of bullet metal are pressed in the vise with a steel ball between them, however, the indents made by the ball provide a hardness measure which can be related to some standard hardness scales, with their advantage of universal applicability.

Since the ball exerted the same force in each dent, the unit force on each is inversely proportional to its area. The diameters of the dents are readily measured. Their areas are to each other as the squares of their diameters; hence the ratio of their areas is the ratio of the squares of their diameters, or of their diameters squared, which is the same thing. This ratio is a direct comparison of the hardness of the 2 samples.

This result can be expressed in terms of some of the standard hardness scales, such as the Brinell. Neglecting certain small refinements, the Brinell hardness number (BHN) is the unit load the material will support. (The units in which it is expressed are immaterial to our purpose, as we shall see.) It is an absolute and not a merely arbitrary scale; for example, a material of twice the hardness of another will have twice the BHN. To learn the hardness of a sample, then, we need only

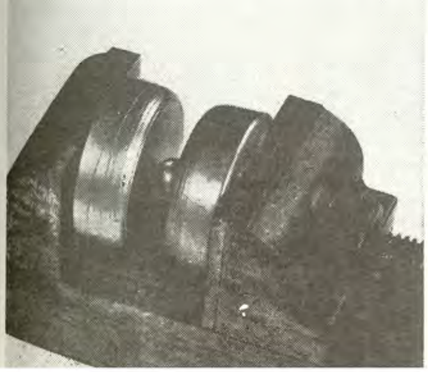

Fig. 3: Steel ball between metal samples leaves indent in each which is accurate measure of their relative hardness, and (when 1 sample is known) can be related to standard Brinell scale as described in text

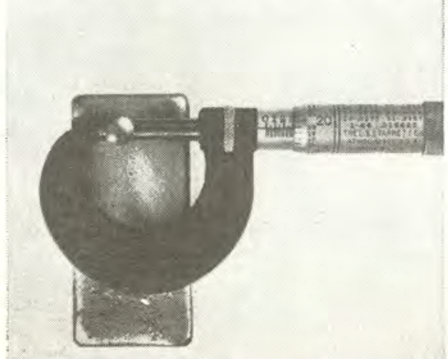

Fig. 4: In measuring, lay anvil and spindle directly on surface to avoid parallax. With care, measuring faces can be set accurately tangent to edges of dent and good measurement obtained. Use magnifying glass

Fig. 5: Inexpensive pocket comparator is neat and convenient tool for same measurement, but does not give better results than micrometer caliper

compare it with that of metal of known hardness.

Convenient standard

The most convenient standard metal for this purpose is pure lead. We require commercial pig lead, which is new metal free of significant impurities. Remelted lead from plumbers' shops, or other used lead, is certain to contain other metals and will not serve as a standard.

The Brinell hardness number of commercial pig lead is approximately 5. The above ball test provides the ratio of a sample's hardness to that of lead. Then we get the hardness number of the sample by multiplying this ratio by 5. In working terms:

$$\text{Appr. BHN} = 5\left\{\frac{\text{diam. dent in lead}}{\text{diam. dent in sample}}\right\}^2$$

For example, in a sample of linotype metal tested by this method the diameters of indents made by the steel ball in the lead and the linotype metal were .210" and .103" respectively. The hardness of the linotype sample was then $5\ (210/103)^2 = 20.8$ BHN. Repeating the test gave diameters of .227" and .113", for a hardness of $5\ (227/113)^2 = 20.2$ BHN.

This illustrates the reproducibility of this method, which is normally within 1 BHN and usually closer. It also illustrates that the diameters of the indents always differ from one pressing to the next—it is the square of their ratio, indicating hardness, which is constant for a given sample.

As a matter of interest it may be noted that the hardness of new linotype metal of usual composition is about 22 BHN. The metal of the example was not quite up to this, which is quite often the case due to loss of tin and antimony during periods of melting. Sometimes even new alloys are found quite short of the hardness they should have, meaning their composition is not as it is stated.

For the determination we need a vise, a steel ball, a micrometer or vernier caliper to measure the indents, and samples of the metal. The steel ball can be of any size; however, to get a conveniently large indent a large ball may be used, ½" diameter or more if it can be obtained. The 1-lb. pigs into which handloaders usually cast their metal are a convenient size for test pieces. Do not chill after casting.

The surfaces into which the ball is pressed must be very smooth. Bottoms of the pigs are too rough from the mold, and even a filed surface is not best. By pouring the metal into the mold at one end, from a very low height, the pig will be left with a smooth surface on the other end large enough for several indents. A special mold for casting the samples can be made if desired (Fig. 2), but is not a necessity.

To press, the sample in question and a corresponding test piece of pure lead are placed in the vise with the steel ball between. The vise is closed slowly until the ball is pressed a little way into each (Fig. 3), not more than one-fourth its diameter into the lead.

Indent readily measured

The indent in lead alloy is beautifully round, with sharp edges. The indent in pure lead is slightly wavy at the edges because of the softness of the metal, but it still can be readily measured.

Lay the anvil and spindle of the caliper directly on the surface, and measure the diameter of each indent (Fig. 4). After measuring, make a scratch or punch mark in each indent to prevent inadvertently using it again.

The measurement also can be made with a 'pocket comparator', available in simple models for less than $15 at current prices. The base contains a graduated transparent reticle which is set on the work to be measured, and viewed with an adjustable magnifier in the top of the device (Fig. 5). This is very neat, but gives no more precise results than a micrometer caliper used as described.

Following are the composition and hardness of practicable lead bullet alloys. They will give the handloader an idea of the real hardness and strength of the alloy he has been using, or the one he may wish to aim for. ■

COMPOSITION AND HARDNESS OF COMMON ALLOYS

Alloy	Tin (Percent)	Antimony (Percent)	Lead (Percent)	BHN
Monotype	9	19	72	28
Stereotpye	6	14	80	23
Linotype	4	12	84	22
Ideal No. 2	5	5	90	15
Electrotype	3	2.5	94.5	12
1-to-10 tin-lead	9	—	91	11.5
1-to-20 tin-lead	5	—	95	10
1-to-30 tin-lead	3	—	97	9
1-to-40 tin-lead	2.5	—	97.5	8.5
Lead only	—	—	100	5

• ZAMAK BULLETS

Editor: Goshen, Mass.

As noted in THE RIFLEMAN in years pa zinc die-casting alloy makes excellent ca bullets, though lighter than lead and e tremely hard. The following summariz some results obtained with Zamak #3, a alloy of this type.

In the .30-'06 rifle, bullets cast in Lyma molds 311413S, 311284, and 308291 we used, as well as bullets from 2 speci molds, 311413ES (.309") and 3112 from which the grease grooves and ga check step were omitted. Here are som typical 5-shot group sizes obtained at 10 yds. bench rest with Zamak bullets, fir from an M1903A3 Springfield with 2¾ Weaver scope, with lead and jacketed bu lets for comparison:

Bullet	*Load*	*Group size*
311413S	10 grs. Unique	1¾"
311413S	12 grs. Unique	1¾"
311413S	16 grs. 2400	1¼"
311284	12 grs. Unique	2.3"
311284	45 grs. 4895	2.0"
311413S (lead)	14 grs. 2400	2.1"
FA-M2-1955 ammunition		2.25"

At 200 yds., the 311413S bullet and 10 gr Unique gave 3.5" groups, and the 3112 with 12 grs. Unique gave 4.5".

The 311413S and 311413ES bulle made smallest groups. As indicated by th letters after the number, these are fro special molds casting their bullets less ove size than usual, while the 311284 bullet the usual .003" above the groove diamete of the barrel. In addition to its effect o accuracy, this oversize probably stresse the rifle barrel considerably since the Zamak bullets are both hard and solid.

When cast of this hard alloy, the ba 311413S bullet grouped better than whe greased or equipped with gas check. Th bare 311284 bullet also performed we It can be loaded to provide the same ze at 100 yds. as M2 Ball ammunition, an with better accuracy. The recovered bulle shows considerable gas cutting, but the is no metal fouling left in the rifle bor

The bare 311413S in Zamak had abou the same penetration in wrought iron a M2 Ball. In ⅞" boiler plate, the Zama bullet fell slightly short of Service armo piercing, but in such material as oak log it out-traveled them all.

In handguns, the 358156 bullet (94 gr in Zamak) in .357 Magnum, and 4524 (122 grs.) in the 1950 S&W revolver, bot perform much better than lead alloy i match loads. The hottest loads leave clean gun. For amusement I recovered th same 452461 bullet 4 times in successio from an oak log and got a 4" group wit it at 50 ft., which shows how hard thes Zamak bullets are.

This hardness all the way through make it very difficult to get the bullets to expan on game. I have had some success with special tip, especially with the long 31128 bullet. Casting such hunting bullets is tim consuming, but the paper-puncher expend far more ammunition than even the full time hunter, and needs no such specia measures.

JOHN BELCK

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Fig. 1: I and bree heavy ca

.45 ACP Handload Accuracy

By Alton S. Dinan, Jr.

During the building of a machine rest to test pistols, the question of barrel accuracy arose. This called for a device to hold the pistol barrel, as hand holding is too susceptible to human error.

The device shown in Fig. 1 was designed and built to accuracy-test barrels, but evolved into an ammunition tester similar to the Mann barrel apparatus shown in Fig. 2.

The Mann barrel is named for Dr. Franklin W. Mann, experimenter and designer of a machine rest which has been proven through decades of use. The very heavy Mann barrel, attached to a rifle action, is laid in a large V-block bolted to a solid base. The barrel recoils freely and can be returned to the same position after each shot.

The Mann barrel is satisfactory for comparing one ammunition with another, but my barrel tester gives the same results using the actual barrel from the pistol.

This device consists of a barrel-holding fixture to which is attached a rifle action. The barreled action is fastened to its own slide and base, making it a self-contained unit similar to the Mann design. The barrel is held in its fixture at the muzzle and breech as it is in the pistol. Barrel vibrations are thus nearly the same as in the pistol.

The tester has a patented trigger, worked with a camera shutter-release so that trigger movement has no effect on shot-to-shot accuracy.

The device is doweled and bolted to a heavy, fixed cast iron machine base weighing about 600 lbs. As the target frame is of steel set in concrete, the only potential inaccuracy is in the barrel and/or the ammunition. The human element is greatly minimized, this being necessary to prove beyond doubt which of the variables is at fault.

The average shooter cannot tell good ammunition from poor, only good from very bad. When ammunition error is added to gun error and these added to the shooter's error, who can say whether one load shoots better than another? As can be seen from the target in Fig. 3, it doesn't take a very small group to score 95. However, this group is the total of all errors, and with test equipment as described each of the variables becomes measurable and subject to correction.

Uniform, balanced bullets needed

All bullets used in these tests were visually inspected for obvious imperfections, then weighed within ½ gr. to discover internal holes or bubbles. A bubble or hole in the center will have little effect on accuracy, but if off-center it will unbalance the bullet and cause a wide shot, or 'flier'.

Bullet hardness is controlled by the ratio of tin and/or antimony to the lead. One of the most widely recommended alloys is 18 parts lead, one part tin, and one part antimony, that is, 18-1-1. Another is linotype metal which is an excellent and quite hard alloy—in fact, harder than necessary. The price of tin being high, as soft an alloy as will do the job is desirable.

A very convenient alloy is furnished by lead reclaimed from the bullet trap. As long as a test sample bullet weighs about 2 grs. lighter than a pure lead bullet, it is hard enough to try. Bore leading is an indication of too soft an alloy, or an inadequate bullet lubricant.

The inexpensive commercial lubricants are satisfactory and are recommended over homemade concoctions.

Bullet sizing recommendations vary from bore diameter to as much as .003″ larger. I find .0005″ to .001″ oversize about right.

This is a good place to discuss the 'as-cast' diameter of the bullet before sizing, and the sized diameter. It has been said before that the cast diameter should be close to sizing diameter, but it is of sufficient importance for repetition.

The firing tests show this very de-

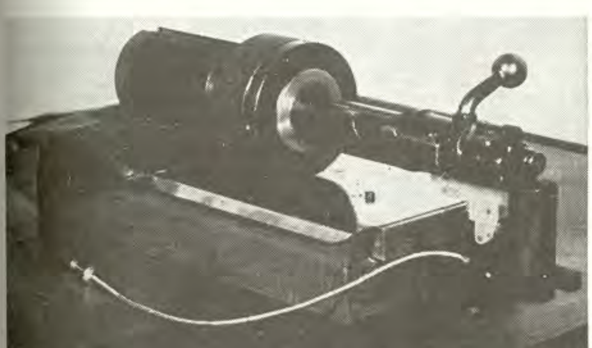


Fig. 1: In barrel-holding fixture, barrel is held at muzzle and breech as in pistol. Device is doweled and bolted to heavy cast iron base. Patented remote control trigger is activated by cable release

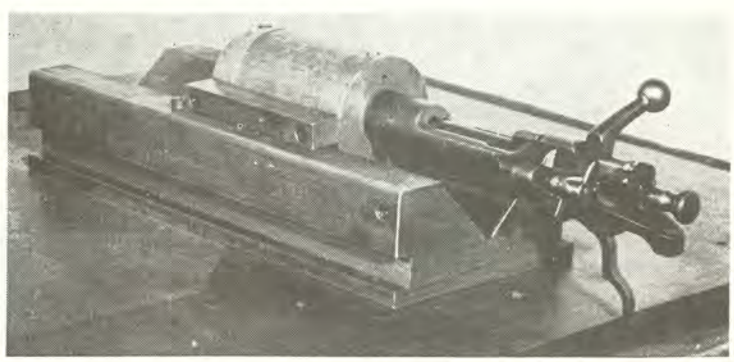


Fig. 2: Mann 6-point rest barrel device consists of very heavy barrel attached to rifle action. Unit rests in V-block bolted to solid base and is free to slide in V-block in recoil. It is returned by hand to original position before each shot

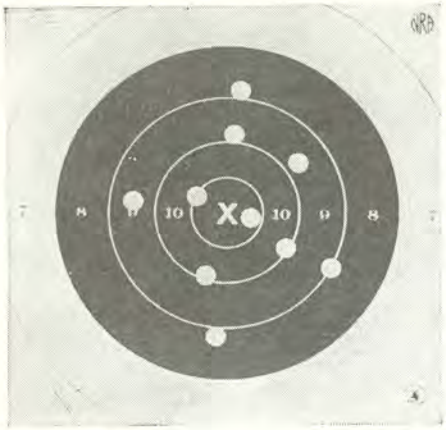


Fig. 3: Although group shown scores 95 it represents total of all errors. Proper test equipment is necessary to measure and correct each of the variables causing dispersion

cidedly, as Tests 3, 4, 5, 6 and 14, 15, 16, 17 are identical except for the as-cast diameters of the bullets.

Group size Oversize Old Mold		Group size Regular New Mold	
3	2.76″	14	2.51″
4	2.75″	15	2.21″
5	3.63″	16	2.81″
6	3.60″	17	2.11″

Bullets making the poorer groups were .4545″ as cast, and the better ones were .453″. Both were sized to .4522″.

Reliable function is the prime requisite for an automatic pistol handload as the most accurate load is worth little if it malfunctions.

Feed failures

The first criterion of a cartridge is that it feed from magazine to chamber. There is no excuse for a feed failure with good ammunition in a correctly accurized pistol.

One common cause of feed failure due to the load is a bullet so soft that its nose sticks on barrel ramp before entering chamber. Another, and probably the greatest cause of feeding trouble, stems from failure to crimp the case onto the bullet.

It has been said that the .45 ACP case must not be crimped because the cartridge seats on the case mouth. This is true as far as it goes, but consider the other aspects of the situation.

The semi-wadcutter bullet, the only one considered here, should be seated out of the case about .015″—.025″ and the case crimped into the bullet shoulder.

The loaded cartridge should be tried in the barrel it is to be fired in to be sure there is sufficient headspace. Insufficient headspace is detrimental to accuracy. With this shoulder exposed the cartridge seats the bullet in the leed of the rifling which seems to be ideal.

Furthermore, the situation in the automatic pistol is different from that in the revolver as the automatic pistol firing pin delivers a heavier blow and has much greater protrusion.

The most important reason for crimping is to prevent the bullet being pushed into the case as the cartridge is fed into the chamber. The bullet strikes the loading ramp with a hard blow and this can push the bullet far enough into the case to change the powder space appreciably. This is equivalent to a variation in powder charge and also gives a variation in seating depth. Either can cause inaccuracy—if the load succeeds in feeding at all.

Value of crimp

Factory jacketed bullets are not crimped, but the cases are new and made to a press fit on the hard bullets. A lead bullet should not fit this tightly, as it could in effect resize those carefully-made bullets down to any odd diameter. A crimp solves these problems and its value has been well proven through much personal experience. See the table for the results of firing tests where the only variation was in the crimp.

The crimp also removes the flare that was put on to facilitate seating the bullet.

There are 2 basic types of crimp used. One, the roll crimp, is done with the standard bullet-seating die. The other is the taper crimp which necessitates another die and another operation on most loading tools. This extra effort is of rather doubtful worth as may be judged by the results.

Roll crimp as used here means that about .020″ of the case mouth is rolled over and forced into bullet. Mouth diameter is reduced to .460″. See Fig. 4.

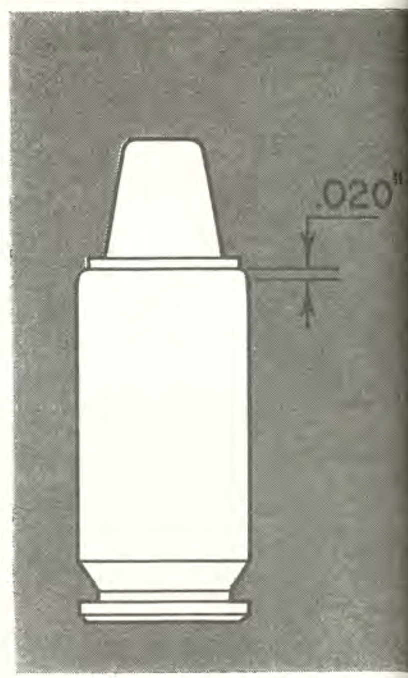


Fig. 4: In roll crimp, .020″ of the case mouth is rolled over and forced into side of bullet. Case diameter is reduced to .460″ at mouth

The taper crimp reduces the case mouth to the same diameter, but has swaging effect on the bullet for a much greater distance.

Tests fired at 50 yds.

All tests were shot at 50 yds. as shorter distance is of little value for showing the true worth of a load in pistol. The same is true for groups of less than 10 shots.

There are many possible loads for the Service pistol. Those listed are some of the most popular for the revolver as well as the automatic. The accompanying table gives the results of many hours of loading and testing. It is hoped that this effort will help pistol shooters attain higher scores.

FIRING TEST OF HANDLOADS

Test No.	Bullet	Bullet Weight (Grs.)	Type Crimp	Powder Charge (Grs. Bullseye)	Alloy (Lead-tin-antimony)	Group 1 (Inches)	Group 2 (Inches)	Group 3 (Inches)	Average Extreme Spread (Inches)	Composite 30-Shot Group (Inches)
1	H&G 78	214	Roll	3.6	18-1	2.45	2.35	3.10	2.63	3.8
2	H&G 78	214	None	4.0	18-1	2.9	2.45	3.35	2.90	3.4
3	H&G 130	181	None	4.0	18-1-1	2.80	2.65	2.85	2.76	3.2
4	H&G 130	181	Taper to .460″	3.6	18-1-1	2.00	2.80	2.75	2.75	2.9
5	H&G 130	181	None	3.6	18-1-1	3.70	3.80	3.40	3.63	4.3
6	H&G 130	181	Roll	3.6	18-1-1	3.70	2.30	4.90	3.60	4.9
7	H&G 130 (New Mold)	186	Light Roll	3.6	18-1	3.20	2.60	2.50	2.76	3.5
8	H&G 130	186	Roll	3.6	18-1	2.55	1.80	1.90	2.08	2.6
9	H&G 130	176	Roll	3.6	Type Metal	1.75	2.30	2.20	2.08	2.5
10	H&G 130	191	Roll	3.6	Pure Lead	3.00	2.90	1.95	2.60	3.2
11	H&G 68BB	200	Roll	3.6	18-1	1.50	2.00	3.00	2.16	3.0
12	Lyman 45266	217	Roll	3.6	18-1	2.00	1.90	2.30	2.07	2.3
13	Super Match	210	Light Roll			2.60	2.00	2.00	2.20	2.7
14	H&G 130	181	None	4.0	18-1-1	2.60	3.00	1.95	2.51	3.4
15	H&G 130	181	Taper to .460″	3.6	18-1-1	2.60	2.35	1.70	2.21	2.7
16	H&G 130	181	None	3.6	18-1-1	3.00	2.10	3.35	2.81	3.5
17	H&G 130	181	Roll	3.6	18-1-1	2.45	1.65	2.25	2.11	2.45

Note: All groups measured from center to center of widest shots
Charge of 4.6 grs. Hercules Bullseye powder with 234-gr. full-jacketed bullet will substantially duplicate Service load. Seat bullet to give over-all cartridge length of 1.275″

Bore Leading

By E. H. HARRISON, NRA Staff

LEADING is a deposit of bullet lead in gun bores in smears, or sometimes lumps. It has a bad effect on accuracy of shooting.

Leading results from an incorrect relationship of gun bore, bullet diameter, bullet lubricant, and powder charge. When only handloaded ammunition is used, leading can be prevented. When it results from firing factory ammunition, it can be removed rather easily except in a few cases. There is, of course, no leading from the firing of fully jacketed bullets.

Rifled bores differ greatly in smoothness. Consequently some lead badly and others very little. Bores improve with shooting and become less subject to leading. In a bore polished by the firing of a few hundred rounds accompanied by several thorough cleanings, used with ammunition not of bad leading characteristics, and cleaned occasionally to forestall lead build-up, leading will not become a problem.

In .22 rimfire arms

The most common and widely used of all ammunition types is the lead-bullet .22 rimfire. This has been noncorrosive since the early 1930's, and it does not rust or roughen the bore. Because of this and also the comparatively good lubrication of the bullets, bore leading of rimfire rifles and handguns is seldom serious. It may be suspected when the arm begins to group poorly in comparison with its regular performance. Then the leading can be removed by pushing several tight-fitting cleaning patches through the bore, followed if necessary by a new brass-wire bore brush of this caliber. A desirable alternative method here is the use of one of the bore-cleaning pastes which have been brought out for removing powder and bullet-jacket fouling from the bores of .22 center-fire rifles.

In center-fire rifles, lead bullets are used principally in handloaded ammunition. Correctly loaded cast-bullet rifle ammunition does not lead. Leading, when it does occur, is caused by loading a bullet which is too large in diameter or which has been damaged by sizing (often both), and by loading too large a charge of fast-burning powder. Such lead is removable with a new brass-wire brush of the correct caliber, assisted if necessary by medium-fine steel wool wound around the brush. Leading is then prevented by changing to a correct bullet and a slower-burning powder even if larger charges must be used.

In center-fire rifles, the firing of one or —at most—2 full-power rounds with jacketed bullet (after scrubbing out part of the lead if there is so much as to constitute an obstruction) removes lead completely. If firing with cast bullets is to be resumed, the bore then should be cleaned lightly with a brass bore brush to remove the bullet-jacket fouling, since this affects the accuracy of cast bullets. Unfortunately this simple method is not effective in .357 Magnum and .44 Magnum revolvers, though jacketed-bullet ammunition is available for them.

Even shotguns are occasionally subject to leading. When severe, it can badly affect the patterns shot. However, the usual leading from factory shells appears as light longitudinal streaks in the forcing cone ahead of the chamber and in the choke. These are easily removed with a shotgun brass bore brush, on which very fine steel wool can be wound without harm. Patented brass wire-wound or wire-mesh cleaners are also good (but not steel brushes, which are damaging). Shotgun leading tends to diminish as the bore is polished by much shooting. If it does not do so, change should be made to another make of ammunition.

There is, however, one kind of shotgun bore leading which is serious. This results from the use of ungreased filler wads in handloaded shells. It consists in a more or less even deposit of lead over the whole bore. This can be very difficult to remove. Being caused by incorrectly loaded ammunition, it is easily prevented by loading well-greased felt or fiber filler wads. These leave a light but effective grease deposit in the bore, and also have the necessary sweeping action to keep the bore in good condition.

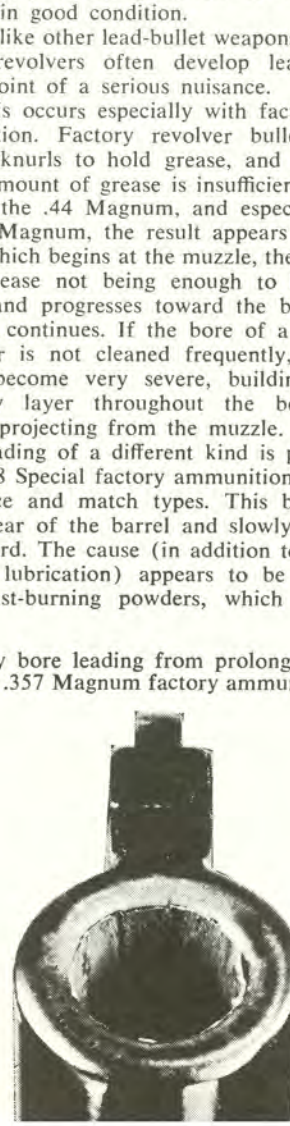
Unlike other lead-bullet weapons, center-fire revolvers often develop leading to the point of a serious nuisance.

This occurs especially with factory ammunition. Factory revolver bullets have only knurls to hold grease, and at times the amount of grease is insufficient.

In the .44 Magnum, and especially the .357 Magnum, the result appears as leading which begins at the muzzle, the amount of grease not being enough to last that far, and progresses toward the breech as firing continues. If the bore of a new revolver is not cleaned frequently, leading can become very severe, building up a heavy layer throughout the bore and even projecting from the muzzle.

Leading of a different kind is produced by .38 Special factory ammunition of both Service and match types. This begins at the rear of the barrel and slowly spreads forward. The cause (in addition to insufficient lubrication) appears to be the use of fast-burning powders, which have a flame temperature high enough to melt off bits of the bullet surface and deposit them on the bore.

Heavy bore leading from prolonged firing of .357 Magnum factory ammunition



Leading is less often a serious problem with handloaded ammunition. The .357 Magnum and .44 Magnum are handloaded with large charges of slow-burning powder which keep the rear end of the bore clear. The large grease grooves in cast bullets carry ample lubrication to the whole length of bore. Correct handloads in the .38 Special leave less leading than factory ammunition. Leading is in part due to cast bullets damaged by sizing before loading, and to the fact that even after sizing they are usually too large. Where this practice is avoided, leading is slight in the .38 Special.

Heavy leading in a center-fire revolver is extremely difficult to remove. No bore cleaner very effective against leading has ever become available, either to dissolve lead or by sufficiently vigorous surface action to loosen it from the steel. Mercury is a partial exception, since it can amalgamate with the lead and thus soften it so it can readily be removed. Without mercury, leading can be removed only by mechanical means. When the leading is heavy, the means must be correspondingly severe.

Leading is often not seen even though looked for, or it may be thought that a bore has been cleared of leading when it has not. Sometimes the gun owner is not familiar with the appearance of leading. Often his visual acuity is simply not sufficient to perceive it. Unless he has youthful, highly accommodative vision, he should use a small magnifier of about 5" focal length (2 power) to scrutinize the bore surface. The test of adequate vision is ability to see bore tool marks.

Polished in cleaning

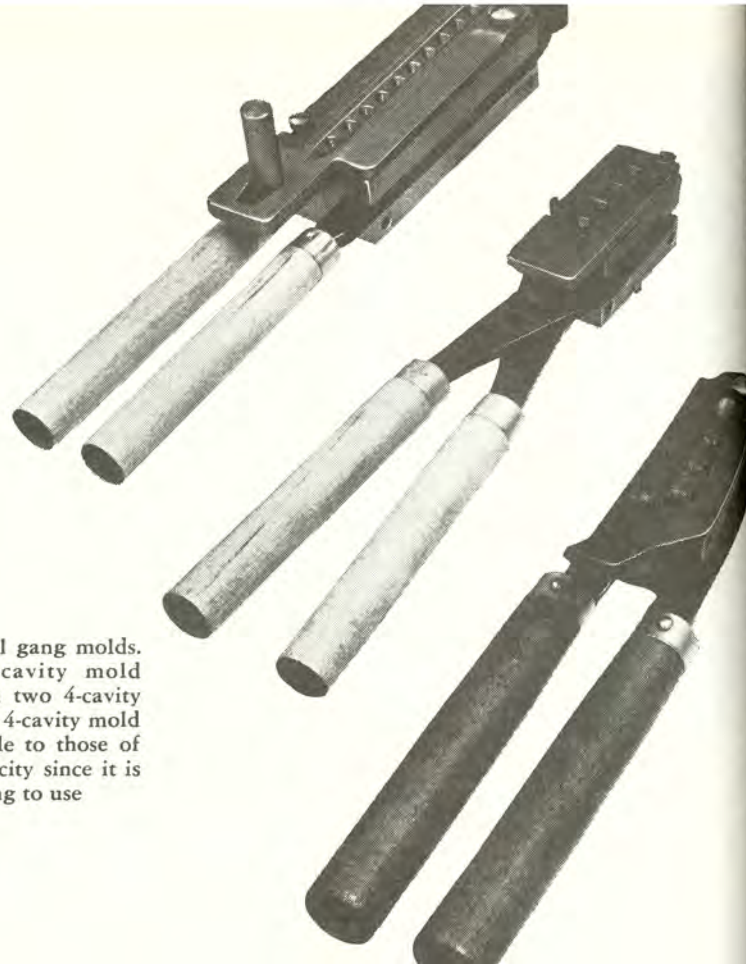
Still another reason for failure to perceive leading is that it is polished and burnished in attempted bore cleaning, giving the appearance of a shiny bore. This usually results from use of brass bore brushes. Necessary as these are, they are comparatively ineffective against heavy leading in revolver bores.

In one manufacturing plant, leading is removed from revolvers being serviced by a Parker-Hale heavy bronze bore brush rotated by a ¾-horsepower geared electric drill. The revolver cylinder and crane are removed, then the barrel is passed over the brush until the bore is clear. Inspection of a sample barrel so cleaned showed no visible damage. The brush lasts for 5 to 10 cleanings, depending on condition ot the barrels. In another plant, bores are treated with mercury before brushing, which makes lead removal easy.

When mercury is not available, the user must remove leading with mechanical means available to him. For bad leading, this generally means a patented scrubber or else a brass bore brush wound with medium-fine steel wool. While the latter is certainly undesirable in principle, careful borescope examination of bores cleaned in this way showed little damage attributable to the cleaning. Frequent cleaning keeps leading from ever becoming serious, and avoids need for severe procedures. ■

BEGINNER'S DIGEST

USING GANG MOLDS



1 Typical gang molds. A 10-cavity mold (top) with two 4-cavity molds. The 4-cavity mold is preferable to those of larger capacity since it is less fatiguing to use

WHERE large quantities of cast bullets are needed, time is saved in their preparation through use of multi-cavity gang molds casting 4 or more bullets simultaneously. Gang molds of current manufacture can be had to cast 4, 6, 8, or 10 bullets. They are not regularly furnished with attachments for making hollow-base or hollow-point bullets. Gang molds are constructed similarly to smaller molds, but their use is somewhat different, primarily because of their greater size and weight.

Machined from cast iron

The mold blocks are generally machined from fine-grained cast iron, but brass has been used. The 2 halves of the mold blocks are aligned by short dowel pins from one block to the other, and the blocks are hinged together so that the mold can be opened to release the bullets. The opposed faces of the mold blocks are lightly scored to vent air from the bullet cavities when the molten alloy is poured into them. Otherwise, the bullets might develop internal pockets or surface imperfections because of air trapped in the cavities.

Tapered pouring holes are drilled in a cutoff plate over the center of each bullet cavity, and these holes are usually connected by a trough or gutter. A dipper with taper-nosed pouring snout matching the tapered pouring holes in the cutoff plate can be used to fill the individual cavities. The usual procedure, however, is to service a gang mold with an open ladle, or a bottom-pouring pot or furnace with lever-operated valve.

The sprue, or stem of excess metal extending above the bullet base, is sheared when the cutoff plate is struck aside preparatory to opening the mold.

A melting pot or furnace holding at least 15 lbs. of bullet metal is desirable for use with gang molds. Vessels of lesser capacity, unless more than one is used, are not as desirable since time will be lost in waiting between melts.

Electrically heated furnaces with thermostatic controls are markedly convenient. The temperature of the bullet metal can be held within the optimum range for casting, yet the melting of ingots may be hastened by elevating the temperature temporarily above the optimum casting temperature.

Use auxiliary pot

Time can be saved by employing an auxiliary pot or furnace to melt bullet metal for use in a small, bottom-pouring furnace, or 2 furnaces can be used so one is always ready for casting.

Regardless of the pot or furnace used, the heat source must be sufficient to melt the bullet metal until it flows freely. Some bullet designs demand higher than normal casting temperature to insure complete filling of the mold cavities. However, care must be taken to avoid overheating the metal as this will burn out the constituents unequally.

Fluxing the bullet metal

Pouring quality of the bullet metal is enhanced by frequent fluxing and skimming to remove the dross that collects on the surface of the metal. Fluxing should be done before skimming to avoid removal of the tin or antimony added to harden the alloy.

A peanut-sized piece of beeswax or fat is satisfactory for fluxing contents of a 20-lb. furnace. Oil-soaked sawdust is also excellent. The alloy should be stirred thoroughly during fluxing.

Fluxing is best done outdoors, and as a matter of safety a suitable carrying sling or hook should be made for furnaces or pots lacking this feature. Where clearance between the bail and surface of the metal is small, a carrying hook will prevent injury to the hand.

If fluxing must be done indoors, the gases from the furnace are best ignited with a match to reduce the smoking.

Temperature of the bullet metal must always be higher than that of the mold if the bullets are to drop when the blocks are opened. A mold that becomes

2 Oppos clean Burrs thro (arrows) s cut file. C of its own faces of m to vent ai molten me

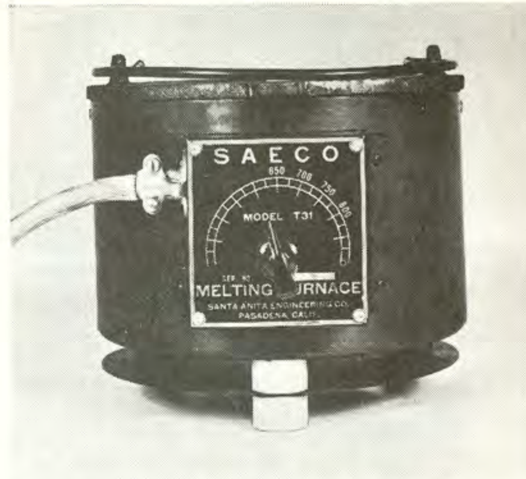
overheated cavities a momentar mold will Cold wat cooling t warp the for coolir temperatu when me face of t plate, or crystallin

Safety

Bullet well-venti helpful i scale, day under a h exhaust should w protectio tect cloth should w molten n to result. been co should b turning from ra spected sure th

2 Opposed faces of mold blocks must be clean if blocks are to close fully. Burrs thrown up around dowel-pin holes (arrows) should be removed with No. 3 cut file. Cutoff plate should swing free of its own weight. Note scoring lines on faces of mold blocks. These are provided to vent air from bullet cavities when molten metal is poured into them

3 For safety and convenience, the melting furnace is best fitted with a carrying sling when fluxing is to be done outdoors. To hold sling in place, plywood sling block has center hole for spout on bottom of pot. Eyebolts in ends of block are long enough so points of attachment of bail are above pot's center of gravity. This makes pot stable when carried



4 A melting pot or furnace holding at least 15 lbs. of metal is desirable for use with larger gang molds to reduce time lost between melts. Electric furnace shown holds 20 lbs. of metal and is equipped with thermostatic control to hold temperature within optimum casting range or increase to hasten melting. Gasoline-heated plumber's furnace is also suitable

overheated can be cooled by filling the cavities and then plunging the mold momentarily into warm water. The mold will dry quickly of its own heat. Cold water should never be used for cooling the mold as this is liable to warp the blocks beyond repair. The need for cooling the mold or lowering the temperature of the alloy is indicated when metal is wiped across the upper face of the bullet mold by the cutoff plate, or when the bullets develop a crystalline appearance.

Safety precautions

Bullet casting should be done in a well-ventilated area and a small fan is helpful in exhausting fumes. Large-scale, day-to-day casting should be done under a hood equipped with an efficient exhaust fan. For safety, the operator should wear gloves and effective eye protection. Wearing an apron will protect clothing. Under no circumstances should water be introduced into the molten metal as an explosion is certain to result. Molds or ladles which have been cooled by immersion in water should be dried thoroughly before returning to use. Bullet metal salvaged from range backstops should be inspected carefully before melting to insure that it is free from loaded cartridges or other explosive items.

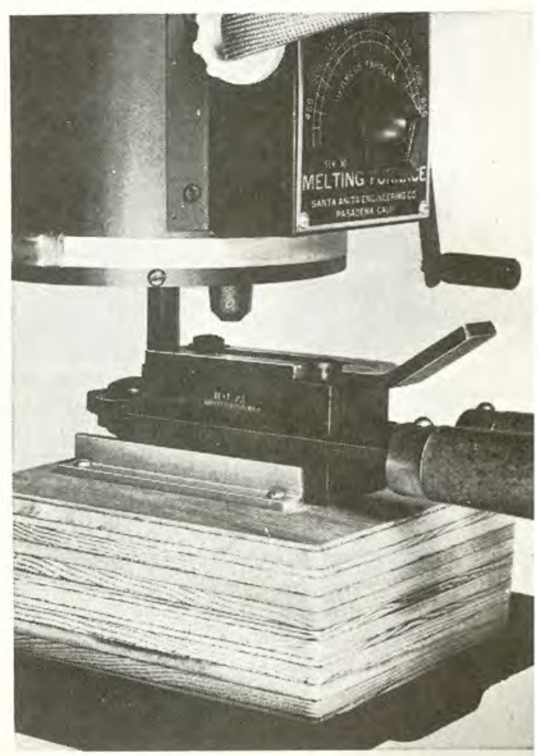
A quality gang mold is rugged and serviceable, but is easily damaged through abuse or neglect. Rusting is best prevented by storing the mold in a closed container with a rust preventive chemical. A piece of VPI (Vapor Phase Inhibitor) paper stored with the mold will prevent corrosion. An application of VPI powder or spray to the mold blocks and handles will also prevent corrosion. Care should be taken to coat all surfaces of the mold blocks. The film of powder or spray is readily removed by pouring hot water over the mold blocks. After the blocks dry of their own heat, the mold is then ready for use.

The application of oil or grease to molds as a rust preventive measure is unwise unless long-term storage is planned. Perfect bullets are impossible to obtain when a film of oil or grease is present in the bullet cavities. It is necessary to boil the mold in a strong detergent solution to remove these films. Do this immediately before use, so the freshly cleaned surfaces will not rust. Petroleum-base solvents are not suitable for this purpose.

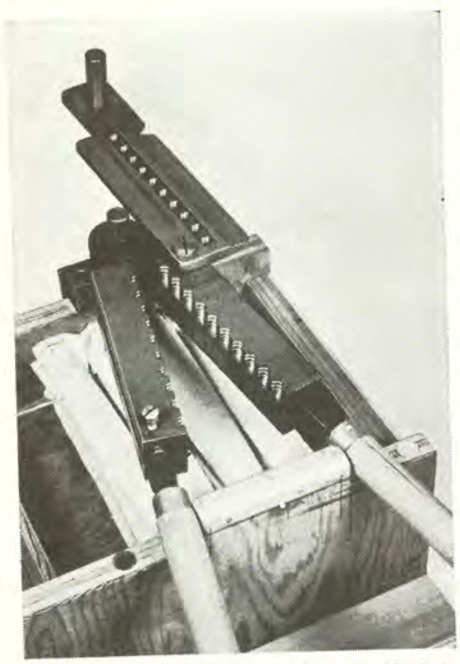
New molds should be degreased in this fashion to reduce the breaking-in time. By doing so the bullets will be less likely to stick in their cavities.

5 Gang molds are serviced conveniently from bottom-pouring furnaces when mold is supported on a pedestal fitted with guide rails as shown. Mold is either pushed away from or pulled toward operator. End of pouring spout should be about ¾" above cutoff plate.

Flow of metal is regulated by adjustment of limit stop on valve handle. With practice, all cavities can be filled with continuous flow of metal. Valve handle can be fitted with foot-pedal release to free both hands for handling mold



6 Casting box shown was designed for convenient casting with heavy 10-cavity mold. Mold hinge pin is supported by a split bracket attached to the side of the box. The handles rest on an elevated bar, made high enough so that mold tilts forward slightly. Pouring is done from rear to front. Sheet of thin metal is placed under mold to catch excess bullet metal running over side of mold



7 With pouring completed, cutoff plate is struck aside to shear sprues. The piece of sheet metal is removed and the mold is opened and its handles knocked against ends of elevated bar to eject bullets. Fall of bullets into collecting tray is broken by several layers of thin leather strips tacked across box beneath mold.

Bullets can be dropped into tank of water, but must be dried before sizing and lubricating. Another technique with large gang molds is to cast over hole cut in top of work bench. Bullets fall through hole into collecting box beneath. Bullets are soft when ejected from mold and will be deformed if dropped on a hard surface

A steel wire brush should not be used to remove bullet metal or rust from the mold blocks. Thin deposits of metal on the blocks or cutoff plate can be removed by bringing the mold up to casting temperature and then wiping off the deposits with a coarse cloth. Stubborn deposits can be removed with a razor blade or keen knife, but care must be taken to avoid nicking the blocks.

Remove rust

Fine rust can be rubbed from the mold blocks with a coarse cloth or with the finest grade of steel wool. A rubber pencil eraser can be used to remove thin rust films and light carbon deposits from the bullet cavities. A mold that is severely rusted should be returned to the maker for possible repair.

After a period of use, the mold blocks may not close completely due to the presence of burrs thrown up around the dowel-pin holes. These burrs should be removed with a No. 3 cut file, with care to avoid touching the edges of the bullet cavities with the file.

The cutoff plate should never be tightened so that it binds; it should be left free to swing of its own weight. Excessive tightening will interfere with venting air from the bullet cavities and may also prevent the blocks from closing fully. In use, the mold blocks should be closed gently. Then rap the mold once lightly on one side. This will seat the dowels fully and will prevent finning of the bullets.

Bullets should not be dropped from the mold into the furnace as the molten metal is likely to splash upward and stick to mating surfaces of the blocks. This will prevent complete closing of the mold blocks and the bullets will be finned and out-of-round.

Use soft mallet

The mold blocks or cutoff plate should never be struck with a steel hammer or other hard object capable of damaging these parts. A mallet of rawhide, plastic, lead, or wood should be provided for seating the mold blocks and striking the cutoff plate.

In respect to over-all convenience, the 4-cavity mold is generally preferable to those of larger capacity. It is the lightest and therefore is less fatiguing to operate than heavier molds of greater capacity. Less effort is required to shear the sprues from 4 bullets than from a larger number, and there is no great difficulty in doing this when hard alloys are used. This can be a problem with larger gang molds where a heavy blow on the cutoff plate is required to shear or break off the sprues. This subjects the entire mold assembly to stresses for which it was not designed. ■

Bullet Mold Tune Up

Much can be gained from a detailed examination of new or troublesome bullet molds and tune-up or overhaul of each.

One mold of mine had a tendency to drag when opening it. Sometimes this is caused by excessive protrusion of one or both pins, which is corrected by tapping them in or out slightly with a small drift and mallet by trial, but in my case the pin was not in alignment with the hole, and struck the edge as it went in, pulling the blocks out of alignment and binding them together.

A minute amount of five valve grinding compound or 280 grit is placed on the pin with a toothpick. The blocks are brought together, permitting the two halves to be rotated around the pin. After twisting the blocks together several times, separate them and wash thoroughly with kerosene to remove the abrasive and prevent further enlargement of the hole.

Lead often adheres to the top surface of mold blocks or bottom of the sprue plate, usually from failing to let the sprue harden long enough, and collects in tool marks or gouges.

Disassemble the mold blocks, removing the sprue cutter and stop pin, then resurface removing tool marks from the top of the mold blocks and bottom of the sprue plate with 280 grit paper or a flat steel plate or piece of plate glass.

If a mold fails to fill out or bullets stick in the cavity, it is probably due to burrs left on the vent lines which clog the vents. Examine the vents at the edges of the cavity with a magnifier. Burred or clogged vents can be cleaned up with a single light stroke of a jeweler's file. Now clean and degrease the mold and cold blue all surfaces of the cavity. If you are set up for bluing, it is better to pickle the blocks lightly and then dump them in the bluing tank.

Remove the set screw for the sprue plate pivot and drop a small piece of brass clipped from a cartridge case neck into the hole. Replace the set screw and adjust the sprue plate until it will pivot of its own weight when flipped smartly in the hand. A tight screw cocks the plate, preventing it from lying flat against the blocks, causing "fins" on the bullet bases. Once you have determined the proper screw position for the sprue plate, file a mark on the screw head, then remove the screw and file a small flat on its shank to engage the set screw to prevent the plate from loosening.

The above steps will make a rough mold cast better and help good ones give many years of trouble-free service. — G[illegible] LAUTARD

REFINEMENTS IN CAST BULLETS

Footnotes for this article on page 144.

By E. H. HARRISON
NRA Staff

CAST bullets give the advantages of ready manufacture by the shooter, low cost, great variety, and unlimited barrel life. They have often involved the disadvantages of poor accuracy (suffered by some shooters, not all), and a marked velocity limitation in high-velocity rifles. Even the velocity is less limited than is generally thought.

The following summarizes, much condensed, the important points in cast-bullet loading in .30-'06 rifles. It resulted from approximately 800 separate shooting trials totaling about 13,000 rounds, fired in 18 rifles with bullets from 26 bullet molds, all directed to this purpose. The particulars and results of every load were typed on punched cards of a small data-sorting system for analysis.

Important points in loading

In conventional cast-bullet loading there are, among a multitude of factors, only a few decisive ones. These are powder charge; bullet hardness, design, diameter, and sizing; bullet lubricant; and rifle quality.

A prevalent error has always been loading too-heavy charges of the reduced-load powders. Heavy charges of these powders may cause leading and are still more likely to open the groups. There is never any leading from heavy loads of slow-burning powders.

Bullets for light loads may be cast of scrap lead. About 2½% tin should be added to make it cast well, which with the small amount of antimony in most scrap makes it as hard as necessary. Bullets for heavy loads must be hard and strong. The best readily available alloy is linotype metal, usual composition 4% tin, 12% antimony, and 84% lead, and hardness 20 to 22 Brinell. Linotype metal is sufficient for all loads given in this article.

Bullets with a long bore-diameter forward part are guided well in bores with broad rifling lands. This is not the case in bores with the more usual narrow lands, which cut unevenly into the bullet forepart and allow it to tilt. Narrow lands therefore require bullets with long groove-diameter bodies for guidance. Cast bullets do not shoot well in bores with excessively fine, shallow rifling.

Bullet diameter is even more important than shape. The front guiding section, if the bullet has one, should be of at least .300″ diameter; .302″ is better and will go into most new barrels without difficulty. The bullet body should be about groove diameter or not over .309″. Unfortunately these proportions are reversed in many cal. .30 cast bullets, with the forward part too small to be of any benefit and the body so big it must be damaged to pass through the bore.

It is not a matter of best diameters only, but also how they are obtained. A .313″ or larger bullet sized to .311″ may be better than if sized to .308″, because it is damaged less. The same bullet cast not larger than .309″ will group better than either.

The better the sizing machine (makes differ), the more nearly its pushing element is aligned with the sizing die. But the machine can guide only the end of the bullet against which it pushes. The free end that enters the die is guided by only the die itself, and whether it starts through centrally depends on the lead-in part of the die. It is the die construction, as much as misalignment of the machine, that accounts for bullets so often found sized heavily on one side.

It is usually possible to choose, from the extensive information available since 1958 in the excellent Lyman "Handbook of Cast Bullets", a bullet of the design and as-cast diameter required.[1]

The remaining important component of conventional cast-bullet loads is the bullet lubricant. Its usual function is to prevent leading, the deposit of lead smears on the bore.

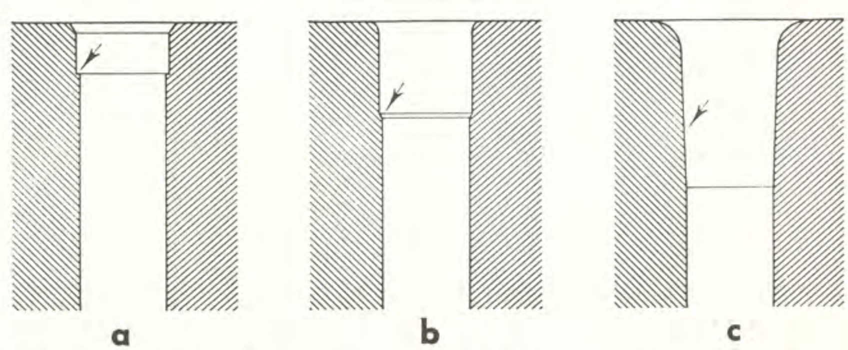
The long-used Lyman Ideal bullet lubricant is one of the best of the stick lubricants made for use in bullet sizing and lubricating tools. Perfect-Lube, though of quite different composition, is also good and should be tried especially in heavy cast-bullet loads.

In very extensive RIFLEMAN tests, a few industrial and automotive greases have given better results than these, though they are less convenient.

Lithium greases best[2]

Best of the greases were the premium lithium types now in increasing automotive and industrial use, and called all-purpose or multipurpose greases because they can replace a number of special-purpose types formerly necessary. Greases of this kind are readily available in automobile filling stations and are usually identifiable by their labeling. Cost is very small in the quantity required. They cannot conveniently be applied in conventional sizer-lubricators and they leave short-nosed bullets inconvenient to handle because the grease is soft.

Graphite, molybdenum disulphide, and other solids mixed in the bullet



All sizing of bullets is damaging, but degree of damage varies with amount of sizing and with die design. In design (a) that has been most common, sizing shoulder (see arrow) is square step with no ability to center bullet, which therefore is often sized off-center. In design (b), shoulder has 7° taper that centers bullet base in sizing. Design (c), in which bullet is pushed straight through die, has long slope which performs same function

lubricants were included in RIFLEMAN trials. The improvement in lubrication was unmistakable, from ease in wiping the bore after firing and lessening of bore leading in a few loads which gave that trouble. However, in nearly all cases it enlarged groups and shifted the impact centers of successive groups. Repeated attempts to correct this all failed. The lubrication improvement obtainable with these solid lubricants might fully warrant their use in some applications. For cast bullets in .30-'06 rifles they are not recommended because of the impairment to shooting accuracy.

Classification of loads

Following seems to be the most natural and useful classification:

1. Most accurate-shooting loads.
2. Cheapest loads.
3. Heaviest loads.

The most accurate .30-'06 cast-bullet load is made up of a gas-check bullet of medium weight, cast to correct diameter *and not sized,* lubricated with soft lithium grease, and with a light powder charge carefully adjusted.

The only best bullets for this kind of load are Ideal U311291 (.297"-.309") and U311413ES (.303"-.309"), *not cast larger and not sized.* (Figures after bullet number in these descriptions are diameters at one or two places on the bullet as will be obvious.) Hardness should be at least 10 Brinell, the hardness of a 1 to 20 alloy of tin and lead. The precise hardness above that is apparently of little importance.[3] Gas checks should fit bullet bases snugly but not require much force to seat. It is ordinarily not necessary to grease the groove before the forward band on bullet U311413ES, or to seat either bullet with any grease grooves out of the case neck. However, if desired the bullet may be seated farther out so its forward band is pressed against the origin of the rifling, which occasionally improves the groups. This will require a readjustment of the powder charge.

Only after all the other components are ready should the powder charge be considered. Approximately 13 grs. 4759, 14 grs. 2400, 15 grs. 4227, or 20 grs. 4198 are correct basic charges for most .30-'06 rifles. Charges are brought to the precise best weight by shooting trial. Rifles with unusually smooth bores may require one to 2 grs. more. Rough bores or bullets seated forward in case necks to touch rifling require slightly less. Half-grain changes during adjustment are small enough.

Small charges like these must, for accurate shooting, lie always in the same position in the case on firing. This can be accomplished by raising the rifle muzzle before each shot. Where this is inconvenient the obvious remedy is a light wad to hold the powder in place, which in a bottleneck case means a ball of some light material. The material found most suitable was kapok fiber. This can be obtained from furniture makers and upholsterers at little or no cost. A tuft is taken which, after being tightly rolled up and released, makes a ball of about ⅜" diameter, and weighs about .15 gr.[4] This is tamped lightly onto the powder. It will require a slight increase in the powder charge to consume the residue. Usually a charge can be found which shoots nearly as accurately as without the kapok. Loaded rounds should be handled with care no to displace this light material.

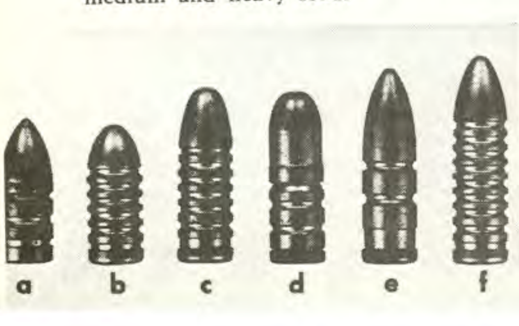
The accuracy of shooting obtain able depends in the first place on wh the rifle and the shooter can do. Cas bullet performance outlined in th article is based on a rifle and shoote able to deliver one-minute, 5-shot group at least half the time, firing Frankfo Arsenal National or Internationa Match ammunition or its equal. Th rifle bore should be cleaned thorough before firing cast bullets, and even be tween different cast-bullet loads.

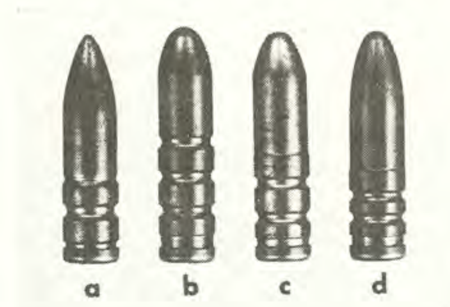
Good groups obtained

With that basic capability of rifl and shooter, it has been the experienc of myself and certain gentlemen gi ing me their results that these best cas bullet loads, made up and refined strict accord with the above direction can deliver a third or a half of the 5-shot groups within one inch diamet at 100 yds. The grouping differs fro that obtainable with jacketed-bull match ammunition only in being le regular from group to group, and being more sensitive to wind.

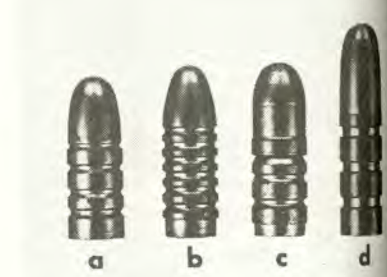
There is much pleasure in shootin .30-'06 ammunition which can mak one-minute groups. The comparative low recoil, report, and cost of th above loads facilitate shooting and en joyment. They reproduce the standar .32-40 low-power load which lo gave good service in both game shoo ing and finest 200-yd. target shootin

Light- and medium-weight cal. .30 Lyman Ideal gas-check bullets (l. to r.): (a) U311359 (.312"), 115 grs., fills need for very light bullet but requires sizing, and accuracy is limited to about 1" at 50 yds. (b) 311465 (.3135"), 120 grs., also unfortunately oversize, but long bearing permits high velocities (see text), should be sized to .313" so loaded round can be chambered. (c) U311466 (.303"-.311"), 150 grs., very good for both light and heavy charges. (d) U311291 (.297"-.309"), 170 grs., best all-round bullet for loads of all kinds. (e) U311413ES (.303"-.309"), 165 grs., one of best bullets with light charges, fails with heavy charges. (f) U311467 (.304"-.311"), 175 grs., good in medium and heavy loads





Heavy gas-check bullets (l. to r.): (a) U311334 (.298"-.310"), 190 grs., the correct heavy bullet for barrels rifled with broad lands. (b) U311284 (.300"-.309"), 205 grs., splendid heavy bullet for conventionally rifled barrels. (c) 311290 (.300"-.309"), 205 grs., interchangeable with U311284. (d) 311299 (.304"-.314"), 210 grs., for .303 British, but with its full forepart is excellent for slightly worn .30-'06 barrels if sized .313" to permit chambering cartridge



Bullets for light loads without gas ch (l. to r.): (a) U311241 (.299"-.311 150 grs., can be loaded to finest accur but sharp-edged base makes it prone lead bore. (b) U311466 (.303"-.311 150 grs., very good, though exposed gre grooves make handling inconvenient. U311291 (.297"-.309"), 170 grs., best let for this use. (In loading 311466 311291 without gas check, it is benef to leave sides of gas-check shank cove with grease.) (d) 311274 (.303"-.311 195 grs., perhaps best of heavy plain-b bullets used before introduction of checks; unfortunately no fully success way of loading these has been found

The second class of cast-bullet loads in rifles, the cheapest loads, are essentially like the first class just described but without the gas check.

Following is approximate components cost per 100 rounds of all 3 types of .30-'06 cast-bullet loads in comparison with jacketed-bullet handloads and with factory ammunition:

	Most Accurate	Cheapest	Heaviest	Jacketed Bullet	Factory	.22 LR
Primers	.80	.80	.80	.80	—	—
Powder	.54	.47	1.78	1.96	—	—
Bullets	.62	.50	1.34	5.25	—	—
Gas checks	.30	—	.30	—	—	—
	$2.26	$1.77	$4.22	$8.01	$22.75	$1.56

It is seen that .30-'06 cartridges of approximately .32-40 power can be reloaded at a materials cost very little greater than the price of standard-velocity, standard-grade (not match) .22 long rifle ammunition.

Best weights of cal. .30 cast bullets without gas check are between 150 and 170 grs., not more. Lighter bullets may be fired with fair accuracy, for example No. U3118 (.310") of only 115 grs. which has long been liked for very light loads, and No. U311465 (approximately .313", without gas check) which however has the disadvantage of requiring sizing. Among bullets nearer the best weight, No. 311234 (.309") and No. 311466 (.311" without its gas check), group reasonably well, but these bullets are inconvenient to handle after lubricating with the necessary soft grease.

The best bullet for this class of load is No. U311291 (.297"-.309") without its gas check. It would be still better if its forward part could be increased in diameter from .297" to .302", retaining its .309" body.

Reasonably good is No. U311241 (.311"). Molds for such plain-base bullets should be manufactured with a very slight flange at base of cavity to avoid undesirable sharpness of the base edge, which was formerly done.

Care in adjusting loads

Powder charges are a little lighter than in loads of the first class and they must be adjusted with great care. A kapok wad, though convenient, is difficult to compensate for. Bullets cannot be more than a very little above groove diameter, otherwise bore leading near the chamber cannot be prevented, and the bullet must be cast to this diameter, not sized to it. Correctly adjusted, loads of this class can be made to group very nearly as well as those of the first class.

The first plain-base bullets for smokeless-powder cartridges were long and heavy. Their poor performance led to the loading of dry Cream of Wheat cereal as a filler to protect the bullet from the hot powder gases. With it some fairly good shooting was obtained even to 600 yds. This filler had the characteristic of raising the powder pressure undesirably, an effect exaggerated in later vague reports. I found that Ideal No. 308278 and especially 308274 occasionally made remarkably small groups. It was, however, impossible with any powder to get good shooting consistently, or even with the lightest charges to prevent the deposit of a kind of burnt leading in the bore. Filling the space between powder and bullet with Cream of Wheat relieved the leading, but ruined the groups, possibly a consequence of the heaviness of this material.

Search for a better filler brought considerable success with rather heavily oiled sawdust, filling the space over the powder and compressed slightly with the bullet to prevent shifting. Charges of 26 grs. IMR 4895 powder gave good groups and left an unfouled bore. Results were also excellent with gas-check bullets and heavy charges. This success was, however, nullified by occasional light but distinct scratches in the rifle bore ahead of the chamber. This happened even with fresh white pine sawdust made under clean conditions in THE RIFLEMAN shops. The oiled sawdust therefore had to be abandoned and with it any successful use of long plain-base bullets.

More powerful loads

For the third class of cast-bullet loads, those as powerful as possible, it is useless simply to increase the charge as that gives wild shooting. As in all cast-bullet loads it is necessary to select powders as slow as can be burned satisfactorily. Also, quite unlike the first 2 load classes, bullets must be cast of linotype alloy or equal with Brinell hardness at least 20.

Following conventional loads have proved reliable.

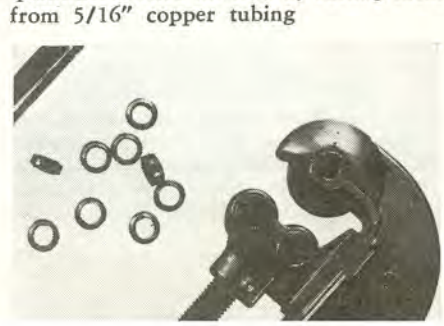
Best is 45 grs. IMR 4831 powder and bullet U311467 (.304"-.311") of linotype alloy, lubricated with soft lithium grease as already described, seated in the case neck to depth that causes it to be pressed against the origin of rifling. Velocity is about 2080 f.p.s. and at least half the 5-shot groups should be within 1½ minutes if fired by a rifle and shooter as specified.

The other conventional heavy load worth mention is 40 to 45 grs. IMR 4831 and bullet U311284 or 311290 (both .300"-.309") of linotype alloy, lithium grease, seated in case neck over the grease grooves. Charge must begin at the lower figure and be increased with repeated testing so long as grouping remains reliable. Velocity

Loads of suitable accuracy can be refined by orienting bullet always the same when loading in rifle. Position of bullet in mold is often shown by off-center sprue (l.), which can be indicated by making a mark on bullet ogive, or the mold can be made to leave such a mark by filing a little notch (r.) on one edge of mold block (see arrows)

Barnes copper driving bands are intended to strengthen bullets for use in the heaviest cast-bullet loads. For Barnes-Henninger bullets, a 2-band design in 120-, 150-, or 180-gr. weight cast in molds sold under Barnes name. After mold is warmed up, bands are laid in mold before casting each bullet. Resulting banded bullets are practical with charges approaching full charges for jacketed bullets. Bands add 68¢ to cost of 100 reloads. They can be used with fair satisfaction on any cal. .30 bullet with broad bands, such as 311334 and 311284 shown here

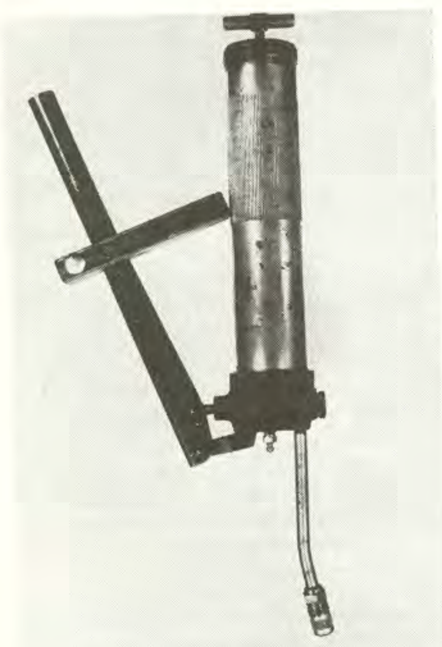
Bands can be improvised in the small quantities needed for trial by cutting them from 5/16" copper tubing



is 1950 to 2075 f.p.s., depending on the charge that can be used successfully. Grouping depends on barrel quality and the care with which the charge is established, but 5-shot groups of 2½ minutes should be practicable. Bullet 311299 (.304"-.314") can be used with advantage if its body is sized to .313", or to .310" in a strong tool with correctly shaped sizing die such as the Saeco Lubrisizer. Bullet U311466 permits increasing the charge to at least 50 grs.

Both these loads shoot at their best when the powder is tilted to rear of the case before discharge. This is made unnecessary by tamping lightly onto the powder a ½" ball of kapok which weighs about .35 gr. The kapok also will improve the grouping of the second load above, and in both loads permits increasing the charge by 2 to 3 grs.

Many trials with heavy cast-bullet loads were performed with the unconventional use of a ½" ball of kapok fiber weighing about .35 gr. tamped lightly onto the powder, and on that 1½ to 2½ grs. weight of polytetrafluoroethylene of fine particle size tamped only enough to permit starting the bullet, and the whole slightly compressed by the bullet which prevents shifting. This chemical synthetic is remarkable for low coefficient of friction, an extraordinary chemical inertness, and a practically complete refusal to stick to anything. Its best-known form is "Teflon", the registered trademark of E. I. du Pont de Nemours & Co. for its fluorocarbon resins including TFE (tetrafluorine) and FEP (fluorinated ethylene propylene) resins. The form regularly used in these tests was Teflon 7, a very light flour of extremely small particle size.



Fillers for heavy loads described in text were replaced with fair results by 2½ to 5 grs. of lithium grease separated from powder by kapok wad. Measured shots of grease are regulated by stop clamped to handle of grease gun. In use, clamp gun nozzle-down or attach right-angle fitting

This filler of powdered Teflon gave some very good results, but not with sufficient reliability in the long run. Disks and wads in this and other materials were quite poor.

However, a filler of 2½ to 5 grs. of lithium grease separated from the powder by a ½" kapok fiber ball proved successful. The grease is readily measured out into the case mouth (see illustration), the only special care necessary being not to force grease past the kapok when seating the bullet. This grease filler can be resorted to if the rifle barrel does not otherwise give satisfactory groups with these comparatively heavy cast-bullet loads.[5]

Unlike the first 2 types of cast-bullet loads described, the most difficult problem with these heavy loads was in defining the degree of accuracy to be expected. When after much experimentation the above loads had been worked out, I found 5-shot groups could be held between 1½ and 3 minutes of angle. This was difficult to reproduce by firings elsewhere, apparently due primarily to differences in barrel performance, but groups improved with refinements in loading. This checking was very greatly assisted by B. E. Hodgdon, Shawnee Mission, Kans., by trial of many loads in different rifles and by chronographing a selection of them.

It is important in cast-bullet loading to note that apparently plausible component changes often do not result as expected. It is best to load to the above values, even reducing the powder charges slightly if necessary for good grouping, before trying variations.

The loading of cast bullets in rifles calls for a slightly different viewpoint than the loading of jacketed bullets. Jacketed bullets are so hard and strong that results from their mere assembly with a suitable powder charge are rather closely predictable. Cast bullets require close attention to certain important points I have briefly given. These are fully mastered only after some experience. I believe the handloader's first cast-bullet loads will be most pleasing if he begins with the light, most-accurate loads, first of the 3 types described above, even though this type may not be his ultimate interest. The handloader is likely to get best results with cast bullets who is interested in them for themselves and therefore puts the necessary time into understanding them. ■

Cleaning Bullet Mold

When I began bullet casting, the bull[...] produced were beautifully smooth [...] bright. Now it seems impossible to [...] them without a dulled and appare[...] rough surface. Is there any correction [...] sides replacing the mold?—J.S.S.

Answer: The usual cause of the appe[...] ance you describe is dirty bullet me[...] That is corrected by thorough fluxi[...] Drop a small lump of wax or fat into [...] pot and stir until it is consumed. T[...] reduces the oxides which constitute [...] slag, restoring them to the mass as cle[...] metal. Lighting the surface gases w[...] a match partly disposes of the smo[...] Fluxing should be repeated as often [...] needed to keep the molten metal visi[...] clean and clear.

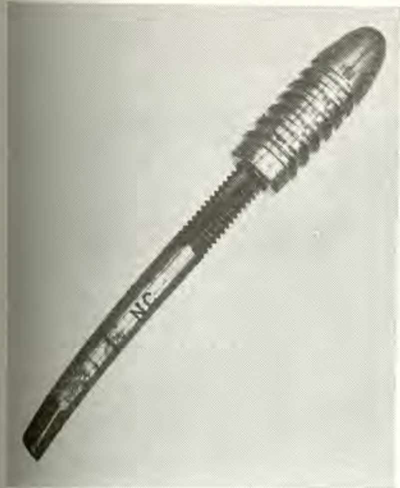
If the trouble persists it is then in [...] mold. When not damaged by rough ha[...] dling, in which case the injury is evide[...] bullet molds can last a lifetime. Howe[...] the mold is likely to acquire in time [...] thin deposit on the cavity surfaces wh[...] affects appearance of the bullets. This [...] most likely from casting dirty, overhea[...] metal, and from preserving the mold w[...] oil or grease which inevitably leaves so[...] residue that is incompletely burned of[...] the next use.

Any deposits are readily removed [...] rotating in the cavity a bullet cast in [...] mold, and coated with a suitably [...] abrasive. It has sometimes been reco[...] mended that the bullet be made up [...] this operation by casting it on a [...] This appears as though it would be [...] difficult to accomplish, particularly in [...] gard to centering the nail in the bu[...] The bullet can however be held o[...] thread tap. Cast the bullet of a hard a[...] Holding it in a lathe chuck, drill for [...] tap from the tailstock. Insert the ta[...] the same set-up. Select a tap with co[...] thread, and a drill only slightly sma[...] than the tap—an 8-32 tap in a No[...] drilled hole is practical. Coat the b[...] with bore-cleaning paste or brass po[...] Remove the mold handles, and holding [...] mold blocks on the bullet with the fin[...] rotate the bullet with a hand drill. A [...] turns of the bullet will clean the [...] cavity.

Before using the mold, wash the po[...] ing compound from the cavity with de[...] gent solution and a soft brush, and [...] in hot water. Do this only when read[...] use the mold, as the washed mold w[...] be very difficult to keep from rusting o[...] wise. As soon as bullets have been [...] in it again, the mold is no longer espec[...] liable to rusting and is best preserved [...] with VPI paper or powder.

The above method requires a lathe [...] satisfactory alignment of the tap, an[...] it is not available to all handloade[...] method that is available is to clean [...] cavity with a suitable bore brush. T[...] have been well-justified warnings ag[...] ever using a wire brush on a bullet [...] meaning a power-driven steel brush [...] would indeed ruin the mold immedi[...] A correctly used brass bore brush [...] clean the mold cavity without damag[...]

A new brass brush of bullet size is [...]



able. Wash the brush in soap or detergent and water, rinse in hot water, and dry. Holding the mold blocks very lightly on the brush with the fingers, turn the brush slowly in the cavity with a hand drill. If the brush shank is gripped tightly in the drill chuck, it can be turned both ways which improves the cleaning. Turning can be done by hand if no drill is available. A few turns clean the cavity excellently, without damage.—E.H.H.

BLUED BULLET MOLDS

I have read that the cavity of a bullet mold must be blued before the mold will perform at its best. Also, I have seen new molds with cavities artificially blued, evidently to assist in breaking-in. How can this be done to an old mold to improve it?—T.R.L.

Answer: It is true that bluing the mold tends to improve its performance. This usually is done simply by casting bullets in it for a considerable time. Immediate chemical bluing can be done by putting a small quantity of potassium nitrate in the cavity, holding the mold tightly closed, and heating it in a clear gas flame until the nitrate is thoroughly melted.

However, the blued condition is not the most important one. Some molds used by the NRA Technical Staff have almost no visible bluing in the mold cavities but cast excellently. The important thing is to clean the mold of every trace of oil and grease. That is not easy.

Petroleum oils and greases have the worst effect. Most oils, greases, and solvents are petroleum based. Even lighter fluid, which is extremely volatile and appears to evaporate completely, leaves the mold contaminated in some way which delays for a long time the trouble-free casting of bullets.

The best method which has been found is to boil the mold blocks for several minutes in a solution of strong household detergent. Lift out of the boiling detergent, rinse in very hot clean water, shake, and immediately wipe off any drops of water with a clean cloth, otherwise the metal will start to rust at those spots. The mold so treated will almost immediately begin to cast full and sharp bullets.

The above procedure of mold treatment is well worth the trouble. To avoid having to go through it each time the mold is used, however, never put oil, grease, or solvent on the mold.

If the mold must be oiled to preserve it, Hoppe's No. 9 Powder Solvent has some preservative qualities and is less inhibiting to the casting action. Then, before using the mold, clean the cavity thoroughly with clean cloth on a soft, pointed stick. It pays to spend several minutes doing this. Also, this is useful before the detergent cleaning, if the mold has had some use and shows any signs of deposits in groove corners.

It is best to leave the mold blocks completely dry, and preserve them by wrapping in VPI paper or by spraying VPI powder into the cavities. The VPI powder is readily removed with hot water before the next use (dry water from cavities before pouring lead into them) and the time is not wasted since this also warms the mold.—E.H.H.

Gas Check Fit

Examining the makes of gas check on the market, I find that they differ somewhat, and some feature a construction which locks onto the bullet base. Are these differences important?—L.B.R.

Answer: Current makes of gas check fit most gas-check bullet bases quite serviceably, despite variations among these bases, and generally there is little to choose among them. In some situations, the handloader can take advantage of peculiar features of gas checks of the different makes.

The Lyman Ideal gas check is made in simple cylindrical form of comparatively thin metal. Its general performance is excellent. It offers the special advantage that with it the gas-check bullet can be loaded without any sizing, and such loading (with bullets cast to suitable diameter) gives the best results. All other makes of gas check, so far as known, must be put through a sizing die after attachment to bring them down to bullet diameter. If the bullet is already nearly correct, the die can be chosen of diameter which reduces the gas check with only slight sizing of the bullet, and the above advantage is then largely retained.

The Sierra gas check is flared at the lip. This permits it to be pushed onto a base on which it is a tight fit, without shaving lead.

Lock-on action is secured in several makes. The Warner gas check is comparatively thick, and the sizing die presses it inward tightly against the bullet shank. The former Kampen gas check adhered well by serrations inside the gas-check wall. The Hornady gas check is made with its edge flared and intentionally thickened. The sizing die turns this edge in so that it bites into the shank and so locks on. The performance of these lock-on gas checks in moderate loads is almost indistinguishable from that of non-locking types. In unusually heavy loads they appear advantageous.—E.H.H.

Lead Poisoning

For several years I have been casting my fishing sinkers and other small items of lead alloys. To melt the lead I used a gas burner in the garage. I tried to keep the garage well ventilated because of carbon monoxide from the burning gas. What I did not realize was that the fumes from the melted lead and the metallic dust of this metal were also dangerous.

Often, after I had finished some casting, I had a severe headache and a nauseated feeling. I later learned that these are some of the symptoms that accompany lead poisoning. Lead is taken up by the body and is removed as a waste only very slowly. Each dose of lead adds to the concentration in the body.

Today, with the revived interest in casting bullets at home, the chances of lead poisoning may be greater. This does not mean that everyone should give up this type of thing; it merely means that one should be careful in the handling and use of lead and its alloys as one would be careful in handling a gun.

The best safeguards against lead poisoning are the easiest: (1) make sure of adequate ventilation, (2) keep the temperature of the melted alloy as far below the boiling point as practical to minimize lead vaporization, and (3) after handling the lead, wash before smoking and before handling food to avoid introducing lead into the body.

Can you comment?

Answer: You will agree that only an experienced physician could determine the cause of your discomfort with certainty. You do not mention such a diagnosis. The symptoms you describe apply also to exposure to carbon monoxide gas. It can only be remarked that your limited exposure and other circumstances point to carbon monoxide as the agent which should be investigated and eliminated first of all.

As to the general experience, bullets have been cast and used for very many years. If there had been any considerable lead poisoning in that time it almost certainly would have become known to the National Rifle Association. The fact that no such situation has appeared is a strong indication that lead poisoning must be uncommon among these users.

Members of the National Rifle Association Staff have cast bullets over a period of many years, and had no trouble.

However, since even isolated cases of lead poisoning would be extremely undesirable, the NRA Technical Staff investigated the matter in detail.

With a Mine Safety Appliances Co. apparatus for the detection of lead dust and fume in air, check was made of the atmosphere around a handloader's electric furnace which was being used in bullet casting. Nothing could be obtained except a light indication close above the pot. Bullet casting was interrupted while this check was made, thus temporarily suspending any air contamination from stirring, dipping, and fluxing the melted lead. Still this result appears to indicate a practical absence of dangerous fumes.

Then the investigator addressed an inquiry to 4 men who have cast bullets in enormous quantities, far greater than any handloader making up ammunition for his own use. These gentlemen generously gave THE RIFLEMAN permission to describe their experiences.

One is a member of the NRA Headquarters Staff who for several years cast 40,000 to 50,000 bullets annually, concentrated in the 4 winter months of the year. The casting was done in gang molds, from lead pots fired by a plumber's gasoline furnace. Because of the furnace, care was taken to provide a current of air through the open-ended building in which the casting was done. There were no symptoms of illness at any time.

Lead poisoning reported

The other men, living in different states, were queried because they were reported to have suffered lead poisoning incident to preparing large quantities of bullets.

One of these men cast bullets on a large scale for 10 years. Source of heat was a gasoline stove fueled with unleaded gasoline. Ventilation was not good. He suffered severe pains in the head and neck at times, and red skin blotches especially on the legs. Pains were always relieved by medicines containing Vitamin B and iron, and ceased when large-scale casting was discontinued. He is still casting on a relatively small scale using an electric furnace, with no trouble. He believed he had lead poisoning, but his physician declined to state that it was lead poisoning.

Another of these men cast over 5 million bullets during 20 years, and is still doing this work though at a lower rate. Source of heat is bottled gas. Fans are used to blow away fumes, and casting is at times done outdoors. Casting was normally carried on for only half of each day.

Often a congested head feeling and other discomfort appeared after 2 weeks of steady casting. These symptoms always disappeared when casting was stopped for a day or so. A high blood pressure condition was detected and is being satisfactorily controlled. The individual states that at one time he felt quite sure he had lead poisoning. Now he is convinced that he never had it.

The fourth man actually had an extremely severe and serious lead poisoning. He suffered unconsciousness, followed by debility, damage to nails and teeth, and a long convalescence after medical treatment. Now he feels no bad effects.

Means of poisoning

He considers that his poisoning came about in 2 ways.

One of these was his supervision of the casting and loading of about one million rounds of .38 Special ammunition annually. After several years, the casting operation was moved to a small room which circumstances did not permit ventilating well. Special 50-lb. electric furnaces made no combustion gases; but it was not possible to remove fully the accumulation of smoke and lead dust from fluxing which hung under the low ceiling. One or 2 days a week apparently did not bother the various individuals doing the bullet casting, but the supervisor was present continually.

The other cause was spending 3 or 4 evenings a week, during the winter months of several years, in an indoor range in heavy use for .22 and .38 Special firing. Without a strong blower to evacuate the fine lead dust, especially that from bullets continually breaking up against the steel bullet-stop, this dust permeates the entire range. (The possibility of poisoning by lead in this manner is well known. The National Rifle Association publishes range construction plans which provide for ample ventilation for health and safety.)

Besides these 4 individuals, many handgun shooters and competitors cast bullets in large quantities without ill effect.

In considering the possibility of lead poisoning, interested persons can bear the following in mind.

It is reported that practically everyone carries appreciable amounts of lead in his body. At usual levels this has no measurable effect. Excessive amounts give rise to symptoms depending on the nature and degree of exposure.

Lead may be ingested with food and drink, breathed in dust, or taken in through the broken skin (rare). Vessels made of lead-bearing materials have long caused poisoning, especially through distilled liquors. Industrially, breathing lead dust is the most serious cause. Unless precautions are taken, the air may be contaminated from processes such as smelting in which the material is highly heated, or making storage batteries with powdered lead compounds. Tetraethyl lead in antiknock gasoline is poisonous. In young children, swallowing dried lead paint can cause the worst form of lead poisoning. On the other hand, metallic lead is not considered a dangerous industrial material to handle.

Certain symptoms of lead poisoning in adults have frequently been mentioned—colic, wrist drop, lead line on gums. In fact the symptoms are various and variable. There have been recorded instances of missed and delayed diagnosis by physicians, and on the other hand diagnosis of lead poisoning when the disorder was something else. An authority has stated, speaking of diagnosis by physicians: "Few, if any, of the occupational diseases are so consistently erroneously diagnosed as lead poisoning." Physicians with an industrial practice usually are well acquainted with lead poisoning in adults. They may request certain blood and excretion tests to confirm the diagnosis. In some locations such tests are administered periodically to workers whose regular exposure makes poisoning a possibility. Sanitation is enforced, to prevent the inadvertent taking in of lead by mouth under unsanitary conditions.

It may appear attractively simple to attribute a malaise to lead poisoning. In reality, the average person knows almost nothing about the subject. In consideration of this, and the other factors mentioned above, it may be well for one to refrain from announcing a self-diagnosis of lead poisoning as fact.

Conclusions

The following conclusions appear d
(1) A maker and user of bullets po
can be poisoned by lead, under suffic
extraordinary exposure. This can b
exist for the individual casting bullets
scale for his own use, with reaso
ventilation and sanitation. (2) Ca
monoxide is a very serious danger w
ever there is combustion—fires in
closed spaces, common stoves, inte
combustion engines, etc. There are sev
hundred deaths from it in the United S
annually. *Every combustion for wha
purpose should be vented.*

The commonsense precautions m
tioned in the original question are
simple and effective that they are repe
here: (1) make sure of adequate ven
tion, (2) keep the temperature of
melted alloy down to minimize vapo
tion, (3) after handling the lead,
before smoking or eating.—E.H.H.

Cleaning Bullet Mold

*I have read that oil in a bullet mold
cause a little smoking and sputtering
use, but will soon burn off and leave
mold better for it. It that correct? In
experience it takes a long time to start
mold making good bullets.*

Answer: It is not correct. While the k
of oil does make a difference (petroleu
based oils, the kind in general use, ca
the most difficulty in this way), any oi
slow to burn off in casting. Users h
wasted a great deal of time at that tedi
business. Then even though they finally
the mold working. this process builds u
deposit in the cavity which impairs
bullet quality.

The mold therefore should be clean
of oil and grease before use. Petroleu
based solvents, even highly volatile ligh
fluid, remove all visible traces but lea
something which still keeps the mold fro
turning out good bullets. The best read
available solvent for cleaning the mold
denatured alcohol. (This does not me
rubbing alcohol compounds, which conta
substances that remain behind as resid
also some rubbing alcohol compounds
made with isopropyl alcohol which is n
a useful solvent of oil.) A mold proper
cleaned with alcohol should make goo
bullets as soon as brought up to worki
heat, which should not require casti
more than a dozen bullets.

Storing the mold dry with VPI to pr
vent rust makes further cleanings seldo
necessary. When oil must be used, it
far faster and easier to remove it wi
alcohol than try to burn it off by castin
Any deposit in the mold from previo
use can be removed easily and safely, b
turning slowly in the cavity a brass bo
brush which has itself been cleaned wi
alcohol or soap and water. Do not use
steel brush of any kind, steel wool,
abrasive.—E.H.H.

Bullet Lubricants

Lubricating materials for handloading, their properties, performance, and value as determined by NRA tests

By E. H. HARRISON
NRA Staff

Footnotes for this article on page 144.

UNJACKETED lead alloy bullets must be greased. This is normally done with a suitable lubricant packed into grooves around the bullet.

Originally the lubricant was needed to soften the heavy fouling from black-powder and permit continued loading and firing. Smokeless powder leaves little fouling. This allows the bullet to rub directly on the rifled bore, and without lubrication, lead would deposit and destroy shooting accuracy. The bullet grease must be a good enough lubricant to prevent this.

However, anyone who does much careful experimenting with bullet lubricants will find some which prevent leading quite well, yet give inaccurate and even wild shooting. The function of bullet lubricants thus is more than to prevent leading. The former Schuetzen riflemen appreciated this, and carefully adjusted their bullet lubricant formulas for most accurate shooting. Present handloaders have generally lost sight of this factor in shooting accuracy.

Lubricants affect accuracy

Prevention of leading is in most cases relatively easy. Needed are a reasonably good lubricant, a bullet alloy suitable to the load, and the restriction of fast-burning powders to light loads. Then the only persistent leading problems seem to be in center-fire target revolvers. The following will take these things for granted, and turn attention instead to the effect of bullet lubricants on shooting accuracy.

It turns out that the bullet lubricants best for shooting accuracy are also highly effective in preventing leading. This will be brought out in what follows, at points where important.

Among current bullet lubricants, the better ones can give good to excellent shooting accuracy in light and medium cast-bullet loads. Heavy loads fail not by bore leading, if suitable powders are used, but by wild shooting. This is the general limitation on cast bullets in rifles. They can be loaded to full power in nearly all handguns.

An extensive RIFLEMAN investigation was therefore directed toward bullet lubricants, to improve the shooting accuracy of cast bullets and raise their velocity limit.

Lubricant composition

Compositions of bullet lubricants sold for handloading are generally not revealed. Many shooters make up bullet lubricants of their own. These, like the bullet lubricants known from the past, are mainly based on only a few materials. Except in *Principles and Practice of Loading Ammunition*, by Earl Naramore, almost nothing has been published for handloaders on the characteristics and specific performance of these materials. Most information had to be obtained by RIFLEMAN investigation.

Materials listed at right, and others, have been recommended to handloaders. Additional unconventional ones were given NRA test. The following identifies the most important materials and tells something of their properties, performance, and value in bullet lubricants as determined in the NRA investigation. Most of the natural materials among them exist in a range of properties (hardness, color, melting point, etc.), depending on origin and refining process; similarly, the synthetic products are made in a wide range of weights and grades. These differences are touched on only as they are considered important for bullet lubricants.

Beeswax, the comb made by the honeybee, has long been used in bullet lubricants because of its availability and its compatibility with other waxes and oils. It may be white or yellow, depending on whether it has been bleached or not. Bleaching impairs the performance in bullet lubricants. Purity also is important. Beeswax is very often adulterated, because of its cost. To get actual beeswax, and not some unknown mixture under that name, it is necessary either to obtain it from a maker known to be reliable or to buy Beeswax USP from a drug supplier. The cost of beeswax appears to have generally limited its use in commercial bullet lubricants. To the shooter making up a bullet lubricant for his own use and not for sale, the cost in comparison with other ammunition components is trifling.

Japan wax is a sumac berry wax imported from Japan and China. Unlike most other waxes, it is a fat (glyceride). It has been used straight by the Army as a bullet lubricant, and apparently at times by sporting ammunition firms.

Adding Carnauba wax

Carnauba is a South American palm-tree wax. It is a valuable ingredient in polishes, though limited in that use by its cost. It increases the hardness and raises the melting point of wax mixtures, but the resulting brittleness makes it poor for bullet lubricants in anything above very small proportions.

Ozocerite, which has been recommended in some bullet-lubricant formulas, is an earth wax mined in Europe and the United States. It is compatible with many waxes, oils, and greases, jus-

COMPOSITION OF EXTENSIVELY USED BULLET LUBRICANTS

U. S. Army, 1855—1 beeswax, 3 tallow.

U. S. Army, 1861—8 beeswax, 1 tallow.

U. S. Army, 1873—8 bayberry wax, 1 graphite.

U. S. Army, 1880 and thereafter—Japan wax.

Sharps Rifle Co., 1878—1 beeswax, 2 sperm oil.

Massachusetts Arms Co. (Maynard rifle), 1890—1 beeswax, 3 tallow.

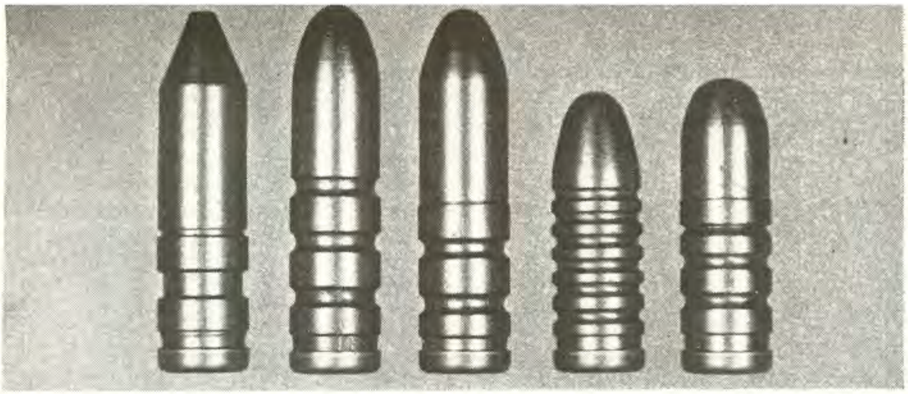
Marlin Firearms Co., 1891—1 beeswax, 4 tallow.

Smith & Wesson, 1891—tallow.

H. M. Pope, about 1900—3 mutton tallow, 2 bay wax, 1 beeswax, 1 steam cylinder oil, .2 of 1 Acheson graphite. The bay wax could be omitted.

Automobile door latch stick lubricant, U. S. Patent 1,920,161 (1931)—5 paraffin wax, 3 petroleum jelly, 2 oil.

A large police department, 1962—1 beeswax, 1 paraffin wax, 1 cosmoline.



Rifle bullets mentioned in this article. (l. to r.) Saeco RG4, Lyman U311284, 311290, U311466, U311291.

tifying its use in bullet lubricants. On the other hand there seems to be no reason to expect any extraordinary results from it. The natural color is black or very dark green, but may be lightened all the way to white by refining. Fully refined ozocerite is called ceresin. Ozocerite is extensively adulterated. It has been stated that the ceresin of commerce may contain 50% or more of paraffin wax.

Montan wax, which also has been recommended for use in bullet lubricants, is a fossil wax obtained from lignite. It likewise has a good degree of compatibility with other waxes and oils, though its use in bullet lubricants does not appear to have led to any remarkable results.

Petroleum extracts

Paraffin wax, often called simply paraffin, is extracted from petroleum. Kitchen paraffin wax is about midway of the range of hardnesses available. Important characteristics of paraffin wax are its wide availability and extremely low cost. In bullet-lubricant mixtures, however, it has the great disadvantage of being incompatible with most other waxes and oils. These tend to enter between the large crystals of the paraffin wax instead of mixing homogeneously with it. The result is a flaky product, which in bullet lubricants gives poor shooting accuracy though successful in preventing leading. It does no good to melt the materials together, since they resume this structure on solidifying. Paraffin wax can be used in bullet lubricants with other constituents which in sufficient quantity have a plasticizing effect—petrolatum is one. The door latch stick lubricant already mentioned is a moderately good bullet lubricant. For the handloader making up a bullet lubricant for his own use, the small money saving in ammunition cost may be considered a poor reason for choosing paraffin wax.

Petrolatum is a soft wax also obtained from petroleum. It differs fundamentally from paraffin wax in being free of coarse crystalline structure. Petrolatum can be used to soften and plasticize many wax mixtures which are too hard and brittle. Petroleum jelly is refined petrolatum. It is available as Petrolatum USP and Vaseline, either yellow or white. Darker, higher-melting grades range in color from amber to dark red, and are used industrially under the general name *cosmoline.* This name was also popularly applied to the heavy rust-preventive compound formerly used by the Army, which while it had a cosmoline base also contained rust preventive additives including rosin. For better identification, "Cosmic" is the trade name of one such rust-preventive compound.

Microcrystalline wax is obtained from heavy-viscosity petroleum fractions, and is available in consistencies from soft to very hard. As the name indicates, it is of very fine crystalline structure. Quite unlike paraffin wax, it has good oil binding and oil retention qualities, and is considered to be compatible with other mineral waxes and most vegetable waxes.

Solid alcohols and derivatives

Solid alcohols (alcohols of high molecular weight) and alcohol derivatives are proposed as bullet lubricants in U. S. Patent 2,193,631 (1940). NRA tests were made with a mixture of one part lauryl alcohol and 2 parts stearyl alcohol, and variations. These were remarkable in leaving practically no deposit in the rifle bore. From suitable light loads, the barrel wiped out with a dry patch as though it had not been fired. These alcohols, however, have only limited lubricating power and may fail to prevent bore leading. Extensive trial, with and without admixture of waxes, greases, and solid lubricants, at times gave superior shooting accuracy with light cast-bullet loads in rifles, but no bullet lubricant adequate for general use could be obtained.

Carbowaxes are solid polyethylene glycols similar to permanent-type antifreeze but of higher molecular weight. They are available in a wide range of hardnesses and molecular weights. While their lubricating qualities appear to
better than those of the solid alcoh
as bullet lubricants they gave about
same results.

Metallic soap greases are quite un
all the foregoing. Greases are made
adsorbing oil (usually mineral oil)
a sodium, calcium, lithium, or ot
metallic soap. Such greases have
greater lubricating power than wax
tures. Greases of industrial importa
are almost all quite soft. Persons u
miliar with them expect them to h
a correspondingly low melting p
something like petrolatum; this h
ever, is not the case and such gre
are melted with difficulty. Bento
greases are of a different type, b
made by adsorbing oils on bentoni
colloidal clay. Bentonite greases
hardly be said to have a melting p
A summary evaluation of greases
bullet lubricants is given below.

Solid lubricants tested

Solid lubricants (more accura
dry lubricants) are flakes or powd
The common ones are graphite, mo
denum disulphide (MoS_2), and m
They are used industrially to imp
lubrication of non-rotating bear
which cannot build up a liquid lu
cating film between rubbing surfa
This seems to correspond to the s
tion of the bullet in the gun bore,
solid lubricants have been added
bullet lubricants for severe conditi
While many NRA tests have sh
that they usually (not always) do
prove the lubrication, the remark
fact is that they almost always deg
the shooting accuracy. This happ
both by group enlargement and
shifting the center of impact as f
continues. Smooth, high-quality b
are least subject to this effect, but s
bores least need the lubrication
provement. It seems evident that
trouble is from variable condition
of the bore surface by the solid lu
cant. Many repeated tests forced
conclusion that solids are a liability
bullet lubricants.

A possible exception is Dupont T
lon. Teflon 7, of very fine particle s
has given excellent results in some N
tests as both a bullet lubricant addi
and a filler between bullet and pow
charge. The successes however have
been consistent. It is difficult or imp
sible with hand methods to incorpor
this fine, fluffy material smoothly i
bullet lubricants.

An outstanding feature of this in
tigation was the impossibility of f
casting which materials would be u
ful in bullet lubricants. Only a thoro
trial in every case could show this. T

following did
general classe
a. Solid (d
ered unsuitab
b. Materia
unsuitable. F
asbestos-fiber
automobile w
sal joints gi
bullet lubrica
tent tenaciou
'fibrous' char
c. Some m
loads tend to
the chamber
remove. Amo
cium soap gr
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cones (very
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suitable for

Attaining g

Many of ti
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and synthetic
sible, are tal
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most success
was general-
grease, obtai
filling station
gave much t
conditions o
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provement i
is too soft to
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best perform
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duced by A
N. Y. These
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the lubricity
qualities of
facturer has
tions availab
indicate that
inum oxide.
The succ
with Alox 3
color and
odor. Its so
of 100° to
for direct us
trial of 12

following did become clear on certain general classes of materials:

a. Solid (dry) lubricants are considered unsuitable, as explained previously.

b. Materials of fibrous character are unsuitable. For example, the special asbestos-fiber grease formerly used in automobile wheel bearings and universal joints gives wild shooting. While bullet lubricants should be to some extent tenacious, they should not have a 'fibrous' character.

c. Some materials except in very light loads tend to leave a bore deposit near the chamber which is very difficult to remove. Among such materials are calcium soap greases, including waterpump grease which has often been used as a bullet lubricant; castor oil; bentonite greases under severe conditions; silicones (very bad); and diester synthetic greases. All such materials are thus unsuitable for general use.

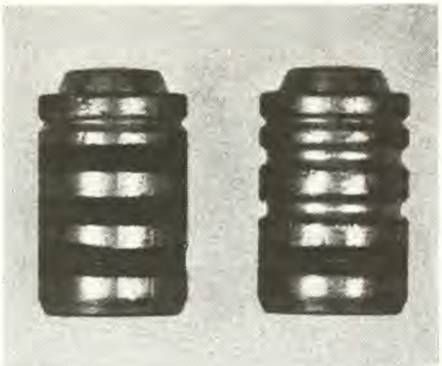
Attaining good results

Many of the possible bullet lubricants tried, among the hundreds of natural and synthetic materials which are possible, are tabulated in the article "Refinements In Cast Bullets" in the *NRA Illustrated Reloading Handbook*. The most successful bullet lubricant found was general-purpose lithium lubricating grease, obtainable in many automobile filling stations in cans so labeled. This gave much the best results in the severe conditions of cast-bullet loads in rifles. On the other hand, it afforded little improvement in handgun loads. Also it is too soft to work satisfactorily through bench sizer-lubricators, and bullets lubricated with it are very inconvenient to handle during loading. It would be possible to obtain a stiff grease of this kind (one commercial bullet lubricant is a soap grease of stiff consistency) but it appears that softness is necessary to best performance of this grease.

The NRA investigation was therefore continued to find a bullet lubricant that is convenient as well as effective.

Remarkable success eventually was obtained with certain materials produced by Alox Corp., Niagara Falls, N. Y. These are derived primarily from petroleum, and are used for increasing the lubricity and corrosion-prevention qualities of oils and greases. The manufacturer has more than 2000 formulations available. The name Alox does not indicate that the materials contain aluminum oxide.

The successful development began with Alox 350, a wax of dark red-brown color and pungent but not unpleasant odor. Its softness and low melting point of 100° to 110° F. make it unsuitable for direct use as a bullet lubricant. After trial of 12 variations supplied by the manufacturer, the one chosen as the lubricant base was Alox 2138F, in which the melting point has been raised to 160° F.



On .38 Special wadcutter target bullet, Alox bullet lubricant in only rearmost grease groove (r.) gave about same lubricating effect as a commonly used bullet lubricant in all 3 grooves.

Practicable consistency was obtained with addition of beeswax, Japan wax or microcrystalline wax, tried in proportions from a preponderance of the Alox base to a preponderance of the hardening wax. All the mixtures left rifle and revolver bores easy to wipe out, and free of lead except as will be noted for .38 Special target revolvers. The Japan wax mixtures however were quite disappointing in target grouping, and the microcrystalline wax mixtures were somewhat so. The final lubricant, chosen on the basis of bore lubrication, target grouping, consistency for use in bench sizer-lubricators, and reasonably easy handling of the lubricated bullets during loading, was composed of equal parts Alox 2138F and pure yellow beeswax. Success of this lubricant is due to the Alox; the beeswax is the best material found to give desired consistency.[1]

Suitable for handloading

The resulting bullet lubricant has a reddish-brown color, translucent in thin sections, and the odor of Alox 350 but less strong. It is smooth and of consistency generally suited to conventional loading practice. Working softens it somewhat; it recovers on standing.

The basic Alox 350, an industrial material, costs about $.42 per lb. in 5-gallon pails (about 37 lbs.), the smallest packing. Price of Alox 2138F is about the same. This is much more than most materials used in bullet lubricants, but less than the beeswax which is a component of the successful lubricant and often used in high-grade mixtures.

Success of a bullet lubricant is established only by thorough firing test. The effect of even small changes cannot be forecast, and is often a surprise. For example, at one point the hard microcrystalline wax tried in these experiments was modified by adding 30% of a vinyl which is commonly used to improve the plasticity and grain size of microcrystalline waxes. The unexpected result was to double the size of target groups. The composition of one part Alox 2138F and one part pure yellow beeswax means that, not something else.

As with other bullet lubricants, the performance possible depends heavily on barrel quality. The following will serve as a guide.

Analyzing performance

In cal. .30-'06, it has long been considered that the maximum practicable cast-bullet velocity is 2000 to 2200 f.p.s. (feet per second). With usual lubricants attainment of this velocity with satisfactory accuracy has often been quite difficult. With the new lubricant in NRA tests it was considered quite easy. A load in this general class is the 190-gr. Saeco RG4 gas-check bullet cast of linotype alloy to a body diameter not greater than .311" and sized to .310", with either 37 grs. DuPont IMR 4895 or 36 grs. Hercules Reloder No. 11 powder. As in all loads in which the powder does not fill the cartridge case, it should be always tilted into the same place in the cartridge case before firing, or held in position with a tuft of kapok fiber under the bullet. This load made up with an excellent commercial bullet lubricant has given superb accuracy from high-quality barrels. The Alox bullet lubricant makes it perform well in only average barrels. Power approximates that favored for 300-meter Olympic and International target shooting.

A somewhat heavier load is the 205-gr. Lyman No. U311284 or 311290 gas-check bullet cast of linotype alloy to .3105" diameter and sized to .310" on the Alox lubricant, with 42 grs. Hodgdon H380 Ball powder. For uniform ignition it is necessary that the powder be back against the primer on firing.

Kapok fiber protection

An old device to permit increased powder charges is to protect the cast bullet with a filler of some inert material over the powder. NRA search found only one material which is completely satisfactory, namely kapok fiber. A tuft of ½ gr. weight, freed of dirt and pulled apart to eliminate matting, is put loosely onto the powder charge before bullet seating. It is completely consumed on firing. Surprisingly, this small amount of feathery fiber permits increasing the powder charge by 10% or more, without material accuracy loss. More than ½ gr. of kapok impairs accuracy.[2]

Barrels of suitable quality can satisfactorily shoot the 155-gr. Lyman No. U311466 bullet cast .311" of linotype alloy and sized .310" on the Alox lubricant, with 50 grs. IMR 4895 powder and ½ gr. kapok under the bullet. This is substantially a .30-'06 full load. The 165-gr. Lyman bullet No. U311291 often may be used, cast and loaded the same, with 48 grs. IMR 4895 powder. The No. U311291 makes a round more convenient for carrying since there are no exposed grease grooves.

Powder charges in the above loads with the Alox bullet lubricant, except the last, may be increased by one or 2 grs. in high-grade barrels. In some other barrels it will be found necessary to reduce them. Target grouping is the guide.

The foregoing loads with the Alox bullet lubricant are at least as good as with soft lithium grease, but with the convenience of conventional application. The same is true down through very light loads.

For proper shooting accuracy with cast-bullet loads, rifle bores should be cleaned thoroughly with a new brass brush before firing.

Bore size a factor

The problem of loading accurate ammunition is of interest to a great many handgun shooters.

The short, wide handgun bore seems to present a less difficult problem than the long, narrow rifle bore in which the fast-moving bullet must push through or over the lubricant film on the surface. The handgun bullet lubricant does prove to be less critical. Nevertheless, there remain marked differences in shooting accuracy among available lubricants.

NRA tests were made on a standard .38 Special target load—the Hensley and Gibbs No. 50BB wadcutter bullet of linotype alloy, with 2.7 grs. Hercules Bullseye powder. Bullets were cast .001" above groove diameter for Smith & Wesson and the former small-diameter Colt revolver bores, respectively, and reduced about .0005" in sizing. As with rifle bullets, reduction should not exceed that amount and die must have a tapered entrance to center bullet base.

The amount of bullet lubricant used makes a difference.

Some center-fire handgunners have filled only 2 or even only one of the 3 lubricant grooves, in lightest target loads. While the purpose was to minimize smoke in indoor ranges, it has been thought that shooting accuracy was improved also. In the 50-yd. load of the No. 50BB bullet and 2.7 grs. Bullseye with other available bullet lubricants, it was found in NRA test that removal of lubricant from one bullet groove brought on undesirable bore leading. Apparently this is why the practice has never become general.

With the Alox bullet lubricant in all 3 grease grooves, 50 rounds in S & W K-38 revolver left the muzzle face covered with grease. Alox lubricant in only the rear groove gave lubrication like that from usual bullet lubricants in all grooves, or from factory wadcutter ammunition—that is, only soot on the muzzle face, but the bore generally free of lead except in the conical counterbore in rear end of barrel. This is the condition for best target grouping.

Bullets with Alox lubricant in only the rear groove, carefully loaded by conventional means, gave about the same accuracy as with best other lubricants in the necessary all 3 grooves. This averages about 3¼ minutes of angle for 10-shot groups, from K-38 revolver in machine rest. Western Super-Match factory wadcutter ammunition under the same conditions averages about 2¾ minutes. The difference amounts to ¼" at 50 yds. (it is not meant that usual handloading does this well). Other factors affect .38 Special handloads, and these results deal only with effects of bullet lubricants.

Filling all bullet grooves with the Alox lubricant nearly prevented lead deposits in the barrel cone. This enlarges 10-shot groups by about one minute (½" at 50 yds.). Such a difference would be of little concern in Service and Magnum revolver loads.

Results using solid barrels

The NRA tests for solid barrels were made in a 16" barrel fired from 6-point rest. Handload grouping was substantially the same as from the revolver. Factory wadcutter ammunition grouped poorly, possibly from its bullet lubricant not lasting to the muzzle though there was no overt bore leading. This is nothing whatever against the factory ammunition, which was not designed for barrels of any such length; it does point up the effectiveness of the Alox lubricant in only one bullet groove, which had no trouble in that barrel. As in the revolver, firing with a usual bullet lubricant in only 2 grooves resulted in bore leading.

In general, cast bullets require loading with a certain amount of skill which comes with experience. They then offer some special advantages. RIFLEMAN articles have made known the actual controlling factors in their use, with very favorable results by handloaders. The Alox-based bullet lubricant described here raises the power limit of cast bullets to a worthwhile degree, and generally improves the performance of cast-bullet loads of all kinds. It can increase the number of handloaders who find them practicable. ■

Point-Cutoff Molds

In descriptions of Schuetzen rifles equipment there is occasional mention point-cutoff bullet molds. Please exp this construction.

Answer: In the final decades of Schuet rifle shooting in the United States, lo continued effort had refined both eq ment and shooting methods to a high gree. These shooters observed, among ot things, that condition of the bullet b was more important to shooting accura than condition of the point. Bullets cas the usual way, by pouring through a sp plate over base end of the mold cav must have some slight imperfection in base from cutting off the sprue. Also shrinkage void in the cast bullet must near the base, that part being upperm in the mold. The point-cutoff mold devised for pouring the bullet from point end, thus moving any unavoid imperfection to that end where it wo have less effect.

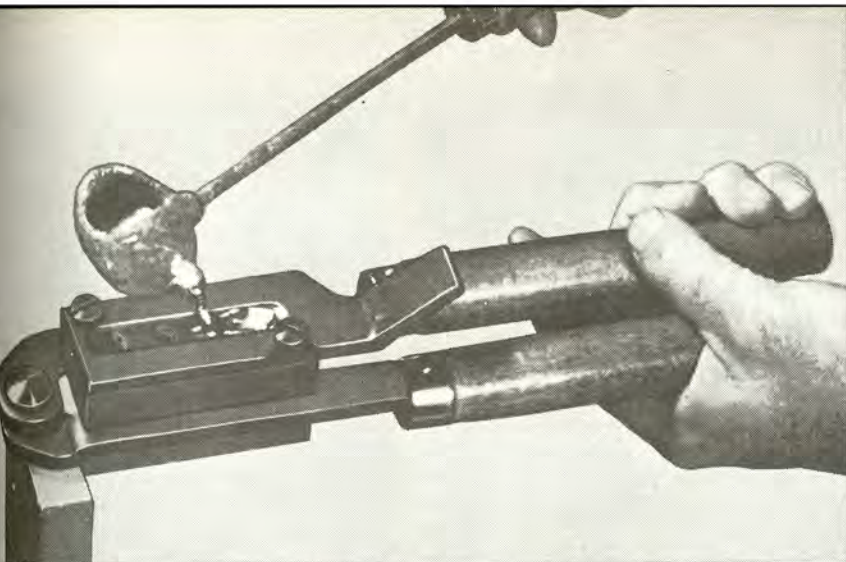
Point-cutoff molds were planed off the point end until the cavity was just posed. The sprue plate was made to sw over that end, and a base plate attach to it covered the base of the cavity. Co struction is illustrated.

A few of these molds are still in ex

Pope cal. .33 point-cutoff bullet mo shown closed (top) and open.

tence and are much prized. There h been, however, little occasion to ma more of them. Height of the point-cut mold must be exactly the same as length the bullet, which restricts such molds bullets of convenient length. Also o flat-point bullets can be made. Very f handloaders develop loads with the co tinued effort necessary to obtain shooti accuracy which could distinguish betwe bullets cast in point-cutoff and conve tional base-cutoff molds.

A different kind of point-cutoff mo however, is made in limited quantity. Th type, required for hollow-base revolv and Minie rifle bullets, is like the conve tional mold but with the bullet cavity verted so as to be filled from the poi and a removable plug put in from the b tom to form the hollow base.—E.H.H.



Method of supporting gang mold while pouring. Ordinarily, gloves are worn to protect the hands from molten metal and hot equipment.

BASICS OF BULLET CASTING

Solutions to common problems encountered in casting lead bullets

By PARRY C. YOB

THE casting of lead bullets is an ancient art, preceding the metallic cartridge and even the rifled barrel. Yet many handloaders approach the subject with a great deal of ritualistic nonsense. Some are unable to cast enough bullets for their needs, and give up what can be a very enjoyable part of the game.

This article offers solutions to common problems not often discussed in handbooks, and a basis for selecting certain kinds of equipment.

Beginners are often confronted with the problem of determining whether the cause of imperfect bullets lies in the mold, the metal composition, the temperature, or a combination of factors.

New mold blocks should be thoroughly washed in a hydrocarbon solvent (gasoline or a safety solvent) and at once rinsed several times with acetone. This should be done outdoors, away from sparks or flame which could ignite the gasoline or acetone. The common safety solvents are chlorinated hydrocarbons, which are safe to health only when used in well-ventilated areas. Acetone will remove the last traces of grease and oil from the mold, and eliminate the question of whether or not the mold is acting up because of oil.

Remove all the screws from the mold blocks for this cleaning, to allow the solvent to enter the screw holes. The handles should be removed and kept away from cleaning fluids because it is difficult to relubricate the joints of most handles. Should lubrication become necessary, the joints should be treated with a non-melting material such as AP-5, manufactured by Jet-Lube Inc., Box 3128, Glendale, Calif.

Bullet metal temperature is not quite as clear-cut a matter as it might seem. Cold molds require hotter metal than molds which have become heated by continuous casting. Even with a clean mold block, good bullets should not be expected until the pool of metal in the sprue hole remains molten for several seconds after the egg-shaped dipper has been removed. When good bullets are being made, the metal temperature should be maintained until sprue solidification time becomes inconveniently long, or bullets tend to stick in the mold. Lowering metal temperatures to eliminate a frosted appearance will not improve the quality of the product.

When a clean, properly heated mold continues to drop poorly filled-out bullets, a venting problem is indicated. When this occurs with a single-cavity mold, fill the casting dipper about half full, and pour in the normal manner. With the dipper still in the sprue hole and the blocks upright, drop the mold blocks firmly on a wood surface such as the end grain of a 2"x4". Keep the mold tightly closed and the dipper solidly in place. The dropping should be done gently, but with sufficient force to jar the metal into the mold. Be sure to wear gloves, since the metal will sometimes slop out of the dipper. It may be necessary to do this with every bullet cast until the mold is broken in. If the mold continues to require this treatment, it should be returned to the manufacturer for venting.

With multiple-cavity molds, sometimes one cavity fails to give good bullets. If the mold cutoff plate has a channel between the sprue holes, fill the channel with metal, and wait until the metal starts to change color which indicates it is solidifying; then drop the blocks firmly on a wood surface, and the stubborn cavity usually fills.

Molds with 2 or more cavities give greatly increased output, provided they are correctly used. However, without proper supporting equipment the advantage is lost. Unless the multiple-cavity mold plate has a sprue channel, it is necessary to cast each cavity separately and the mold cannot be tipped to fill a cavity until the preceding one has solidified. This results in as many operations as there are cavities, and is not much faster than a single-cavity mold. The extra handling of the mold is very tiring on the hand and wrist, necessitating frequent rests. With a sprue channel, the mold block or handle joint can be rested on a wood upright as shown in the photograph, while the entire channel is filled in one smooth motion.

Individual-hole plates are easily converted by milling a channel between the existing holes, and polishing the channel with a small hand grinder. With this conversion, the output can be tripled.

Melting equipment

Bullet metal can be melted with anything from the kitchen stove to a blacksmith's forge. What is best for one location may not be suited to all. Where natural gas is readily available, pistol shooters and others using large numbers of cast bullets should not overlook gas-fired furnaces such as the one shown on page 52. Propane-fueled plumbers' furnaces are portable and require little maintenance. These are particularly useful to the shooter who lives in a remote area where bottle gas is used.

In a fireplace with gas outlet for a log lighter, the gas-fired pot can be connected by an adapter substituted for the lighter. The fireplace will also act as a fume hood. Be sure to cover the work area with a sheet of thin plywood or Masonite to protect the floor.

If the kitchen gas range is used, make a cover of ¼" transite with a hole exposing only one burner, and place this over the stove. Spilled lead will permanently discolor the enamel on most appliances. Be sure the cover does not cut off the air supply to the pilot light which could result in an explosion. Here, too, it is wise to cover the floor with plywood before starting to work.

When melting scrap, determining the composition or hardness of a batch of metal, or making up an alloy, ingot molds such as supplied by Lyman and Saeco are excellent. It is sometimes desirable to produce quantities of bars for convenience in weighing. Random lengths of common angle iron can be supported in wooden V-blocks, and long bars poured in the resulting troughs. When the bars have cooled, they can be chopped into convenient lengths with an old hand-ax. Any cast-iron or steel container will serve as an ingot mold provided its sides slope outward like those of a bread or muffin pan. Ingots weighing more than 2 lbs. are impractical.

For catching the easily damaged bullets as they drop from the mold, blankets or other padding are often used. A 12"x24" frame made of 1"x4" wood strips placed on edge, with a piece of old bed sheet stretched across, will be found more satisfactory. Attach the cloth to the frame with tacks or, better yet, a staple gun.

With the cloth firmly stretched in place, the bullets are dropped directly onto the resilient surface. An accumulation of bullets can be gently pushed to one end of the frame with a large kitchen spoon. The spoon prevents burned fingers. (A similar spoon with wood handle is handy for skimming dross from the melting pot, and returning sprue cuttings to the pot.) Up to 100 bullets can accumulate before it becomes necessary to remove them from the frame.

If a shallow cardboard box is placed between the pot and the bullet catching frame, the sprue can be cut and dropped into the box before dropping the bullets onto the frame. Contents of the box can be conveniently returned to the pot at various intervals.

After a lot of casting, the dipper handle may be loosened by the heat. Plastic compounds are available for temporary repair, but none is satisfactory in continued heating. The permanent solution is to drill through the handle with a #48 or #49 drill, going through the ferrule, the wood, and the metal rod. Place a common shingle nail through the hole, and cut it off with about 1/32" projecting from the ferrule. Set the head of the nail on a solid metal support, and rivet the cut end with a small ball-peen hammer. If you do not wear gloves while casting, keep your finger off the rivet as it gets hot enough to inflict minor burns. When much casting is done, leather-faced gloves are good, and for the heavy caster a pair of welders' gloves is a good investment.

Lubricating cast bullets can be a slow process if the equipment is not working properly. Assuming you have graduated to a combined lubricator and sizer, it may be difficult to fill the grooves completely without depositing a wad of grease on bottom of the bullet. At the least there may be a thick film on the bullet base. This is caused by the fact that sprue cutters leave some roughness on the base of the bullet, or even a pronounced bump, which keeps the bullet from seating against the bottom punch of the sizing die. Grease naturally fills the space between bullet and punch when sufficient pressure is applied to fill the grooves in the bullet. The punch end is concaved to prevent this, but not sufficiently so.

Punch in lathe

Have a gunsmith or a machinist place the punch in the headstock chuck of the lathe, and a center drill in the tailstock chuck. Run the center drill in until the 60° taper hole is only about 1/16" smaller than the punch (see illustration). This leaves a flat rim 1/32" wide. If the center drill is not large enough for a punch of large caliber, run the drill in to its maximum diameter and then use a lathe bit to reduce the width of the flat surface to 1/32". The narrow contact seals against the bullet base.

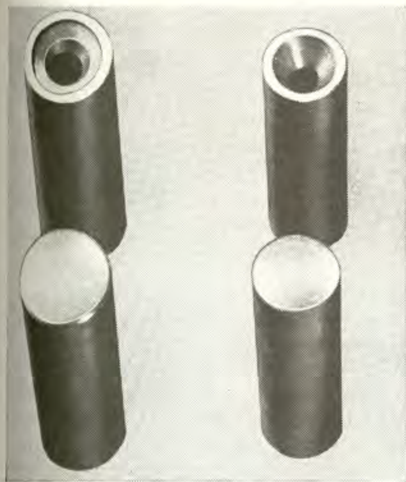
Without removing the punch from the lathe, drill through the punch from end to end with a drill of same diameter as the pilot of the center drill. This last step is not absolutely necessary—in fact, the die will work perfectly with only the countersunk center hole. But without a hole to bleed off accumulations, it will be necessary to clean out the depression periodically.

Bullets lubricated with this modified punch in the die will seldom require cleaning of any sort. Should you wish to remove all trace of lubricant from the base of a bullet, draw it across a strip of cloth dampened with light machine oil.

Packaged stick bullet lubricant is now available in excellent quality. It flows satisfactorily through the lubricator at any temperature above a cool 60°F and a single stick greases so many bullets that no argument can be made for the economy of homemade lubricants. On the other hand, if you wish to experiment, buy a cheap electric hot plate and a long extension cord so you can melt the material outdoors, rather than subjecting your home to the smoke or worse which can result from a wax fire.

One of the greatest rituals of bullet

(l. to r.) Gang mold with channel sprue plate; multiple mold with individual-hole sprue plate; mold with individual-hole plate modified by milling and polishing channel between holes.



Lyman lubricating die bottom punches modified with cavity and bleed hole (top), and unmodified punches for comparison.

casting is the addition of tin to harden the metal. There is little advantage in adding as much as 10% tin as a hardener. What is not always recognized is that the more tin you add, the closer you come to a solder. Too much tin can cause excessive leading which is difficult to remove, being literally soldered to the barrel. Excess tin and a good hot mold can result in smears wiped across the top of the mold block by the sprue plate. These impair the function of the mold, and are very difficult to remove without damage to the blocks. In fact, about the only thing which works is rubbing with fine brass cloth of the type supplied with the Lewis Lead Remover revolver cleaning kit. This method came to light when the writer picked up a bargain mold which was smeared but otherwise new. Chemical analysis indicated the smears contained about 30% tin, corresponding with the composition of plumbers' so-called 'common' solder.

The following table gives a numerical picture of what happens to lead-tin mixtures as the tin is increased:

% Tin	Melting Temp. °F	Brinell Hardness
0	619	4
10	577	10
20	532	12
30	490	15
40	445	16
50	400	15
60	370	15

Obviously the greatest gain in hardness is made between zero and 10% tin. The lowered melting point from added tin offers a strong argument for use of gas checks rather than adding tin to increase hardness beyond a moderate level.

The effects of antimony on melting point and hardness are:

% Antimony	Melting Temp. °F	Brinell Hardness
0	619	4
6	572	6
8	554	16
10	518	17
15	482	18

Again, going beyond 8% antimony gives very little improvement in hardness. This leads to the conclusion that a composition of 90% lead, 5% tin, and 5% antimony with its Brinell hardness of 16, is better than any solder-like mixture. The development of type metals under engineering controls has produced still better alloys. ■

Fireplace casting setup. Foreground: stretched-cloth bullet catcher; handling spoons; sprue box. Background: (l. to r.) ingot molds; wood mallet to knock mold sprue plate around; support for gang mold while pouring; gas furnace; lead pot and dipper.

Lead Bullets After Jacketed

Is it correct that lead bullets do not shoot accurately from a rifle fouled by firing jacketed-bullet ammunition? Would not this reduce their practical usefulness?

Answer: Cast lead-alloy bullets do shoot very poorly after jacketed. One experiment by the NRA Technical Staff indicated that the cast-bullet target group then may be 3 times as large as when fired from a clean bore. This effect is clearly due to the hard fouling left by jacketed bullets in the rifle bore.

Whether it is of practical significance is another matter. Modern sportsmen can hunt big game during only a relatively brief open season. The minority who are also in position to shoot small game while so engaged can make up a suitable reduced load with a jacketed bullet.

Most shooting with either full or reduced loads must be done at targets and game near home, where bore cleaning is readily done. For cast bullets it is necessary only to clean the bore with a bronze brush if the rifle has been fired with jacketed bullets. It is desirable to clean the bore similarly when changing from one cast-bullet load to another.—E.H.H.

Omitting Gas Check

Can gas-check type bullets be used without the gas check in light loads?

Answer: Light and medium weight gas-check bullets can be used with good results without the gas check in light loads.

They have often proved better than plain-base bullets. The reason appears to be the bullet lubricant deposited on the exposed gas-check shank by normal lubricating procedures (see illustration). This should be left in place when the bullet is seated in the cartridge case.

Gas-check bullet with gas check omitted and bullet lubricant on shank (arrow).

Good light loads in .30-'06 are 14 grs. Hercules 2400 or 15 grs. DuPont IMR 4227 powder, and a light or medium weight gas-check bullet without gas check and lubricated as described. The bullet may be made of any lead alloy that casts well.—E.H.H.

Sizing Bullets

It has been pointed out in THE RIFLEMAN *that sizing cast bullets damages them. However, a lubricating and sizing machine is always a convenience, and it becomes a practical necessity in preparing large quantities of bullets. Is there any way these requirements can be reconciled?*

Answer: The undesirability of heavily sizing bullets has become generally appreciated. Manufacturers of bullet molds now supply them to cast bullets much closer to the finished size than formerly, especially when this point is mentioned in ordering. When the bullet is sized only lightly, the effect is much less serious.

In addition, the dies of all sizer-lubricators are now made with a tapered lead-in to center the bullet base as it enters the die, a construction long used by some makers. This prevents sizing bullets one-sidedly.

When the 2 improvements are used together (bullets cast near the correct size, and a centering die) the sizer-lubricator practically loses its unfavorable feature of bullet injury, while retaining all its advantages of speed and convenience.

Lyman sizer-lubricator die of new construction, sectioned to show slightly tapered lead-in (arrow) which centers bullet entering die.

This construction also makes the sizer-lubricator more adaptable. When bullets cast large in a mold of former manufacture must be used, the centering die sizes them with minimum damage. At the other extreme, it correctly lubricates bullets which are little, if any, larger than the die. With some care in adjusting the screw pressure on the lubricant, bullets can be smoothly lubricated which are as much as .002" under die diameter.—E.H.H.

Shrinkage Voids In Bullets

Dr. F. W. Mann's book "The Bullet's Flight" illustrates on page 262 a series of lead bullets containing blowholes. The implication is that such cavities are usually to be found in cast lead bullets, impairing the shooting accuracy.

Is this correct?

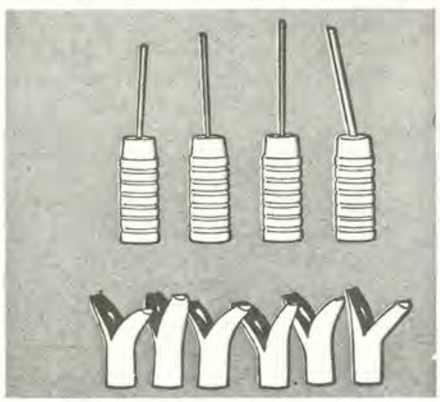
Answer: While reality of the holes shown is beyond question (see illustration) there is no information on how the bullets were cast. It is therefore only possible to make some comments.

The holes are shrinkage voids. All lead alloys regularly used for casting bullets, and this includes type metals, shrink slightly in solidifying. Unless the shrinking mass can be fed until solidification is complete, a void or 'pipe' must be left.

This possibly was accentuated in the bullets shown. They evidently were cast in point-cutoff molds, a type then used in making target bullets. With such molds it was the practice to cut off the sprue before it set hard, to avoid bending the hot, soft bullet. The caster knocked the sprue plate around, often with his bare hand, as soon as it could be done without dragging too much melted lead across the top of the mold. The exceptional shooting at least occasionally done with such bullets shows that cavities in them were not necessarily a fatal defect.

The NRA Technical Staff has sectioned many cast lead bullets and looked for such cavities. In bullets up to cal. .38 cast in conventional base-cutoff molds with the dipper held to the mold several seconds and the sprue then allowed to set before being cut off, no visible cavities could be found. In larger bullets, especially .50's, there was a small, teardrop-shaped cavity near the bullet base and rather accurately on the bullet axis. So centered, it appeared unlikely to have much effect on accuracy.

Handgun bullets cast by present handloaders are sometimes defective for another reason. For speed in production, the lead dipper is not held to the mold long enough to fill it thoroughly. Resulting bullets are often badly holed in an irregular manner near the base. Take a little more time and fill the mold properly.—E.H.H.



Bullets with internal defects illustrated in "The Bullet's Flight" are reproduced. (At top) Bullet points cut off and wires inserted into cavities to show their diameters and directions. (Below) Bullets split to show cavities.

Solidification Shrinkage

In answering a question, THE RIFLEMAN *stated that all lead alloys used in casting bullets shrink in solidifying, including type metals. I believe type metal expands in setting. Can* THE RIFLEMAN'S *answer be correct?*

Answer: It is correct. Type metals contract slightly in solidifying.

The belief you express is a long-standing one. It is popularly held to account for the sharpness of printing characters.

In reality, sharpness is obtained by fluidity and low surface tension of the alloy. These in turn are obtained by the carefully developed compositions of the various type alloys, process cleanliness, and freedom of the alloys from undesirable metals, together with correct temperatures of alloy and mold.

Following are solidification shrinkages of type metals and their constituents:

Type Metal	Solidification Shrinkage, % Volumetric	Linear
Electrotype	2.6	.87
Stereotype	2.0	.65
Linotype	2.0	.65
Monotype	2.0	.65
Lead	3.4	1.13
Tin	2.8	.90
Antimony	1.4	.47

The old belief is correct to the extent that shrinkage in type metals is less than in pure lead and tin-lead alloys. The lesser shrinkage of type metals is due principally to the antimony they contain. In .38 Special, bullets cast in linotype alloy shrink about .001" less than in a soft lead alloy. This makes linotype bullets drop less freely from the mold, though otherwise they cast easily and well. Thus ease of casting, as well as cheapness, favor the softer alloy where its performance is adequate.—E.H.H.

Cartridge Space Fillers

In articles on cast bullets, THE RIFLEMAN *has referred to the use of kapok and other filler materials in the space between powder and bullet. Can the information be summarized, with current findings and loading directions?*

Answer: Continued investigation by THE AMERICAN RIFLEMAN has made it clear that cartridge space fillers constitute quite an extensive subject. They will therefore be covered in detail.

The first known use of such fillers (not wads) in rifle cartridges with smokeless powder, was recorded in 1905 in *Shooting And Fishing,* predecessor to THE RIFLEMAN. The purpose was to protect the bases of cast bullets used in the .30-40 Krag rifle from the hot smokeless powder gases (the copper gas check had not yet been introduced). The filler was dry Cream of Wheat cereal. It was partly successful, at once making it possible to shoot acceptable scores at 500 and 600 yds. A fatal drawback was increased pressure. In reality the pressure was still within allowable limits for that rifle, and case failures experienced were due in large part to the primitive quality of cartridge brass. Still the pressure increase was quite undesirable, and when the gas check gave better results without the pressure, the Cream of Wheat filler was at once dropped. Then there appears to have been little U. S. activity in the subject for many years.

In the 1930's, it was the practice at Aberdeen Proving Ground to insert a tuft of kapok fiber over the powder charge in cal. .30 and .50 armor-piercing rounds loaded for testing light armor plate. The rounds were loaded singly to give desired velocity, which was measured on every round, and it was important to come as close to the desired velocity as possible. The kapok filler made velocities far more uniform and reliable, especially in (but not limited to) reduced loads, apparently by positioning the powder charge uniformly. The purpose was thus quite different from that of the earlier Cream of Wheat filler.

THE RIFLEMAN took up space fillers in connection with cast-bullet loading, thus returning to the original purpose. The following were carefully tested:

Common granular materials	Dry Cream of Wheat Dry oatmeal Dry sawdust, of soft and hard woods Oily and greasy sawdust
Lubricants	Graphite Mica Molybdenum disulfide (MoS_2) Greases of widely varying types
Synthetics	Polytetrafluoroethylene (TFE) resin Fluorinated ethylene propylene (FEP) resin Polyethylene resin
Fibers	Tissue and other soft papers Cotton Wool Kapok Dacron

Wads were also tried. Wads were used in many of the early blackpowder metallic cartridges, notably the British .577 Snider and .577-.450 Martini-Henry, and the Sharps and other American cartridges. The combined card and wax wads were intended to condition the rifle bores for the smooth, paper-patched bullets of those rounds. A tough fiber wad is loaded under the bullet in British military and sporting Cordite ammunition, to lessen the bore erosion by that propellant. When the .22 center-fires began to be popular in this country, there was considerable interest among handloaders in graphited wax wads intended to minimize the rapid bore erosion. After long trial these were generally dropped.

Wads were unsuccessful in RIFLEMAN trials also. Wax wads showed remarkably little effect under cast bullets. Wads of other materials (card, felt, fiber, TFE and FEP resins (Teflon) and polyethylene) were ineffective when made of a diameter to fit in the case neck. When made larger and pushed into the enlarged powder space to give an effective gas seal on entering the neck, the wads markedly impaired the target grouping.

Among the fillers, different types gave astonishingly different results. Dry Cream of Wheat and dry sawdust were very poor. Oily sawdust, on the other hand, markedly improved the grouping consistency and made heavier powder charges practicable. It was, however, inconvenient to load. It introduced the danger of oil seeping into the powder charge, and it occasionally scratched rifle bores in spite of care taken to use only clean sawdust. The solid lubricants (graphite, mica, MoS_2, and also TFE and FEP) obviously improved rifle bore lubrication but almost always enlarged the target groups. Also they required loading 2 extra components instead of only one, since they had to be separated from the powder charge by filler or wadding of some kind.

The fibers gave best results. For a long time the most successful was kapok, one use of which has already been mentioned. Kapok fiber is extraordinarily light and delicate. In this use a suitable quantity is ½ gr., loaded loose into the space over the powder. It is consumed on firing, except in quite light loads, which throw some shreds of kapok into the air. Loaded as described, it makes the performance of cast bullets more consistent and permits increasing powder charges by 10% or more with such bullets.

Polyester fiber

THE RIFLEMAN then tried DuPont Dacron polyester fiber for this purpose. Dacron of this type is a pure white artificial fiber, slightly heavier and coarser than kapok. Ordnance tests in ammunition components show that such polyesters do not enter into the powder reaction. Tufts of ½ gr. to 1 gr. weight, loaded as described, perform like kapok but in many cases more effectively. The weight used should be found by trial, starting at ½ gr. and increasing until it is seen to be thrown from the muzzle, then cutting back until this is no longer noticeable. The amount varies with the powder charge, heavier charges allowing more filler to be used. When a satisfactory load has been found, trial can then be made to see whether the filler makes some powder charge increase possible while still giving good results.

To load, the fiber is simply pushed loose into the space above the powder. It should be weighed at first, until the user becomes practiced in taking the desired amount, and then occasionally check weighed during loading.

Kapok and Dacron fiber are sold at retail for stuffing pillows. Sears, Roebuck and Co. is one supplier. The cost is low.

Such fillers would be undesirable if they might set fires. Felt and fiber shotgun wads have been accused of this. The fiber fillers might do the same in loads which throw large shreds from the gun. Correctly loaded, however, they produce little visible residue and should be less a hazard than shotgun wads.

It is not clear how the light fiber produces its effect. Apparently it protects the bullet during peak pressure of the powder gas, incidentally conditioning the bore surface. It also prevents, to a considerable extent, the shedding of gas checks in flight. In light loads the small amount of fiber tends to position the powder charge, and in heavier loads the larger amount of fiber (Dacron should then be used) positions the powder charge positively, which is always an advantage.

It then becomes a natural question as to whether such a filler could be used in full loads with jacketed bullets. Position of the powder charge in the .30-'06 cartridge has a definite effect on velocity, pressure, and height of impact even when the air space is as small as 3/16". Lake City Army Ammunition Plant, the current manufacturer of Cal. .30 and 7.62 mm. Match ammunition, considers that the slightly better accuracy of the 7.62 mm. M118 Match is due to the fact that it has no air space, while one is present in the .30 M72.

However, there have been no pressure measurements, at least in this country, to determine any possible influence in that respect. The fiber, light and fragile though it is, might have some effect on powder pressures, or such an effect might be attributed to it in case of trouble from any cause. Until pressure measurements have been made, THE RIFLEMAN has no recommendations for the use of fiber fillers with jacketed bullets in full loads.—E.H.H.

Drossing Of Lead Alloys

The formation of dross on the melted lead is a nuisance in bullet casting. How can it be minimized?

Answer: Dross consists of oxides produced when the heated metal is exposed to the air. Oxidation is minimized by casting at as low a temperature as practicable.

The figures in the following table are a useful guide.

Metal	Melting Point Degrees F.
Lead	621
Tin	451
Antimony	1167
Lead-tin-antimony alloys	465 approx.
Metal	**Pouring Temperature Degrees F.**
Lead-tin-antimony alloys	620-655 *
Linotype alloy	525-560 **

* Recommended by various authorities.
** Recommended by a large manufacturer of type metals.

Pouring temperature thus should be, at most, only slightly higher than the melting point of pure lead. A trial will show that lead drosses quite slowly when held only slightly above melting point. Much drossing in practice occurs because the metal is too hot.

Contaminated metal may have to be heated above recommended temperature to cast sufficiently well. The comparatively low pouring temperature for linotype alloy in the table is possible only with metal of high purity and uniformity. The shooter using salvaged metal has little control over its quality, but he can at any rate flux and skim it well before beginning to cast. A clean bullet mold, without burnt oil residue in the cavities, is also necessary.

After the mold has been brought up to temperature and is casting well, the temperature of the molten alloy can be lowered. A little experimenting shows how far this can be carried in the individual case. On the first trial it may be found that bullets continue to cast well as the alloy becomes cooler and cooler, until unexpectedly the metal freezes in the pouring sprue. This causes an annoying loss of time while the temperature is readjusted. With experience the caster has no trouble avoiding this difficulty.—E.H.H.

MAKING ACCURATE .38 HANDLOADS

A guide for reloading reliably accurate .38 Special ammunition

By E. H. HARRISON, NRA Staff

THE .38 Special is reloaded by more shooters than any other cartridge except the .30-'06 and the 12-ga. shotshell, according to information gathered by THE AMERICAN RIFLEMAN.

Police departments reload the .38 Special to extend their training. Clubs and individuals reload it to obtain target ammunition for practice and competition. Not many shooters consider they could otherwise afford the quantity of ammunition which must be fired to reach and retain match proficiency.

The .38 Special ammunition loaded for this purpose is standardized with a light powder charge and a "wadcutter" (flat-ended) bullet. The purpose is target accuracy.

Indications of failures

There have been increasing indications of failure in this purpose. Few leading handgun competitors fire reloads in important competitions. Reports reach THE RIFLEMAN of reloaded .38 Specials giving yawed impacts, almost keyholes, in the target, or producing much poorer scores than obtained on changing to better ammunition. Poor ammunition is self-defeating where shooting accuracy is required. Its value may be questioned even for practice.

This does not, of course, mean that all handloaders obtain such results. There are individuals and organizations who produce excellent .38 Special target ammunition, and others whose product sufficiently meets the demands made on it. But as to reality of the general problem, when target scores are counted, there appears to be no doubt.

Few handgun target shooters have a reliable idea of their ammunition's performance. They might get it by firing several hundred rounds of factory wadcutter ammunition and their reloads at targets under the same conditions, and comparing results. This would require keeping an accurate record of all scores. The comparison would have to be made in presence of the shooter's own target dispersion, which may be greater than that of the ammunition. Appreciating this, not many shooters go through with the comparison.

Rifle handloaders can test their ammunition with relative strictness by firing from a rest. Pistol handloaders, however, in general are at a serious disadvantage in having no equivalent way in which they can check their product.

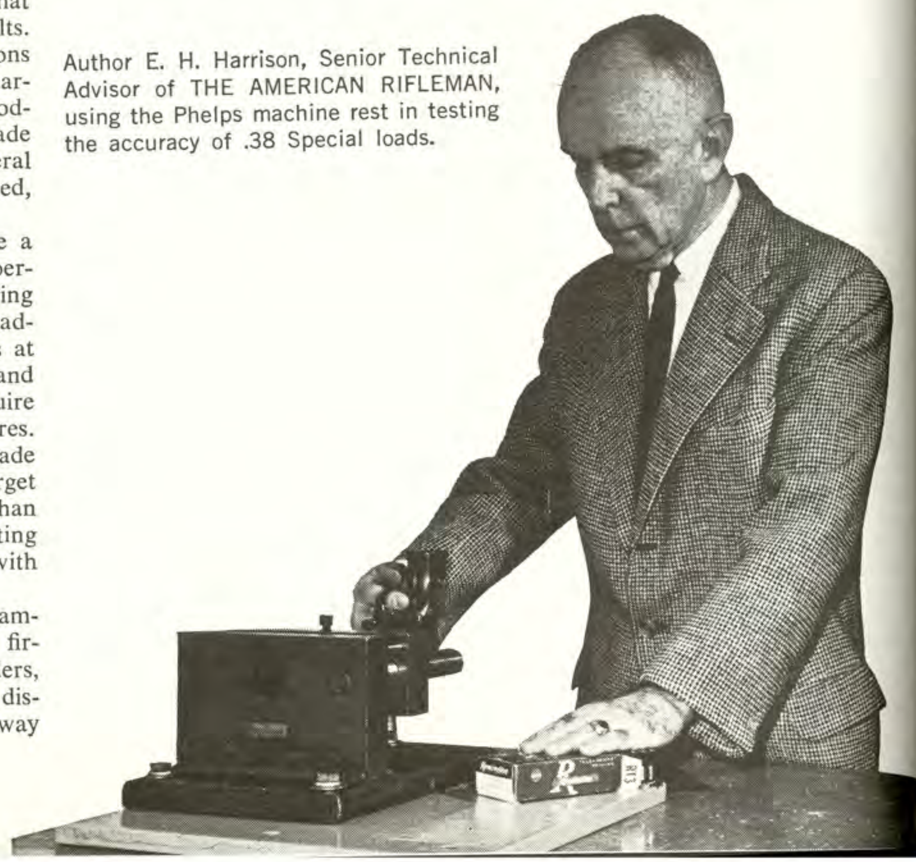
Some shooters have improved their scores by buying custom bullets for loading instead of casting the bullets themselves. There has been little further definite information on the effect of components and loading procedures.

THE RIFLEMAN therefore carried out a thorough investigation to determine the factors in .38 Special target ammunition accuracy, and to establish the accuracy level obtainable with handloads. The findings proved definite enough to guide the loading of reliably accurate ammunition.

The principal firing was done from 2 Smith & Wesson K-38 revolvers and a Colt Officers Model revolver. The Colt had the small .354" barrel groove diameter which formerly was standard in that make. It was used because of the great number of guns with that groove diameter in service, and also to obtain an idea of the effect of a barrel bore considerably smaller than the cylinder throat diameter. Extensive check firing was done in a Winchester single-shot rifle with heavy barrel of target quality, 16¼" long. Barrel groove diameters in the S&W revolvers and the rifle were .357".

The semi-automatic pistol has assumed the leading position over the revolver in .38 Special competition. Nevertheless, this investigation was done mainly with the revolver because its fixed barrel can be held reliably in a machine rest. Also, the revolver presents certain special obstacles to ammunition success in its chamber throat larger than barrel groove diameter, the gap between cylinder and barrel, and its large, roughly reamed cone in rear end of the barrel. Ammunition successfully surmounting these difficulties should do well in the easier conditions of the semi-automatic chamber and barrel. (It is not meant that the semi-automatic is more accurate than the revolver; the revolver may be the more accurate.) Check firing was also done with 2 semi-automatic target pistols, one in .38 Special and the other in .38 AMU.

The revolvers were fired from Phelps machine rests, in which the barrel is held solidly in a block which slides to the rear in recoil. This type of machine rest was chosen because it is insensitive to small variations in handling, and is capable of giving very small target grouping. The rifle was fired without stock from a 6-point rest, and the pistols from a Broadway rest. The results



Author E. H. Harrison, Senior Technical Advisor of THE AMERICAN RIFLEMAN, using the Phelps machine rest in testing the accuracy of .38 Special loads.

are therefore representative to the maximum possible extent of the ammunition's capability.

The firing was done in indoor test ranges at 50 ft., 75 ft., and 50 yds. It was found that group sizes at 50 ft. and 50 yds. were substantially in proportion to the range, and the final firing was carried out at 75 ft. (25 yds.). Groups were recorded in minutes of angle to make them comparable regardless of range—the reason rifle groups are often reported in that manner. A minute of angle is very nearly ½" at 50 yds.

In tests of handgun ammunition the groups obtained have often been compared with the regulation target 10-ring, and if as small as the 10-ring they have been called good. Diameter of the 50-yd. target 10-ring is 3.39" or about 6¾ minutes of angle. In reality, the firer's dispersion in holding and let-off are added to the gun and ammunition dispersion as given by machine-rest firing (just how they are added need not be gone into here), and if the firer's group is not perfectly centered on the 10-ring there is a further loss of score. Consequently, ammunition which groups as large as the 10-ring cannot score possibles except by accident. As will be seen, group sizes of 6 minutes of angle (3" at 50 yds.) are poor. They must be very small to be good.

The test firing comprised approximately 360 groups of 10 shots each. Some of these were fired incident to an investigation of half-jacketed bullets, but most were fired for this investigation. Approximately 295 of the groups were with handloads, the rest with factory wadcutter target ammunition fired at intervals as control. Gun bores were cleaned only after each 50 rounds, since it was considered that handgun target ammunition used in competition should perform that long. The number of load variations and the great number of machine-rest groups, all of which were accurately recorded, made definite conclusions possible.

Following are the results. They are described first by the components tried.

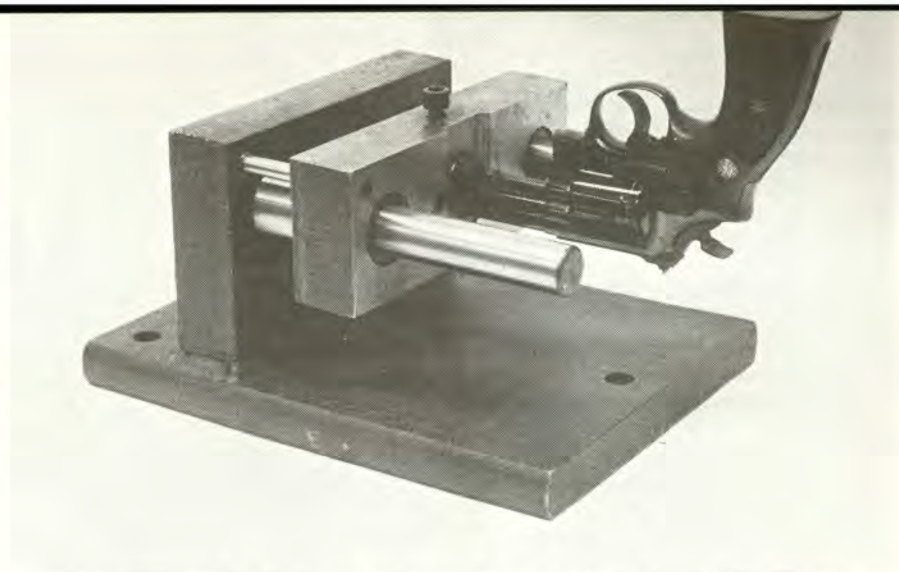
Primer choice significant

The Remington No. 1½ small pistol primer was used in most loads. A magnum small pistol primer was also tried, but the result was nearly a doubling in group size.

Most loads were fired with the widely used charge of 2.7 grs. Hercules Bullseye powder. Extensive check firing was done with Du Pont PB powder, in the charge of 3.4 grs. recommended by Du Pont for .38 Special target loads. Other powders could have been chosen; however, among powders in this range PB is about as unlike Bullseye as can be obtained. PB measures with outstanding smoothness and regularity in this small charge. In the outcome, average group size with PB was substantially the same as with Bullseye. The amount of barrel leading with the 2 powders was also about the same.

The revolver load of 2.7 grs. Bullseye failed to function the auto pistols when held in the rest, making it necessary to fire them single shot. The load was therefore increased to 2.9 and then 3.0 grs. in these guns to get functioning. The 3.0 gr. load was then check fired in a revolver, and gave groups averaging ½ minute of angle larger than the 2.7 gr. load. It also showed greater leading tendency.

Examination of factory .38 Special target ammunition showed powder of different types in different ammunition lots. Samples from a single lot were less uniform in charge weight from round to round than is usual in handloading.



Target revolver in Phelps machine rest for test of .38 Special handloads.

Effect of crimp

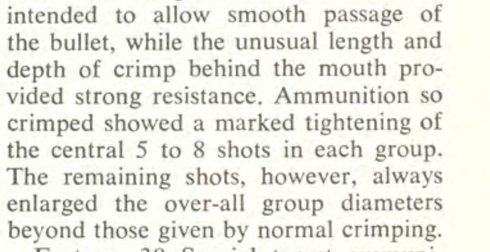
Case mouth crimp was long thought necessary to regular ignition and good groups. That did not prove true in these tests. Changing from heavy crimp to light, and to no crimp at all, had no detectable effect on grouping. (This does not refer to need for crimp in heavy revolver loads to hold bullets in place during recoil.) It did not even matter whether the case was sized or not. There was usually enough grease friction to hold the bullet in the unsized case until some crimp could be applied, and the loads still grouped the same.

This does not state that crimping has no effect. Different crimps may (not necessarily will) give different centers of impact, and if mixed might enlarge groups. There is no need for mixing. Taken singly, the different degrees of crimp, and no crimp, gave about the same target dispersion.

There was one exception. By selection among crimping dies it was possible to form the case mouth fully into the rounded crimping groove in the bullet (illustration below). This form of crimp, with mouth edge turned outward, was intended to allow smooth passage of the bullet, while the unusual length and depth of crimp behind the mouth provided strong resistance. Ammunition so crimped showed a marked tightening of the central 5 to 8 shots in each group. The remaining shots, however, always enlarged the over-all group diameters beyond those given by normal crimping.

Factory .38 Special target ammunition shows one or 2 case cannelures rolled into the bullet (not counting the one below the bullet to insure against receding). Position of these cannelures varies among ammunition lots of different date, even in the same make. Few handloaders have any way to indent such case cannelures into the bullet after loading. If they had, they would still be unable to test the effect on target grouping and make adjustments before loading the ammunition lot, as the factories can do.

After taking all these points into con-



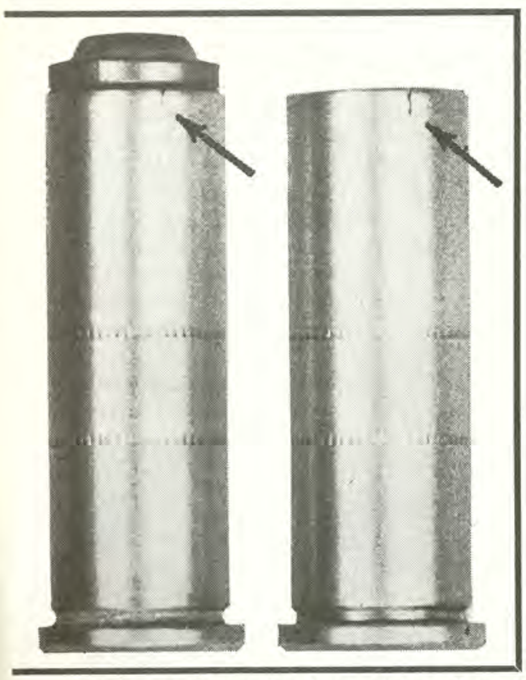
Specially formed heavy crimp (arrow, r.) was unsuccessful in improving grouping. Standard crimp shown for comparison.

sideration, the tests were completed with moderately resized cases, moderately crimped. This procedure is applicable on normal loading equipment, is suitable for reloads in both pistols and revolvers, and appears to give grouping as good as any.

Much .38 Special loading is done with sets of 3 or even 4 dies, instead of the 2 dies which are conventional in loading bottle-neck rifle cartridges. Purpose of the additional die in 3-die sets is to bell the case mouth as a separate operation after sizing; this works the mouth less than in belling during sizing, and the cases last longer. A 4th die separately crimps after seating the bullet, to avoid possibly shaving the bullet at that stage. Most loading for the present tests was done in 3-die and 4-die sets. These are successful in the respective purposes. There was nothing, however, to indicate that they load better ammunition than a 2-die set correctly adjusted. The loads making the smallest groups among handloads in these tests were assembled on a 2-die set.

It has often been pointed out that cases of variable length result in variable crimping. The condition is most likely in cases picked up at random on the range, or otherwise mixed. The present tests were done with cases bought new or left from control firing of factory ammunition, and kept together throughout use. They were found to crimp uniformly.

While most factors in connection with the cartridge case thus proved to be of no special importance, this was not true for case mouth condition. A small crack in the case mouth (illustration below) was found to throw the shot out of the group. A deviation of 3 to 4 minutes of angle appeared to be typical. Such cracks probably would have little effect if the case mouth were not crimped onto the bullet. Since crimping is usual, the cracks are serious.



Case mouth cracks (arrows) in crimped ammunition have very bad effect on grouping, and must be inspected for.

Bullet is most important

We come now to the bullet, the only remaining component. These tests showed the bullet to be by far the most important factor in .38 Special target ammunition accuracy.

The following bullets were tried (see illustration on page 37).

a. *Hensley & Gibbs No. 50 BB.* A wadcutter bullet of form which has become usual in revolver target bullets. The 50 BB has, however, a markedly beveled base edge, intended to simplify starting the bullet into the case mouth during loading. This and the 2 other cast bullet types tried (listed below) were cast in Hensley & Gibbs (H&G) gang molds bought new for these tests, in separate sizes for .357" and .354" barrel groove diameters. These high quality, beautifully working molds were valuable both in quantity production of bullets and in obtaining consistent test results.

b. *Hensley & Gibbs No. 50.* The same design without base bevel, the base edge coming to substantially a sharp edge in the conventional way.

c. *Hensley & Gibbs No. 73.* Body with sharp leading edge for wadcutter effect, and long conical nose with flat end. Essentially same form as the similar revolver bullet used by handloaders for field shooting.

d. *Custom target wadcutter.* Machine-swaged (not cast) bullet of substantially same form as H&G 50 BB, of a leading make. Sold lubricated ready for loading.

e. *Custom hollow-base target wadcutter.* Machine-swaged (not cast) bullet of the same make, of somewhat similar form, but with large base cavity like that of bullet in factory target cartridge. Sold lubricated ready for loading.

f. *Remington No. 22850 factory hollow-base target wadcutter.* Machine-swaged bullet used in Remington .38 Special target ammunition. Sold lubricated ready for loading.

All these bullets are of nominal 145 to 148 grs. weight.

The H&G No. 73 long-pointed bullet can be disposed of first, as being not normally considered suitable for competition with the target wadcutters. Results of the present tests confirmed that view. Groups were about one minute of angle larger than those obtained with H&G No. 50 BB. Note that the comparison relates to ammunition for competitive target shooting. The No. 73 would be preferable for field shooting at higher velocity.

The H&G No. 50 BB gave best results among the cast bullets tried. Correctly made and loaded, it averaged just over 3.5 minutes of angle in the 10-shot groups fired in all this testing.

The H&G No. 50 grouped about as well. It was, however, less convenient to load, and also leaded the barrel co[...] more than No. 50 BB.

The custom wadcutter bullet of solid form gave 2.5 to 7.9 minutes of angle in individual 10-shot groups, averaging 5.1 minutes. This bullet was loaded with the same equipment and care as the other bullets and machine-rest fired the same way. Its comparatively wide and variable grouping thus had to be considered the measure of its target quality. (These and all other group diameters given in this article refer to groups made by the target revolvers.)

The custom hollow-base target wadcutter also gave variable results. While a few of its groups were under 4 minutes of angle, others were over 6 minutes, and the average was 4.8 minutes.

The Remington No. 22850 factory hollow-base wadcutter bullet, in startling contrast, averaged between 2.5 and 3 minutes of angle. Some details of this performance are examined later in this article.

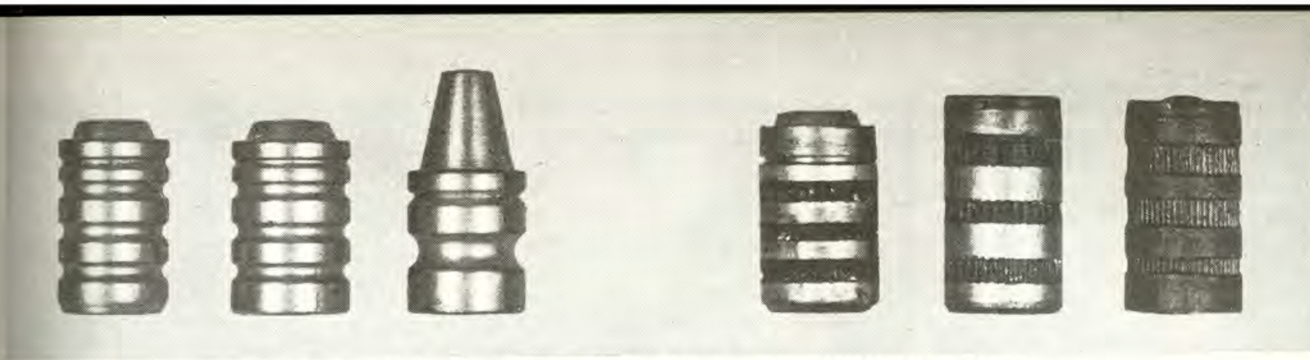
Remington and Winchester-Western factory .38 Special target ammunition were fired at intervals, as control. The groups averaged within 2.5 minutes of angle. Also, while an occasional series with the H&G No. 50 BB was more uniform from group to group, the factory ammunition performed most uniformly in the long run. *The factory .38 Special target ammunition is the standard against which handloads must be judged.*

Within the ranking of bullet types resulting from these tests, it is useful to consider the procedures found necessary for best grouping.

Best loading procedures

The bad effect of case mouth cracks shows clearly that cases should be individually inspected at every loading. Mouth cracks can appear during the final crimping; hence if the inspection is made on the empty cases before loading, the finished ammunition still may contain cracks. It is therefore best to inspect for this defect after loading. Only a few rounds are lost in this way—any more would call for scrapping the entire lot of cases.

Only linotype alloy is adequate for



Bullets used in handloads in these tests. (l. to r.) H&G No. 50 BB, H&G No. 50, H&G No. 73, custom target wadcutter, custom hollow-base target wadcutter, Remington No. 22850 hollow-base target wadcutter.

best grouping. Since some handloaders still use traditional compositions of bullet alloys, and very many use salvaged metal, the tests included an alloy softer than linotype for comparison. A Brinell of 10 (about half as hard as linotype) was chosen, since this is the hardness of the 1-to-20 tin-lead mixture long recommended for bullets of this kind, and also might roughly represent recovered bullets and other salvage. Groups averaged about one minute of angle larger than with linotype metal, and their uniformity was poorer.

Effect of bullet lubricant

THE RIFLEMAN has pointed out ("Bullet Lubricants", July 1965, and other articles) that the bullet lubricant used has a strong effect on shooting accuracy. The effect, as expected, proved to be less marked in the short, wide bores of handguns, which give less opportunity than in rifles for bore conditioning to influence the bullet. Nevertheless, the effect still exists. Some lubricants tried, though satisfactorily preventing leading, increased group diameters by more than 50%. Attention was therefore concentrated on a few lubricants which were found to deliver good groups.

Bullet lubricant in the final tests was applied with either a Schuetzen lubricating pump, leaving the bullet unsized; or with a SAECO Lubrisizer, reducing the diameter by .0005" to .001". There was no distinguishable difference in the grouping. The finely made, accurately aligned SAECO Lubrisizer, with its smooth dies incorporating the correct tapered mouth to center the bullet base entering the die, was largely responsible for the success of bullets lubricated in this manner.

While the lubricant chosen has a very marked effect, bullet lubrication itself is a necessary evil. These tests showed conclusively that the less lubricant used, the better the grouping. The limitation on this is, of course, the disastrous lead fouling which appears when lubrication is reduced too far. Lubricants, otherwise good, differ in the quantity that must be used.

Lyman and SAECO bullet lubricants, applied in all 3 grease grooves of the cast bullet, produced the full accuracy of which the load appeared capable. Leaving them out of one or 2 grooves resulted in excessive barrel and cylinder leading after 2 or 3 groups. The Alox-beeswax lubricant described in THE RIFLEMAN article gave equally good accuracy, and no undue leading, when used in only one bullet groove and the other grooves left dry. It can be used in all 3 grooves if extra lubrication is desired, though target groups are somewhat enlarged. In that case it provides so much lubrication that after 50 rounds the revolver muzzle is covered with grease. Advantages of the Alox lubricant in .38 Special loads are thus limited to use of less lubricant, giving convenient handling of the greased bullet and less smoke in indoor ranges; or much greater lubrication if desired, with enlargement of groups. These advantages, while real, are less decisive than this lubricant possesses in cast-bullet rifle loads, in which it is superior in all circumstances.

A final point in connection with lubrication is its effect on the factory bullet.

Lubricant applied

The Remington hollow-base wadcutter target bullet, as supplied, has so little lubricant on it that at first sight there appears to be none. The bullets seem merely to have been tumbled in some solid lubricant leaving a trace on or in the surface. To prevent possible lead fouling of the test gun the first loadings of the factory bullet were done with Alox bullet lubricant applied in 2 of the bullet grooves, all of which appeared empty. Groups averaged about 3.5 minutes diameter. Grease on the revolver muzzle indicated much more lubrication than necessary. The bullet was then loaded with Alox lubricant in only one groove; the result was 3-minute groups and still a quantity of grease on the muzzle. Eventually the bullet was loaded simply as received. In that condition it grouped only a little larger than the 2.5 minutes of the factory ammunition, and with no more bore leading than from best loads of cast and custom bullets.

During the experimentation it was observed that this bullet with Alox lubricant added, even in only one groove, left no leading at all in the revolver barrel cone. This was the only bullet and manner of loading which left no leading at all (even the excessive lubrication provided by Alox lubricant in all grooves of the No. 50 BB cast bullet did not completely prevent it).

At this point we leave the tests, and turn to use of the information as directly as possible for the handloader.

It is absolutely necessary not to assume that such excellent results will automatically follow from handloading. All available indications are that .38 Special target handloads vary in practice from very good to highly unsatisfactory. Only reasonable care was taken with the handloads in these tests. Why then do not all handloads perform well?

The primer is not to blame. The standard small pistol primer appeared consistent throughout these tests, and evidently compatible with the target powder charge.

The powder is not to blame. Two quite different powders performed well in these tests. Powders of various types have been used by the factories in .38 Special target ammunition, and round-to-round uniformity of the powder charges is only fair at best; yet the factory ammunition shoots with superior accuracy.

The cartridge case does not appear basically to blame. Irregular crimping admittedly is undesirable in principle, though crimped and uncrimped rounds shot into the same group in one of the tests. Case mouth cracks do have a very bad effect, as already explained. It seems unlikely, however, that reasonably careful handloaders would load cases showing widespread cracking, which would be necessary to produce a generalized condition of poor grouping.

The home-cast bullet is without any doubt the main cause of poor performance. Some handloaders have found this out for themselves, when a change to purchased bullets brought immediate improvement in scores.

That points to a simple solution—buy the bullets for loading. A still simpler one is to buy the factory ammunition, thus obtaining best possible results and skipping all the trouble of handloading. However, comparatively few users, either individuals or organizations, consider they can afford the cost of this solution for the quantity of ammunition they wish to fire, or need to fire for proficiency.

Cost comparison

Since cost is an unavoidable consideration, a rational choice among methods includes comparison of their costs. These are for 1000 rounds.

	Factory Ammunition	Handloads, Bullets Bought	Handloads, Bullets Cast
Cases	—	$ 4.40	$ 4.40
Primers	—	8.00	8.00
Powder	—	1.70	1.70
Bullets	—	28.00	4.40
	$101.00	$42.10	$18.50

Components costs are approximate; for cases and bullet metal they are frequently less than those shown. Loading tools are assumed to have been paid off.

These figures provide a clear-cut comparison. Many shooters are also interested in handloading for its own sake, including making their bullets.

The problem, then, is to find and eliminate the causes of poor bullets.

Unlike the investigation up to this point, which produced firm information from specific tests, there are obvious difficulties in reaching conclusions about the product of many individual handloaders. Still, the available information points to the following 3 factors as controlling:

1. Bullet casting.
2. Bullet sizing, including the dies used.
3. Bullet lubricants.

The short, fat handgun bullets cast easily. A glance at the bullets produced shows whether they are filling out cleanly in the mold. Any trouble in this respect is normally soon corrected as the mold gets up to temperature, aided if necessary by cleaning the mold.

But even when it appears acceptably filled out, a bullet may be partly hollow. The illustration shows cavities produced by not allowing time for the mold to fill completely and the sprue to solidify, before knocking the sprue plate around.

Undesirable as such cavities are, much worse ones can occur. These may be very large (described as sometimes large enough to contain a small pistol primer) and may be in any part of the bullet base, even near the edge. The unbalancing effect obviously is severe. The cavity may be covered by a thin layer of metal, so that the bullet looks solid; or instead of one large hole there may be a honeycombed condition.

Defects of this type were described, with illustrations, in the article "Cast Bullets And Fliers" (THE RIFLEMAN, February 1957). They were attributed to bullet metal not hot enough, to an unvented spout on the bottom-feed electric pot used with a single-cavity bullet mold (not a gang mold with its open-trough sprue plate), and to excessive speed in casting without inspecting the product.

Poorly cast bullets with base defects. Bullets with defects such as these appear to be often cast and loaded.

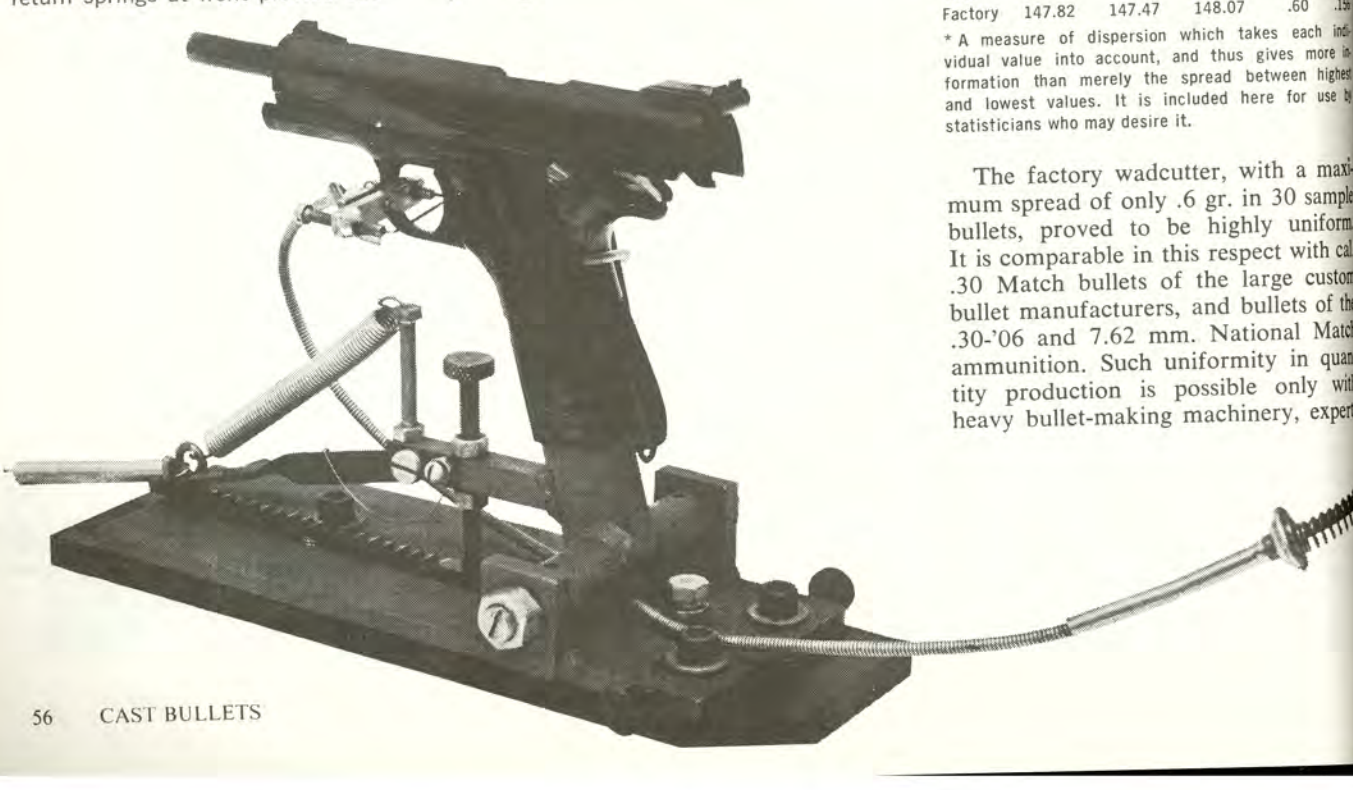
Cast bullets cannot be perfectly uniform. The following summarizes the weights of 30 linotype bullets cast in a 4-cavity Hensley & Gibbs No. 50 BB gang mold, compared with the same number of Remington No. 22850 hollow-base wadcutter bullets. The cast bullets were well cast and then given only a rapid visual inspection. The Remington bullets, taken from a single box, were boiled in detergent solution before weighing to remove the lubricant which might be a cause of variation (boiling did not seem to affect the lubricant much). Weights were obtained on a laboratory balance and recorded to the nearest .01 gr.

	Average	Lightest	Heaviest	Spread	Standard Deviation*
Cast	136.13	135.24	136.77	1.53	.43[illegible]
Factory	147.82	147.47	148.07	.60	.15[illegible]

* A measure of dispersion which takes each individual value into account, and thus gives more information than merely the spread between highest and lowest values. It is included here for use by statisticians who may desire it.

The factory wadcutter, with a maximum spread of only .6 gr. in 30 sample bullets, proved to be highly uniform. It is comparable in this respect with cal. .30 Match bullets of the large custom bullet manufacturers, and bullets of the .30-'06 and 7.62 mm. National Match ammunition. Such uniformity in quantity production is possible only with heavy bullet-making machinery, expert-

Accurized M1911 pistol of cal. .38 AMU in Broadway machine rest. Light and heavy return springs at front provide choice depending on recoil.



ly operated, and Remington is to be complimented on such a product.

Even though extremely uniform, this factory wadcutter bullet groups in about 2½ minutes of angle instead of the 1 minute or less of cal. .30 Match bullets. Evidently, other factors are decisive in determining the size of target groups. Reasons for grouping superiority of the factory bullet will be investigated later.

The cast wadcutter showed a weight spread of 1.5 grs. in 30 bullets, or about 2½ times the factory spread. It appears the difference is due mainly to a small variation among the cavities of the gang mold, since staff experience with single-cavity molds indicates a weight spread of about ½ gr. in well-cast bullets of both rifle and pistol types. This is about the same uniformity as in factory wadcutters and cal. .30 jacketed Match bullets.

Cast vs. swaged bullets

It has at times been stated that swaged bullets, being free of internal voids, must shoot better than cast bullets. The statement, made without proof, appears to be based on a belief that it should be true. Here it is sufficient to note that the cast bullets in these tests performed excellently, grouping only slightly larger than the factory bullet, while the custom swaged bullets did comparatively poorly.

The answer, as to cast bullets, is found in the words "well-cast bullets" used above. It is absolutely necessary to give the mold time to fill. Then weighing a few bullets verifies that there is no other condition causing non-uniformity. Such check weighing need be done only until the casting procedure is established. Production is obtained not by hurriedly casting poor bullets in a one- or 2-cavity mold, which cannot give quantity in any case, but by using a gang mold. Ten-cavity molds are available, giving real quantity. Even a 4-cavity gang mold turns out with ease all the bullets an individual will wish to shoot.

The bench sizer-lubricator is a decided convenience in preparing even a few bullets. In production it is an unquestioned necessity.

Two past practices were damaging—casting bullets too large and then heavily sizing them, in the hope of improving poor bullets, and doing the sizing in dies which deform the bullets eccentrically (see illustration above). The present, correct practice is to cast bullets only very slightly above finished diameter, and to use lubricator dies with a conical mouth which centers the bullet for the small amount of sizing done.

Many poorly dimensioned molds and sizers are still in existence. The owner can readily replace the dies, which are comparatively inexpensive, with dies of the centering type which at least minimize the disadvantage of starting with excessively large bullets.

The final factor in performance is the bullet lubricant. The lubricant must work satisfactorily through the sizer-lubricator and then remain in place until the bullet is put into the cartridge case. It is easy to produce a lubricant which does that. It is much harder to provide the bore-conditioning action which makes bullets group well. This is true even though handgun requirements are not so difficult to meet as those of rifles. Lyman, SAECO, and Alox-beeswax bullet lubricants gave about equal grouping in these .38 Special target loads.

Some others were much less successful. The Alox lubricant has the advantages of use in only one groove on the bullet instead of all 3 grooves, and of preventing all revolver bore leading when added to one groove of the factory wadcutter.

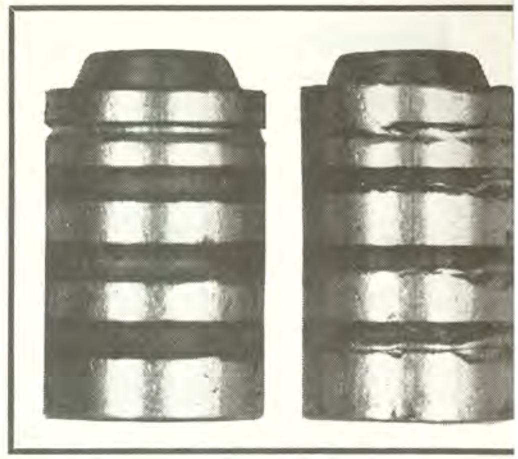
Comparatively little has been said in all the foregoing about swaged target wadcutters from the custom bullet manufacturers. The solid and hollow-base custom wadcutters, of a single make, tried in these tests, did not perform nearly so well as factory and cast target bullets. The custom manufacturer has changed the design of both bullets since the time of the tests. The products of other makers are, of course, different also. It would, therefore, be wrong to take the present results as unfavorable to custom .38 Special target bullets in general. Leading bullet makers provide superior jacketed target bullets for rifles, and certainly can be expected to develop correspondingly good .38 Special bullets. But since the bullets differ from maker to maker, their performance can be known only by adequate test of each make and production style. Test of rifle bullets is readily within the ability of a good rifle shot. It is not within the capability of most pistol shooters, and this greatly limits their ability to select accurate target ammunition.

Prices of the factory wadcutter bullets and most of the custom bullets are the same.

Findings summarized

This completes the account. Because of its length, necessary for reasonable completeness, the most important points are summarized:

1. The ammunition's target spread is added to that of the shooter. Thus there is no given ammunition dispersion (10-ring diameter, X-ring diameter, or any other) which is as small as desirable; it can only be desired that the ammunition have no dispersion.



Bullet (r.) damaged by sizing down .004" in a die of non-centering shoulder type. Shown with bullet correctly sized down ½ of .001" incident to lubricating, in die of centering type.

2. The factory target wadcutter ammunition proved best, showing itself capable in high-grade target revolvers of averaging 2½ minutes of angle in 10-shot groups, or 1¼" at 50 yds.

3. Handloads made up with the factory wadcutter bullet were very nearly as good. Factory bullets are sold for handloading at the same price as most custom bullets.

4. Handloads made up with *correctly prepared* wadcutter cast bullets averaged within 3½ minutes of angle in 10-shot groups, or 1¾" at 50 yds.

5. Handloads made up with solid and hollow-base wadcutter custom bullets, of designs being produced at that time by a large manufacturer, averaged considerably larger groups.

6. Cartridge case, primer, powder charge, and crimp, so long as suitable for the load and assembled with reasonable care, have little effect on the grouping of .38 Special target handloads. The bullet is the decisive component.

7. Successful cast bullets must be:

- **a.** Well cast, allowing the mold to fill completely; and made of metal which is sufficiently hard and strong.
- **b.** Sized only lightly, in a die that centers the bullet; or not sized. A correctly made die makes best use of an oversize bullet.
- **c.** Lubricated with a bullet lubricant which conditions the bore for close grouping.

This investigation was directed entirely to fundamentals. It may still be possible, by refinements, to equal or perhaps even surpass the factory ammunition and bullet. ■

Antimonial Lead

A commercial metal called antimonial lead is comparatively inexpensive. Just what is this form of lead? Is it good for casting bullets?

Answer: Antimonial lead is the designation of lead alloyed with antimony by the manufacturer. It is made for uses in which pure lead is too soft and weak. The proportion of antimony, while not fixed, is often about 6%.

Antimony adds greatly to the hardness and strength of lead alloys. It also increases their fluidity when melted, and so improves their casting qualities.

Antimonial lead casts well, and makes very good bullets.

The metal can be improved by adding a small amount of tin if desired. Tin further increases fluidity of the molten alloy, and improves toughness. Its hardening effect is limited. Excessive tin causes loss of strength under only moderate heating, with early failure of the bullet. From 2½%-4% of tin is most useful in cast bullets.—E.H.H.

Cast Bullet Liabilities

Miami, Fla.

Editor:

Recent articles in THE AMERICAN RIFLEMAN show that cast-bullet reloads can compare favorably with factory ammunition. A stipulation, always repeated, is that care be used in making the bullets to insure the quality and uniformity needed for reliable accuracy. This requirement can be met if the loader is willing and able to devote the extra time and effort.

For most shooters reloading is a means to an end, and is usually not enjoyed. When time is limited, there will be a natural tendency to rush or inadequately perform the distasteful tasks. Although most parts of reloading require only a moderate amount of care to obtain good results, bullet casting requires full attention and care at all times, and this hot, tedious process will be one of the first to suffer when a shooter is faced with the necessity of rationing his time. When it is necessary to produce large quantities of ammunition, laxity often becomes the rule. The results will eventually show up at the range.

Our club was using cast bullet loads in our .38 revolvers with fair results. We never bench-rest tested our loads, but generally good scores at our matches convinced us that our ammunition was of adequate quality. True, we had fliers, but we attributed them to jerking, flinching, etc. Even keyholes far from the center were explained away by a theory that while the heel of the bullet was still in the muzzle, a delayed jerk or other movement occurred imparting to the bullet an end-over-end motion. Rationalizations were directed away from the ammunition, since one of the great folk tales of shooting is that handloaded ammunition is, by definition, the most accurate.

One day we had been practicing at 25 yds. with good results, and decided to try our skill at 50. Our 50-yd groups resembled buckshot patterns. Ten-shot groups averaged only 2 or 3 in the black, with usually at least one completely outside the scoring rings. There was a high percentage of elongated and profile entries.

It was just by chance that an extraordinarily high number of the cartridges happened to be of inferior quality. The components used were of the same lots which had been used in the manufacture of successful ammunition. This includes the cast bullets which had been made in very large lots and visually inspected, and seemed to be uniform and in good condition. Because of the large quantities of bullets and the time involved, we did not feel it would be feasible to make a check by weight. For the most part, our ammunition delivered good accuracy and enabled us to establish a good competition record. We therefore felt that reasonable care had been taken in manufacture of the cast bullets and assembling the loaded cartridges.

On that day we were fortunate to have a different ammunition to use as a control. Because we had been finding it difficult to devote the needed time to bullet casting, we purchased a quantity of the bullets which leading manufacturers make available as components to handloaders, and we had taken along several boxes of ammunition loaded with these bullets. The accuracy was excellent, showing that it had been the ammunition, and in particular the cast bullets, which had been at fault.

Factory bullets used

Therefore we discontinued the use of cast bullets in our .38 Special shooting and used factory bullets exclusively. The cost was higher, but it is a waste of money to invest in match entry fees and then shoot with inferior ammunition.

We do not condemn cast bullet reloads. For years we had had good performance with carefully assembled loads. But obtaining these good results required many hours of meticulous casting, inspecting, sorting, and rejecting. For those who have the desire, time, and patience to produce well made cast bullets, the results will be outstanding accuracy and a great feeling of satisfaction. But for those who do not have a consuming interest in the art of handloading, and view it only as a means of obtaining economical shooting, the use of precise, factory manufactured bullets is recommended.

We have very little experience with cast bullets in handgun calibers other than .38 Special, or in rifles, but we assume that all weapons react in the same way to inadequately prepared ammunition.

GEORGE A. SKOKAN

Salvaged Type Metal

Linotype metal which I bought at a scrap-metals yard was found to make beautiful bullets. However, test on a sample of the metal (procedure given in "Measuring The Hardness Of Cast Bullets", in the NRA Illustrated Reloading Handbook) *showed a Brinell hardness of only 15, instead of the 20 or 22 of new linotype alloy. Does this mean the metal is not li[notype] alloy? Is it any less useful for cast bullets?*

Answer: The hardness indicates li[notype] metal with a considerable admixt[ure] of a softer type metal, such as electroty[pe]. There probably is no other contaminat[ion]. The superior casting qualities you ment[ion] could not have been retained if comm[on] scrap lead had been added.

The metal will do very well as a co[m]paratively hard alloy for many bull[ets]. This includes .38 Special target bullets, [an] important use. It would not suffice [for] heavy cast-bullet loads in rifles, which [re]quire the maximum hardness and streng[th]. The metal could be used in such loads [by] decreasing the powder charge 10 or 15[%].

The importance of salvaged metal [in] cast-bullet handloading is not to be deni[ed]. Accepting it by name only, however, [can] result in getting something less than [ex]pected. A hardness test reveals whether [it] is up to requirements.—E.H.H.

Testing Reduced Loads

Greenville, Tenn.

Editor:

The testing of full-power rifle loads [is] done with an accurate rifle and scop[e] generally from bench rest. In testing [re]duced loads, the average good prone sh[ot] obtains much more representative resu[lts] by firing prone with sling.

A case in point is the difficulty in o[b]taining meaningful information by fir[ing] a .22 match rifle from the bench. Prac[ti]cally every smallbore match shooter [I] know determines the status of his equ[ip]ment and ammunition by prone shooting.

The reason is obvious. Slow loads ha[ve] much longer barrel time than fast load[s] and the effect of any displacement wh[ile] the bullet is still in the barrel is increase[d], hence it is a much greater problem [to] control the gun uniformly.

I suspect many accurate reduced loa[ds] are erroneously evaluated, whereas th[e] cause is in actuality poor shooting.

ERIC FARR

Cast Bullets In Rifle Loads

Laurel, Miss.

Editor:

I have been shooting cast bullets w[ith] the Alox bullet lubricant described in th[e] article "Bullet Lubricants" (RIFLEMA[N], July, 1965), with gratifying results.

The loads in the table on the followi[ng] page have been used.

All these are gas-check bullets, and th[ey] were loaded with Hornady and Lyma[n] gas checks. The kapok filler is a ½-g[r.] tuft of kapok fiber inserted loose in th[e] space over the powder. Alox lubricant w[as] used throughout.

The .30-'06 load with No. 311316 bul[let] is the best squirrel load I have ever fir[ed]. Little meat is damaged. I have fired it i[n] 4 rifles and it shoots well in all of the[m]. I felt rather smug about the ¼" gro[up] with this load using a 10X scope until [a] friend equaled it with peep sight, and [...]

Rifle	Lyman Bullet No.	Lyman Bullet Wt., grs.	Lyman Bullet Metal	Powder Charge	Kapok Filler	Best 5-Shot Group
.30-'06	311291	174	hard	37½ 4831	No	⅞" at 100 yds.
.30-'06	311316	116	{wheel weights	8½ Unique	Yes	¼" at 25 yds.
.243 Win.	245496	80	hard	8 Unique	No	*⅛" at 25 yds.
.22-.250	225415	50	hard	10 4198	Yes	⅛" at 25 yds.

*3-shot group.

kapok filler in the load. I do feel that the kapok is necessary for consistency.

The .30-'06 load of 37½ grs. IMR 4831, however, does better without a filler.

There is something about shooting cast bullets that arouses my interest—maybe it is the challenge, or maybe the economy appealing to my Scottish ancestry. In my shooting the Alox lubricant has meant the difference between occasionally acceptable groups and consistent week-after-week tight groups that can be counted on.

Ed Breland

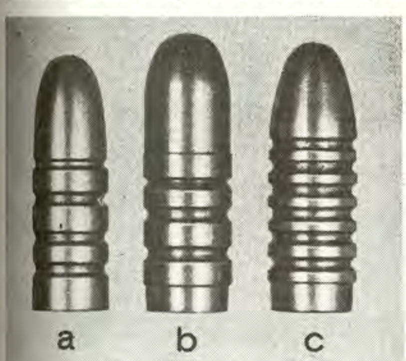
Plain-Base Cast Bullets

I get fantastically poor shooting with a plain-base cast bullet in .30-'06 even after trying several powders, though results with gas-check bullets are very good. The bullet mold manufacturer considers the bullet in question to be very accurate and reliable in all .30 calibers up to 200 yds. What is the reason for this discrepancy?

Answer: Quite unlike gas-check bullets, cal. .30 plain-base bullets are satisfactory in only a few light loads, giving at most the velocity of the .32-40 blackpowder cartridge. Best loads in .30-'06 are 13 to 14 grs. No. 2400, or 14 to 15 grs. IMR 4227 powder. These should shoot well from the beginning, and can be improved by slight adjustment based on trial.

The above powders are the most suitable among those now available, because they are of the coated type and consequently give somewhat lower flame temperatures at beginning of burning. Two other reduced-load powders, Unique and the former SR 4759, are uncoated and therefore less suited to the requirements of a plain-base bullet, though they are most excellent powders for other purposes.

Again unlike gas-check bullets, the plain-base bullet may leave lead fouling in the rifle bore even from correct loads. The fouling can be minimized by loading ½ gr. of kapok fiber loosely under the bullet. In any case it should not interfere with grouping for 20 to 30 shots, then is readily removed with a brass bore brush. Alternatively, one or 2 jacketed bullets fired through the barrel followed by a light brushing remove any leading at once.



Cast bullets for loading without gas check. (a.) Lyman U311241 (plain base), (b.) U311291, and (c.) U311466. Lubricant in multiple grooves of U311466 allows it to withstand heavier loading.

It is absolutely necessary to use a high quality bullet lubricant.

In buying a bullet mold for light loads of this kind, one might well choose a gas-check bullet. It can be used without a gas-check in the same loads as the plain-base bullet. If sides of the gas-check shank are left covered with bullet lubricant, it gives better results than the plain-base. Then the user has also the added adaptability of the gas check when desired.—E.H.H.

Cleaning Lead From Mold

How can I remove a lead deposit now smeared across the top of my bullet mold? This deposit affects the bases of bullets cast in the mold.

Answer: When such a deposit appears during casting, at once touch a piece of wax to the deposit, pour bullet metal over the spot, and wipe with a coarse cloth. Repeat several times. Keep the mold up to casting temperature while doing this.

Note that there will be an equal or greater deposit on the underside of the sprue plate which, if not removed, will cause the mold deposit to re-appear.

Brass wire gauze or a brass suede leather brush (not steel in any form) can usefully be employed instead of cloth for wiping.

Any remaining deposit should be completely removed after casting is completed, or it will recur at next use. As soon as the mold is cold, cover the leaded surface generously with mercurial ointment (so-called blue ointment) and allow to stand as long as possible. The mercury in the preparation amalgamates with lead and tin of the deposit, softening it enough to allow relatively easy removal. It may have to stand 2 weeks or longer to produce much effect. Reapply if necessary. The ointment is a preservative of iron and can be left on as long as required. If any gets into the mold cavities, remove with acetone or denatured alcohol (not petroleum solvent) before next use, to prevent interference with casting.

The sprue plate can be cleaned separately by means not safely applicable to the mold blocks. Remove the plate, and rub it on fine abrasive cloth laid over a glass sheet or other smooth flat surface. Continue until all the lead is removed, then preserve against rusting since the original oxide layer will also have been removed (sufficient oxide will again appear at next use, even though invisible). The plate also could be heated enough for most of the lead to be readily wiped off, with precautions against warping; but such treatment should not be necessary.

Lead deposit on mold and sprue plate is thus a nuisance which is best avoided. It is caused by knocking the plate around before the sprue has set fully. This happens through either (a) trying to cast too fast, or (b) allowing mold and plate to become too hot, requiring excessive time for the metal to set.

The plate is the main site of trouble. It can be kept from overheating by pressing it at intervals against a wet sponge or cloth pad. Do this as soon as the mold can be inverted without spilling metal, and before knocking the plate around. Trial soon indicates how often it is necessary. Correctly done, it keeps the parts completely clean and free of lead.

Should a gang mold eventually become too hot in the body also, it may be cooled by momentarily plunging it (with cavities and pouring holes still full of metal) endwise into warm water.—E.H.H.

Lead deposits on the underside of the sprue plate of a gang mold.

Gas-check Attachment

The gas checks come off my cast bullets in flight. Is this consistent with good results? I get good accuracy with my light loads, but not when I increase the charge.

Answer: Gas checks regularly come off cast bullets fired with comparatively heavy loads, often with only light loads. The gas check leaves the bullet at the muzzle. The American Rifleman has had one report of a gas check actually left in the rifle bore.

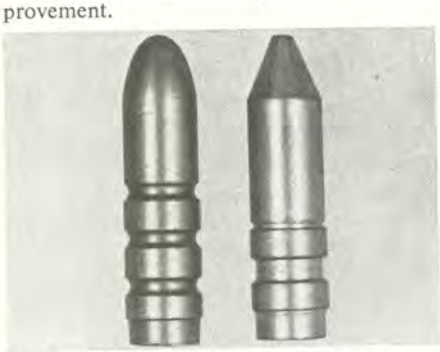
It appears that in light loads the gas checks can come off without much effect on grouping. In heavy loads, the coming off is evidently connected with overheating and deformation of the bullet, and is fatal to good grouping.

Recovered bullets and separated gas checks show melting of a very thin layer of the bullet under the gas check.

The excellent Hornady gas check has a thickened edge, designed to crimp into the bullet when passed through the lubricating die. This does improve the attachment. The amount of improvement necessarily is limited since the gas check cannot grip molten metal.

Much the best preventive is an inert filler between powder and bullet. THE AMERICAN RIFLEMAN has tested a great variety of these (see "Cartridge Space Fillers", January 1967). They differ widely in effectiveness. The best found so far is Du Pont Dacron fiber, with kapok fiber next. In .30-'06, the correct filler in medium and heavy cast-bullet loads is one gr. weight of Dacron fiber over the powder. With a correct bullet, cast of linotype metal and lubricated with best-quality bullet lubricant, this Dacron filler reliably prevents gas checks coming off at velocities up to 2300 f.p.s. At 2600 f.p.s. the gas checks begin to come off despite the filler, and the grouping becomes uncertain.

The bullet base is subject to some improvement.



Tapered (l.) and untapered bases on gas-check bullets.

The left-hand bullet in the illustration has a tapered base for the gas check. This reproduces the original form in which the gas check bullet was introduced in 1905. It was designed to drop the gas check on leaving the muzzle, and it does so. The right-hand bullet has an untapered base which holds the gas check somewhat better.

The Dacron fiber filler, however, is far more effective in keeping gas checks on than the shape of bullet base.—E.H.H.

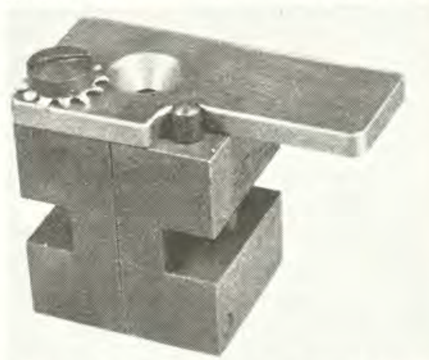
Mold Cut-Off Plate

When I cast gas-check bullets of hard alloy for my .30-'06 rifle, the cut-off plate leaves a sloping lump on the bullet base. Tightening the plate hinge screw on its lock washer, and striking the plate at various angles to cut off, make no improvement. Is the pouring hole in the cut-off plate too large?

Answer: A large hole tends to cause this trouble, and a smaller hole will leave a much better base. However, the smaller hole will make it more difficult to obtain a well filled out bullet. Because of these conflicting requirements, the correction is best found in other design features. The most useful are a thicker cut-off plate and better cutting edge.

The difficulty you describe occurs with old style cut-off plates only ⅛" thick. A plate 3/16" thick provides part of the correction. The deeper hole of the 3/16" plate also better accommodates the dipper spout, which then does not have to be set in place with such precise care.

The rest of the correction is provided by an effective cutting edge. Examination of the factory plate will show that its conical hole comes out not to a sharp edge but



Bullet mold blocks with replacement plate of tool steel.

to a short cylindrical section, necessary because the plate is made of soft metal and a cutting edge would not last. This cylindrical mouth scrapes smooth the base of a bullet of soft alloy and does fairly well on medium-hard alloy. But on linotype metal or equal, which is necessary for best performance in comparatively heavy cast-bullet rifle loads, a large hole of this shape leaves the lump you describe. Attempts at correction by tightening the screw, etc., are useless.

Replacement plate

The user therefore has to make, or have made, a replacement plate. The best material is 3/16" ground flat tool-steel stock. A strip 1" wide makes up into plates for Lyman bullet molds with minimum cutting and waste.

Using the old plate as a template, the outline and 2 holes are laid out on the flat stock, and the plate is shaped with hacksaw and files. The hinge screw hole and a small pilot for the pouring hole are drilled, then the pouring hole is cut with a center drill (machine countersink) 82° included angle, using plenty of cutting oil. The maker who has a lathe can set a piece of stock on the lathe face-plate and bore the pouring hole with a single point tool; this is easiest done before the plate is shaped. Either way, the conical hole is run through to an edge.

Size of the clear hole should be in some proportion to bullet diameter. With most bullets, a diameter of .150", the same as in the Lyman factory plate, works well with a plate made as described, and the large hole helps in getting full, smooth bullets. This steel can be left in the annealed condition, in which it is hard enough.

In use, adjust the hinge screw to leave the plate swinging just freely; making it any tighter gains nothing in cutting of hard alloys. Cut the sprue off with several light taps on the plate, which shaves the bullet base satisfactorily smooth. Another way is to strike the plate one rather light but very sharp rap, causing the plate to swing clear around. With the thick plate and cutting edge described, this snaps the sprue off level.—E.H.H.

Slag From Bottom Pour

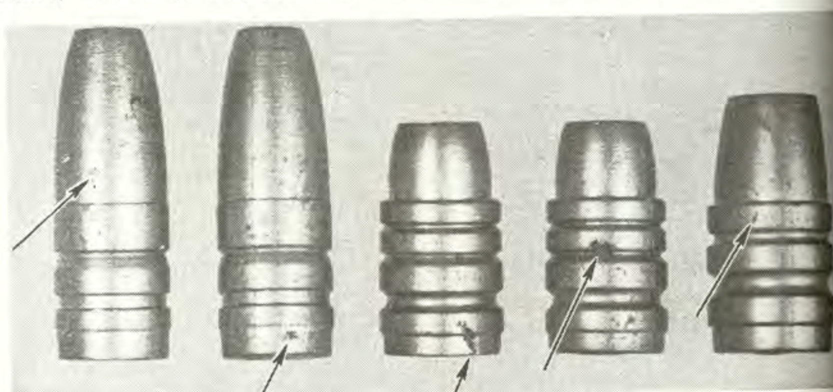
What causes the spots of some apparently foreign material in my cast bullets? I cast from a bottom-pour electric pot and flux the metal carefully.

Answer: The spots (see illustration) are slag inclusions not removed by fluxing and skimming the melted metal.

It may surprise bullet casters to learn that some slag or dross sinks in melted lead instead of rising to the top. This happens especially in certain kinds of scrap lead. It becomes most apparent in bottom-pour pots because these are stirless and because metal is taken from the bottom where that kind of slag accumulates.

When this occurs, allow the melt to stand quietly for 20 minutes to settle. Then cast it into ingots with as little disturbance as possible. Clean the bottom of the cooled ingots with a wire brush. Thoroughly clean out the bottom of the pot where most of the settled material is found.

With the old-fashioned simple pot used over a fire, allow the metal to harden. Dump it out in one piece, and both the slug and the pot are easily cleaned.—E.H.H.



Slag (arrows) in bullets cast from bottom-pour pot.

ACCURACY AND POWER WITH CAST BULLETS

Footnotes for this article on page 144.

A decade of testing leads to refinements not thought possible

By E. H. HARRISON
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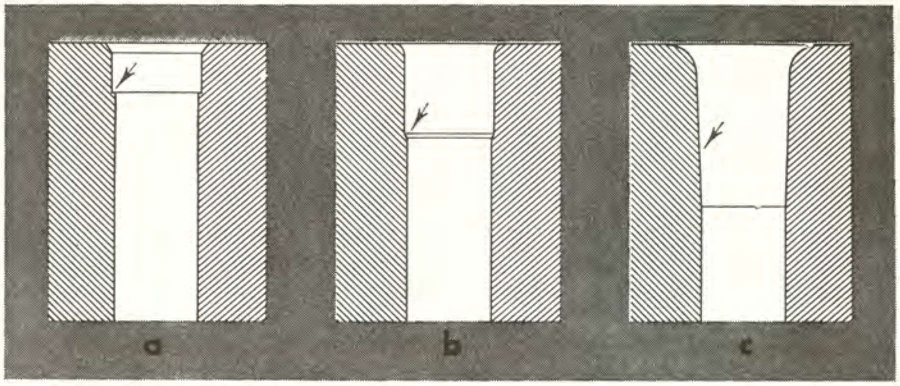
PART 1 OF 2



All sizing of bullets is damaging, but degree of damage varies with amount of sizing and with die design. In design **a** that has been most common, sizing shoulder (see arrow) is square step with no ability to center bullet, which therefore is often sized off-center.[1] In design **b**, shoulder has 7° taper that centers bullet base in sizing. Design **c** has long slope which performs same function.

Cast rifle bullets give the advantages of production by the handloader himself, very low cost, variety to suit many uses, and unlimited rifle barrel life.

They often involve, on the other hand, the disadvantages of poor accuracy (experienced by some shooters, not all) and limited velocity. The art of loading cast bullets is in minimizing these limitations. Often they can be eliminated entirely.

Early developments

The use of cast bullets with smokeless powder in rifles began before 1900. In 1905, John Barlow of the old Ideal Manufacturing Co. introduced the copper gascheck and bullets designed for it, and results at once reached a level attracting serious attention. Then the death of Barlow and some other pioneers, and the onset of World War I, brought the development to an end. Later the manufacture of Ideal loading tools and bullet molds was taken over by Lyman Gun Sight Corp., together with continued publication of the *Ideal Reloading Handbook*. This was most fortunate for handloading. But despite some successes by individuals, the ability to improve cast-bullet results had been lost. Even the World War II shortages of ammunition and reloading components failed to restore it.

Since handloader interest was still there, THE AMERICAN RIFLEMAN began to investigate the problem on a systematic basis, and in 1957 and 1958 published the initial results in an extensive 4-part article. The effect was immediate. The investigations have since been continued at intervals and the findings published. It is clear that with correct loading, results can be obtained which a few years ago were considered impossible.

The following summarizes the decisive points and refinements on them, in loading cal. .30 cast bullets. The information was obtained by nearly 1000 firing tests totaling about 13,000 rounds, fired in 18 rifles with bullets from 26 bullet molds. The composition of each load and the results it gave were entered on punched cards for analysis. The essentials and refinements then became evident.

Fundamental factors

The fundamental factors, which must be correct for success, should be summarized first. They are a suitable powder charge; adequate bullet hardness, design, and diameter; a really good bullet lubricant; and a clean rifle barrel.

Powder charge. During much of this testing, the best powder charge usually was the lightest one which burned satisfactorily. It still is true that in most cases the charge must be less than a full load for a jacketed bullet. But continued improvement in other factors has made possible a much wider choice. The following can now give excellent results in .30-'06:

Powder	Charge (grs.)	Approx. Muzzle Velocity (f.p.s.)
Hercules 2400	13-20	1250-1700
Du Pont IMR 4227	14-22	1250-1700
Du Pont IMR 4198	20-25	1500-1900
Hodgdon BL-C, Lot 2	28-34	1700-2100
Du Pont IMR 4895	30-38	1800-2250
Hodgdon H-380	35-42	1800-2250
Hodgdon 4831	40-50	1800-2250
Hodgdon H-450	40-50	1800-2250

It is sometimes practicable to exceed these charges and velocities. Successful loadings will be explained.

Bullet hardness. Bullets for light loads may be cast of scrap lead. From 2½% to 3% tin should be added to make the metal cast well; this with the amount of antimony in most scrap makes it sufficiently hard. However, a hard alloy gives more reliable results.

Bullets for all other loads must be hard and strong; this is an absolute requirement. The best available alloy is linotype metal, with hardness 20 to 22 Brinell. The subject of bullet metals will be returned to below in some detail because of its importance to success.

Bullet design. Bullets covered by grease grooves almost their full length provide the maximum in both lubrication and guidance. They have the disadvantage that in most loads they leave grease exposed outside the cartridge case, which is often a nuisance and sometimes unacceptable.

Bullets with body of moderate length, and the forward part fitting on the barrel rifling lands for guidance, meet nearly all requirements. In barrels with wide rifling lands the forward bore-riding part may be longer, leaving the body only a third of the bullet length. But in all cases the forward part should fit the lands; a diameter of .296" to .297", as has often been the practice, is too loose for most accurate shooting. It should be a full .300", and .301" is better except that may give stiff loading in new barrels. Bullet molds now sold appear to have been improved in this dimension.

With few exceptions, successful cal. .30 cast bullets are of the gas-check type.

Bullet diameter and sizing. The bullet body should be of .308" to .310" diameter, but may be .311". It is not a matter of diameter only, but of how it is obtained. A .313" or larger bullet sized to .311" may be better than when sized to .308", because it is less damaged.

Fortunately, all dies for bench sizer-lubricators are now made to a design which sizes bullets concentric, and this together with a more moderate approach by mold makers to diameters of cal. .30 cast bullets has ameliorated the diameter and sizing difficulty.

Bullet lubricant. Unjacketed lead alloy bullets must be lubricated to prevent "leading" the rifle bore (depositing or even soldering flakes of lead to it). Present-day handloaders have tended to assume that this is the only function of the lubricant, but in reality it has a marked effect on shooting accuracy also. After exhaustive NRA testing, the best rifle bullet lubricant found is composed of equal parts yellow beeswax and an industrial petroleum derivative designated Alox 2138F. The prepared bullet lubricant is available from several suppliers.

An explanation will bring out what is involved in each of these decisive factors, and give an idea of the reasons underlying them.

Powder charges

Cast bullets are, at best, much less strong than jacketed bullets, and this imposes a limitation on the propellant charge that can be used. Pressure exceeding the cast bullet's strength deforms it until the shooting is wild. This normally happens well before the bullet "jumps the rifling", so the latter reputed mode of failure is not the problem.

Disregarding the very light loads employing shotgun and pistol powders, the table shows the smokeless propellants which in these tests have been most successful with cast bullets. In each, the charges shown range from the lightest to the heaviest which gave reliable performance in .30-'06, other components being correct. They cover a wide range of practical usefulness. The beginner should get good target grouping at once with a low or middle charge of No. 2400, IMR 4227, or IMR 4198. That is what he should start with, since above all he needs the feel of success.

Some other current powders have given more or less good results in this application, still others have not. The reasons are not clear. The above list is long enough, and problems with the other components in cast bullet loading are sufficiently troublesome to make it seem unnecessary to try to make less suitable propellants work.

In practice, most cast bullets are produced from scrap and salvaged metals. The motives are economy and convenience.

Very light loads work with bullets cast of almost anything that will melt. Adding 2½% to 3% tin improves the casting. Tin is bought in bars, either pure or in solder containing stated proportions of tin and lead.

Soft scrap metal can be used in loads up to about 1300 feet per second (f.p.s.) with fair satisfaction. But it is objectionable because really inadequate for even that application, requiring careful and skilled adjustment of the powder charge to get accurate shooting. This is especially unfavorable to the beginner. To obtain results in this range without difficulty, and extend them to the 1700 f.p.s. readily practicable with No. 2400 and IMR 4227 propellants, the metal must be at least half as hard as required for heavy loads. This means at least 10 to 12 Brinell, or the hardness of the old alloy of one part tin to 10 of lead. (Brinell hardness is explained in "Measuring The Hardness Of Cast Bullets", which is reproduced in this handbook. Pg. 29.) Greater hardness than that does no harm at all, and tends to make reliable grouping come easier.

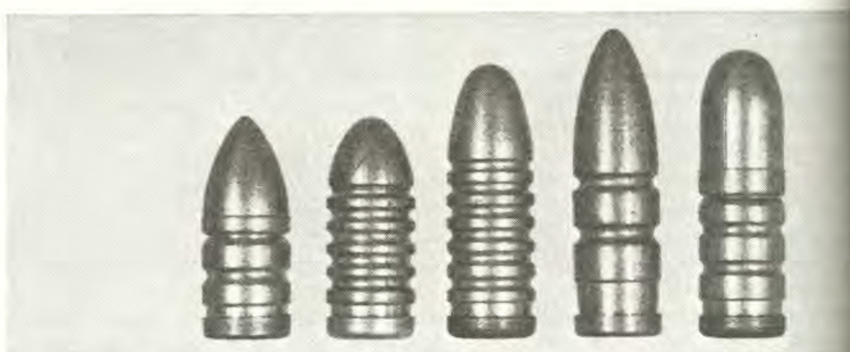
Heavy cast bullet loads require the hardest and strongest lead alloys practicable. Disregarding this causes failure.

Tradition, regrettably kept alive in published information, has been a heavy handicap. At the beginning of this century there was still perhaps some excuse for the weak and i[ll]proportioned bullet metals used. [In] present times the physical properties [of] alloys including type metals, with sp[e]cific compositions of tin, antimony, a[nd] lead, are well known.

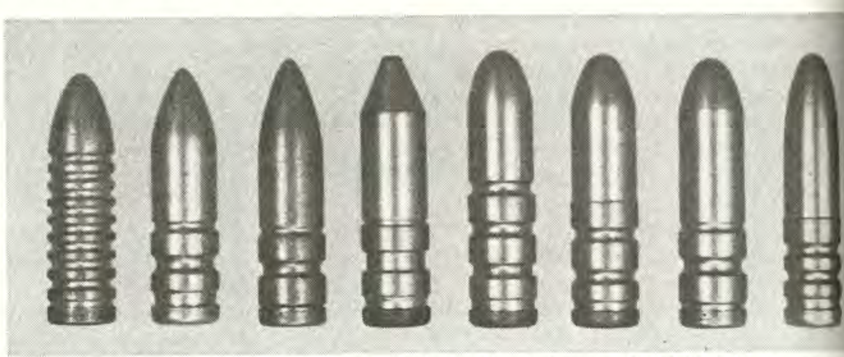
Briefly, tin improves the cast[ing] qualities of lead alloys and incidenta[lly] has some hardening effect. After t[he] first few per cent the added harden[ing] is slight. The long-recommended "1-[to-]10" mixture (one part tin to 10 lea[d]) had a hardness less than 11 Brin[ell], only about twice as hard as pure le[ad], and was a costly absurdity.

Antimony has far greater harden[ing] and strengthening effect. Lead-an[ti]mony alloys can practicably be ma[de] 4 times as hard and strong as lead. B[ul]lets cast of straight lead-antimony [al]loys give very good results.

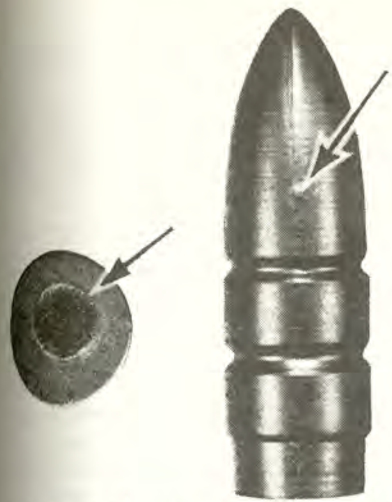
Lead and antimony together give b[etter] results. The tin improves casting qua[li]ties and adds some toughness. T[he] gross physical and the microscopic a[nd] micrographic properties of lead-ti[n-]antimony alloys have been exhaustive[ly] investigated for their use in type metal[s] which have essentially the same requir[e]ments for hardness, strength, wear r[e]sistance, and smooth casting that ca[st] bullets require. The most suitable ty[pe] metal usually available is linotype, ord[i]narily 4% tin, 12% antimony, a[nd]



Light and medium weight cal. .30 cast bullets: (l.-r.) Lyman 311359-115 grs., excellent in .30 carbine also; 311465-120 grs. Loverin; 311466-150 grs. Loverin; 31141[3]-165 grs., fails above light loads; 311291-170 grs., best single cal. .30 cast bullet.



Comparatively heavy cal. .30 cast bullets: (l.-r.) Lyman 311467-175 grs. Loverin; 311332-180 grs.; 311334-190 grs.; Saeco RG4-192 grs.; Lyman 311284-205 grs.; 311290-205 grs.; 311335-200 grs.; 311299-205 grs.



Loads of suitable accuracy can be refined by orienting bullet always the same when loading in rifle. Position of bullet in mold is often shown by off-center sprue (l.), which can be indicated by making a mark on bullet ogive, or the mold can be made to leave such a mark by filing a little notch (r.) on one edge of mold block (see arrows).

84% lead, with hardness 20 to 22 Brinell. It is highly successful in cast bullets. (Monotype metal, composed of 9% tin, 19% antimony, 72% lead has about 28 Brinell and may materially extend the possibilities of cast bullets, but that possibility has not been pursued.)

The 44th Edition of the *Lyman Reloading Handbook,* published in 1967, took the important step of dropping most of the old bullet alloys and recommending only Lyman No. 2 alloy (composition 5% tin, 5% antimony, 90% lead) or equivalent. The same composition is also available as Division Lead Co. Bullet Alloy No. 7. Hardness of the latter has been given as about 18 Brinell though 16 might be more realistic. But Lyman No. 2 and Division Lead No. 7 are comparatively hard and strong, and of course cast excellently. They are a very great improvement over many bullet metals used.

Sources of linotype metal must be sought out locally. This is inconvenient, and is likely to result in getting mixed or mislabeled metals. Antimony costs only about 3 times as much per pound as lead while tin costs at least 12 times as much as lead.[2] This results in the total metals in Lyman No. 2 costing about the same as in linotype, though the performance potential of linotype is greater. Improvement in the cut-off plate of Lyman single and double cavity bullet molds (see "Mold Cut-Off Plate" and later items in this handbook) would allow them to cast linotype metal without difficulty in cutting off the sprue. Then linotype could be sold as a regular bullet metal.

Of course bullets must be well cast. Molds should be stored without oil or grease, and mold and metal should be at proper operating temperature. Then the cause of poor bullets is in casting too fast, not allowing the mold time to fill. Cal. .30 bullets properly cast in a single-cavity mold, and inspected for surface defects, should be about as uniform in weight as cal. .30 jacketed match bullets—within ½ gr. extreme spread in a sample of 20. After the quality of cast bullets has been thus established they need be check-weighed only occasionally.

Flux the molten alloy regularly during casting, keeping it clean and clear. Even so it will lose tin. Therefore, add about 1% tin to the metal each time it is remelted.

Bullet diameter and sizing

Cal. .30 cast bullets have an unlucky history in this respect. Molds supplied have produced bullets up to .314" diameter. The handloader was directed to "size" these down sufficiently for use, in a die which cut the bullets down off-center. He was told this improved them.

The reason appears to have been partly historical. It has been stated that barrels of the first cal. .30 Model 1892 (Krag) rifles measured from .305" to .315" or more in groove diameter. It appeared easier to provide cast bullets to fit these by means of bullet sizing dies than by separate bullet molds. A virtue was made of this by claiming that sizing improved the bullets (in the face of the fact, quite well known, that by far the best cast-bullet shooting was done by Schuetzen and bench-rest riflemen who shot their bullets unsized). In any event, most rifle barrels made since World War I have been uniform enough, and the sizing practice long outlived the usefulness it may originally have had for that purpose.

Sizer-lubricators are desirable without any such excuse. They grease bullets far easier and faster than it can be done by hand, and attach gas checks at the same time. Also, most gas checks are made of outside diameter greater than the bullet, and if merely pressed on they form an oversize base which keeps the bullet from being held well in the case neck. A sizer-lubricator brings the gas check down to bullet diameter and attaches it somewhat more securely.

In more recent years, other manufacturers made their molds to cast bullets very little oversize, and made sizer-lubricator dies with a tapered lead-in which centered the entering bullet to avoid cutting it down off-center (see illustration). In 1963, Lyman adopted this form of sizer-lubricator die. This correction has largely removed this old handicap.

Bullet design

The limited strength of lead alloy bullets makes it necessary to support them during discharge. Otherwise they are distorted and shoot wild.

Like any bullet, these must be positively guided or they will tilt. Also the cast bullet being plastic tends to slump from the great force applied to its base, and bend if not held straight.

This was encountered as soon as elongated bullets began to be used. The solution in most blackpowder ammunition was to allow only a short bullet nose, the body taking up all the rest of the bullet and being covered by a paper patch or by grease grooves. This provided the maximum in support and guidance. In recent decades the Loverin design of cast bullets has been essentially the same, with gas-check added and diameter of the leading bands tapered slightly down to fit into the barrel bullet seat. These bullets give excellent results. They may have somewhat greater performance potential than any other form of cast bullets. But as already mentioned the grease grooves left exposed in the cartridge may be objectionable. Also, long Loverin bullets, despite their desirable leading taper, have to be loaded deep in short-necked cartridges, especially when they must be fired in a barrel with short unworn bullet seat.

To accommodate long heavy bullets without incurring similar disadvantages, the final blackpowder military cartridges were designed for bullets with longer noses, these being exposed while only the bullet bodies were held in the cartridge case. To preserve the bullet shape and alignment, the lead was hardened. The U.S. Cal. .45 Model 1881 service bullet, weighing 500 grs., had a parallel-sided nose making up more than half its length. The first of John Barlow's cal. .30 gas-check bullets—the present Lyman 311284, 311290, 311291, and 311299—were designed in this form, and to this day they are among the most successful of all gas-check bullets. While expansion by a heavy load may shorten and bulge the nose section to fit on the barrel rifling lands, this part of the bullet should fit before discharge.

The most widely known bullet deviating from this form is Lyman 311413, which appeared as the Squibb in 1929 and was later made in somewhat modified form. This long-recommended bullet (see illustration) reproduces to a considerable extent the shape of jacketed spitzer bullets. Its target grouping is excellent in light loads up to about 1400 f.p.s. At higher velocities its record is one of repeated failure. This results from insufficient guidance during discharge, the long point being unsupported. THE AMERICAN RIFLEMAN at the start of its cast-bullet investigation in 1957 pointed out in specific terms the poor performance of No. 311413; bullet No. 311291 of the same weight was found to perform excellently. In 1967, Lyman in its *44th Edition Reloading Handbook* made an explanation of good and bad forms of cast bullets, and no longer recommended No. 311413. This removed a long-standing handicap to users.

Since cast bullets thus must be comparatively blunt, the user must accept a greater velocity loss and accompanying greater wind deflection than with long-pointed jacketed bullets at the same muzzle velocity. If desired, he can minimize this effect by selecting a cast bullet which while retaining the necessary parallel-sided nose has a sharp tip. Examples are Lyman 311332 and 311334.

Bullet lubricants

Despite common fears of bore leading when low velocities are exceeded, *leading is not a real problem.* It has never been experienced in AMERICAN RIFLEMAN testing, even with cast-bullet loads of 2800 f.p.s. muzzle velocity, when components of the load were correct.[3]

If experienced by the user it is because the load is wrong in some obvious way. One of the most common is use of insufficiently hard bullet metal. In short-nosed multi-groove bullets of Loverin design, the result in most cases is merely poor target grouping; even under deformation no unlubricated lead can reach the rifle bore. Other bullets, when fired under more pressure than the material can resist, are upset in the nose as well as in the body, forcing bare metal of the nose against the bore and leading it.

But since with correct components (including sufficiently hard metal) any reasonable lubricant prevents leading, the real problem is to find the lubricant giving best grouping on target. There is an astonishingly large effect. The old Schuetzen riflemen understood this and gave great attention to it. Present-day handloaders often choose a bullet lubricant more or less perfunctorily, with poor results.

The old Lyman and the excellent new Saeco lubricant give very good to excellent shooting. There are other good ones; still others are notably poor. But even the best ones did not deliver the grouping in test under all conditions that it seemed should have been possible. The subject was therefore gone into in considerable depth.

Bullet lubricants are in the form of a wax or grease. There are:

- waxes and waxy mixtures, formerly containing fats also;
- lubricating greases;
- unconventional materials;
- lubricant additives.

The first class has been traditional for bullet lubricants and its general properties are familiar.

Lubricating grease, the second class, is a gel of oil, usually petroleum lubricating oil, and a metallic soap, usually sodium, calcium, or lithium. Its properties are well known to industry but apparently not to most shooters. These properties depend on the viscosity and kind of oil used in making the grease, the kind of metallic soap (each gives certain distinctive characteristics), and the proportion of oil to soap. Lubricating grease is not readily melted, unlike petrolatum with which it is sometimes confused. There is a special type of grease in which the soap component is replaced by a colloidal clay called bentonite, and this type can hardly be said to have a melting point. The quality of industrial and automotive greases impressively high.

Some materials not in the above classifications can be used as lubricants, and there are also solid additives which have often been resorted to.

Variety of lubricants tried

Careful trial was made of all the lubricating materials in the left-hand column below, and of the same materials with the additives indicated. In most cases the additives were tried in several proportions in the lubricant.

One unexpected result was eventual failure of all the dry solid additives—graphite, molybdenum disulphide, mica, zinc oxide, and Teflon. Mixed into wax and grease lubricants they often improved the lubricating effect but nearly always enlarged target groups. This seemed especially unfavorable in this respect when only small quantities were added to the base lubricant. There was some indication they might be more successful when added heavily—2 or times the base lubricant by weight—but that remained uncertain and eventually all these solid additives were dropped.

For a long time the best-performing lubricant was soft lithium-soap grease. Target groups were smaller and more reliable than with anything else. This is a soft general-purpose lubricating grease, available most readily in one- cans at some filling stations. Besides the shooting accuracy, an interesting characteristic is its comparative insensitiveness to both high and low te

Wax and Fat Lubricants	Additives Graphite	MoS_2	Mica	Teflon
Ideal	—	—	—	—
Ideal—sperm oil	—	—	—	—
Ideal—lanolin	X	—	—	—
Beeswax—castor oil	X	—	—	—
Beeswax—EP transmission oil	X	—	—	—
Crisco (cooking fat)	—	—	—	—
Amoco Door-Ease	—	—	—	X
Wilbayco R.P. Grease—sperm oil	—	—	—	—

Fixed Lubricating Greases	Additives Graphite	MoS_2	Mica	Teflon
Amoco and other chassis greases	X	X	—	—
Esso waterpump	X	X	—	—
Texaco waterpump	X	—	—	—
Cities Service Trojan EP-1	—	X	—	X
Cities Service Trojan H-2	—	—	—	X
Cities Service Trojan HM-2	—	—	—	—
Cities Service Trojan H-EP-2	—	X	—	—
Sinclair MP	—	—	X	X
Delco-Moraine Brake Lube	—	—	—	—
Fiske Lubriplate 110-D, and others	—	—	—	X
Siloo White Lube	—	—	—	—
Anderol Gun Grease	—	—	—	—
Valvoline Outboard EP Gear Oil	—	—	—	—
Valvoline Outboard Gear Grease	—	—	—	—
No. 120 EP transmission oil	—	—	—	—
Locomotive side-rod grease	—	—	—	—
Perfect Lube	—	—	—	—
Chevron Cannery Grease 550	—	—	X	—
Bardahl AP No. 1	—	X	—	X
Herter's Silicone Gun Grease	—	—	—	—

Unconventional Lubricants	Additives Graphite	MoS_2	Mica	Teflon
Graphite-water paste	—	—	—	—
MoS_2-water paste	—	—	—	—
MoS_2 in polyalkylene glycol	—	—	—	—
Lauryl—stearyl alcohols	—	—	—	X

perature effects. This is astonishing to many persons, who because of the softness expect it to melt easily in the manner of waxes including petrolatum. In reality it is a fundamentally different material.

Unfortunately however the soft lithium grease does not work satisfactorily through usual sizer-lubricators, ruling it out for either convenience or quantity loading. Hand application and handling the greased bullet during loading are quite inconvenient. Ultimately therefore it also was dropped and the search for the best lubricant renewed.

Eventual success was obtained with the use of Alox 350 at first, then Alox 2138F. These are derivatives of petroleum, used industrially for increasing the lubricity and corrosion-preventing qualities of oils and greases. They are products of Alox Corp., Niagara Falls, N.Y., which has more than 2000 formulations of them available. Twelve Alox variations were tried, and Alox 2138F was chosen entirely empirically on the basis of shooting trials (the only real basis of choice in all this investigation). While these and some other Alox types could be used straight, they proved best as bullet lubricants as a mixture with pure yellow beeswax (not white or bleached beeswax which is less effective). The bullet lubricant finally chosen consists of equal parts by weight of Alox 2138F and yellow beeswax. It can be made up by the user. To do so is not always practical however, since the Alox manufacturer does not offer it in very small quantities. After publication of these results and many others in THE AMERICAN RIFLEMAN ("Bullet Lubricants", July 1965, pages 46-49) several firms introduced the prepared lubricant at retail. All known reports on its performance have been favorable.[4]

Fiber fillers

Distortion in firing is not the only limitation on cast bullets. Even worse is the great heat of the propellant gas. Plain-base cast bullets loaded above 1300 to 1400 f.p.s. muzzle velocity in .30-'06 are so cut by this gas that all shooting accuracy is lost, and the rifle bore is likely to be leaded. The copper gas check protects the base of the bullet and to some extent its sides, raising the practicable velocity by several hundred f.p.s. Quality of bullet lubricant is important here also.

Early experimenters tried protecting the bullet base with a filler of dry Cream Of Wheat over the powder charge, with some limited success. This was dropped on introduction of the gas check in 1905. But most cast bullet loads leave a space over the powder, and consideration was given in AMERICAN RIFLEMAN tests to utilizing this for additional protection to the bullet. Every material that seemed to offer reasonable promise was tried. Cream Of Wheat turned out to be one of the worst. Unquestionably best were light fibers.

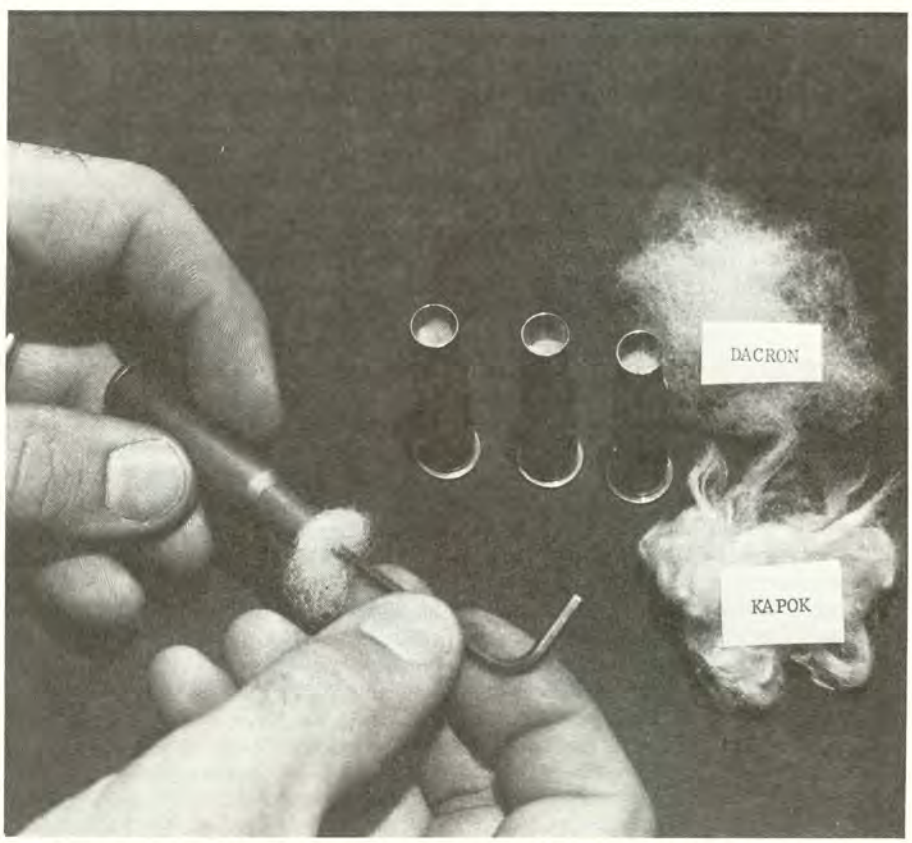
Kapok successful

Most common of these, and for some time the most successful in trials, is kapok, an extremely light and delicate natural fiber from the seed pods of a tropical tree. It is sold as a cushion filler. A tuft of it is simply pushed into place over the powder before seating the bullet. About ½ gr. weight was successful, but continued use (by other handloaders also, after publication in THE AMERICAN RIFLEMAN) showed ¾ to 1½ gr. to be better. The exact amount for best target grouping is found by trial in the given load. This may result in some shreds of filler thrown from the muzzle unconsumed. If objectionable it may be eliminated by reducing the filler slightly. After a little practice, fillers near the desired weight can be estimated by eye in loading, and need be check weighed only occasionally.

Dacron better

A still better material is Dacron fiber fill. Dacron, a du Pont artificial fiber, is pure white and (unlike kapok) is completely clean and uniform. It is so springy that it never mats down. Dacron fiber was until recently sold by Sears Roebuck in bags as a cushion filler, like kapok. Now it is sold in batting for the same use; this can readily be pulled apart for the material.

The fiber filler allows successful charges to be increased about 10%. Or the charge can be left unchanged, and the filler then may tend to make target grouping more reliable. Even in light loads a carefully adjusted filler may markedly improve grouping. Also, in most cast bullet loads the powder does not fill the cartridge; then it must be positioned uniformly before each shot by tilting the rifle up or down, otherwise shots will string vertically on target. The filler holds the powder charge in place so no attention need be given it. This convenience compensates for the one extra operation in loading. ■



Fiber fillers are stuffed loosely into the case neck so no airspace is between the filler and base of the seated bullet.

CAST BULLETS AND HOW THEY PERFORM IN RIFLES

By E. H. HARRISON
Senior Technical Advisor,
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PART 2 OF 2

It is absolutely necessary that a rifle barrel which has fired jacketed bullets be cleaned thoroughly before firing cast bullets. Jacketed bullets iron propellant residue onto the bore, leaving a hard deposit which destroys the accuracy of cast bullets shot over it. Even the fouling from cast-bullet loads must be removed before firing a different cast load, to avoid influencing the accuracy, often considerably.

To clean, pass a brass or bronze bore brush 2 or 3 times through the bore. Then clean the bore with one or more patches wet with government bore cleaner or commercial powder solvent (not oil), the number depending on bore condition. Wipe the bore dry before firing. Using the brass brush at the beginning of cleaning prevents trouble with sticking patches.

Good light loads with cast bullets leave only a soft fouling which wipes out with ease, needing no brush. But one cannot be sure of this. A smooth feel in wiping out is not an infallible indication. Young eyes can examine that part of the bore near muzzle and breech. A middle-aged rifleman can be sure he does not see the real surface. Use the brush.

Removing fouling

Unsuitable loads can leave lead fouling or "leading". With sufficiently poor loads it can become very bad. Then the brass brush cannot remove it, though some burnishing of the lumps may be accomplished. If this is doubted, apply a brass brush to exposed solder on some article and see whether any of it comes off.

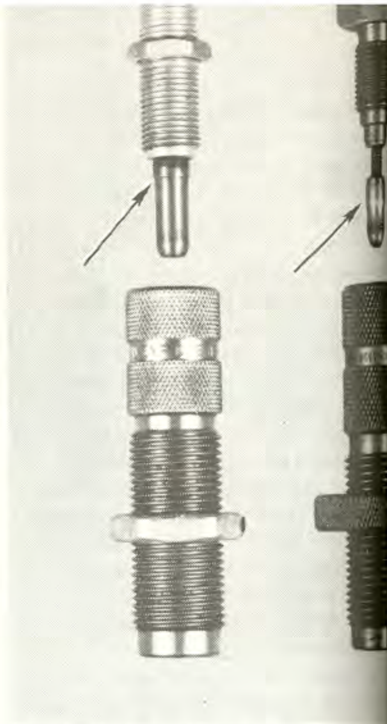
Provided the lead fouling is not so severe as to constitute a bore obstruction, it can be removed by firing 2 or 3 full-load jacketed bullets. (Incidentally, this illustrates the severity of friction and heat from jacketed bullets compared to a brush.) Then the conventional cleaning already described is all that is required. When firing is not possible, the lead can be removed with medium steel wool wound on an old brush. This looks harmful and no doubt is, but in a standard cal. .30 barrel is not seriously so. One .30-'06 NRA test rifle has fired almost every conceivable kind of load, and the bore has necessarily been so cleaned actually dozens of times. Under low-power magnification the forward portion of the bore, uneroded by firing, still looks like new. Of course it is ultimately simpler to prepare cast-bullet loads correctly and have no trouble with leading.

Not every rifleman owns proper cleaning equipment. He should have a good cleaning rod, preferably steel, and bore brushes, cut patches, and solvent. A rod guide to slip into the rifle breech is desirable. Brass brushes are worn after several cleanings and should be discarded—they are cheap. Reversing the brush within the rifle bore destroys the bristles, and possibly may damage the finish of a fine bore; move the brush all the way out each end of the barrel. So used, the brush does no harm to a cal. .30 barrel.

Cast bullets must be seated in the cartridge case with some precautions against shaving. The case mouths must be "chamfered" (inside edge beveled) and usually should be enlarged slightly as an extra operation after case sizing. Lyman makes a 2-diameter expanding plug for this (see illustration); the lower part fits in the sized case neck while the upper slightly enlarged section enters only a short way. This plug is carried in a die which does not touch the cartridge case. Lyman recommends its use also in assembling the most accurate jacketed bullet loads.

It used to be prescribed that case necks be expanded with a .311" plug for cast bullets of that diameter. That is not necessary. Most of THE AMERICAN RIFLEMAN's extensive cast bullet testing has been done with case necks expanded with the standard .3065" plug used with jacketed bullets. This leaves the neck a tight fit on cast bullets of .308" or greater diameter. When powder charges are adjusted for it there is no harm to shooting accuracy, and there are the advantages of easy neck expanding, a rigid and reliable cartridge, and ability to push the cast bullet into the origin of rifling if desired without danger of shoving the bullet back into the case. It is necessary only that the case mouth be enlarged for a short distance, as described, to allow the bullet base a smooth start in seating.

The most successful cast bullet loads fall into 2 classes: light and medium power.



Dies for belling rifle case mouths to ea[se] loading of cast bullets. (l.) Lyman expanding die; bottom of plug expands case neck normally, and step (arrow) bells mouth to desired depth. (r.) Conventional expanding button (arrow) selected for desired oversize and mounted is shown in a conventional seating die.

Light loads are here taken as those 1250 to 1450 feet per second (f.p.s.) muzzle velocity. No. 2400 and IMR 4227 powders, in charges of 13 to grs., provide such velocities in .30-'06. (A special class of extremely light loads is described in the article "Ultra-Light Rifle Loads", in the *NRA Reloading Handbook.*)

Shooters these days are likely to think 1400 f.p.s. loads are good for only target and small-game shooting up to 1 yds. But in fact they reproduce the .32-40 cartridge, which for many years was used in highly accurate target and bench-rest shooting at 200 yds. The standard .32-40 factory round, firing 165-gr. expanding bullet at 1440 f.p.s. has long served as a whitetail deer cartridge. These light loads therefore have respectable power from many practical viewpoints, they are pleasant and reasonably quiet to shoot, and they can give most excellent accuracy.

Loading is not difficult. Best bullet in .30-'06 is Lyman U311291. The cast bullets should be of respectable quality. Add tin to the casting metal until bullets are bright and well filled out. Give the mold time to fill in casting. The bullets are better when not sized. If they are sized it must not be in the former style (no longer made) of Lyman sizer-lubricator dies, which cut bullets off-center. Fill the bullet grooves with high quality bullet lubricant. Seat the bullets in the cartridge case without shaving them. Seat them far enough forward in the case neck to be marked by the barrel rifling before firing, or at least to have only a short jump; this is important with cal. .30 service barrels, in which the origin of rifling is cut away in manufacture and in an individual rifle may be worn as well.

For best grouping the powder charges should be adjusted by careful shooting trial. Make initial adjustments in one-gr. steps, then ½-gr. steps. The adjustment is affected by temperature (see "Beating The Temperature On Cast-Bullet Loads", THE AMERICAN RIFLEMAN, March 1968, Page 39). This can be avoided if one is willing to lubricate bullets by hand with lithium grease, which is not temperature-sensitive.

A kapok or Dacron fiber filler of ¾ to 1½ grs. weight improves regularity. If it is not used, the small powder charge must be positioned all forward or all back in the cartridge by tilting the rifle muzzle down or up before each shot. A few experimenters believe that placing the powder forward gives best results, but most find placing it back against the primer is best and that agrees with AMERICAN RIFLEMAN experience. This requires raising the muzzle before each shot, which may not be

Diameter of bullet body affects seating depth. (l. to r.) Bullet of .3105" diameter as necessarily seated for use in a new .308 Winchester match barrel, and same bullet sized .3085" seated for use in same barrel.

permissible for safety reasons. All this is obviated by the fiber filler.

Firing a light load of this kind shortens the case body. Large pistol primers shorten cases less than large rifle primers, and the loads group as well or a little better, if adjusted by target trials with the primer used (which should be done anyway). But any shortening means excessive headspace with rounds thereafter assembled in those cases. Therefore keep light-load cases for that use only, not mixing them with cases used for other loads.

Medium-power loads

The other most successful type of cal. .30 cast bullet load is of medium power, firing bullets weighing up to 205 grs. at muzzle velocities up to 2250 f.p.s.

This equals or surpasses the .30-40 Krag-Jorgensen (.30 Model of 1892) firing its standard 220-gr. bullet at 2000 f.p.s., with which very good target and competition shooting was done up to 1000 yds. With sporting bullets this cartridge was considered suitable for all North American big game. The British .303 Mk VI shot a 215-gr. bullet at 2050 f.p.s., and in its time was a standard cartridge for match rifle competition up to 1200 yds. In .30-'06, the 173-gr. boattail bullet at 2200 to 2300 f.p.s. was for years the U.S. load in 300-meter Olympic and International competition, being used by U.S. teams and individuals in some of their most successful seasons.

The above type of cast bullet load thus has sufficient power for many purposes.

The handloader who already has a mold for the 165-gr. Lyman No. 311291 bullet can use that. It is the most widely successful of all cal. .30 cast bullets in .30-'06, as THE AMERICAN RIFLEMAN pointed out some time ago. Should however he wish to make a selection especially for this medium-power loading, he may find a comparatively heavy bullet appropriate. No. 311284 has long been used and No. 311290 has received more attention lately. However, they were designed for the .30-40 cartridge with its long neck, and when seated over the lubricating grooves in the .30-'06 cartridge they project below the case neck. This is especially so with No. 311284, and No. 311290 is better. The 182-gr. No. 311334 was designed for the .30-'06 case. But molds sold for it have produced bullets with an undersized forward parallel, and these have not shot well except in 2-groove barrels. The Lyman No. 311332 of similar shape and weight, and the heavy No. 311335, were also designed for .30-'06 and, probably because of molds made with unworn "cherries" (the formed cutters producing the mold cavity) are of correct .300" to .301" diameter in that part. Also the .303 No. 311299 is suitable in body length, and its .304" forward part is best in bores which are somewhat worn.

Best results have been obtained with the 192-gr. Saeco No. RG4. Body of this splendid bullet is of suitable length for the .30-'06 case neck, and as cast in Saeco molds the desirable .301" diameter in the foward part is obtained without excessive oversize in the body.

IMR 4895 powder has proved to be excellent in .30-'06 cast bullet loads of this type. Charges are 36 grs. with 200-gr. bullet, 37 grs. with 180 to 195-gr., and 38 grs. with 165-gr. bullet. The corresponding muzzle velocities are 2000 to 2300 f.p.s. Hodgdon BL-C Lot 2 also is excellent, in charges of 34, 35, and 36 grs. with the above bullet weights. The slower Hodgdon H-380 does well in corresponding charges of 39, 40, and 41 grs.

As in light loads, a fiber filler of one to 1½ grs. kapok or Dacron, while not necessary, is valuable for improving reliability and for making it unnecessary to position the powder charge before firing.

Much slower propellants can be loaded. THE AMERICAN RIFLEMAN used Hodgdon 4831 in many tests from the very beginning of its cast bullet investigations in 1957. Not much information had been developed at that time, but it was known that the plastic strength of lead alloys is the basic limitation on cast bullet loading, and slow propellants offered means of holding down peak pressure and thus the force on the bullet. Also the larger charges of slow propellant more nearly fill the cartridge case, lessening the annoyance with powder position in the round. The earliest reliable grouping at velocities above 2000 f.p.s. was obtained in this way.

In long use, however, some disadvantages appeared. Fouling from the slow powder is often troublesome by caking midway of the barrel and affecting accuracy. Perceptible recoil at the same muzzle velocity is greater, partly because of the heavier propellant charge to be moved and partly because of the louder report. Still very good results can be obtained with Hodgdon 4831 and H-450, and the above velocity bracket is approximated in .30-'06 with 45 to 50 grs. of these powders. A fiber filler is beneficial even in these loads.

The one absolute necessity is a strong

bullet alloy. Linotype is best among reasonably available metals. Still harder and stronger alloys are desirable but at present cannot commonly be obtained.

A third class of lead alloy cast-bullet loads is possible, principally with the No. 311291 bullet, nearly equaling .30-'06 factory velocity. Their reliability is not yet up to that of the first 2 classes and they will not be discussed at this point. It is however reasonably easy to load light gascheck bullets, such as No. 311465, to 2450 f.p.s. with good grouping.

In other calibers

The .30-'06 is not the only cal. .30 rifle cartridge for cast bullet loading. Some others do better than the .30-'06 with these bullets.

This is outstandingly true of the .30 M1 carbine. A number of handloaders, and the *Lyman Reloading Handbook 44th Edition,* report that cast bullet loads can be loaded up to service power and surpass the shooting accuracy of service ammunition. Especially remarkable, such loads can even perform well with plain-base bullets (no gascheck). These results were generally confirmed in NRA tests.

Following are among the ballistic test results in cal. .30 carbine carried out for the NRA by H.P. White Laboratory, including .30 carbine service ammunition tested at the same time:

Bullet Wt., grs.	Bullet Type	Powder Type	Charge, grs.	Velocity, f.p.s.	Pressure, p.s.i.
109	311257	4227	15.0	1938	39,080
114	311359	2400	12.5	1837	39,200
114	311359	4227	13.5	1805	39,240
111	Service cartridge			1943	36,280

Bullets were cast of linotype metal in Lyman molds. They were sized to .3105 diameter because seriously oversize as cast, and loaded to 1.67" cartridge over-all length. Velocities are as measured at 20 ft. from muzzle, and the velocities and pressures shown are the averages of 10 rounds.

Much the same appears to be true for the .30-30 Winchester cartridge. This has not been included in AMERICAN RIFLEMAN cast bullet tests; but competent cast bullet handloaders have reported fully equaling the factory ammunition in velocity and accuracy. The bullet used almost universally is the excellent No. 311291, which was designed originally for the .30-30.

Some attention has been given the .303 British cartridge in these tests by THE AMERICAN RIFLEMAN. Many nominally cal. .30 cast bullets come from available molds so much oversize in the body that they can be used in the .303. But a further requirement is that the bullet's forward parallel be large enough to fit on the .303 barrel lands. The best bullet is No. 311299, designed for the .303. In linotype metal it weighs a little over 200 grs. Most .303 barrels were quite roughly drilled and reamed before rifling, consequently the broad lands of the bore are comparatively rough. This undoubtedly imposes some handicap on cast bullets; it is overcome well enough with a high-grade bullet lubricant, a fiber filler over the propelling charge, and of course a very hard bullet alloy. Results indicate that with No. 311299 it is practicable to equal the .303 Mk VI (215-gr. bullet at 2050 f.p.s.). Since they represent a full load, the charges will be tested for pressure as well as velocity before publication.

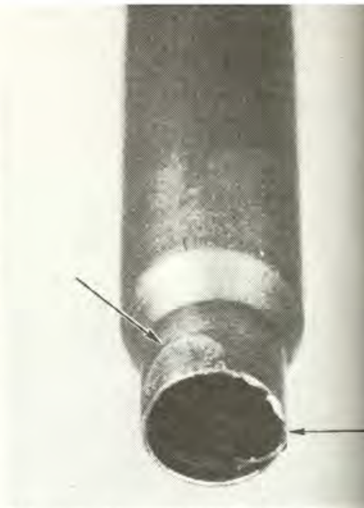
The .308 Winchester

This leaves the .308 Winchester (7.62 mm. NATO). Like the other cartridges mentioned above, it is of less volume than the .30-'06, a condition apparently favorable to success with cast bullets. Results bear this out.

A special difficulty however arises from the .308's short neck, causing bullets of medium body length to project into the powder space; long-bodied bullets can hardly be used. The obvious remedy of choosing a bullet short-bodied enough not to project below the neck is difficult because there are few such bullets which also meet other requirements. Lyman No. 311334 and especially Saeco RG4 are most suitable when the rifle barrel permits seating bullets only deep enough to cover the lubricant grooves, leaving the forward bullet band outside the case. In some new barrels the rifling lands come back almost to the chamber, and in these the most appropriate bullet seems to be Lyman No. 311332 which has a short body capable of being contained almost entirely in the case neck.

Accurate light loads with cast bullets in the .308 are prepared with ease, given a correct bullet. Medium power loads in these experiments have so far been limited to 2000 to 2100 f.p.s. Excellent charges giving about this velocity are 34 grs. IMR 4895, 37 grs. Hodgdon H-380, and 44 grs. Hodgdon H-450. The usual requirements of linotype metal and high-grade bullet lubricant apply. A fiber filler is beneficial even with the slow-burning H-450 propellant. After the charge of H-450 is dropped into the case its level is lowered well below the case shoulder by tapping; then one gr. of kapok or Dacron fiber is tamped into place, pushing it outward into the shoulder.

Poor target accuracy has been the greatest complaint against cast bullets. The accuracy obtainable is therefore a fundamental question. No precise answer is possible for any ammunition whatever, not cast bullets only. Still the question is pertinent and an effort will be made to answer it.



Medium power cast bullet loads in the short-necked .308 Win. (7.62 NATO) case tend to leave lead on case mouth and neck (arrows). This does not result in bore leading or prevent accurate shooting in otherwise correct loads.

A reasonably good answer is possible for light loads. Long experience in the investigation indicates that with a moderate degree of care and competence in loading, an accurate rifle, and corresponding shooting ability, such loads in .30-'06 after development by the user should average 1¼" diameter for 5-shot groups at 100 yds. One rifleman who for years devoted primary attention to these loads, and kindly assisted in the present work, would have been much concerned if more than a very few of his groups fired in heavy-barrel rifles had been as large as 1". This is given to show what is possible. Some users (no one knows how many) get 100-yd. groups several inches to a foot across. That is not necessary, as to the ammunition at least. Some suggestions will be given for trouble shooting.

Much less is known of the possible accuracy of medium power cast-bullet loads, primarily because nearly all the work on them in this investigation has been directed toward finding the factors fundamental to reliability, rather than toward much refinement. With the experience available it is believed that, at the present stage, well-made loads of this kind in .30-'06 should make target groups about twice as large as from match ammunition and somewhat larger than from good sporting ammunition. An expert rifleman having a .30-'06 rifle from which he can shoot 1" groups with match and 1½" groups with sporting ammunition, apparently should expect about 2" groups with these medium power loads properly assembled.

Some testing has been done on medium power cast bullet loads in the .308 Winchester cartridge, assembled with some attention to refinements. They were fired in a bench-rest rifle with barrel of 1⅜" diameter, and in 2 free-rifles, and the firing was limited to a 25-yd. indoor test range. Five-shot groups averaging one minute of angle were obtained. This is of course materially larger than would be expected of such rifles with the ammunition ordinarily used in them, but these limited results do indicate a respectable grouping potential. These medium power loads thus are not crowded to the limit or otherwise marginal. It should be mentioned also that the Saeco engineers have obtained match-rifle accuracy with them.

Trouble shooting

It clearly would be useful to know just why some handloaders do poorly with their cast bullet loads though others do well. Specifics are needed. The following gives them positively rather than negatively.

The rifle must be clean to start. Fouling from jacketed bullets destroys cast bullet grouping. The shooter must remove it with good brass brushes, solvent, and patches before firing his cast bullets. He should do this even when changing from one cast bullet load to another. Thorough cleaning becomes especially necessary when the bore brush is felt to move tighter toward the middle of the barrel. See the earlier remarks on bore cleaning.

The rifle must be shot accurately. Obviously, but this refers to a special point in testing cast bullets. Some experienced handloaders have pointed out in THE AMERICAN RIFLEMAN that the generally longer barrel time of cast bullets (since their velocity is less than that of most full loads) tends to enlarge groups shot from a rifle held loosely on bench-rest. These shooters suggest testing from prone position with sling, from which solid position there is no trouble. Much the same can be accomplished at the bench by grasping the fore-end of the rested rifle with the non-firing hand and pulling back solidly against the shoulder, minimizing any irregular movement until the shot has gone. The shooter's elbows must of course remain solidly on the bench. Such procedure is important with light rifles, and also with those (Springfield M1903 and original Mauser 98) having a slow striker, which has an astonishingly bad effect. Testing with careful regard to this point will show the ammunition's capabilities more truly.

The bullet metal must be sufficiently hard and strong. Economy is an understandable desire. But when it leads the handloader to use a metal which insures failure, he may wish to re-examine his system of values. It appears that in all except light loads, **the use of inadequate bullet metal may be the leading cause of failure with cast bullets in rifles.** Linotype alloy is the most nearly adequate among reasonably available metals. Even it has no more than a limited margin of strength for requirements.

The bullet must not be damaged excessively in preparation. The sizer-lubricator is a splendid convenience in lubricating bullets, and a necessity for bringing most gas-checks down to bullet diameter. For these purposes the sizing die is best chosen at the diameter of the bullet as cast. But the available bullet may also have to be sized down to fit the cartridge or barrel acceptably. Then the old-style Lyman dies with an internal cutting shoulder must not be used. They are no longer made, but many are still in service. All current sizer-lubricator dies are correctly made with a tapered lead-in to center the entering bullet, as well as being properly hardened and finished, and these do a good job of sizing.

The bullet lubricant must permit accurate shooting. It has been mentioned that prevention of leading, while of course necessary, is not the only factor in choice of a lubricant. Target grouping is heavily involved also. In extreme cases the groups made in NRA test by the same load with one lubricant were 3 times the size made with another, though there was no bore leading with either. The handloader can engage in almost interminable tests of lubricants if he feels so inclined, though he may wish to read the article "Bullet Lubricants" already mentioned. But if he desires merely to load accurate ammunition, he can take advantage of work done and use one of the best among existing lubricants. They are readily available and the cost is insignificant. Lyman and Saeco bullet lubricants give very good targets, and the standardized Alox lubricant has been described.

The user's viewpoint. The handloader's own viewpoint is decisive. Successfully making and loading cast bullets requires attention to the points outlined above. Cast bullets thus are for the handloader interested in their special advantages, and in the details through which these are obtained. ■

Cast Bullets In M1 Rifle

Annandale, Va.

Editor:

When I could no longer obtain cheap M2 ball ammunition for use in my M1 rifle, I set out to develop a suitable cast bullet load. This had its difficulties, since to be useful for rapid-fire practice the load had to be sufficiently heavy to operate the action, yet it had to be accurate enough to permit analysis of shot groups.

I decided to use 4895 powder because it was readily available, plus the fact that it bulks up well in the case. Ignition is uniform with standard primers even with charges one-third below normal.

For casting bullets I use linotype metal or an alloy of equal hardness made from automobile wheel weights hardened with 50-50 solder. The Lyman-Ideal #311414 gas-check bullet is sized .001" over groove diameter as insurance against gas cutting. This bullet has only one grease groove at the heel and it is necessary to employ a high quality lubricant. I have had excellent results with a lubricant made from a 50-50 mixture of Alox 2138F and beeswax.

I assembled my test loads in once fired Lake City 1962 Match cases, using the Remington No. 9½ primer and a 45.0-gr. charge of 4895 powder with a 1.0-gr. tuft of Dacron fiber over the powder charge. Cases were mouth chamfered to eliminate bullet shaving and bullets were seated level with the top driving band and were not crimped.

Test firing

Test firing was done prone at 100 yds. Groups ran about the same as with ball ammunition under the same conditions. I was careful to remove metal fouling from the bore prior to firing so I could easily judge degree of leading present. No leading was detected after 50 rounds other than a light wash from the gas port forward.

After obtaining my zero, I began shooting at 200 yds. Functioning was excellent over the rapid-fire stages and accuracy was sufficient to hold the 10-ring of the "A" target. However, after approximately 500 rounds I began to detect a gradual zero change that I couldn't account for. My windage zero had shifted about 2 minutes of angle. After checking and finding the sights in good order I decided to clean the bore thoroughly and fire a few groups with jacketed bullets. I found that the zeros I had used with jacketed bullets had shifted to the same extent. I was puzzled because I did not encounter heavy leading, just the usual light wash around the gas port.

On dismounting the rifle and removing the operating rod and gas cylinder plug, the trouble was immediately apparent. Although the bore had not leaded, small particles of lead had shaved from the bullets as they passed over the gas port. These particles were driven into the gas cylinder where they were deposited on the piston face and gas cylinder walls. After removing this fouling and reassembling the rifle, it was test-fired again for zero. Using match ammunition my sight settings were back to normal and accuracy was as good as ever.

Because of this experience I have refrained from using cast bullet loads in this rifle. It is both unwise and impractical to tear down an accurized rifle to remove leading. However, there is no reason why cast bullet loads should not be used in an as-issued rifle where dismantling after each firing is not apt to be harmful.

I found that cast bullets will perform nearly as well as their jacketed counterparts when due care is taken in making and loading them.

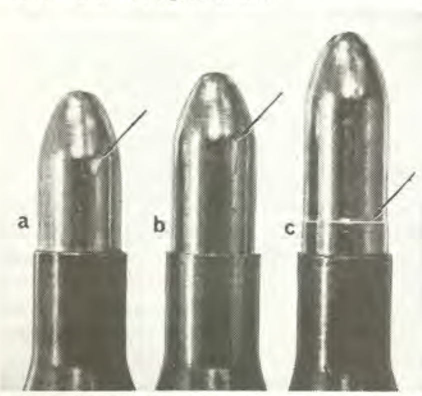
CHARLES E. HARRIS

Barrels For Cast Bullets

I have loaded and shot cast bullets in my cal. .30 rifles for many years. Recently I tried a favorite load with the Lyman No. 311290 bullet in a new .30-'06 sporting rifle owned by a friend, and found the loaded rounds would not chamber. Rifling marks on the bullet showed that the bullet ogive (diameter .3005") was too large for the rifle bore. Is this condition usual?

Answer: It is not usual, but it does happen occasionally.

The illustration shows 3 rounds of .30-'06 loaded with the No. 311290 bullet and tried in 2 new imported .30-'06 rifles of different makes. The left-hand and middle rounds would not chamber fully in one of the rifles because of interference between bullet ogive and rifling lands; this is the condition you encountered. The right-hand round chambered without difficulty in the other new rifle. In that one it is seen that the bullet band just outside the case mouth was marked by the origin of rifling; this is often desirable for accuracy with cast bullets, but if the resulting stiffness in loading is objected to, it can be avoided simply by seating bullets a little deeper in the case. The rifling did not mark the bullet ogive at all.



Lyman 311290 bullets loaded in .30-'06 and tried in 2 new rifles. On bullets **a** and **b,** rifling lands interfered with ogive (arrows). In other rifle, origin of rifling only marked .3105" bullet band on bullet **c** (arrow).

Your difficulty thus resulted from the combination of a bullet with full-diameter ogive and forward parallel, and a barrel of slightly subnormal diameter on the rifling lands.

Rifle barrels now differ comparatively little. The diameters of bullets of various types cast in current bullet molds, though for the same caliber, differ a good deal. Some for cal. .30 measure only .297" or less in the supposedly land-riding forward part, and such bullets can never cause such interference. But they are not aligned so well in the barrel and do not group so well. Under present conditions, it is best to choose a cast bullet of full .300" diameter in this part. In the rare cases of bores tight enough to give interference, the trouble disappears after a few hundred jacketed-bullet rounds have been fired.

When the origin of rifling has become sufficiently eroded by jacketed bullets for any erosion at all to be visible at that point, the barrel will accept the Lyman No. 311299 bullet and that is the best choice. No. 311299 was designed for the .303 British cartridge, and its ogive forward of the leading band is of about .304" diameter. Its body measures a corresponding .314". This of course should be sized smaller for cal. .30 barrels; .311" is satisfactory.—E.H.H.

Bullets For Small Game

Information on cast bullets has emphasized that for accurate shooting they must be made of hard alloy. I find that hard cast bullets in my .30-'06 tend to slip through small game like full-jacketed bullets, and for effectiveness I have to use a soft alloy. What else is possible? My mold is for the Lyman No. 311413 bullet.

Answer: The long-pointed No. 311413 performs as you describe on small game which is too light to tumble the bullet. Several corrections are possible.

The immediate one is the soft alloy mentioned. By careful loading, bullets of moderately soft alloy can be made to group well at comparatively low velocity (1400 f.p.s.). This is the practical course for handloaders who have a No. 311413 mold and do not wish to replace it.

Accuracy at higher velocity requires, besides hard alloy, a bullet formed so as to be held straight in the rifle bore, as already explained by THE AMERICAN RIFLEMAN. Such bullets may have a short point, a round point (as on the excellent No. 311291), or even a flat point if desired for effect; all are available.

Most of these bullets in cal. .30 weigh at least 165 grs. Such weight hardly seems necessary on small game. Excellent gascheck bullets of 115 to 130 grs. are available, with flat point if desired. They cast easily, are economical of metal, give light recoil and are pleasant to shoot. At low velocity they are practical in soft alloy, while in hard alloy they can be fired at comparatively high muzzle velocities. It appears that many requirements of a small game bullet can be met from among these.—E.H.H.

Bore Polish By Lead Bullet[s]

A handloader of many years' expen[…] tells me that in his opinion the cont[…] firing of cast bullets imparts a fine p[…] to the rifle bore. Has this been the […]eral experience?

Answer: The opinion you mentio[…] shared by many experienced handloa[…]

It does not agree, however, with ob[…]vations made during extensive deve[…]ment work on cast bullet loads in r[…] carried out by THE AMERICAN RIFLE[…] during a period of years after 1957. Th[…] observations indicated that the bore […] .30-'06 rifle was affected very little if […] by the firing of more than 10,000 […] bullets. On careful cleaning and exam[…]tion with optical aid, the bore surf[…] appeared unchanged.

The question arises as to why […] disagreement. The reason is uncert[…] though there are 2 established facts wh[…] may bear on it.

One is that accurate shooting with c[…] bullets requires that the rifle bore […] thoroughly clean to start.

The other is that the firing of jacke[…] bullets leaves fouling, which under […]favorable conditions (infrequent clean[…] firing of armor-piercing bullets or o[…] types tending to foul) becomes quite […]ible. It then requires severe cleaning […] remove. Brass bore brushes are not s[…]ficient in that case, bore cleaning paste […] other adequate means being necess[…] along with some time and labor. Succ[…] when it does come seems to be ra[…] sudden; the bore continues to look fo[…] under close examination for some ti[…] during cleaning, then all at once is cle[…]

The polished appearance of the bore […] then very striking. Just possibly this co[…]dition, which as experienced handload[…] know is necessary for success with c[…] bullets, has given rise to the opinion t[…] it results from their use.—E.H.H.

Cartridge Space Filler

The usefulness of a light space fi[…] (kapok or Dacron fiber) in reduced lo[…] has been pointed out in THE AMERI[…] RIFLEMAN. *Loaded into the space betwe[…] powder and bullet, it holds the powd[…] back against the primer and gives mo[…] uniform ignition of reduced charges, a[…] also it tends to protect cast bullets wh[…] these are used.*

Would not a similar space filler impro[…] full loads which leave an air space und[…] the bullet?

There is evidence that even a limi[…] space reduces velocity uniformity, and […] filler would correct this.

Answer: THE AMERICAN RIFLEMAN d[…] not recommend a cartridge space filler […] full loads at present.

While it seems unlikely that a li[…] filler would be dangerous in any way, […] the possibility may exist and extens[…] testing would be needed, either in a varie[…] of cartridges or on a large scale in o[…] or a few cartridges, to settle the point.

It is quite true that a small empty space left by a full charge widens the velocity spread, and a light space filler would supply a correction. This has been made clear by THE AMERICAN RIFLEMAN Technical Staff experiments, and confirmed by Du Pont for a variety of loads. But note that the relatively small space above almost any recommended full load has only a limited effect, not enough to change ordinary serviceability. When the handloader wants a highly refined load with as many small variables removed as possible, that is sufficient reason to select a powder which in the recommended full load fills or nearly fills the powder space. Such loads are practically always available. This is the simplest and furthermore the best solution.

It thus appears that the filler of one grain or so of kapok or Dacron fiber is for reduced and midrange loads. Its usefulness in such loads is well established.—E.H.H.

Kapok Or Dacron Filler

After using Dacron fiber as a space filler in some light loads for my .30-'06, I found fragments of a black residue in some of the fired cases. The loads were 7 to 10 grs. Hercules Unique powder, with Lyman 311359 cast bullet weighing about 115 grs. Is this Dacron filler unsuitable?

Answer: A space filler of Dacron fiber is not completely consumed or ejected in very light loads like the ones described, and some of the fiber may be left melted down as a residue. In such loads use kapok instead.

Such fiber fillers (tissue paper also may be used) are the most reliable way to position a reduced charge uniformly in the cartridge case. (Raising the rifle muzzle just before the shot to position the charge may not be safe or practical.) The filler also tends to protect cast bullets from the hot powder gases; *The American Rifleman* makes no recommendations for use of such fillers with jacketed bullets.

The American Rifleman investigated and described this use of kapok a number of years ago, based on proving ground employment in the loading of .30 and .50 caliber ammunition for test of armor plate at pre-determined velocities. In continued testing here it was found that Dacron fiber fill offers some advantages in relatively heavy cast-bullet loads, and it has become widely used along with kapok. In most cases kapok and Dacron can be used interchangeably, with about equal results except that the kapok, being lighter, bulks up more and so less of it needs to be used. Also the kapok leaves no residue even in the lightest loads, where this and its greater bulkiness therefore make it preferable.

Some experience has shown kapok filler to be successful in .357 Magnum revolver loads, with resultant cleanliness of the cylinder throats. With Dacron a light deposit of melted residue interfered with cylinder rotation ("Kapok vs. Dacron Filler", *The American Rifleman,* August 1970, page 91).—E.H.H.

4831 With Cast Bullets

I have been using in my .30-'06 a load of 50 grs. Hodgdon 4831 powder and a moderately heavy gascheck bullet, with very good accuracy. Recently however I found on gauging my cartridge cases that they tend to be shortened in the body. This has the effect of excessive headspace which of course is undesirable. What is the cause of this condition?

Answer: The case shortening is due to the slow No. 4831 propellant at the charge weight used. This occurs in some rifles and with some handloaders but not others, for reasons which are unknown.

The best correction is to load 38 grs. IMR 4895 instead. This requires for best results a fiber filler of 1 gr. Kapok or 1½ gr. Dacron under the bullet. Muzzle velocity in .30-'06 is about 2250 f.p.s., about the same as with 50 grs. No. 4831.

The No. 4831 can be used satisfactorily at the same velocity by loading 2 grs. weight Hercules Unique or Herco next to the primer, then 45 grs. No. 4831. The faster ignition of this load prevents case shortening. The load requires the fiber filler to prevent shifting of the components, for best results.

Note that using 2 grs. of either of these fast-burning propellants requires reducing the main charge of No. 4831 to 45 grs., for the same muzzle velocity. Or by loading 48 grs. No. 4831 over the 2 grs. Unique or Herco, again with a fiber filler under the bullet, the velocity is raised to about 2375 f.p.s. and the load usually still shoots accurately.

It is worth noting that the faster ignition of these two suggested loads, which is quite perceptible, makes them easier to shoot well.—E.H.H.

Sprue Hole Diameter

It is noticeable that the pouring hole in bullet mold cut-off plates is standardized in molds of a given make, but varies between makes. How is the size chosen? Can it be improved in an individual mold?

Answer: The largest size of pouring hole in general use is about .16" diameter and the smallest about .10". The difference looks greater than these figures indicate, and it has a considerable effect in use.

The diameter of this hole involves opposing requirements. A moderately large pouring or "sprue" hole makes it easier to cast bullets cleanly filled out in the mold. A small hole leaves a more nearly perfect bullet base, which is important for accurate shooting. A small hole also allows the sprue to be cut off more cleanly in very hard bullet metals, whereas the large hole tends to leave either a lump or a crater in the base, or a combination of these (the large hole, however, does well enough in metals which are soft or no more than moderately hard). The size thus requires some compromise.

The hole diameter properly relates also to bullet diameter, and it is rather surprising that little if any notice has been taken of this. The gascheck heel of a .22 cast rifle bullet is very little larger than a large sprue, with the consequence that the rough and non-square cut-off surface forms almost the whole bullet base; when the hole is imperfectly centered the result is even worse. The same hole is small in proportion to a large-caliber bullet, requiring a higher pouring temperature in casting than otherwise would be necessary.

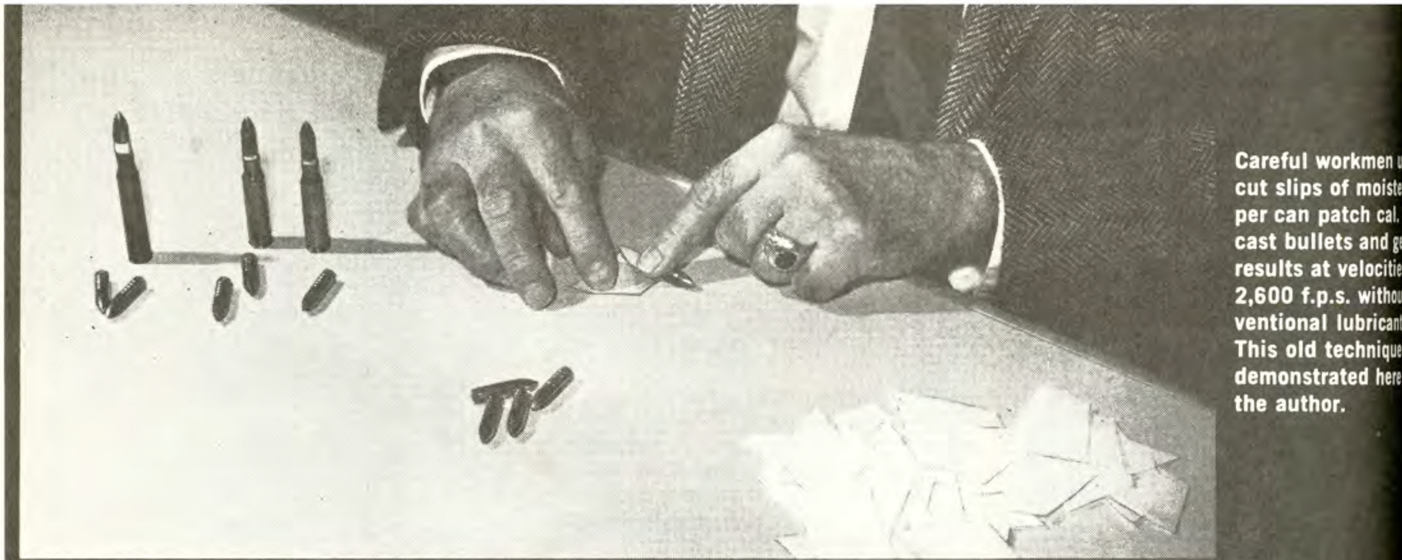
In considering whether to improve an individual mold in this respect, the user should of course remember that all the various sprue plates supplied with bullet molds have produced serviceable results over the years. This factor is of interest only when one desires the best possible bullets.

In that case, evaluate the hole in the existing sprue plate in light of the considerations above. It may be just right as it is. If undoubtedly too small it can be enlarged with a standard 82° countersink, with great care not to go too far. Then stone the plate dead flat and smooth on the under side.

But think carefully before enlarging the sprue hole. It is far more likely to be too large than too small. The only remedy for too large a hole is to make a new plate. Drill and countersink the hole in it smaller than desired at first, to avoid being misled by the burr thrown up at bottom of the hole which makes it look smaller than it is. Remove the burr to check the hole size before finishing it.

Making a new plate gives the opportunity to replace an old-style thin plate of only ⅛" thickness, with one 3/16" thick which is easier to cast with and makes better bullets ("Mold Cut-Off Plate", *The American Rifleman,* Sept., 1968, pages 95-96).—E.H.H.

Various cut-off results in cast rifle bullets. (l. to r.) Large, rough cut-off from large dull-edged sprue hole, smoother cut-off from large sharp-edged hole, desirable bullet base produced by small sprue hole.



Careful workmen use cut slips of moistened paper can patch cal. .30 cast bullets and get results at velocities to 2,600 f.p.s. without conventional lubricants. This old technique is demonstrated here by the author.

PAPER PATCHING MAKES A DIFFERENCE

Revamped technique improves high-power cast bullet loads

(Note: Sometimes old ideas can be applied to modern products with startling success. Here is an instance of the kind which should benefit handloaders. It resulted from experimentation initiated by the author of this article.—The Editor.)

By E. H. HARRISON,
Senior Technical Advisor,
THE AMERICAN RIFLEMAN

SHOOTERS of 100 years ago used paper-patched bullets with great success in their large-bore rifles. Now the use of paper patches has been adapted to modern high power rifles and cartridges with results that should please handloaders.

The writer began this development in 1966 with several aims in mind. These were:

1. To simplify the bullet-maker's equipment by eliminating the lubricating-sizing machine.
2. To improve performance without a copper gas check.
3. To enable the handloader *to make a complete rifle bullet.*
4. To improve the performance of cast bullets above 2200 f.p.s., where they have been most limited.

These aims were realized through newly-developed methods of making and loading paper-patched bullets.

Experimentation was conducted with .30-'06 and .308 rifles and cartridges, using lead alloy bullets which were wrapped in paper instead of being lubricated as usual with stiff grease.

As the last large-scale use of paper-patched bullets appears to have been more than 80 years ago with semi-smokeless powder, and as most such bullets were propelled by blackpowder, the use of smokeless powder presented at least three major problems. Solutions were found to all.

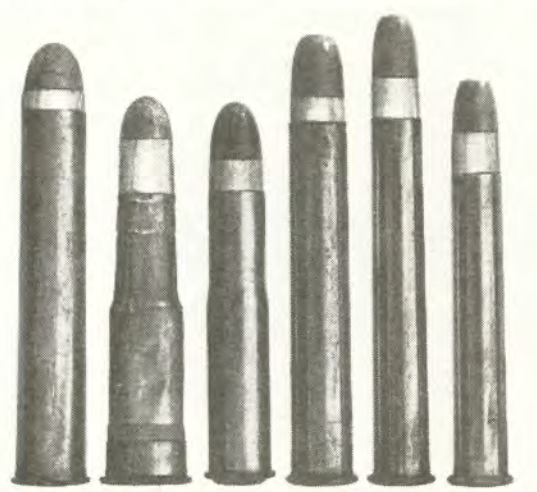
It can now be said that correctly made paper-patched bullets in .30-'06 give good results without gas checks to 2000 f.p.s. With gas checks added, the 200-gr. bullets went to 2400 f.p.s. and the 160-gr. bullets to 2600 f.p.s. Nearly the same results were obtained in .308 Winchester.

What is the patched bullet?

Unlike the grooved, lubricated bullet, the 19th-Century patched bullet was smooth and wrapped twice around with paper to keep the bare lead off the bore. For lubricating and sweeping the bore it was usual to load under the bullet a wax wad between card wads, or two grease-soaked hard felt wads.

Military rifle ammunition began with the grooved and greased bullet. In Britain and most European nations the paper-patched bullet soon took its place. These countries used both bullet types in their large, blackpowder sporting cartridges, and mostly the grooved bullet in medium and small bores.

American users of specialized single-shot target rifles for 200-yd. shooting favored the paper patch at first, using special single-layer forms designed to leave the bullet most freely at the muzzle, though such patches made it necessary to clean the rifle bore for each shot. These riflemen went over to the grooved bullet in the 1890's. The American paper-patched bullet lived longest in some large blackpowder cartridges. The famous long-range matches at



Some blackpowder cartridges having paper-patched bullets (l. to r.) .500-3" Blackpowder Express, .450 Martini-Henry Mk III coiled case, 11 mm Mauser Model 71, .45-100 2⅞" Sharps Straight, .40-85 370 Ballard, .40-65-2½" Sharps Straight.

Creedmoor in the 1870's were fired with paper patches, and the buffalo hunters used them. Winchester and Remington offered the cartridges, and the paper-patched bullets to load them, until about the beginning of World War I.

There was an attempt to introduce paper-patched bullets for handloading the .30 and smaller calibers. Several Ideal Handbooks (Nos. 12, 14, and 17 have been verified, the last dating from 1910) listed molds for casting the smooth bullets and made some claims for them. Remington actually listed .303 Savage ammunition loaded with paper-patched bullets about 1911. Then these listings also disappeared.

The last large-scale use of the paper-patched bullet appears to have been in the Swiss 7.5 mm. Models 90 and 90/03 cartridges for the Model 1889 Schmidt-Rubin rifle. Their 211-gr. bullets of .304" diameter were fired at about 1970 f.p.s. by a charge of semi-smokeless powder ("Swiss Military Ammunition" by Heinrich F. Grieder, *The American Rifleman*, Feb., 1956, pp. 37-38).

Paper-patched bullets were used on a large scale in the latter half of the 19th Century in large calibers, primarily large-caliber blackpowder cartridges. Some who still load these cartridges still use paper patches. The methods of making up such cartridges have little success in the .30 calibers. We thus had to discover and develop a distinctive procedure. Possibly some part of it may have been discovered by some experimenter, but if so, nothing of the kind has been made widely known.

These special problems in smokeless loadings had to be solved:

1. The greater heat and pressure which smokeless produces (above very light loads) without the insulating solids blackpowder provides.

2. The incomplete patch coverage. The short necks of most present smokeless cartridges, the short bullet seat, and the deep rifling require that a good deal of the bullet extend over the rifling lands where the patch cannot cover it. (The blackpowder patched bullet was used in shallow-grooved barrels designed for it and could be patched over practically all the body.)

3. The high rifling lands and, in new barrels, the sharp rifling origin, which cut the patch to shreds in firing.

One rifle Col. Harrison used over the six-year period was this Rem .40X, cal. .308 Win., single-shot, bench model with Hart stainless heavy barrel rifled one turn in 12". Scope is a Unertl 15X Programmer-200 in Unertl Posa-mounts. Total wt. is 18 lbs. 1 oz.

Development began with cast bullets of standard grooved types, both as cast and turned in a lathe to experimental forms and diameters (photo below).

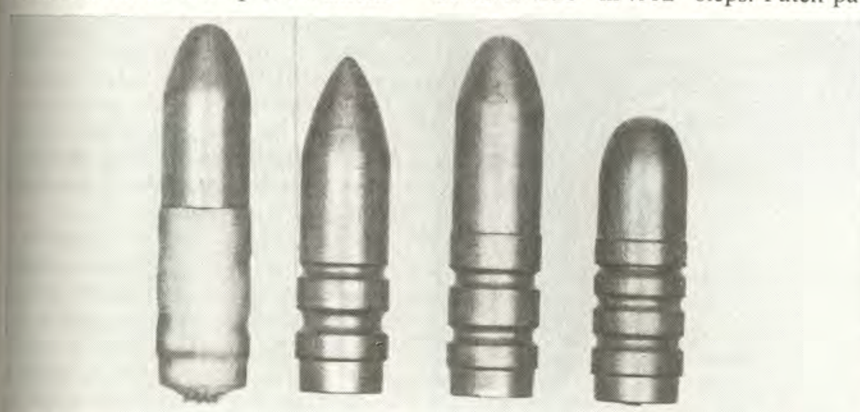
Standard blackpowder patch papers had been from .0015" to about .003" thick, chosen to bring the bullet up to the size desired. Bullets and papers thus affect each other. Conventional bullets were tested in diameters from .310" down to .298" in .002" steps. Patch papers .002" to .005" thick, tried on various bullets, brought them to diameters of .307" to .317" over the patch.

The extreme dimensions did better than one might have expected. The best however proved to be a bullet turned to .301" diameter and patched with paper .0035" thick. Diameter of the patched bullet then is .313" (the patch is wrapped damp and shrinks tightly onto the bullet, making an over-all diameter somewhat less than the simple sum of the bullet and four thicknesses of paper). This combination shot better on the whole than any other, it provided the greatest practical paper thickness for severe smokeless requirements, and it gave the advantage of adaptability by patching more or less of the bullet length to suit different cal. .30 cartridges and barrels (see photographs).

All the bullets were of gas-check type. The stepped base facilitates patching and loading, by preventing a paper ridge around the base edge which otherwise is hard to avoid. Seating the patched bullet in a tight case neck is thus eased. The gas check can extend performance to somewhat higher velocities if desired. The stepped base gives these advantages and no known disadvantages.

The gas checks were tested by reducing Lyman checks in specially made dies and machining the bullet bases to fit. Gas checks had to be smaller than the bullet body, to keep target groups from stringing vertically. A diameter of .297" to at most .298" corrected this and worked well.

The machined bullets eventually performed satisfactorily. Then a smooth



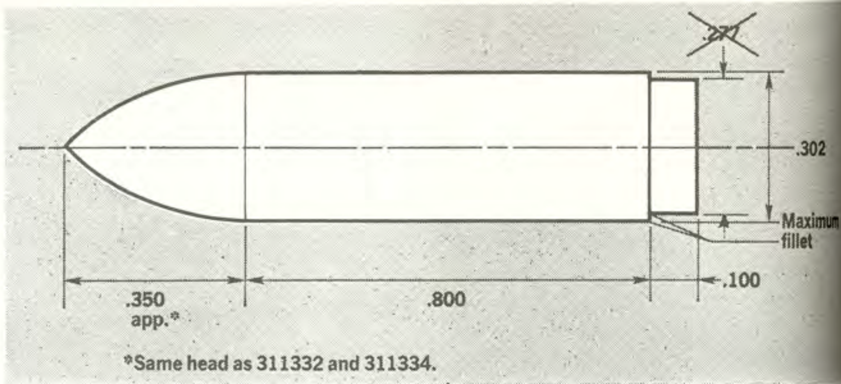
Conventional cast bullets patched during this development. (From left) 311290 patched, 311332, 311290, 311291. Note that patch turns down a little forward of front band to prevent tearing back. These bullets also were machined to various diameters in trials, and a body diameter of .301" was found to be best for paper patching.

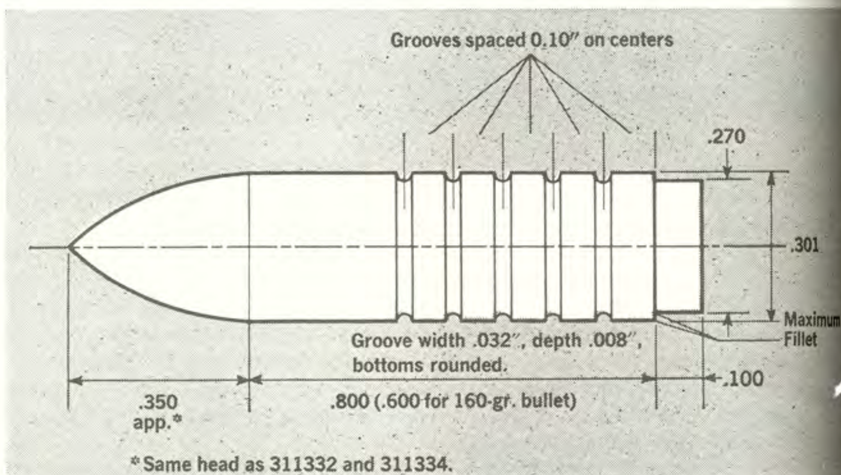
bullet was designed to the indicated dimensions and a mold to cast it was obtained by special order from Lyman Gun Sight Division. Unexpectedly, this bullet performed only fairly well. It became clear that its traditional smooth shape was the cause; the machined test bullets had been more reliable because of remains of the grease grooves left after machining. This forced the design of a new, lightly grooved bullet and procurement of a new special-order mold for it. Both designs are shown in the drawings herewith. The small, spaced grooves in the second design provide for patching to suit any cal. .30 or .308 cartridge as will be explained.

The patch is the old standard paper strip with the ends cut at an angle, and wrapped twice around the bullet leaving the ends almost butting. Old directions give procedures for finding the length which are unnecessarily elaborate and also unrealistic since the dampened paper stretches in wrapping. Multiplying the bare bullet diameter by 2π gives a good trial result. With the .301″ bare bullet this gives a basic patch length of $2\pi \times .301'' = 1.89''$.

It is best to cut patches individually until the patching operation is mastered and the preferred length found. Then making patches in quantity is quite easy by cutting through four to six paper sheets at once with a razor blade or sharp knife. There were several old procedures for cutting to dimensions, the most usual being to make a template of sheet metal and cut around that.

Most successful so far has been typewriter paper of 16-lb. weight: it is about .0035″ thick. A medium quality containing 25% cotton fiber is best; that of 75% cotton content stretches too much when wet. Tightly wrapped, the .0035″ paper adds about .012″ to bullet diameter, making the .301″ bullet measure .313″. It is readily loaded in





Dimensions of bullets cast in two molds specially manufactured for this development (see text).

prepared case necks.

Conventional grooved bullets of not more than .309″ diameter can be used, as will be explained. Patch them with typewriter second sheets of 9-lb. weight .002″ thick.

The patching procedure is based on the old standard method, but performed and finished differently.

Lay the bullet on the moistened patch, positioned as shown in the illustration, which was published in the early Ideal Handbooks.

Place the patch just covering the appropriate bullet groove (the reason will appear). Press the leading point down into the groove and make sure it stays there until rolled under; moistening with saliva helps here. Then, *pressing down hard,* roll the bullet the rest of the way. Gather the projecting paper at the base and twist it *slightly.* At this point the patch should be found almost too tight to rotate on the bullet.

Now *roll, not twist,* the tail as fine as possible, with care not to tear the paper. Then twist it snugly.

Allow the patched bullet to dry, shrinking still tighter. Then clip off the dried tail close and press it flat against the base.

Some points: The patch should be wide enough to leave ½″ over-hanging for twisting. The paper should be limp, but not sodden, since that allows it to tear at the base. It is best to roll the patch on a rubber surface, which in these trials was heavy sheet rubber cemented to a small wooden block. Smooth the wet paper down on the rubber to anchor it, and *pull back on the bullet to tighten the patch.*

How to roll on patch, from Ideal Handbook (see text).

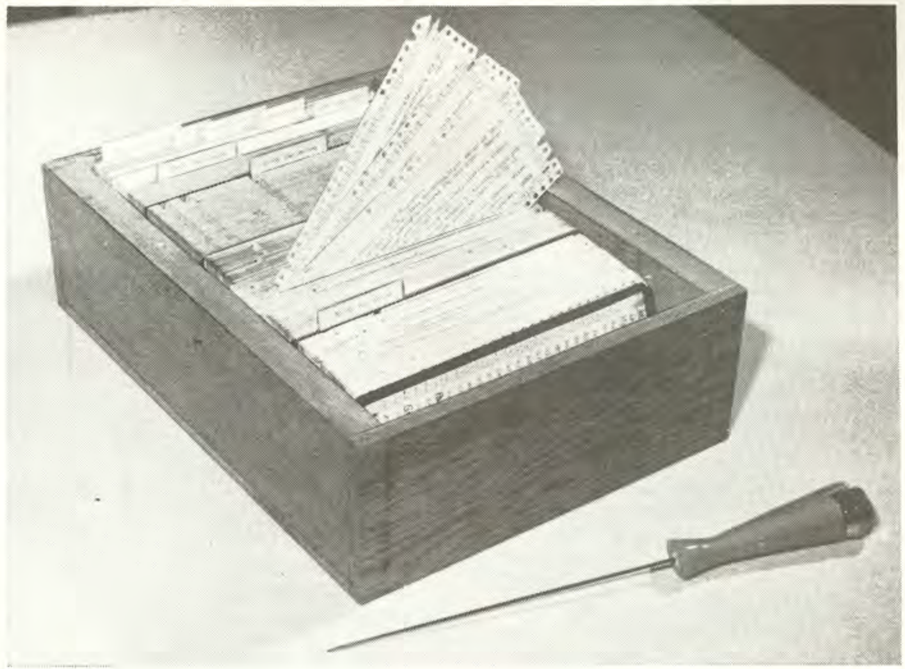
For the relationship between patch and bullet grooves, note that the length of bullet body which can be patched depends on the length of the cartridge neck, and also on barrel wear. Choose among the first three of the five small grooves, specially provided for this purpose in the second new paper-patched bullet design, for the amount of coverage which the cartridge and barrel allow. The patch leading edge should turn down into the chosen groove to prevent stripping back; when the groove is just covered the patch turns down into it properly. The first three grooves are required for this purpose, depending on length of coverage. The two rear grooves never come into use for this but have some patch anchoring effect.

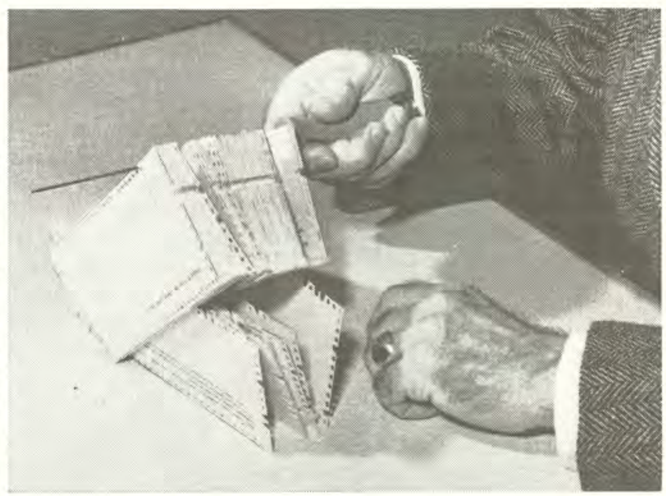
The patch paper on the old paper-patched bullet often was greased for lubrication. In fixed ammunition there was always some form of wax wad under the bullet as well. However, the wad did not lubricate the bore in the manner believed.

Though smokeless propellants leave little fouling, it soon became evident in this development that the patched bullet required some lubrication. Merely greasing the patch was not enough; a few shots often went into a very small group, then the dispersion increased even when there was no noticeable bore deposit (there was a stubborn deposit on the case necks instead). The successful solution was to rub the patched bullet with a mixture of equal parts Motor Mica (or other solid lubricant) and lithium grease before seating in the case. About 1½ grs. weight of Dacron fiber fill is loaded below the bullet as already described in *The American Rifleman* for grooved lubricated bullet loads.

To prepare the case, expand the neck enough to take the oversized patched bullet, and expand the mouth additionally to permit starting the bullet without tearing the patch. The stepped plug of the Lyman "M" die does these expansions simultaneously. Choose the No. 31R plug, which has steps of .310" and .314", and mount it in the "long" style of die body supplied. A conventional cast bullet of not over .309" diameter can be patched with .002" paper, making it measure about .316"; this requires improvising a slight additional mouth expansion, and polishing inside of the case neck to preserve the thin patch against abrasion in seating.

Seat the bullet in one smooth motion. A hesitant motion may let the patch stick in the case neck and break loose from the bullet. Finally, wipe off the cartridge including the exposed patch surface. The grease-treated paper withstands handling and moisture (lithium grease is waterproof) and the grease left on the patch inside the neck helps to make the round water-resistant.





The author's 1,200-odd firing experiments were recorded for quick retrieval in a McBee Keysort system of over 1,000 cards. Holes around edge of card are cut away according to code so that cards of experiments with similar results will sort out when rod is inserted through the hole governing that kind of information.

There is only one rule for seating depth—seat the bullet to base of neck. Differences among lengths of cartridge necks and barrel bullet seats are taken up by covering more or less of the bullet with the patch.

Obviously this loaded paper-patched bullet cannot stand extremely rough handling like jacketed bullets, or grooved alloy bullets seated over the grooves. But it withstands reasonable handling and exposure.

Paper-patched bullets cannot be crimped into the case mouth in the ordinary way, since it would damage the patch. The British .450 Martini-Henry patched bullet of some marks was secured in the case by two case cannelures rolled into mating grooves on the bullet. These cannelures were of rounded form allowing the bullet to move out smoothly, but most handloading tools cannot roll such a crimp. This may exclude paper-patched bullets from use in tubular-magazine rifles.

Bullet coverage with the patch is limited by interference from the barrel rifling. This cannot be compensated by seating the bullet deeper, since these paper-patched bullets group poorly when seated below the case neck. So the best that can be done is to seat the bullets to base of the neck, using all the patch coverage available there, and extend the patch as far forward as the origin of rifling permits. Thus the .30-'06 cartridge permits more patch coverage than the short-necked .308, and worn barrels permit more coverage than unworn. Any eroded bore before the chamber should be polished smooth.

A bullet having the same body, but a shorter forward length exposed, thus is patched more nearly all over and also is lighter. The 200-gr. bullet shortened in this way by machining weighed 160 grs., and with gas check grouped serviceably at considerably higher velocity.

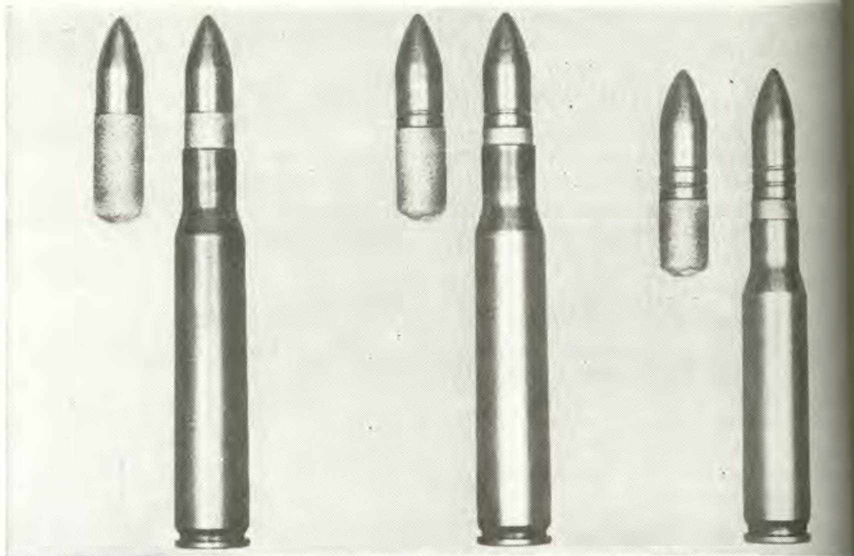
The following loads were successful among a great many tested, the bullets and loading being in all respects as already described:

Bullet	Brinell Hardness	Approx. Equiv. Alloy	Gas-check	Charge	Velocity (f.p.s.)
In .30-'06					
200-New PP	10	1-10 tin-lead	No	16 grs. No. 2400	1500
"	15	Lyman #2 alloy	No	34 grs. IMR 4895	2000
"	15	"	Yes	37 grs. IMR 4895	2200
"	20	Linotype metal	Yes	42 grs. IMR 4895	2450
160-New PP	20	"	Yes	44 grs. IMR 4895	2600
165-311291	15	Lyman #2 alloy	No	15 grs. No. 2400	1500
"	15	"	No	34 grs. IMR 4895	2000
"	20	Linotype metal	Yes	37 grs. IMR 4895	2200
200-311290	15	Lyman #2 alloy	No	26 grs. Reloder 7	1800
"	15	"	No	34 grs. IMR 4895	2000
"	20	Linotype metal	Yes	37 grs. IMR 4895	2200
"	20	"	Yes	42 grs. IMR 4895	2450
In .308 Win.					
200-New PP	20	Linotype metal	Yes	35 grs. IMR 4895	2200

Bullet designations above are weight in grains and bullet identification. "New PP" means the new design for grooved paper-patched bullets described in this article. Others are already existing Lyman bullets.

The target grouping of any bullet depends so strongly on the rifle used that it cannot be specified by itself. More practical is comparison with some known ammunition fired in the same rifle. Under that condition, correct .30-'06 and .308 loads with these paper-patched bullets have grouped within 1½ to 2 times the grouping of best match ammunition; thus one minute groups with best ammunition have meant 1½-to-2 minute groups with these paper-patched bullets correctly made and loaded. This is about the same as factory sporting ammuntion of these calibers. Up to and including 2000 f.p.s., five-shot groups with the patched bullets can from such a rifle be kept within two minutes, usually well within. First clean the rifle bore well.

This is about the same performance as that of conventional grooved-lubricated gas check bullets made and loaded in the manner which *The American Rifleman* has shown to be best. It was



Patching and seating of the second special bullet, for use in .30-'06 and .308. (l. to r.) For worn .30-'06, unworn .30-'06, and unworn .308. Bullet always seated to base of neck and patched for given barrel. Patch just covers chosen groove, to turn down into it and prevent tearing back.

attained far more easily with the patched bullets, admittedly with the advantage of long experience in the grooved-lubricated type.

Molds for the 200-gr. bullet will be available, since the form reamer remains with Lyman. A new 160-gr. mold should have the same body and same nose form as the 200-gr., which intentionally reproduced an old Lyman nose form because it represents about the best combination of comparatively low air drag and firm alignment in the rifle bore. Gas checks at present must be made up by the user as done in this development; this does not impede the extensive use of these bullets without a gas check.

Case necks should be expanded slightly larger than bullet diameter to ⅛" depth to permit hand starting of patched bullet.

The user must develop an adequate dexterity in patching bullets. Also, for some loads (see table) the bullet metal must be softer than for best grooved-lubricated bullets, because the bullet under the patch is only a little above land diameter and must expand on firing to work properly. Do not over-do this. The user does have to avoid the trap presented by this point; there is a deep desire among cast-bullet loaders to use inadequate metals, but the loader should not give way to it unless he enjoys failure.

Prepare the case necks well. Reject rounds in which the patch has caught and torn during bullet seating; this trouble will disappear with correctly prepared bullets and cases.

Good results can be obtained (see table for loads) with conventional cast bullets which are not above .309" diameter, patching them with .002" paper. A handloader already possessing such bullets thus can start without any additional investment.

This paper-patched bullet development is not meant to supplant the conventional lubricated cast bullet but to give the handloader something new and different, with the possibility of performance improvement. As in conventional cast-bullet loading, these patched bullets will respond to users who learn and understand them. ∎

Kapok vs. Dacron Filler

Greeneville, Tenn.

Editor:

It is as important to discuss the failures as it is to report successes. With this in mind I should like to report on the use of Dacron filler in heavy revolver loads, in particular the .357 Magnum.

We have been using Kapok filler on top of 15.0 gr. No. 2400 in this caliber with fine success, and have noted the resultant cleanliness of the cylinder throats.

However, when equal amounts of Dacron were used, the gun became difficult to cock after a few shots. Examination revealed a light deposit of melted Dacron on the breech end of the barrel, which had built up impairing cylinder rotation.

It would seem that Dacron is not suited to this application.

FRED C. GETTINGS

Antimony For Bullet Metal

Handloaders who cast large quantities of bullets must use antimony to harden their bullet metal as required. Straight antimony metal is available, but must be brought up to practically red heat to melt and alloy it with lead. This requires equipment and procedures which are inconvenient and not always available. THE AMERICAN RIFLEMAN *has pointed out correctly that the various type metals are in themselves superior as bullet alloys, and also that antimonial lead (6% or so) does well. These, however, cannot harden a large quantity of lead, but must be used as they are, and that would be expensive in large-scale use.*

Clubs and police departments, and also individual handgun competitors who practice a lot to keep up their scores, get the bulk of their metal from recovered bullets supplemented by scrap lead. It is necessary only to add sufficient make-up antimony and a little tin, and it is for this that antimony in a more practicable form is needed. Can you give any advice in this matter?

Answer: Antimony is tractable when prealloyed with a limited amount of lead. This is seen from the temperatures involved:

	°F.
Melting temperature, pure antimony	1167
Melting temperature, 50-50 antimony-lead	
— melting begins	477
— melting completed	930
A usual casting temperature, bullet alloys	650

The alloy of equal parts antimony and lead is what one gets with the recommended procedure for handling straight antimony—that is, pulverize the antimony, melt it by some special means, and mix in an equal amount of lead. The resulting alloy melts at a lower temperature than antimony itself, and its use to harden a larger quantity of lead is within the capability of the ordinary bullet-casting furnace.

A metals manufacturer can readily make up this concentrated alloy, and there is little additional cost since in general simple alloys are supplied at about the price of the pure metals in them. (The buyer thus would have to pay also for the lead in this alloy, which would not cost much.)

For the user not equipped to melt and alloy straight antimony easily, the best course is to try to buy his antimony already mixed in equal parts with lead. —E.H.H.

Shedding Gas-Checks

I believe the gas-checks on my cast bullets are coming off in flight. Does this harm the shooting accuracy? If so, how can I prevent it?

Answer: Gas-checks do tend to come off in flight. They were designed to do so in the form introduced in this country by J. H. Barlow of the old Ideal Manufacturing Co. about 1905. The gas-check was a plain copper cup and the bullet shank for it was tapered, facilitating the gas-check dropping off after discharge. Both these features remain in existing gas-checks and gas-check bullets, with the exceptions described below.

Gas-checks may leave the bullet at or very near the rifle muzzle. They veer from the line of fire by angles up to about 30°, and may travel 25 yds. or more. Whether they are coming off is determined readily by firing through a large sheet of paper six to ten feet from the muzzle, far enough not to be torn by the muzzle blast. Fire ten rounds to detect any marginal condition in which only some of the gas-checks come off.

Loss of the gas-check is not likely or important in light loads. It becomes increasingly likely to occur in medium and heavy cast-bullet loads. The experience of THE AMERICAN RIFLEMAN Technical Staff is that it has a bad effect on shooting accuracy, besides the accuracy impairment from the heavy charges themselves. It is thus worthwhile to keep the gas-checks on as long as possible when such loads are fired. The following procedures all help:

- Use Hornady gas-checks. These are made with a thickened edge, which is crimped into the bullet by passage through the lubricating die and holds considerably better than a plain cup.
- Select a bullet design having a straight rather than tapered gas-check shank. The excellent Saeco gas-check bullets have straight gas-check shanks.
- Use a high-grade bullet lubricant. While its effect is indirect, it is markedly helpful in keeping the gas-check on.
- Load 1 to 1½ grains weight of kapok or Dacron fiber under the bullet. This procedure, recommended here for only cast bullet and not jacketed bullet loads, lessens the tendency of bullet metal to melt under the gas-check and release it. —E.H.H.

Pencil Solves Casting Problems

Madison, Wis.

Editor:

Two of the more annoying problems that occur while casting bullets can be solved with the help of an ordinary lead pencil.

The first problem is that of the bullet refusing to drop from the opened mold. The tip of the lead pencil is run around that half of the offending mold cavity until the cavity is well covered with graphite. Loose graphite must then be blown from the cavity or else the following cast bullet will have tiny pit marks. If this does not work, then other conditions such as nicks or burrs are present and require correction.

The second problem is leading on the underside of the sprue plate and on top of the mold block, the result of cutting the sprue before the metal has sufficiently cooled and hardened. I initially postpone this trouble by running the end of the lead pencil over these parts while the mold is still cold.

When the problem comes up in casting, I remove the leading with a razor blade held at a very shallow angle and then apply the graphite to the problem areas. These areas can be treated during the casting, while the mold is hot, by exercising a little simple caution.

This graphite solution is easy and cheap. and it need be applied only on selected areas. It has none of the nuisance of a spray, that has wide coverage and may keep the bases of bullets from filling out as they should until a considerable amount of casting has been done.

VERNON F. SCHULTZ

Hardness of Bullet Alloys

Bullet metals have been described by The American Rifleman *by their Brinell hardness. Can you state the hardness of various bullet alloys?*

Answer: Following the text are the compositions and Brinell hardness numbers (BHN) of standard type metals and of some alloys which have been used for cast bullets.

The American Rifleman has published this before, but such standard information does need to be repeated. An explanation also would be in order.

The limiting factor in cast bullet performance is strength of the material. Hardness is not the only measure of metal strength, but it is the most practical and useful single measure. Among the standard methods of measuring and specifying hardness, *The American Rifleman* staff chose the Brinell because a Brinell measurement adequate for this purpose can be made in almost any shop, and because the Brinell hardness numbers (unlike those in some other systems) are directly proportional to the hardness. For example, in lead alloys a BHN of 20 represents almost exactly twice the hardness and strength of BHN 10. These factors make the system relatively easy to apply and understand.

The printer's type metals are prominent in the table because they are designed for the same qualities that cast bullets should have—easy and smooth casting, hardness and strength appropriate to the use, and practicable economy. The simple tin-lead mixtures long used and recommended were suitable in black-powder cartridges, and still are more or less so in current revolver cartridges (not pistol cartridges). They are quite inadequate for any but light and very light loads in cal. .30 and like cartridges. These alloys, including the costly and ineffective 1-to-10 tin-lead, for half a century had a crippling effect on the handloading of cast bullets in rifles.

The alloy which meets more severe demands as a bullet metal than any other is linotype. Monotype and stereotype metals are too brittle, because of their extreme antimony content; but they readily may be diluted to equivalence with linotype. Electrotype is the superior softer alloy. Lyman No. 2, in between, is good and should be chosen when the sprue plate of the mold used does not cut off the stronger linotype metal satisfactorily.

Bullet metals made up from scrap are successful according to the degree in which they reproduce the above. The measured hardness is the best guide in this.—E.H.H.

COMPOSITION AND HARDNESS OF COMMON ALLOYS

Alloy	Tin %	Anti-mony %	Lead %	BHN
Monotype	9	19	72	28
Stereotype	6	14	80	23
Linotype	4	12	84	22
Lyman No. 2	5	5	90	15
Electrotype	3	2.5	94.5	12
1-to-10 tin-lead	9	—	91	11.5
1-to-20 tin-lead	5	—	95	10
1-to-30 tin-lead	3	—	97	9
1-to-40 tin-lead	2.5	—	97.5	8.5
Lead only	—	—	100	5

Kapok In Handgun Loads

Greenville, Tenn.

Editor:

The American Rifleman has made known the use of a kapok filler in cast-bullet loads in rifles. I have tried the kapok with good results in cast loads in .30-'06.

Relating this to the .357 and .44 Magnums, and in not only light loads but heavy as well, there is a definite benefit in using that tuft of kapok on top of the powder.

In these magnums a hard fouling ordinarily accumulates in the revolver chambers just before the case, and also in the barrel cone. It may not hurt accuracy, but it is almost impossible to remove by any normal cleaning means, and possibly may be a place for corrosion to start, so it is disturbing.

The kapok added to the loads apparently prevents this build-up. So far as I can see it really works.

Eric Farr

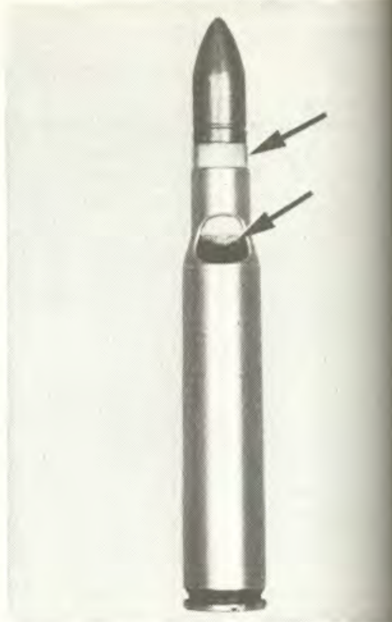
Patched Bullet Seating Depth

In loading the paper-patched bullets described in The American Rifleman, *should the bullet be loaded so as to press the patch into the barrel rifling before firing? Certainly with some other kinds of bullets a long jump there is undesirable.*

Answer: A long, free run to reach the rifling is quite undesirable for paper-patched bullets. Loading so as to press the patch against the rifling is far better.

Alternatively, the bullet may be loaded barely short of contact with the rifling. Target grouping will determine whether this is preferable to loading for positive contact.

This adjustment was easy to make in the old, large-bore, blackpowder cartridges for patched bullets, in which the



Paper-patched bullets should be seated to base of case neck, and patched so paper projects as far as rifle barrel allows (arrows).

cases were either straight or had long necks, and the barrel rifling usually was shallow. It is less easy with the short-necked .30-'06 and especially the .308, and with the high rifling lands of their barrels. Paper-patched bullets do not shoot well when loaded in such cartridges with the bullet extending below the case neck.

Therefore, as explained in the original *American Rifleman* article ("Paper Patching Makes A Difference," Mar., 1972, pp. 18-22) the bullet should be seated just to base of the neck, and patched so the paper projects from the case mouth as far as the individual barrel rifling allows. The bullet design must permit this.—E.H.H.

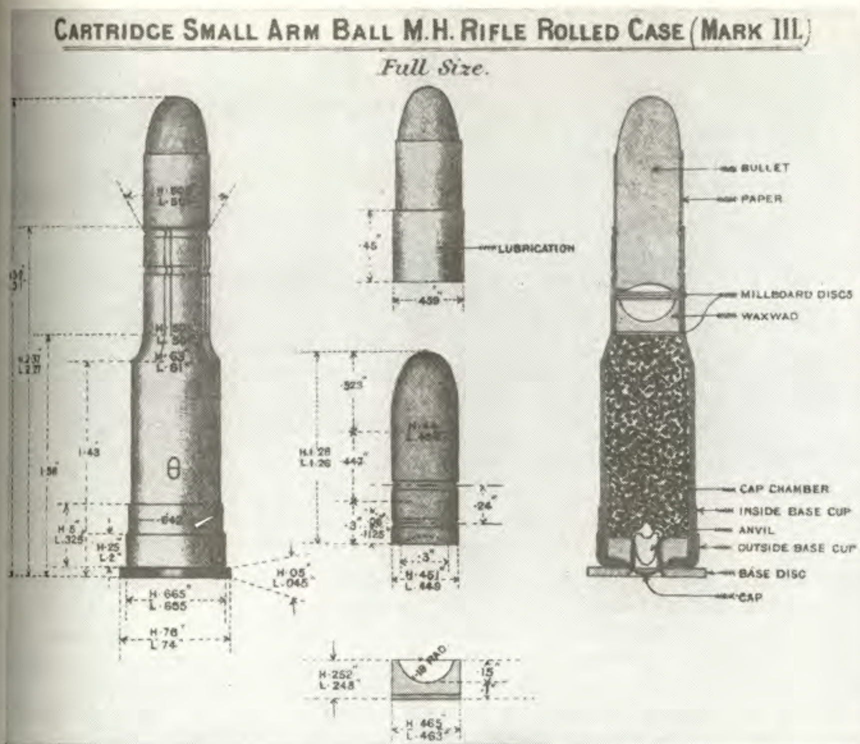
Clockwise from above.

Whenever you add metal to the pot, or if dirt or oxides accumulate on the metal surface, you should flux the melt well.

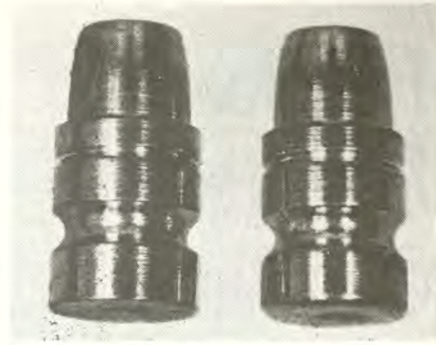
Non-smoking, powdered fluxes, like Marvelux, are more pleasant to use than waxes or greases, and have a very effective action.

Stir the metal vigorously and scrape the sides and bottom of the pot to dislodge impurities, which are skimmed and discarded.

After fluxing and skimming, the surface of the melt should be bright and clean. You are now ready to start casting again.



.450 Martini Henry cartridge and its patched bullet. Note that lubricant is applied to bullet patch, with no reliance on the wax wad for lubrication.



Handgun bullet cast by pouring through sprue hole (r.) compared to one cast conventionally with dipper held in sprue hole. Difference is mainly in base edge; rounded edge is a slight practical advantage in use.

Wads Under Patched Bullets

In an article introducing the loading of paper-patched bullets in modern smokeless-powder rifles ("Paper Patching Makes a Difference", The American Rifleman, *Mar. 1972, pp. 18-22) there appears this remark: "The patch paper on the old paper-patched bullet often was greased for lubrication. In fixed ammunition there was always some form of wax wad under the bullet as well. However, the wad did not lubricate the bore in the manner believed." Just what is meant by that last statement?*

Answer: The above paragraph was included as part of an explanation of patched bullet lubrication, and the last statement was to caution readers against the usual belief that a grease wad in blackpowder ammunition lubricated the rifle bore.

The matter appears to have been best covered in the British *Treatise on Military Small Arms, 1888,* an official publication which preceded the British *Textbooks of Small Arms.* The text on that point is as follows (p. 83):

"It used to be generally supposed that wads of wax or grease lubricated the interior surface of the barrel as they were driven from the breech to muzzle, and were gradually expended as they passed up the bore by being smeared on its surface. That this is not the case can easily be proved by an examination of the wax wads which have been fired from a Martini-Henry rifle. Numbers of these wads can be picked up on any range where these rifles are fired, and they will be found to be of the same weight as similar wads taken from unfired cartridges, and only differing from them in having been set up into the rifling. The wads do not lubricate the surface of the bore, but rather tend to remove the fouling by their scouring action."

The wax wad in the Martini-Henry cartridge was deeply cupped and was held between millboard disks (see illustration), to insure upsetting outward into the rifling. The description of wads picked up after firing as being set up into the rifling shows that the design was successful in that purpose. If any wad could have lubricated the bore it would have been that one.—E.H.H.

Bullet Casting Methods

I note that many bullets are cast from bottom-pour pots, dropping a stream of the molten metal to the bullet mold held a convenient distance below (up to an inch or so). Some handloaders now do the same even in casting with the single covered dipper, simply pouring from the dipper through the mold sprue plate instead of setting the dipper spout into the sprue plate hole and turning mold and dipper upright together, the traditional method. Gang molds always have had an open-trough sprue plate into which the metal is poured. What then becomes of the old instruction that the traditional method described above is required to make good bullets?

Answer: *The American Rifleman* Technical Staff investigated the effects of these different methods, most recently during NRA test of new Ohaus bullet molds (*The American Rifleman*, Mar. 1972, pp. 56-58).

Bullets were cast in two ways—with dipper nose held to the plate in the conventional way, and with the metal simply poured through the plate from the dipper. Ohaus No. 358150K bullets cast the old way gave slightly heavier bullets, averaging .7 gr. heavier than those cast by pouring from the dipper. But the weights of bullets were about equally uniform, the range in 10 bullets of each type being .8 gr. and 1.0 gr. respectively, a difference which was not significant. (The bullets were cast in a two-cavity Ohaus mold and were taken as they came from both cavities, so the small weight spreads speak well for the accurately matched cavities also.)

Other *American Rifleman* tests likewise have indicated excellent uniformity in poured bullets, for example the .41 Magnum handgun bullets cast in that way with the Lee mold and open dipper (*The American Rifleman*, Dec. 1971, pp. 72-75), in which the weight spread from that single-cavity mold was about .4 gr.

As a matter of interest, the small weight difference produced by the two casting methods lies evidently in the relative sharpness with which the bullets are filled out (see photograph). The quality, however, as indicated by weight uniformity within each class, appears to be the same.

Thus the old claim that casting under pressure is necessary for making uniform bullets did not stand up well.

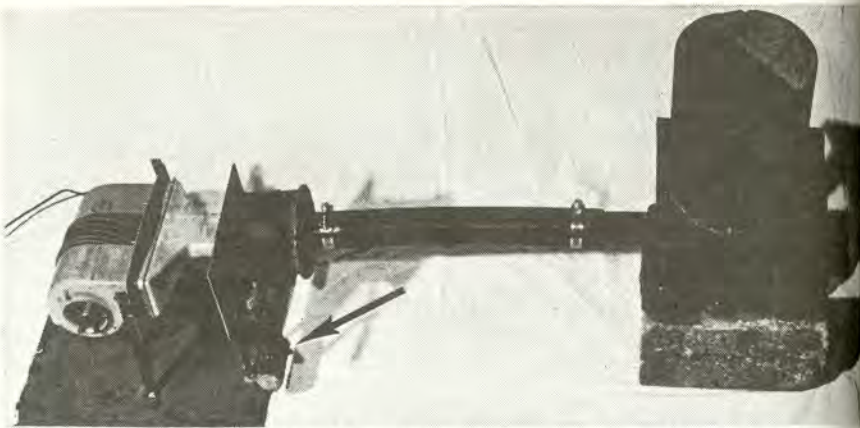
But note two points. For one, the pouring in these tests was done from a dipper, not directly from a bottom-pour pot which, therefore, should not be assumed to give equally good results until the product has been check-weighed. Checking should be done even if pouring from a dipper, since not all users will perform this action the same.

The other point to note is that all the foregoing is for handgun bullets only. These cast easily because of their short, wide proportions. Long rifle bullets are less easy to cast well, and the weight difference produced by the different ways of using the dipper is greater than with handgun bullets, though the uniformity within each type can still be good (regrettably not true in pouring direct from the pot, however). Such rifle bullets cast in the conventional manner can be kept well within a weight spread of 1 gr. for 10 bullets, and one should not be satisfied with another method unless it does as well.—E.H.H.

Handloaders, Prepare Your Own Alloys

In a charcoal blast furnace made at home

By J. M. WICKENDEN



Blower, damper, and firebox for melting antimony in a crucible. Weight (arrow) clamped to damper shaft is means of adjusting angle of inside vane.

THE long and careful investigation of cast bullets carried out by *The American Rifleman* produced the first authoritative definition of the mechanical properties and configuration of successful bullets of this kind.

Early in the work it became evident that the lead-tin bullet alloys so long in use are weak and deficient for velocities above 1500 f.p.s., failing by plastic deformation (slumping) when accelerated from rest. In consequence the investigation was extended into the field of alloys in search of a bullet metal having superior mechanical properties.

Among the easily managed alloys of lead, linotype metal (average composition 84% lead, 4% tin, 12% antimony) is outstanding in its resistance to abrasion and plastic flow. Handloaders have accepted these criteria so generally as to cause a newcomer to bullet mold manufacture (Ohaus Scale Corporation) to base the dimensions of his molds on the expansion coefficient of linotype metal.

But the problem of getting linotype metal has been frustrating. Newspapers have often brusquely refused to sell metal and the small buyer may have little success with print shop suppliers. And now the photomechanical process, which eliminates the linotype machines, is rapidly coming into use on small newspapers.

With the prime source of linotype metal dried up, the bullet caster may be forced toward the only permanently successful solution of his supply problem—preparing the alloy himself.

Preparation of linotype alloy from its component metals is difficult for the bullet caster because of the high melting point of antimony—1167°F. The inexpensive and easily-built charcoal blast furnace detailed here substantially exceeds this temperature. It makes the alloying operation practical.

The blower is a junker vacuum cleaner, available anywhere. It will be necessary to improvise a duct to lead the vacuum cleaner air output into the damper housing. As the photograph shows, a transition of light sheet steel, silver soldered, is an effective solution.

After the blower and damper have been connected by the transition, the assembly can be made rigid and maneuverable by mounting it on a light steel plate. Small members and tack welds are more than adequate.

The firebox and grate are straightforwardly simple. Although it would be laborious, the grate could be cut out with a cold chisel and the edge ground until the grate drops freely into position on the firebox lugs.

All materials for the furnace are readily available and a competent welder can do the fabrication in two hours or less.

Any vacuum cleaner you are likely to find will deliver many times the optimum volume of air, so its output must be metered. Whenever the flow of air into the firebox exceeds the transporting velocity of smaller burning particles, the performance of the furnace becomes wasteful and potentially dangerous. An adjustable damper therefore is necessary to regulate the air flow.

Note that the vane and rod subassembly must be in place in the damper housing before welding the housing end plates. In addition, it would be a good idea to peen the ends of the screws attaching the vane to the rod.

Thin-wall plastic pipe, secured by clamps, carries the air from damper to firebox.

Adjusting the damper is quite simple. When the briquets are evenly aglow, free the setscrew on the counter-weight hub, which will allow the weighted arm to swing freely on the vane rod. Close the damper by means of the lever at the end of the vane rod and start the blower. Slowly, while watching the fire, open the damper until satisfied with the rate of combustion. Finally, secure the setscrew on the vane rod and the damper will hold the adjustment. You will intuitively recognize an efficient fire—clean, bright and fierce.

I made a crucible for the antimony by welding a bottom into a 3" length of 3" steel pipe and adding a handle of ½" round steel. A pouring lip was formed by red heating a spot on the crucible rim and forging it out with a dull cold chisel.

Electrolytic antimony is available from the dealers in base metals. The yellow pages of the Seattle directory, for example, show several sources. Price at this time is $1.10 per pound, plus shipping.

Prepare the antimony for melting by breaking it into small particles. Enclosed in a pouch of strong cloth such as denim or canvas, it is easily pulverized by hammering it over a smooth, hard surface. Before melting, cover the metal in the crucible with a layer of powdered charcoal, which will reduce exposure to oxygen and retard drossing. Melt the lead and tin together in a pot as usual. When the antimony in the crucible has melted, take the crucible out of the furnace and add the antimony to the lead and tin. Pour very slowly, and stir not only during the addition but at least 30 seconds longer to assure uniformity of alloy structure.

Carbon monoxide—odorless, tasteless and invisible—is one of the gaseous products of charcoal combustion. It is poisonous to breathe. Massive inhalation deprives the body cells of oxygen; prolonged massive exposure brings on collapse and death.

This warning may appear to lose credence when we consider that millions of meals are prepared without incident over charcoal grills; but no contradiction exists. The explanation is that a small quantity of charcoal burned in a well ventilated area cannot produce a damaging concentration of carbon monoxide.

Therefore, use the furnace where the operation can be briskly cross-ventilated, or drive the off-gases up the flue of a fireplace.

Wear thick gloves when handling the hot crucible, and *never* handle molten metal without eye protection.

Production of good bullets demands scrupulous attention to fundamentals. I am convinced few casters know the prime importance of frequent thorough fluxing. Oxidation losses proceed rapidly at casting temperature and degrade the alloy below specification. We must accept the fact that these losses are beyond control with the bullet casting equipment available to handloaders. The only corrective action we can take is that of treating the oxides with a reducing agent—a flux—thus freeing the lost metals to reenter the melt.

The surface of newly fluxed bullet alloy is unforgettable: clear, alive, almost as reflective as mercury. At this moment the melt is in optimum condition, bright and on grade. Deterioration begins at once; after only a few minutes the surface becomes dull and begins to slush with semi-solids.

Experience alone will teach how frequently you must flux your alloy to put it on grade. Stir the alloy at least 30 seconds after fluxing, to homogenize its structure. When you are negligent, your bullets cannot have uniform properties and accuracy will fall off.

Fluxing has another beneficial effect not so generally appreciated; it strikingly enhances the casting quality of the alloy by lowering its surface tension.

Cast bullet performance is governed by a host of interactive variables. Of these the shooter has only fragmentary knowledge and over their effects he can exert little control. Statistically, then, the probability of failure would appear to be dominant in cast bullet shooting.

Many decades ago men with skill and judgment, men such as Pope and Rowland, did the superb shooting that proves how deceptive such appearances can be. ■

Aluminum Sprue Plate Success

Albany, Ga.

Editor:

After reading "Aluminum Sprue Plate Rated High" in the March, 1973, issue of *The American Rifleman,* I thought I'd try one on an old four-cavity .38 wadcutter mold I'd acquired in a swap.

The blocks were really a mess, so after cleaning as best as I could with a soft wire brush and solvent, I lapped out the cavities. This was done by taking some bullets which matched the mold (one for each cavity) and drilling a small hole into the bases of the bullets. A nail was then driven in so the bullet could be chucked into an electric drill. Fine valve grinding compound was then wiped on the bullets and each cavity polished by closing the mold lightly around the bullet, polishing only enough to remove the remaining rust and smooth the rough surfaces.

After rinsing the blocks in solvent and making the aluminum sprue plate according to the article, I heated up the mold and produced some of the best bullets I've seen. The bases were uniform and clean and the edges sharp.

These procedures have saved me the cost of a new mold. I hope others may profit by them.

ALLEN E. LOWELL

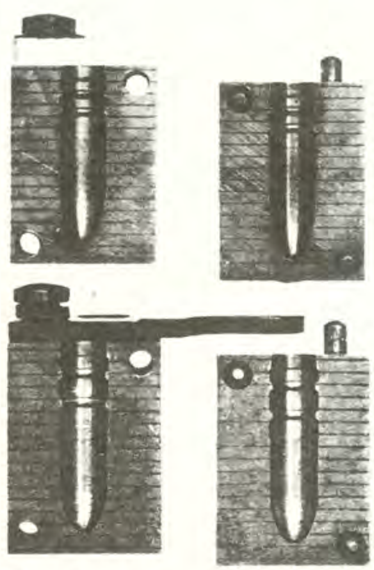
Smoking Bullet Mold Cavities

The old Schuetzen riflemen often smoked their bullet molds to produce better bullets. We never hear of that any more. Has it proved to be a bad idea?

Answer: During its fundamental investigations since 1956 on making and loading cast rifle bullets, *The American Rifleman* has not thought it necessary to resort to that expedient. In general it has not been necessary. However, smoking the mold cavities does help, and it can be useful in even a good rifle bullet mold.

This old practice was reintroduced by Lee Precision Manufacturing, in the directions supplied with their aluminum molds for rifle bullets. Long rifle bullets are harder to cast well than the short, wide bullets of handguns. The Lee directions prescribe smoking the mold cavity in the flame of a paper match.

The photograph shows conventional iron mold blocks for two rifle bullets, in which the cavity in the top pair of blocks has been smoked in this way and the conventional 1/8" steel sprue plate replaced with a 3/16" plate made of aluminum alloy. This top pair shows the slight darkening of the cavity still present after smoking and brushing out, followed by casting several hundred rifle bullets.



Interior of two conventional iron molds for rifle bullets. On upper mold, sprue plate has been replaced with one of aluminum alloy, and mold cavity has been smoked and later used extensively.

Aluminum sprue plates were introduced to handloaders by the article "Aluminum Sprue Plate Rated High", *The American Rifleman,* March, 1973, pages 28-29. As stated in that article, the aluminum plate greatly improves the mold performance.

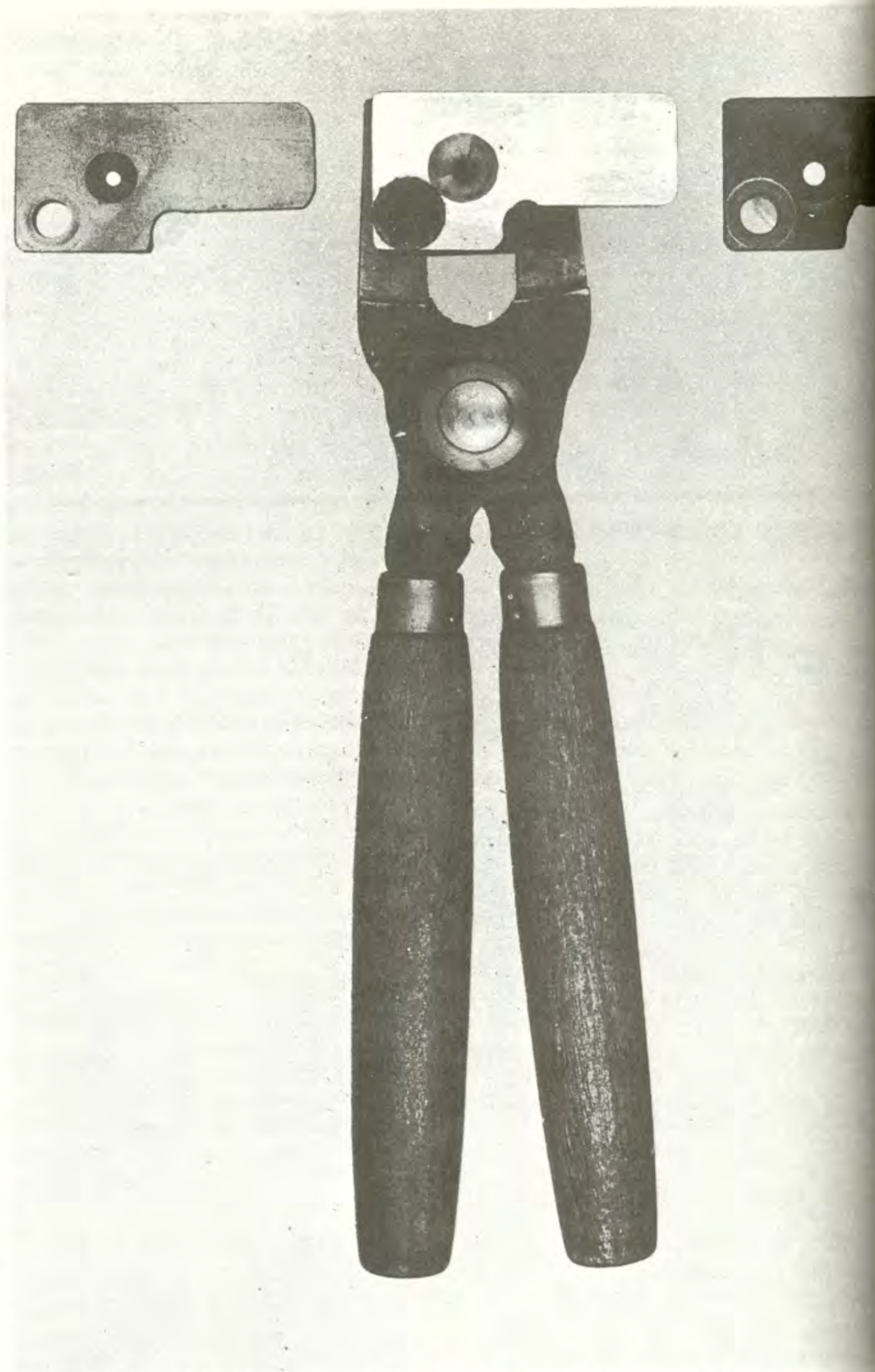
The aluminum plate together with smoking the mold cavity improved this performance still further. Good bullets were cast with astonishing ease and speed in comparison with the original mold. A further advantage is lower temperature of the molten metal required, minimizing oxide formation or "drossing". This effect is so considerable that it changes the bullet weight by about one grain, possibly due to the minutely smaller diameter of the mold cavity when the blocks are cooler. Accordingly, bullets cast at usual temperature of the melt should be kept separate from those cast later after the practical lower temperature has been found.

As to details, the old directions commonly prescribed smoking the cavity and then brushing it out with a small brush which has been well washed. If that is not sufficient the mold can be smoked again and used without brushing out. (For a current reference see page 159, *The Breech-Loading Single-Shot Match Rifle* by Major Ned H. Roberts and Kenneth L. Waters. D. Van Nostrand Company, Inc., 1967. NRA Book Service, price $12.50.)

Both procedures were found to work in NRA test. These old directions however called for smoking in a candle flame. The steady candle flame is convenient, but the soot from it tends to be greasy and any trace of grease is undesirable in a bullet mold. The Lee direction that it be done with a paper match therefore seems better. The NRA test of smoking the mold was done that way.—E.H.H.

ALUMINUM SPRUE PLATE RATED HIGH

By E. H. HARRISON
Senior Technical Advisor
THE AMERICAN RIFLEMAN



Single-cavity mold with aluminum cut-off plate (center) is flanked by specially-made tool steel plates with which it was compared in tests. Aluminum plate performed better throughout.

THE last major mechanical improvement in bullet molds was the separately attached mold blocks introduced by Modern-Bond Co. (later, Modern-Bond Corp.) after World War I. This made it possible to interchange blocks on handles, but the more important result was to free the loosely attached blocks to fit together without interference from the hinge. The discontinuous attachment also minimized heat transfer to the hinge and handles; this however does not seem to have been much noted.

Another feature of the Modern-Bond molds was their thicker cut-off or sprue plate—3/16" instead of the 1/8" of the Ideal and Lyman molds. The thicker plate keeps its flatness better. An additional advantage is its wider and deeper pouring recess, which is a material convenience in use. There is a less favorable effect of the thicker plate which will be dealt with later.

But these improvements are mechanical. There has been practically no consideration, expressed as such, of the bullet mold as a device which must absorb and radiate heat—a few remarks like "heavy blocks hold the heat better", nothing more. Yet heat and elevated temperature are fundamental in the functioning of bullet molds.

The American Rifleman staff therefore tried an aluminum sprue plate and compared it with well-made tool steel plates. The aluminum plate was tested with .117" and .140" sprue holes, and the steel plates likewise provided large and small holes (all the plates were 3/16" thick). For a clear-cut comparison, the plates were alternated on a single mold for a long 200-gr. cal. .30 rifle bullet, which is a more difficult type to cast well than the short, wide bullets of handguns. The aluminum plate was superior throughout. With a small sprue hole it produced good bullets more readily than did the corresponding steel plate, and it made good bullets at a lower metal temperature, estimated from thermostat settings on the electric melting pot as 100° F. lower than required by the steel plate.

An obvious objection to aluminum here is its relative softness. The aluminum used had a superficial Rockwell hardness (15 kg. load) of 80, decreasing to 73 on the sprue plate after casting. These figures indicate an aluminum alloy of moderate hardness which the heat of casting then annealed slightly. The plate was unmarred by being knocked around with a rawhide hammer several hundred times, and remained fully serviceable. It could be made of hard aluminum alloy, anodized for additional surface hardness if desired.

The aluminum plate appears to abstract less heat from the metal poured through it into the mold, leaving more heat usefully in the metal. The mechanism is not fully clear. While the high thermal conductivity of aluminum would carry heat away rapidly, there is no sink for it to flow into except the mold blocks, and the path is through only an inefficient contact between plate and blocks. The plate itself takes up less heat than a steel plate of the same size and that action is in the right direction; but on examining the quantities involved one finds that the heat capacity (quantity of heat required to raise the temperature of the item by a stated amount) of an aluminum plate is still about two-thirds that of a steel plate of the same size, a difference which hardly seems sufficient to account for the benefit obtained from the aluminum. (It is fair to add that the old-style 1/8" steel plate thus had no greater heat capacity than a 3/16" aluminum plate. This is the one advantage of a thin steel plate over a thick one.) Lead cannot wet an oxidized aluminum surface, while it does tend to wet and stick to iron. This characteristic of aluminum is desirable in itself, and possibly it may have something to do with the general casting benefit obtained. In any case, the important thing is that an aluminum sprue plate does provide the advantages in use which have been described.

A user can make his own sprue plate. Choose aluminum 3/16" thick, or only 1/8" thick if an extreme effect is desired. First drill the pivot hole (1/4" in most molds) and bolt the factory sprue plate to the aluminum through the hole. Spot the new sprue hole through the original factory plate; if the bases of bullets already cast in the mold show the distance from pivot to sprue to be not quite right it can be corrected in the new plate. Drill a very small pilot sprue hole with a combination drill and countersink. Outline the plate on the aluminum, and saw and file it to dimensions. Finish the sprue hole with a standard 82° countersink, running the countersink in to the depth required to produce the desired hole diameter. This should be only about .12" to start, especially for a rifle bullet, since a small hole leaves the most nearly perfect bullet base. The hole is readily enlarged with the countersink after trial, but of course making it small again requires a new plate. Lightly stone the top and top edges of mold blocks to remove small burrs which would score the underside of the aluminum plate.

An aluminum plate can be made in this way with hand tools alone.

One naturally thinks of advantages from mold blocks also of aluminum. Having less heat capacity than similar blocks of iron, they take up less heat from the entering bullet metal and thus allow it to fill the mold cavity more exactly. That requires lowering the temperature of the molten metal, an advantage in itself as it is with the aluminum sprue plate. The Lee bullet mold has blocks of aluminum alloy and a 1/8" steel sprue plate, and works most excellently (*American Rifleman*, Dec., 1972, pp. 72-75). An aluminum sprue plate might have to be anodized to prevent galling against aluminum blocks. ■

Venting Bullet Molds

There used to be a great deal of advice that bullet molds be "vented" by scoring a line from any groove in the mold cavity that did not fill well. Now one never hears of it. If it was necessary then, why not still?

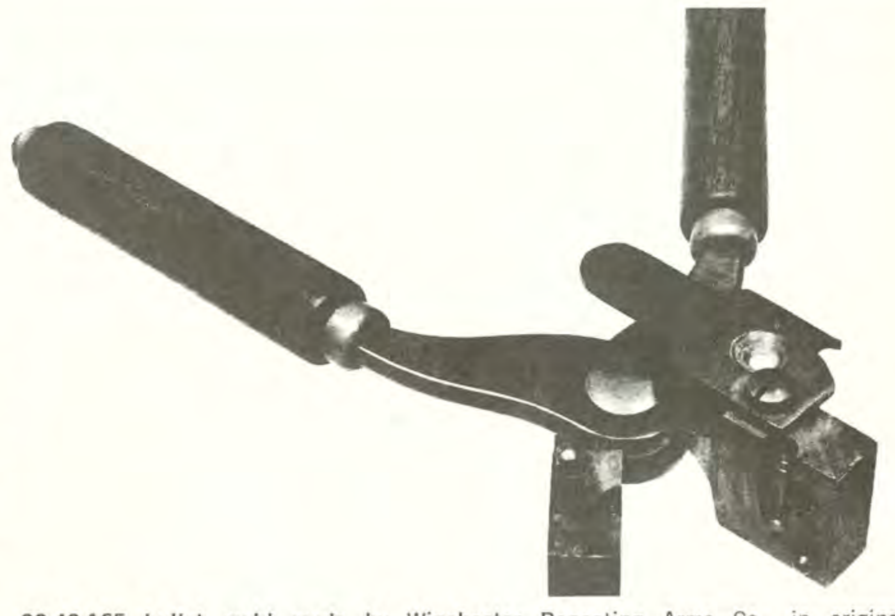
Answer: Two circumstances have caused this old practice to be dropped.

One is that the faces of mold blocks now manufactured are machine-scored in production to provide venting.

The other factor is the gradual realization by users that mold cavities must be extremely clean. Molds have long been oiled or greased to keep them from rusting, and the old advice was simply to wipe this out before using the mold and burn out the residue by casting bullets (often an extremely tedious procedure). It was stated that this improved the mold. On the contrary, it was fatal to good performance, and eventually would ruin the mold.

The American Rifleman has pointed this out and described methods of cleaning the mold adequately before use. The most effective is boiling the blocks in detergent solution just before use; casting bullets then prevents immediate rusting. Cleaning with alcohol and some other non-petroleum solvents also can give good results. Petroleum solvents tend to leave something on or in an iron mold which still interferes with making good bullets.

Then the mold should be kept from rusting, not by putting any oil or grease on it, but by wrapping it up tightly with VPI-treated paper, or with a little VPI powder in the cavity. This will preserve the mold from rusting, and leave it ready for use as soon as it has been washed out with hot water.



.32-40-165 bullet mold made by Winchester Repeating Arms Co., in original condition. Most such old molds are found with the block faces scratched for "venting" (see text).

Some of the old bullet molds indeed were finely made, and when one sees their closely-fitted blocks he may conclude that some special venting must be necessary to let the air out as the melted lead enters. However, the Lachmiller bullet molds as introduced in 1971 had just such smooth and closely-fitted blocks. The only venting was a light bevel on the top edges of the faces, providing a channel for the escape of air under the cutoff plate. (Some old bullet casters had noticed that it sometimes was necessary to loosen the plate hinge screw for the same purpose.) This top-edge venting worked very well.

In any case, no special venting should be needed by bullet molds now manufactured. If the user cannot get his bullets properly filled out, assuming clean metal and the mold and metal up to operating temperature, the fault almost certainly will be that the mold is not thoroughly clean.—E.H.H.

For Best Results Be Sure Your Alloy Is Adequate

Bullets should not be loaded beyond strength of the material

By E. H. HARRISON
Senior Technical Advisor
THE AMERICAN RIFLEMAN

CAST bullets have been loaded in smokeless powder rifles for many years, with mixed success, though there has been a marked improvement in recent years.

Loading cast bullets requires more specialized knowledge than loading jacketed bullets. The cast bullets must be made correctly by the handloader, not bought ready-made, and they are mechanically less strong than jacketed bullets which are comparatively so hard and strong as almost to assure serviceable results.

The limitation on cast bullets thus is in their limited hardness and strength. *The American Rifleman* began in 1956 a fundamental reexamination of cast bullet loading in rifles, and since that time has stated this fact repeatedly. Still it is not fully appreciated.

It is best appreciated when seen. Photographs of fired and recovered bullets illustrating the point are therefore shown here.

The photographs and accompanying information were kindly supplied by Richard Lee, manufacturer of Lee loading tools and bullet molds. Lee recovered the bullets by firing straight down into his swimming pool and picking them up off the bottom. He found the bullets lost all energy in three feet of water, though they were broken on the bottom in less depth. The firing was done in an inexpensive .30-'06 M1903A3 rifle with two-groove barrel since it was expected to get wet. The splashing, however, was moderate, less than from .22 rimfires fired similarly.

The bullets were cast in a Lee mold No. C-309-109-F, which means a gas-check bullet of .309" body diameter, weighing 190 grs., and having a flat point ("Lee Rifle Bullet Molds", *The American Rifleman, December*, 1972, pages 66-69). These bullets have three body bands and a bore-riding forward section. They were cast of mostly wheelweights with some tin and lead added, and lubricated in a Lyman sizer-lubricator using a .311" die so the bullet was not sized but only lubricated.

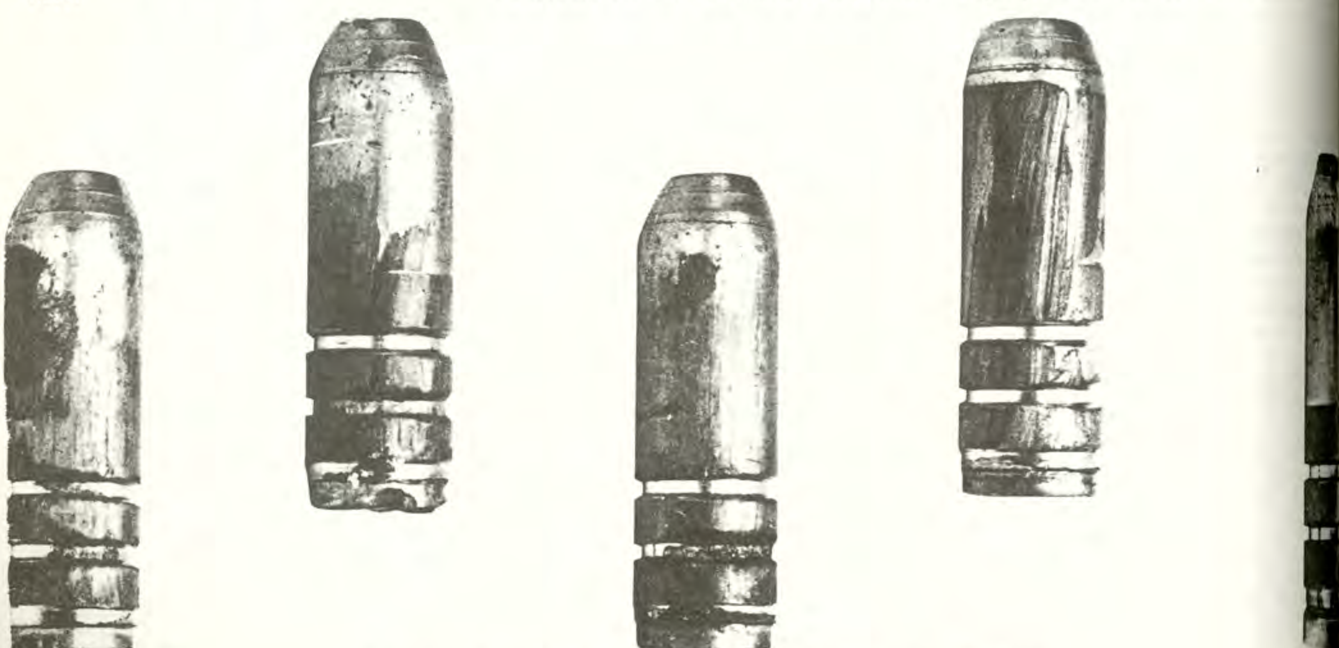
It was remarked that the recovered bullets clearly showed the reason for their behavior on target.

Bullets 1 and 2 were fired with a charge of 12.5 grs. Red Dot shotgun powder. The bands of No. 1 are seen to have been cut down by the barrel rifling and the hot powder gas, and the bullet was not rotated; it certainly would "keyhole" or turn more or less sidewise in flight, making an elongated hole in the target. No. 2 retained enough metal on its two leading bands to take some engraving from the barrel rifling and probably would at least remain point on. The load grouped poorly and some shots keyholed.

No. 3 was fired with 15 grs. Red Dot. It was not spun at all by the rifling, and also was so upset (bulged) by the powder gas pressure that almost all the nose section shows rub marks.

No. 4 also was fired with 15 grs. Red Dot, but the fiber of a milkweed pod (!—*Editor*.) was placed behind the bullet in loading. This small amount of light fiber actually prevented most of the gas cutting. Mr. Lee commented that it showed dramatically how a fiber packing such as kapok or Dacron benefits the load. However, the sharp acceleration by the charge of fast-burning shotgun powder upset the bullet until it filled the bore for nearly the bullet's full length.

No. 5 was from a load of 23.2 grs. of the slower-burning IMR 3031 powder, which grouped well. The rifling engraving is clear and the nose rubbed only slightly on the barrel rifling lands. And



Recovered bullets Nos. 1 through 5 (from left), described in text.

the velocity was higher than the other loads, as indicated by the bullet nose starting to spread and shear off on striking water. (The gas check was recovered and replaced on the bullet before photographing.)

When furnishing these photographs and the data with them, Lee remarked, "In future tests we'll use only linotype." He was alluding to the obvious need which the recovered bullets show for a stronger bullet metal, to prevent this deformation in firing. (They show also the need for choosing propellants which neither gas-cut the bullets nor deform them by an excessive blow on the base, but that is a separate subject.)

Linotype metal is the generally most satisfactory hard alloy for rifle bullets. It is the strongest practical one for that purpose among all the type metals, which are by far the most thoroughly developed of all lead alloys. The use of primitive concoctions for bullet metal has heavily handicapped the loading of cast bullets in rifles. Following the repeated explanation of this by *The American Rifleman,* many handloaders have adopted linotype for all their cast rifle bullets other than in light loads, with great success.

But general adoption of linotype has been impeded by certain practical considerations. One has been the lingering effect of old advice, imprinted by long repetition, which recommended inadequate and yet costly mixtures; fortunately that is passing. Another is the recent and continuing replacement of "hot type" (cast metal type) by other techniques in printing, with the result that linotype metal is becoming less readily available.

Most important of all is the cost of all-new bullet metal. The handloader in most cases wishes to use his recovered bullet metal, or equivalent, bringing it up to the required physical standards by adding only the necessary make-up. This is just what the printer does!

Linotype metal regularly is 4% tin, 12% antimony, 84% lead. The handloader can bring his salvaged metal up to linotype standard by cleaning it with thorough fluxing, then adding tin and antimony as required. The tin is costly, but fortunately not much is needed, it is readily bought locally, and it melts and alloys easily in the lead. The antimony while harder to find is available, and it costs far less than tin. The single difficulty is its relatively high melting point. Directions for making up bullet metal with antimony have glibly prescribed raising the pot to a red heat to alloy the antimony with the other components. The trouble is that few handloaders have a ready way to do this.

The American Rifleman (June, 1970, page 87) pointed out that antimony is tractable if prealloyed with an equal weight of lead. The melting point of pure antimony is 1167° F., but a 50-50 lead-antimony mixture begins to melt at only 477° and is fully melted at 930°. Though the latter temperature is above the regular design range of handloaders' electric pots, this 50-50 mixture alloys satisfactorily with lead in these pots at regular working temperatures. Thus if antimony were available already mixed 50-50 with lead the problem would not arise, but so far it is not so available.

Two NRA members have developed practicable means for the handloader to melt and alloy straight antimony. One of these ("Handloaders, Prepare Your Own Alloys" by J. M. Wickenden, *The American Rifleman,* December 1972, pages 60-61) describes the construction of a small, simple furnace which will melt antimony with ease. The other ("Make Your Own Bullet Metals" by Clark S. Campbell, on the lower half of this page) is done with a plumber's lead pot rented for a day; 100 lbs. of 50-50 lead-antimony in small pigs can be prepared in that time, enough to provide the antimony content of a handloader's bullets for months or years. Campbell's description includes simple formulas for then making up linotype as needed, using this 50-50 antimony with new or salvaged lead and tin, the other components of linotype metal, in the handloader's small electric pot. ■

Make Your Own Bullet Metals

To upgrade salvaged lead, salvaged .22 bullets, or automobile wheel weights into bullet metal requires the addition of tin and antimony.

Tin melts very easily and is readily added in the desired amount when it has been cast into thin half-pound bars in a ¼" x ⅜" x 13" aluminum channel, scribed with file cuts at ¼ and ⅓ points for cutting off. The 1-lb. bars in which tin is bought can be similarly marked for cutting, and bars of tin-lead solder also can be used.

Antimony requires a much higher temperature. It melts at 1167°F., which is a low red heat well above the working range of the electric melting pots used by handloaders. The practical way to use it is in a 50-50 mixture with lead made up beforehand, in which form it alloys at ordinary operating temperatures with the other constituents of bullet metal. Making up the 50-50 lead-antimony mixture requires equipment capable of melting antimony.

After being pulverized with a heavy hammer, the antimony can be melted readily in a rented plumber's "lead pot", using a flame which will make the pot red hot. (It is unwise to play a blowtorch on the metal to speed melting, since powdered antimony can ignite at flame temperature). When the antimony is melted add an equal weight of lead, which will melt and mix with the antimony. Melting and mixing 40 lbs. of antimony with lead in this way will take about four hours and consume a $3 tank of propane. It will provide the antimony for a large quantity of bullet metal. Of course this combustion operation should be performed out of doors.

The lead should have been made ready by casting into 1-lb. ingots in one of the convenient four-compartment ingot molds now supplied with handloaders' electric pots and also sold separately. To insure the correct 50-50 lead-antimony mixture, balance six ingots of lead against an equal weight of powdered antimony to make each charge for the plumber's lead pot. Melt the antimony, add and stir in the lead, and cast in 1-lb. ingots. The ingot mold will need water cooling in continuous use, but make sure it is dry again before the next pour.

This 50-50 lead-antimony mixture will not melt fully by itself in the handloader's electric pot, but it will mix without difficulty with lead and tin to make bullet alloys. The 50-50 ingots are easily broken with a cold chisel at the desired points, and they melt easily into the pool of melted lead with which they are to be alloyed.

To make linotype alloy, the best hard bullet metal, use the following:

(a) *With lead:* 5 lbs. lead, 2¼ lbs. 50-50 lead-antimony mixture, and ⅔ of a ½ lb. bar of tin.

(b) *With salvaged .22 bullets:* 5 lbs. .22 bullet metal, 1⅔ lbs. 50-50 lead-antimony mixture, and ⅝ of a ½ lb. bar of tin.

(c) *With wheel weights:* 5 lbs. wheel weights, ½ lb. 50-50 lead-antimony mixture, and ⅜ of a ½ lb. bar of tin.

It is best to cast each batch of the bullet metal thus produced into 1-lb. ingots, leaving a little of each melt in the pot to conduct heat to the material of the next batch.

These ingots are taken at random when casting bullets, to provide additional homogenizing.

Antimony marketed for handloading use should be in this same 50-50 lead-antimony mixture, which is practical for use and at the same time contains the minimum of lead on which transportation must be paid. And it should be in thin bars, not biscuits, for breaking into weights needed and for feeding into the narrow space in small electric pots having a central valve rod.—Clark S. Campbell

Cast Bullet Loading Method

Westwood, N.J.

Editor:

By following the information published in *The American Rifleman* on loading cast bullets, I have had years of enjoyment and very little difficulty in obtaining accurate and reliable results with several rifles.

For several years I have done most of my cast bullet shooting in two single-shot rifles built by myself on heavy military Martini actions. One has a two-groove Springfield barrel in cal. .30-'06, and the other still has the original Enfield 21" barrel but sleeved at the breech and chambered for the .45-70 cartridge. The .30-'06 has a 10-power scope and the .45-70 a low-power variable. Both actions have been reworked with bushed firing pin holes and refined trigger pulls. I have also found it desirable to place a spacer behind the firing pin spring to get faster lock time and a heavier striker blow.

Using these rifles I have developed a loading technique that I have never seen published. I never size or lubricate the cast bullets and yet obtain excellent accuracy and no leading whatsoever. One of the successful loads for the .30-'06 **consists of Lyman bullet No. 311413ES cast of type metal, with gas check but unsized and unlubricated, and a charge of 48 grs. Hodgdon 4831 powder. The space over the powder is filled with 1-1½ grs. of Dacron fiber and on that 2-3 grs. of lithium grease. This load consistently shoots groups of 1¼-2 minutes of angle, which is about the best capability of this light rifle and its war surplus barrel. Not only does no leading occur, but the bore after shooting has an appreciable film of lithium grease. Pushing a couple of dry patches through results in a spotless bore, and no resistance from powder fouling can be felt. As usual, grease is also apparent on the muzzle face.**

I am aware that the No. 311413 bullet usually gives poor accuracy in loads approaching full power. However, my barrel is throated very tight so the bullet is well supported on firing, and it is seated well out so that the body, which measures .3085", is in contact with the rifling, and the .301" ogive is lightly engraved by the lands.

Equally good results are obtained with a reduced load of 14 grs. Hercules 2400 powder.

A similar procedure is used in the .45-70. The Lyman No. 457483 bullet, cast of type metal but without gas check, is loaded with 27 grs. No. 2400 powder and the same Dacron and lithium grease under the bullet. There is no leading, and the accuracy is good, averaging about 2 minutes of angle with a complete absence of fliers. The bullet cast hollow-point weighs 350 grs. and measures .457" diameter. This is pleasant to shoot and should make an excellent deer load in the brush.

The lithium grease is dispensed very conveniently from one of the small air pumps that are given away with basketballs and footballs. The inflation needle is removed and the pump body filled with grease. The proper amount is judged by the length of grease extruded, checked by weighing a few samples.

Considering that the usual bullet grooves might be unnecessary with this loading technique, I bored out an old Lyman mold in the lathe to cast a 400-gr. bullet with smooth ungrooved body of .457" diameter and a front section of .450" or bore diameter. The first few shots, though loaded as above, gave massive leading and poor accuracy, and additional trials gave the same result. I then chucked some of the smooth bullets in the lathe and turned three large grooves in the body with a parting tool. These grooved bullets were entirely satisfactory when loaded in this way. Whatever the reason, the grooves thus are necessary.

I find this to be a very satisfactory way of loading cast bullets. I have no need to buy equipment for sizing and lubricating bullets, and the time to add lithium grease to the rounds is less than the time required to size and lubricate. Actually the most time-consuming operation is putting in the Dacron fiber, but that has to be done anyway for best results.

Since writing the above, I have fired two 5-shot groups from the .45-70 with ammunition which was loaded in this manner 18 months ago. The loads performed exactly the same as freshly loaded, indicating no deterioration in the 18 months.

J. J. Larson

Bench-Shooting Cast Bullets

There have been at least two comments from qualified riflemen, published in The American Rifleman, *that testing cast bullet loads from bench rest does not give a correct indication of their accuracy. The difficulty is attributed to the longer barrel time of most such loads. It does not arise in firing from a solid prone position with sling, which therefore should be used in testing such loads. But very few shooters and handloaders other than competition riflemen are experienced in prone shooting; others must do their testing from the bench. Does this mean that most of us cannot test our cast loads reliably?*

Answer: The published comments have been justified in our experience also. The difficulty is least with very light loads, heavy match rifles, and short lock times.

Some effort therefore has been devoted here to the problem since it affects most users of these loads. It is found that a different way of supporting the rifle, unlike that regularly used in bench-rest shooting, makes it possible to test cast bullets reliably from the bench. The necessary thing is to hold the rifle solidly.

Grasp the rifle fore-end with the left or non-firing hand, instead of the rear sandbag or toe of the rifle butt in the regular bench-rest manner. Grasping just behind the sandbag appears to give the most reliable results. Then hold the rifle down hard on both sandbags with both hands and solidly back against the shoulder. Hold the face to the stock as desired, but uniformly. The hard holding must be done with complete uniformity from round to round.

Then let off the trigger with absolute steadiness. A small extra sandbag under the firing wrist and hand is beneficial.

Excellent results and a better test of cast bullet target grouping can be obtained in this way.—E.H.H.

Reduced Load Filler

San Diego, Calif.

Editor:

Kapok, toilet tissue, fibers, and other fillers are often recommended for use in reduced rifle loads to hold the powder charge in the rear of the case against the primer. However, these materials are not entirely satisfactory for the purpose as they are not easy to poke into the cartridge case and obtaining uniform weight of the filler is time consuming. They don't necessarily remain in contact with the powder charge unless the case is full and some of the filler may mix with the powder and interfere with its ignition.

Because of these problems I did some experimenting with polyurethane foam, first trying a circular patch. But circular patches proved difficult to cut with a sharpened pipe on a wood block and, after additional trial, I found a filler patch that meets all objections for use in the .30-'06 case. It is a ¾" square of polyurethane foam cut from ¼" sheet foam.

Polyurethane foam in ¼" thickness is available in 18" width in hardware and do-it-yourself stores. Easily marked in ¾" squares with a felt tip pen, it can be cut readily with sharp shears or tin snips.

An ⅛" dowel with point of a pin extending about ⅛" beyond the end is ideal for picking up the patch and pushing it into a .30-'06 case on top of the powder. Insertion of the patch picks up loose granules of powder sticking to the side of the case and pushes them downward where they belong.

The polyurethane patch does not mix with the powder charge and expands sufficiently to stay in place. I found that square patches stay in place better than round ones.

In my .30-'06, a 14.5-gr. charge of Hercules 2400 powder and the Lee No. C309-200R (200 gr. gas check) bullet group more consistently with the polyurethane patch than with 1.5 grs. of kapok. Other cases, of course, will require different patch sizes and diameters of dowel for inserting them.

Douglas A. Tooley

Shrinkage In Casting

It is quite noticeable that different alloys produce bullets of somewhat different diameters from the same mold. Can you give definite figures on this? It might be worth an experimental program to establish the effect.

Answer: This is already known. The basic information was given in "Solidification Shrinkage," *The American Rifleman*, December, 1966, p. 88. The following summarizes the information and relates it to bullet diameters as cast.

Type Metal	Composition, % Tin	Antimony	Lead	Brinell Hardness	Shrinkage Linear, %
Electrotype	3	2½	94½	12	.87
Stereotype	6	14	80	23	.65
Linotype	4	12	84	22	.65
Monotype	9	19	72	28	.65
Lead	—	—	100	5	1.13
Tin	100	—	—	app 7	.90
Antimony	—	100	—	app 50	.47

Last column of the table herewith gives amount of shrinkage as the cast item solidifies. There is a further contraction of about 1% in all these alloys as the solidified item cools to room temperature, but that need not be considered since we are interested here in only differences.

This definite information exists for only the standard type metals, which also are the best bullet alloys. For other alloys it can be approximated, as to both hardness and shrinkage, by interpolating according to their composition.

For example, the solidification shrinkage on diameter of a nominally .357" bullet cast of linotype metal could be expected from the table to be about .0065 × .357" = .0025"-; and in a soft alloy of lead and tin, about .01 × .357" = .0035". The .001" difference is in agreement with observation.

For another example, the composition of Lyman No. 2 bullet metal is given as 10 parts lead, one part tin, one part antimony, which approximates 8% tin, 8% antimony, 84% lead. (It is also stated to be 90 parts lead, 5 parts tin, 5 parts antimony.) Its physical properties thus will lie between those of electrotype and stereotype metals, so its solidification shrinkage may be expected to be about .75%.

This information indicates the solidification shrinkages to be expected from general classes of alloys in a range of bullet diameters. Thus, in .001" on diameters:

Alloy	Bullet diameter, in. .308	.357	.452
Linotype	.002	.0025-	.003
Lyman No. 2	.0025-	.0025	.0035
Soft	.003	.0035	.0045
Pure lead	.0035	.004	.005

The effect on bullet diameter of changing from one alloy to another in this table is the difference between their shrinkages. —E.H.H.

Schuetzen Load Refinements

Remarks have been made on the extreme loading refinements with which the old Schuetzen and bench-rest riflemen were able to do their fine shooting. But precise descriptions are very hard to find. Can any particulars be given?

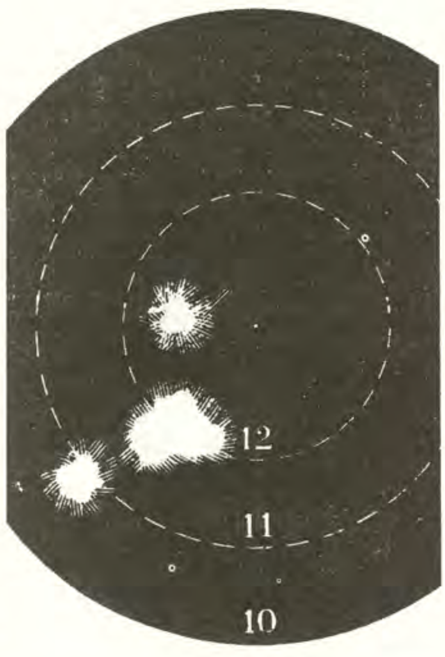
Answer: The operating knowledge of these special refinements faded when they were no longer practiced. Much of this disappearance was due to the inevitable loss of information with time, and much to its unindexed and scattered distribution among old records when they still exist.

The following detailed report (omitting a paragraph on measurement of the target) appeared October 9, 1902, in *Shooting And Fishing*, a predecessor of *The American Rifleman:*

"We have received the original of a remarkable target made by the veteran and painstaking rifleman, C. W. Rowland, of Boulder, Colo. The shooting was done at a range of 200 yards, on the Standard American rest target, shoulder and muzzle rest, and consists of 10 consecutive shots. The shooting was done with a Stevens-Pope rifle, with 32-inch muzzleloading barrel, with Pope rear wind gauge and Martin front aperature sights. The target is herewith produced full size. It counts 119 out of a possible 120, but as riflemen say it was grouped for a perfect score. The 11 was the first shot, after which Mr. Rowland moved his sight; since the shooting he has said he was sorry he did this as he had rather have had the group than the score.

"The following description of Mr. Rowland's methods will perhaps explain some of his fine shooting, and give some shooters an idea of the great patience possessed by a painstaking rifleman when after the finest possible work, which effort to the average man seems wholly unnecessary.

"In preparing bullets for his finest shooting Mr. Rowland's method is substantially as follows: A large lot is cast, something like 500, all of which to the average man would appear perfect. These bullets are carefully weighed, and all varying over one-tenth of a grain are laid out; the remaining bullets are then carefully greased with a Pope pump and again carefully weighed, and those not balancing are laid aside. By this time his original 500 bullets are reduced to something like 160 or so. He has, however, bullets with precisely the same amount each of lead and grease. The bullet is loaded as usual in a Stevens-Pope muzzleloading barrel. After the rifle is laid on the rest, a shell with a projecting wire is inserted in the breech, to learn if the rod has seated the bullet too deep. Powder is loaded with a Stevens-Pope flask, rattled five times, repeated tests by Mr. Rowland proving that it is not necessary to weigh the powder.



The target referred to, shown actual size. For verification, correct diameters of the 10, 11, and 12 rings are 3.36", 2.33" and 1.41".

"The load used in making this target was 3 grains No. 1 Du Pont's smokeless, 7½ U.M.C. primer, and the shell filled nearly full with Hazard FG powder, making a bulk charge of about 46 grains. Before using powder it was very carefully sifted through several sieves to be perfectly sure that it was of an even grain. The bullets were 1 to 10, lubricated with Leopold's No. 6 lubricant. Oleo grease wads were employed. The rest was a Stevens-Pope No. 1 rear and No. 2 front, supported on a very heavy wooden frame, deeply seated in the earth, and strongly braced."

C. W. Rowland's bench-rest shooting came near the end of the Schuetzen era and was among its highest developments. This report answers your question probably as well as any single note could do.

A great deal of information has however been preserved in two books: *The Story Of Pope's Barrels* by Ray M. Smith, Stackpole, 1960; and *The Breech-Loading Single-Shot Match Rifle* by Ned Roberts and Ken Waters, Van Nostrand, 1967. The latter is available from the NRA Book Service, price $12.50—E.H.H.

Brinell Hardness Measurements

Using the method of hardness measurement described by The American Rifleman, *I have measured three samples taken from the same melt of bullet metal, and obtained hardness figures of 13, 12, and 13. Is this satisfactory agreement? If not, how can I improve it? Please explain.*

Answer: This refers to *The American Rifleman's* application of the standard Brinell hardness system to this special use ("Measuring The Hardness of Cast Bullets," *The American Rifleman,* January 1959, pp. 43-44). It is re-summarized in the Question & Answer "Brinell Hardness," January, 1969, p. 57.

Successive measurements on the same bullet metal should agree within one Brinell hardness number, as there stated. Your figures show satisfactory agreement for the normal uses of bullet metal. Obtaining closer agreement is quite practical. A short review of the method makes it clear.

In the regular Brinell system, a steel or carbide ball is forced a little way into the steel or other metal of interest and diameter of the indentation is measured with a microscope; a table then gives the BHN. This is the load divided by area of the impression, and is approximately the unit compressive stress the material can support. An apparatus to apply accurately the necessary heavy test force is required.

The method you refer to was devised by the NRA staff as a system for use in bullet metals with equipment available to most bullet casters. A steel ball is pressed between samples of bullet metal and of pure lead in a vise, and the two impressions measured; their areas (corresponding nearly to their diameters squared) compare hardness of the sample to that of pure lead, for which the Brinell hardness is well known (it is about 5). If, for example, the pressing gives an indentation of .105" diameter in bullet metal and .175" in pure lead, the bullet metal BHN $= 5(.175/.105)^2 = 13.9$. Several measurements thus made should agree within 1 BHN, usually less, and their average can be recorded as the Brinell hardness of that metal.

Measuring hardness of bullet metal sample by comparative indentation (see text).

There are a few requirements, which are not unreasonably exacting. The comparison standard must really be pure lead, not melted lead from plumbing shops or guessed lead, which to a certainty will contain other metal and be harder in some unknown degree; so get commercial new pig lead for this. Both sample and pure lead piece should be smooth and must be sound, not porous or layered. For similar reasons the indentation must not be deeper than ¼ the thickness of the piece; also its diameter must not exceed ¼ the ball diameter. (These two requirements will apply to the pure lead piece since it will be indented more than the bullet metal.) Measuring the impression diameters must of course be done carefully; it is quite practical with a vernier or micrometer caliper and a small magnifier.

Most bullet casters already have or can readily obtain all these items except the steel ball. A relatively large ball is needed for impressions of convenient size, since these must not exceed ¼ the ball diameter. A 1" ball is best. It is obtainable from machinery suppliers.—E.H.H.

Chase Patch

For some time I have been trying to get a Remington rolling-block rifle to shoot well with paper-patched bullets. I recall reading an article in The American Rifleman *that mentioned paper patches made from a single thickness of paper instead of the usual two layers. How does one make and apply this type of patch? Does it work?*

Answer: The article ("Paper Patching Makes a Difference," *The American Rifleman,* March 1972, pg. 18.) referred only briefly to that system of patching. It was named for its originator D. L. F. Chase, a noted marksman during the 1880's and 1890's, and a member of the Massachusetts Rifle Ass'n.

The Chase patching system was described first in the July 19, 1888, edition of *Shooting and Fishing,* a predecessor of *The American Rifleman.* Chase patches were intended specifically for breech-seated bullets and required that a bullet seater be used to insert the patched bullet into the throat ahead of the chamber. They were cut like a double-wrapped patch, but were "just long enough to reach once around without lapping, and only wide enough to cover the desired portion of the bullet without folding over the base." Mr. Chase cut his patches in a rectangular shape, but stated that a bias cut could be used if desired.

To put on a Chase patch, the user rolled the pre-cut patch into a cylinder and inserted it into the bullet seater, so that about 1/16" of patch remained showing. The bullet was placed, base first, into the patch cylinder and the patch and bullet assembly then seated into the bore of the rifle. Using the Chase patch required thicker paper than that used for double-wrapped patches and also that the seater be relieved slightly so the bullet could slide into the patch without crumpling it.

Chase claimed that his patch was easier to apply than the double-wrapped patch, that it always came off as the bullet left the barrel, and that there was no fold at the bullet base to disrupt its exit from the muzzle. Within five years after its introduction, the Chase patch had practically replaced the older double-wrapped patch among U.S. target shooters. Dr. Franklin W. Mann called the Chase patched bullet, "one of the most accurate shooting bullets" and shot a number of 100-yd. 10-shot groups with them averaging 1.59" in an 1898 test.

The Chase system remained in general use until the turn of the 20th Century, by which time paper-patched bullets in Schuetzen rifles had been replaced by the grooved, lubricated bullets developed by Schoyen, Zischang, and Pope.—J.B.R.

Bullets For Worn Barrels

I do my cast-bullet shooting in a .30-'06 heavy-barrel match rifle. The barrel, while excellent, is somewhat worn from years of use with National Match and similar ammunition. Should the cast bullets now be of diameter to fit the worn barrel throat, or the rest of the bore which remains unworn?

Answer: The bullet should fit the worn bore just before the chamber.

Obtaining this fit is not entirely simple, but fortunately there are some practical ways to get it.

Bullets which are especially suitable for worn barrels: (from left) Lyman Nos 311299, 311466, 311467.

Usual rifle bore erosion is practically limited to the rifling lands before the chamber, not the rifling grooves. Only in severe erosion will the grooves be deepened materially (though they may look eroded much earlier). This spoils the fit of those cast bullets which have a bore-riding parallel ahead of the body, which means most of the popular designs. This forward parallel should fit snugly on the rifling lands if it is to be useful. Therefore it should be larger for worn barrels, to fit onto the lands where they have been worn away; but there is little need for the bullet body to be larger since the rifling grooves are little changed. Ideally then the worn barrel should be fitted with a new bullet in which only the forward parallel is suitably enlarged. The practical difficulties in the way of providing such variations are obvious.

An immediate expedient is to load the bullet far enough forward in the case neck to press against the barrel forcing cone when the round is chambered. This old practice is nearly always desirable in loading cast bullets. Adjusted to maintain this contact as the forcing cone advances from wear, it does much to align the bullet.

For cal. .30 cartridges, certain cast bullets do provide the desirable forward fit in worn barrels. One is Lyman No. 311299, the regular cast bullet for .303 British. Its diameter forward of the body is about .304" and on the body about .314". This .304" nose prevents chambering the round in an unworn cal. .30 bore but not in a bore which is even slightly worn. Astonishingly little wear suffices; if the rifling lands at rear show any visible wear at all to careful examination, the bullet chambers readily. The .314" body of course is much too large, but can be sized serviceably to .311" in all sizer-lubricators of modern construction. The .311" body then usually will touch the forcing cone before discharge without the bullet having to be loaded out of the case mouth enough to expose any lubricant grooves.

A similar fit is provided by Lyman No. 311466 and 311467 Loverin bullets. The bodies of these bullets extend almost to the bullet nose, tapering to a slightly smaller diameter on the first two or three bands. This fits very well into the worn lands, the wear being similarly tapered. The bullet is loaded far enough out to obtain this contact. The only objectionable feature is exposure of lubricant outside the cartridge case in all loadings which is often undesirable.—E.H.H.

Action Of Paper Patch

We are interested in paper-patched bullets and have some questions about them. In particular, this statement appears in the article "Paper-Patching Rifle Bullets" (The American Rifleman, *February, 1974, p. 24): "The bullet must expand into the barrel rifling." We would like to know how the bullet can expand into the rifling if it is wrapped in paper. Also, does the paper stay on as the bullet passes through the barrel?*

Answer: For success, the bore-diameter bullet mainly used in this development must expand into the barrel rifling despite the paper. Anyone doubting this has only to shoot some of these .301" diameter bullets (the present development has so far been in cal. .30 and 7.62 mm.) cast of a very hard alloy, patched with quality .0035" paper according to directions, and fired with a light charge so as not to expand them. The bullets will not be spun and will shoot wild.

As the article points out, this necessary expansion of bore-diameter patched bullets requires that their hardness be reasonably well proportioned to the load. This is not a feature in the alternative procedure of patching bullets of groove or .309" diameter with paper of appropriate quality but only .002" thick; then the bullet fills the rifling grooves as it is.

The paper evidently does stay on the bullet all the way through the barrel. This can be verified by looking into the bore at an angle across the muzzle, with back lighting. Little if any whitening by lead from the patched bullet should be visible, while it usually is conspicuous after firing grooved lubricated bullets even though no lead deposit can be seen by looking through the bore.

The paper is always shot out the muzzle in fragments. On a few occasions I have had these come out in long, even strips as cut by the rifling, but nearly always the pieces are small and irregular. In contrast, the old blackpowder barrels designed for patched bullets had shallow rifling and a specially long, gentle forcing cone, allowing the patch to stay in one piece. That cannot be accomplished in present relatively small bores with their deeper, quicker-twist rifling, and (in unworn barrels) steep, sharp-edged forcing cones.

The American Rifleman's re-introduction of the art of paper-patched bullets in modern rifles is being done with the detailed loading methods required for success in this situation.—E.H.H.

Neck Sizing For Paper Patch

The American Rifleman *article of March 1972, p. 18-22, introduced paper-patched bullets for modern rifles, but described only briefly how to seat them in the cartridge case. Isn't the paper patch rather delicate for this operation?*

Answer: As there outlined, the sized case necks should be given an extra expanding at the mouth. The patched bullets then seat without difficulty. An explanation does make this clearer.

Lyman stepped expanding plugs and die bodies, "M" die on right. Arrows indicate enlarged step which bells the case mouth.

The paper patch turns out to be surprisingly strong. Correctly applied, it shrinks on tightly in drying. It should be so tight that the narrow grooves of the recommended bullet (page 20 in the March, 1972 article) show clearly through the paper. Clip off the dried tail closely with smallest available side-cutting pliers (not flush-cutting), closing the base securely.

The best patch lubricant so far found is equal parts by weight of Motor Mica or other solid lubricant, and lithium automobile grease (not some other automobile grease), mixed into a smooth paste. Rub it sparingly all over the applied patch except the base. It will stay on when the bullet is seated.

The patched, lubricated bullets seat with almost perfect smoothness in case necks suitably belled and free of rough edges. Most of *The American Rifleman's* firings have been done with case necks expanded by the .3065" to .307" diameter plugs regularly used when loading jacketed bullets, then by a .314" plug to one-fourth or one-half the neck length. This makes a mechanically strong cartridge, which is also desirably water resistant from the lithium grease in the lubricant.

The Lyman stepped expanding plugs (see photograph) are excellent. They are held in die bodies bored straight through so only the plug touches the cartridge case. The .308" assembly for the Lyman 310 tong loading tool (used with a Lyman ⅞" adapter in bench loading tools) has a .307" plug with .311" mouth expanding step above, which is a little small for this use but is serviceable with carefully chamfered case mouths. The larger Lyman "M" die is preferable. The No. 31R plug for this die has diameters of .310" and .314", and for .30-'06 and .308 or 7.62 mm. NATO cases it is used in a "long" die body. This plug leaves the case neck well belled to start the bullet smoothly, while holding the seated bullet securely.—E.H.H.

Powders For Cast Bullets

I have always carefully selected my powders for use with cast bullets in my .30-'06 rifle, in accordance with the load—fast burning reduced-load powders for light loads, and medium and even slow burning powders for velocities of 1800 f.p.s. or more. Now some recommendations prescribe only shotgun and pistol powders for all such loads. Does this work?

Answer: Shotgun and pistol powders can be used over nearly the full velocity range of cast bullets in rifles, provided the heavier loads are established by velocity and pressure measurement. The NRA staff experience however is that cast bullets shoot accurately with such powders in only light to quite moderate loads. Exceeding these has always resulted in poor and eventually wild target groups, and even bore leading. For accurate shooting it has been necessary to choose propellants to suit the load, as you describe.

This table, published in *The American Rifleman* and now appearing on page 114 of The NRA Handloader's Guide, indicates powders which have been successful with correct gas-check bullets in .30-'06:

Powder	Charge (grs.)	Muz. Vel. (f.p.s.)
Hercules 2400	13-20	1250-1700
Du Pont IMR 4227	14-22	1250-1700
Du Pont IMR 4198	20-25	1500-1900
Hodgdon BL-C, Lot 2	28-34	1700-2100
Du Pont IMR 4895	30-38	1800-2250
Hodgdon H-380	35-42	1800-2250
Hodgdon 4831	40-50	1800-2250
Hodgdon H-450	40-50	1800-2250

Among the many other powders now offered, it is to be expected that some will correspond to the performance of these.

Though all these powders are excellent, each in its field, all usual .30-'06 cast bullet requirements can be met with only two or three of them or their equivalents. For light loads one can take No. 2400 or IMR 4227, or SR 4759 now that it is again available (substitute IMR 4198 for loads a little heavier). IMR 4895 has been found here to be best on the whole for medium through heaviest loads practicable with conventional gas-check bullets. Slower burning propellants can give equal velocities with good target grouping, and very reliably, but they have the undesirable characteristics of heavy muzzle blast and heavy fouling.—E.H.H.

Making Bullet Alloys

A lot has been written on bullet metals, but not much on making up alloys with specific desired properties. Most bullet casters have scrap and salvage lead alloys on hand which they wish to use. Can you provide guidance for making up alloys from such metal to get a specific product?

Answer: The following method does this. It is based on two observations made during long-term investigation of cast bullet alloys by the staff of *The American Rifleman*:

1. The characteristic of a bullet alloy which is most fundamental to performance is strength, indicated by hardness.
2. The hardness of a mixture of usual lead alloys is approximately in proportion to hardness of the separate alloys in it. This includes straight lead, Brinell hardness 5, as a constituent.

Hardness of the salvaged alloys to be used therefore must be known. *The American Rifleman* has given a simple method for measuring it: "Brinell Hardness", January, 1969, p. 57; and "Brinell Hardness Measure", December, 1974, p. 63-64.

The product having desired hardness is obtained by using the metals on hand in quantities according to the hardness each supplies. One-lb. pigs cast in the small iron molds sold to handloaders are most convenient. The following was made up most recently, aiming at a Brinell hardness of 15 and using three lots of scrap found to be of 20, 17½, and 12½ Brinell hardness number respectively. These weights of each therefore were taken:

Wt.		BHN		
2	x	20	=	40
3½	x	17½	=	61
4	x	12½	=	50
9½				151

The BHN to be expected from this calculation obviously is 151 ÷ 9½ = 16. The product should approximate this. In this case it actually had a hardness of 16½. Alloys made up by this method regularly show a slightly greater hardness than their proportions indicate, which can be allowed for in the make-up or accepted as being tolerably close.

The above proportions were arrived at by a few trial calculations. These often show that a desired result can be obtained in more than one way. Thus the method has considerable flexibility. For example, a calculation with the same three available metals shows that weights of 1, 5, and 3 lbs. respectively could be expected to produce an alloy of (1·20 + 5·17½ + 3·12½) ÷ 9 = BHN 16, close though a little harder than wanted. If only the last two lots of scrap were on hand, 5 and 4 lbs. of these could be expected to give (5·17½ + 4·12½) ÷ 9 = 15½, practically the same as the alloy made above.

Thus a few trial calculations, with the simplest kind of arithmetic, indicate at once the combination(s) of available metals which will make an alloy of specified hardness, within the physical possibilities of course.—E.H.H.

Cleaning Bullet Molds

The cavities of bullet molds have to be cleaned occasionally. Otherwise the bullets eventually become less well filled out and even with care cannot be made very good. Reviewing my file of The American Rifleman, *I find several methods for such cleaning, from revolving in the cavity a bullet mounted on a thread tap, to cleaning with a brush and hot detergent or else with alcohol. Which method has experience shown to be best?*

Answer: The essential thing is to get the mold cavity really clean. All the methods you mention can do it. Continued experience of the Staff here has developed the following combination of methods as most desirable.

Clean the mold cavity with denatured alcohol and a soft brush, and allow it to dry completely. (Hot detergent solution may be used instead, with rinsing in hot water and careful drying.) Clean a brass bore brush of the same caliber and mount it in a hand drill. Closing the mold blocks lightly on the brush as shown in the photograph, give the brush a few turns in both directions. A small electric drill could be used without having to clamp it in place as a hand drill must be in this use, but an electric drill turns the brush undesirably fast.

All deposits will come out as a dry powder, leaving the cavity beautifully clean and quite unharmed. This procedure also removes any very small burrs along the cavity edge which tend to keep bullets from dropping freely from the mold. All this applies to the procedure just as described; it does not mean a wire wheel, which certainly would damage the mold.

Cleaning bullet mold by slowly rotating brass brush in cavity (see text).

Obviously it pays to minimize these mold deposits. The causes have become clear and they can be largely avoided.

First, and worst, is trying to burn oil or grease out of a mold by casting bullets in it. This unluckily recommended old practice required prolonged, laborious casting before even moderately acceptable bullets could be obtained, and of course it left a burnt residue in the mold. Instead, remove any preservative oil or grease with alcohol or hot detergent solution before first use of the mold. Do not use any petroleum solvent, which contaminates iron molds in some obscure way of its own.

Then do not cast with dirty metal which will itself leave a deposit. Keep the molten bullet metal clean by frequent fluxing.

Flux with care not to foul the mold. Remarkably, this effect seems never to have been pointed out. It is hardly possible to take exactly the right amount of flux every time. If there is a little too much, and any melted wax is left floating on the metal, some will be picked up in the casting dipper and put into the mold, where it will make trouble. (This is not a problem when all casting is done directly from a bottom valve in the pot; but long rifle bullets may not cast well in that manner.) Use a dry powder flux which leaves no wax.

Finally, do not put any oil or grease in the mold to preserve it; that makes for a cleaning job all over again. Put a little VPI rust-inhibiting powder in the mold cavity, and store the mold in a closed box without any cloth wrapping. The VPI vaporizes slowly and inhibits rusting. In a closed box it will last for several months. Wash out the mold with very hot water just before using it again, and allow it to dry a few minutes. It will then cast good bullets practically at once.

Short, large diameter pistol bullets are easy to cast well. Long rifle bullets are less easy; they fill out best after the mold cavity has been smoked in a candle flame or preferably the flame of a paper match. Then wipe out the cavity with a clean, soft cloth before storing the mold with VPI.

All the above is for the usual iron molds.

Aluminum molds cast excellently but even they do better with the cavity smoked as above. They need no preservative treatment except to keep the steel cut-off plate from rusting. But they do require special care against damage in use. In particular, they must be protected against galling under the steel cut-off plate. Do this by applying graphite (readily done by rubbing the blocks on top with a soft pencil) before first use of the mold, and often thereafter. —E.H.H.

Paper Patches Wear Barrels?

The development of cal. .30 paper-patched bullets by The American Rifleman *is certainly interesting, but won't the paper patches wear the rifle bore? That has not been mentioned so far in the articles describing this development.*

Answer: No erosion or bore wear have been found in the .30-'06 and .308 test rifles and machine-rest barrels used in testing paper-patched bullets. While no more than several hundred of these patched bullets have been fired in any one barrel, it should be possible to see any wear under the low-power magnification used in examining the bores. There may have been some polishing effect, though not enough to be sure of.

Remarkably, your question is asked more often than any other on these patched bullets. Perhaps it is thought paper would be abrasive.

Possibly there may be some recollection of barrel life with the paper-patched bullets once used in muzzle- and breech-loading match rifles. The little authoritative information on this point that has been found turns out to be contradictory.

The American blackpowder match barrels then used were made of soft steel, often specially chosen and extremely soft, and in match shooting the barrels were cleaned after every shot, which may have worn them more than the shooting. Also the barrels did not wear out in the manner now usual. Differing accounts have them worn and requiring re-cutting because edges of the rifling lands became dulled, or on the other hand because the bores became glazed (the term used) and thereafter would not shoot well. Exact quality of the bore surface was most important. All that has little to do with present cal. .30 rifle barrels.

It may be pointed out that while present cal. .30 jacketed bullets give heavy forcing resistance and must involve great friction, they wear out bores only in the part exposed to high flame temperatures near the chamber.

At any rate, the paper-patched bullets have not worn any cal. .30 bores so far. —E.H.H.

Fluxing Bullet Metal

For a long time I have noticed that when I buy new metal, and especially type metal, for my bullet casting, the bullets are strikingly smooth and bright. As the alloy supply is remelted and replenished, the bullets produced become dull-looking and no longer quite smooth. Why are the type metal bullets so much better? I flux the molten metal regularly, so do not believe I am doing anything wrong.

Answer: Nevertheless, the cause of the poor appearance you describe is insufficient fluxing. Examination will show the metal contains many tiny bits of oxide. These tend to freeze out on the bullet surface, as you will see by rubbing the surface hard with coarse cloth or paper, which removes much of this dross. But some remains throughout the bullet. Type metals as bought are free of such dross, and they make smooth and bright bullets.

Type metals themselves seldom are new metal but normally have been used repeatedly. Investigations of type metal have shown that its constituents burn out at rates about what one would expect from their physical properties—the tin most rapidly, then lead, and antimony least. This upsets the alloy proportions on which the performance of each kind of type metal depends. When the metal gives trouble, it has been the practice to send samples to large suppliers who analyze it and furnish the necessary amount of the correct make-up alloy to return the type metal to original composition. But this ordinarily is not done primarily to clean it. In a well-run printing plant, the alloy is kept clean and clear (or was, before most printing with 'hot type" became outmoded) by thorough fluxing in the furnace when casting the metal into pigs for re-use.

Individuals can do the same by repeated thorough fluxing of their bullet alloys.

Clean metal casts most easily and well. This makes it possible to lower the casting temperature and thus lessen drossing. Then thoroughly cleaning the bullet mold cavity with alcohol or hot detergent solution, followed by brushing out with an equally clean brass bore brush ("Cleaning Bullet Molds," *The American Rifleman*, September 1975, p. 80-82) also helps the casting and allows the temperature to be lowered further. These procedures make casting easier and more pleasant, and at the same time minimize the formation of dross which requires fluxing to remove.—E.H.H.

Effect Of Fluxing

The Question & Answer "Fluxing Bullet Metal" (The American Rifleman, *March, 1976, p. 48) explains clearly the need for fluxing bullet metal to restore its condition. But it does not explain how the fluxing works. In fact, I have never seen an explanation which I found convincing. Will you please explain it?*

Answer: The action in fluxing is well understood in the printing industry. Handloaders, however, have not noted this available knowledge. One outstanding handloading report on fluxing lead alloys did appear ("Dross And Fluxes" by A. J. Hammer, *Precision Shooting*, Nov., 1964, p. 4). This reflected Hammer's research in the industry practice and literature, and some high-grade investigations of his own; but the information did not spread among handloaders.

The following summarizes the matter more briefly.

The "dross" or slag and other contaminants of lead alloys are in part metallic oxides, with a much greater weight of metal in the form of very small spheres. The oxides are irreducible at the temperature of ordinary fluxing. The entrained metal, which by weight may amount to as much as 80% of the dross, can be returned to the melt by fluxing.

This "shotted metal" is held in that form by a thin layer of oxide on the spheres and by grease and other contaminants surrounding them, which keep the spheres from being wetted by the molten lead alloy. This is the coating often seen on inner walls of the pot as well as floating on the metal. Purpose of the flux is to separate the oxide from the metal which it holds in the form of shot, and allow these to reunite with the main body of metal. It appears the loosened oxide, when wetted by the flux, is coagulated and suspended in the flux body, which then can be skimmed off.

Many mixtures of oils, waxes and carbonaceous materials have been used as fluxes, and they all work. Most make a cloud of disagreeable smoke when stirred into the melted lead alloy; lighting this with a match causes much to burn off and disappear, but by no means all of it. Non-smoking fluxes have appeared in recent years and these are a desirable improvement. On the other hand, sal ammoniac (ammonium chloride) is reported to be an effective flux but prone to rust tools, etc. which its fumes touch, so it is less desirable. In any case, fluxing and all casting should be done in good ventilation.

Some details are important practically.

Much of the dross will be finely divided and distributed through the alloy, rising to the surface only very slowly. The flux, however, acts almost entirely at the surface. The metal therefore should be stirred thoroughly while fluxing. After allowing a moment for dross and flux to rise to the surface for skimming, the fluxing and skimming should be repeated at least once and better two or three times.

Repeated fluxing with an oily or waxy material is likely to leave some oil or melted wax floating on the metal. This is picked up in the casting dipper and gets into the mold, which it spoils for satisfactory casting until the mold is cleaned. To prevent this time-consuming annoyance, finish the fluxing operation with a dry material, for example sawdust or charcoal, to clean the surface before proceeding.

Dross from the first melting of scrap metal will contain much dirt and grease. Thereafter any dross will be mostly metallic oxides. These are minimized by casting at the lowest practical temperature. Clean metal and a clean bullet mold are most important for this. Additionally helpful are an aluminum alloy cut-off plate on the mold, and smoking the mold cavity. —E.H.H.

Oiled-Sawdust Casting Flux

Years ago there was mention of a special flux for use in bullet casting, namely oiled sawdust. Is it still good? Please explain.

Answer: It is still good, but has become less useful in comparison with some new fluxes now sold to handloaders.

The oiled-sawdust mix is prepared simply by adding to dry sawdust, preferably hardwood, the amount of mineral oil it will conveniently retain. There seems to be nothing special about the kind of mineral oil.

This item was described in *The American Rifleman*, Jan., 1958, p. 30, in the second of four articles which reformed the loading of cast bullets in rifles. More questions and comments came in on that flux than on almost any other feature of the series. It was a bit disconcerting to find such a minor point seized on, to the disregard of the fundamental requirements for success which were brought out in those four articles: bullet metal adequately hard and strong, bullet lubricant favorable to good grouping, correctly dimensioned bullets, and powder type appropriate to the load. However, since that time the gradual acceptance of these fundamentals has brought great improvement in results.

Returning to the flux, an NRA Life Member has reported using this oiled sawdust in salvaging scrap lead filled with dross and foreign matter and considered to be beyond recovery by ordinary means. He stirs the oiled sawdust into the melt repeatedly and in relatively large quantity, and allows it to flame up until consumed. The operation of course is done in the open air where this procedure is safe. A very high yield of metal is obtained.

But the new non-smoking fluxes now available are so much pleasanter to use that the bullet caster is no longer tempted to slight the required thorough fluxing during use. On the whole, these new products are better.—E.H.H.

Buying Bullet Metal

Handloaders in non-industrial areas often have difficulty in obtaining lead alloys (other than the simple lead-tin) for bullet metal. They tend to overlook the advertisers of alloyed-to-order metals. By buying their bullet metal thus made up as desired they can know exactly what they are using, instead of some uncertain mixture concocted from local materials. After comparing some prices I believe the made-to-order alloys cost not much more than the new metals in them bought separately. Should this be more generally known?

Answer: You make a very good point. Certainly the user of cast bullets can assure his alloy quality in this way, and at a price which under favorable conditions may not be excessive in comparison with other shooting costs.

But there remain serious disadvantages to this otherwise desirable method.

One is transportation costs. Even highly alloyed lead, for example the very successful linotype metal, still is mostly lead, and the expense of shipping it from a distance makes it cost much more than equivalent lead procured locally. That can add heavily to the advertised price of the alloy.

Then the handloader may wish to use scrap or salvaged lead accessible to him locally at a more favorable price. Certainly there is nothing against this if he can alloy it as required. He can get tin as bar tin or half-and-half solder. But tin is very expensive and its hardening effect quite limited, so for strong alloys only a few percent is used and necessary strength must be obtained with antimony. And there the difficulty appears—antimony may not be readily available, and alloying it with lead requires raising both metals to a low red heat. This may not be compatible with the electric melting pots which are now deservedly popular.

There is a simple and effective solution, but it requires antimony already alloyed with an equal weight of lead. In that form it melts without difficulty and mixes further with lead in any desired proportion. If it must be shipped in, the small weight of lead involved does not add excessively to the transportation cost. It should be supplied in small 1-lb. ingots for adding conveniently to the melting pot.

Making up such a half-and-half antimony alloy is simple for a metals supplier. The handloader who prepares his own bullet metal and needs only antimony should try to obtain it in that form.—E.H.H.

Conservative Casting

Racine, Wis.

Editor:

With the growing emphasis on conservation of energy and resources and out of desperation at the rising cost of electricity, I began to wonder what I could do to cut down the costs of my handloading. Nothing occurred to me, though, until I was casting bullets one evening.

Previously I had gotten good results by casting linotype bullets at the 750° temperature setting on my lead pot. On this particular day, I noticed what appeared to be an exceptional amount of dross on the alloy. And, the pouring spout was leaking. I concluded that the interior of my furnace needed cleaning. After emptying the furnace, I removed the spigot plug and allowed it to cool down. I then fitted a ⅜" electric drill with a cup-shaped wire wheel and proceeded to "clean" the bowl of the furnace. The amount of dirt that had accumulated over a period of years was staggering. I then cleaned out the spigot opening and relief opening on the inside, reassembled the unit and returned to the task of melting metal. Did I get a surprise! The metal melted faster and at a lower temperature. I finished casting at 650° on the furnace scale.

Good bullets can be cast earlier if the mold is hot, so I place my mold on the furnace while it is being brought up to operating temperature. Then, when I am ready to shut down my operation, I unplug the furnace and continue casting until the alloy begins to cool. In this way I make up for some of the wattage used to bring the furnace up to temperature.

Most of my casting is done in the basement, near a window with a fan installed for exhaust.

During the warm months, I move the operation to a garage and eliminate the use of the window fan.

All this is basic, but basics have a way of eluding us on occasion and in these times of higher costs, better basics can't hurt.

—Frank Tyl[illegible]

Smoking Bullet Molds

There's much misunderstanding as to why smoking a bullet mold improves casting. It's not so hard to understand when you think about it. Soot deposited by a match or carbide lamp is an extremely porous layer of carbon which contains trapped air. This gives the layer insulating qualities which slow the rate at which heat is transferred from the molten metal to the mold blocks. This means the alloy can retain its heat longer, giving more time to fill the mold cavity. Another benefit is that it often permits a reduction in pot temperature which helps reduce drossing.

The layer never gets overly thick because of the insulating nature of the soot. Mold blocks rapidly conduct heat away from the flame, cooling the combustion products, causing a portion of the carbon to condense on the mold surface. But once the layer has developed the flame is insulated from the mold and there is no longer a cool surface on which additional carbon may be deposited. This makes the process self-limiting. So smoke a little . . . smoke a lot, the results will always be the same. — Dennis Marshall

A thin, transparent film is adequate to smoke the cavity. Aluminum mould blocks in particular benefit from smoking them.

Paper Patched Bullets Come Of Age

By E. H. HARRISON

PAPER patched cast bullets now can be loaded in .308 and .30-'06 rifles to the full power and grouping accuracy of factory ammunition. *The American Rifleman* staff completed this fundamental development in late 1976.

Paper patched bullets were used alongside grooved lubricated bullets throughout the blackpowder cartridge era. After rifles designed for smokeless powder were introduced in the 1890's, there began a long development of cast bullets for these rifles also. While there was a limited trial of paper patched bullets made like those used with blackpowder, the development soon became devoted entirely to grooved lubricated bullets, with a copper "gas check" cup attached to the base for protection so far as possible from the hot, high pressure smokeless powder gas.

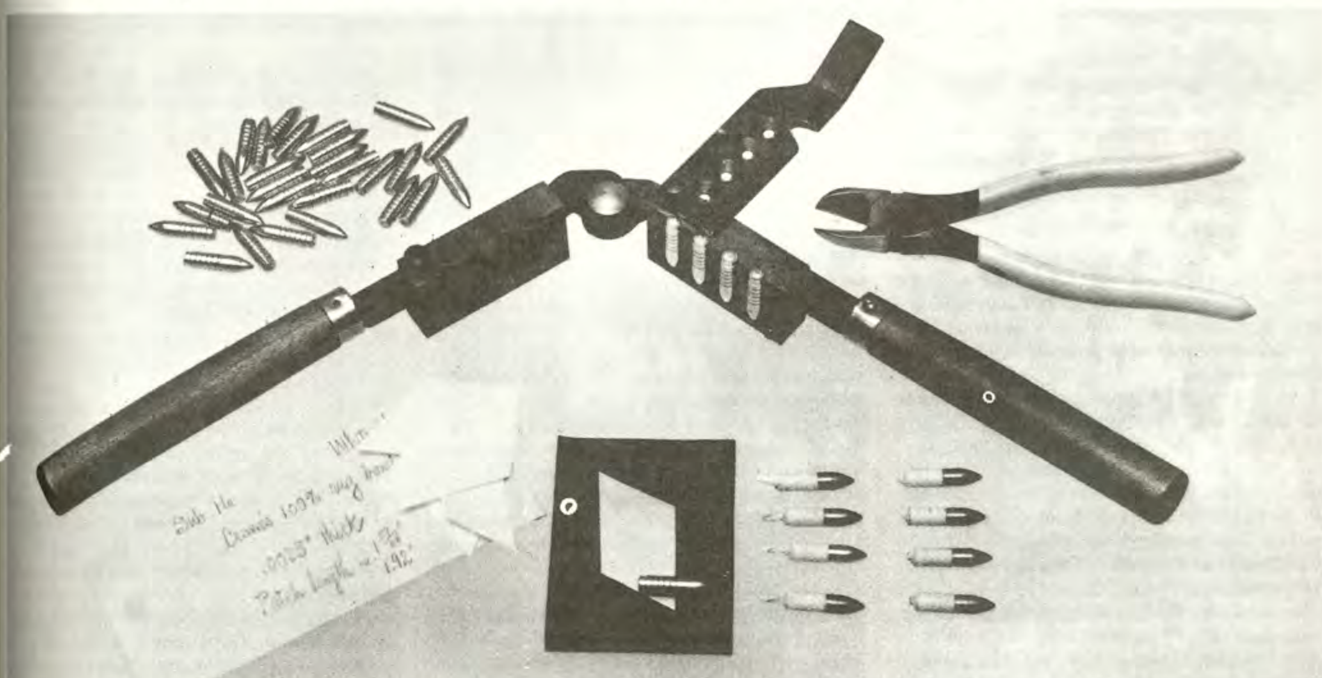
For more than 50 years the success of these bare lubricated bullets remained equivocal. Factory velocities of such cartridges as the .30–'06 could not be equaled, and shooting accuracy often was unsatisfactory even at much reduced velocities. Some handloaders did well enough to keep them going, while others tried and dropped it. Many more never attempted it, deterred by its reputation for failure. Most published material simply repeated old information and misinformation from decade to decade to decade.

Then *The American Rifleman* reexamined the subject in a fundamental way, beginning with a four-part article "Cast Bullets In Rifles", December, 1957–March, 1958. The examination continued in succeeding staff articles, until by 1965 the basic requirements for success had been established—hard and strong bullet metal, correct bullet dimensions, sizing in non-damaging dies, a bullet lubricant which provides accurate shooting in smokeless powder rifles, a fiber filler over the powder where appropriate, and powders appropriate to the load. Understanding of these requirements is slowly spreading among handloaders, and performance is obtained which with the old methods was totally out of reach.

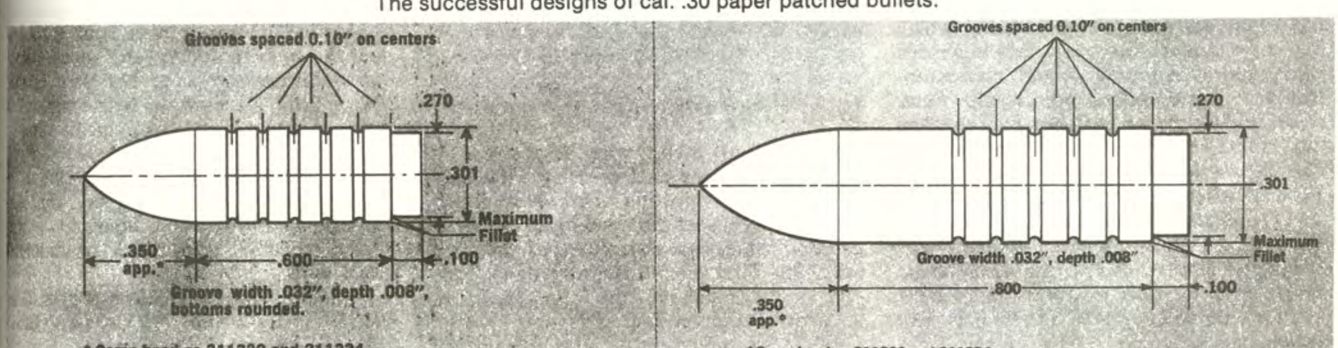
It now appears that the capabilities of this cast bullet system may have nearly been reached, though of course refinements (as opposed to the basics toward which *The American Rifleman's* development was directed) can continue almost indefinitely, as with all ammunition. The limiting factor has become clear: it is softening of the lead bullet surface by the hot, high pressure propellant gas, which cannot be kept off it by methods used hitherto.

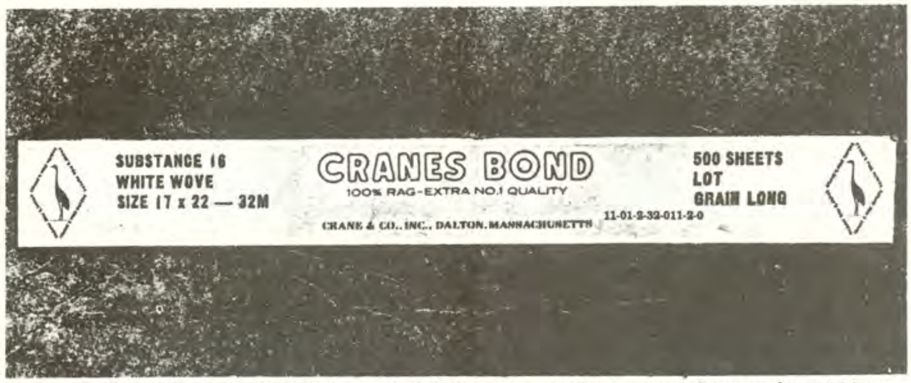
This limitation is removed by wrapping the bullet in paper. The initial development was reported in the article "Paper Patching Makes A Difference", by this writer (*The American Rifleman,* March, 1972, p. 18–22). Additional notes appeared in February, 1974, p. 24; May 1974, p. 62; and January 1975, p. 63. Some fundamentals remaining unsettled have been worked out since

Bullets as they come from four-cavity mold are shown at upper left. After paper patches are rolled on, the remaining tail is snipped off with side-cutting pliers.



The successful designs of cal. .30 paper patched bullets.





Specifications of Crane extra No.1 quality 100% rag paper, the best patch paper found. However, standard water-marked 16-lb. bond paper is more practicably obtainable and does well.

then in long testing, with results recorded in a data-sorting system for analysis.

Bullet, patching, loading

The development was begun with conventional cast rifle bullets lathe-turned to dimensions for patching. Then bullets specifically designed for the purpose were cast in molds made to order by Lyman Gun Sight Division, now Lyman Products For Shooters.

(This is the place to recognize, with appreciation, the excellent molds which Lyman has made for these paper patched bullets. Lyman has long provided bullet molds for all requirements. There have been times when, without these, much rifle and especially handgun loading could not have continued.)

The first of the paper patch molds was designed for a smooth bullet, according to the practice in blackpowder patched bullets. Its shooting was quite unsatisfactory in these smokeless powder calibers, until small grooves were lathe-turned in each bullet. The design therefore was modified by adding five small grooves, and this succeeded. The function of the grooves will be explained.

The two bullet designs which proved successful are illustrated. They are identical except for length forward of the grooves and the consequent difference in weight. The longer bullet weighs 196 to 204 grs. depending on the alloy (harder alloy is lighter); the other bullet 160 to 166 grs. Molds for both are available from Lyman, the 160–166 gr. as No. 301618 and the 196–204 as No. 301620.

Gas checks for these bullets were obtained by sizing Lyman gas checks in a die made by *The American Rifleman* Technical Staff. The gas checks improved performance somewhat at highest velocities. Then continued improvement of the loading methods made the bullets successful without gas checks up to full allowable pressures, and hence velocities, so the gas checks were dropped. The gas check shank on the bullet base helps in closing the applied patch over the base, and also helps anchor the patch during bull et seating in case necks, so the gas check base is retained.

For full loads in .308 and .30–'06 rifles these bullets should be cast in an alloy of 16 to 20 Brinell hardness number (BHN), which is a little softer than linotype metal. For 2000 f.p.s. loads they can be as soft as 12 to 14 BHN, the equivalent of two parts Lyman No. 2 metal mixed with one part lead. Such an alloy is much softer, hence less costly and more easily procured, than is required for even this modest velocity in .308 and .30–'06 with conventional cast rifle bullets.

A high grade paper of suitable type is required for patching, as one would expect. The best readily available paper found for the purpose is Southworth Four-Star Bond No. 402 C, 25% cotton fiber content, in 16–lb. weight. It is about .0033" thick, correct for these bullets. Paper of other makes, if of equal type and quality, might do as well.

This matter of patching paper has been followed up because of its importance. The very best so far found is a Crane 100% rag paper as described in the illustration. It is difficult to obtain at retail. Also, the matter should be kept in perspective. An experimenter who tries to buy success with efforts to obtain this particular paper, while failing in any of the fundamental requirements laid out here (there are only a few, but they are necessary) will fail.

Cut the patches to a length which, when wetted and wrapped on tightly, will go just twice around the bullet; this length is about 1.92" or 1-59/64". In American blackpowder rifles designed for patched bullets, it was considered important that the long fiber of the paper run with the patch length, since in those rifles the patch could be made to stay in one piece on the bullet during discharge. But the rifling in .308 and .30–'06 rifles cuts the patch to pieces, and the fiber direction does not appear to matter significantly. Still, it is as well to lay the patches out with the fiber direction along their length—the long way of the paper sheet. Angle the patch ends at about 60° to the patch length; the exact angle is not important, but it should be the same on the two ends of the patch. Make the patch 1-1/8" wide, to allow for closing and twisting it positively at the base.

Patching the bullets is simple. It does require developing by practice a degree of manual skill with these small cal. .30 bullets, where .45 rifle bullets are very easy. Wet the patch with saliva on both sides. Lay it down pointing away from you. Lay the bullet on it with the near corner of the patch started over. Holding that corner against the bullet, lift the bullet and pull the patch tight while holding its far end down. Set the bullet down; still pressing down on the near patch corner, roll the bullet back a little to make sure the point is stuck down; then roll it forward all the way while continuing to press down hard. Stop at each half-inch to see that you are rolling it straight, and adjust direction as required. Wrapping tightly in this way is done most easily on a thick rubber sheet.

As soon as you have started to roll the bullet

Cast Bullets For Game

MODERN developments in cast bullets in rifles—bullet lubricant favorable to accuracy, hard and strong bullet metal, correct bullet dimensions, fiber fillers, powder suitable to the load and paper patching—have been described in staff-prepared articles in *The American Rifleman*. These have brought the performance of cast bullets in rifles up to a remarkable level compared to what it used to be. The articles also have prompted many NRA Members to inquire why the use of such bullets on game has not been described.

The American Rifleman has not proposed these bullets for use on large game because there has been no real need.

One of the important advantages of cast bullets to the handloader is great cost reduction. (As it works out, the effective advantage is in permitting more shooting within available means.) This aspect does not apply in game shooting, other than small game. Bullets shot on large game represent a trifling consideration compared to all the other costs of hunting. The big game hunter therefore can buy factory bullets for that purpose, and take advantage of the long development which has gone into them for the special purpose of game shooting.

Still, the matter unquestionably is of interest to handloaders, and cast bullets have been used on large game with success.

The fundamental development of paper patched bullets in cal. .30 rifles has only recently been completed, and is published here for the first time. But there is material on conventional cast bullets.

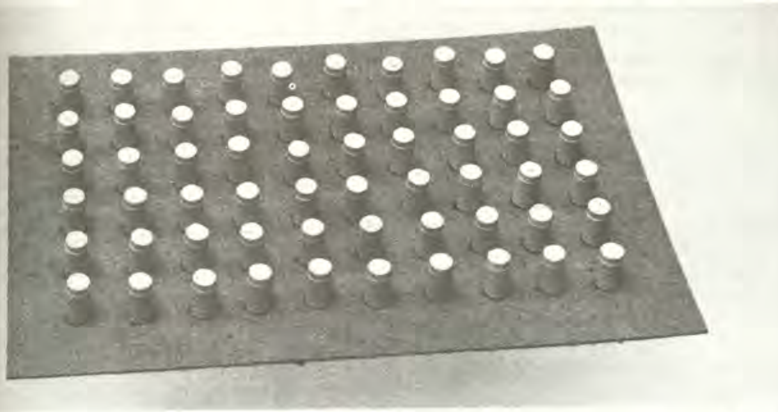
Cast bullets of large caliber have been used successfully on the heaviest American game. Some years ago Winchester published as a matter of interest the experience of a Western hunter who used a .45-90 Model 1886 Winchester rifle. It was loaded with gas-check bullets, other details not given. While the hunter planned to fill his license with a meat animal, a near-record head appeared, and he downed the big elk with two shots and no complications at all.

Such bullets are considered in the article "Matching Bullets With Hunting Methods" by Will Hafler (*The American Rifleman*, Oct., 1971, p. 28-34). The author notes that cal. .45 cast bullets of 500-gr. weight have proved to shoot through elk almost from end to end, anchoring them to the spot; this was considered to be the most favorable type of performance against such game in heavy cover. He lists a 500-gr. gas-check bullet among his preferred bullets for elk in these conditions.

But whitetail deer is the "big game" of most U.S. hunters. The practical question is whether cast bullets can be effective on that game, when fired from cal. .30 rifles in which practically all the rifle cast bullet development carried out by *The American Rifleman* has been done.

When that is proposed, the first reaction of

(continued on p. 96.)



Patched bullets stuck in a cardboard or wood block can be Teflon-sprayed most rapidly and evenly.

forward, it will be obvious whether the patch is on tight. If not, it is because the point was not stuck down.

When the patch is all rolled on, hold the exposed edge down and gather the projecting base paper into as fine a tail as possible, then twist to tighten the patch. Though the patch is quite wet, you will be able to close and twist it firmly without tearing the paper. Then the patch, even while still wet, should be so tight that it is difficult or impossible to turn it on the bullet.

Allow the patch to dry hard. It will shrink tightly on the bullet. Drying can be speeded if desired by gentle warming. The dried patch should be impossible to turn. Cut the dried tail off close with small side-cutting pliers, leaving a very small twisted stub to prevent unwinding.

Patch lubrication

This paper patch must be lubricated for good shooting. U.S. Target riflemen in the black-powder era often shot the patch dry when they cleaned the rifle bore for each shot, but in fixed ammunition the patch might be lubricated with sperm oil and a wad loaded under the bullet. The patch of the British .450 Martini-Henry service bullet was lubricated with wax, and a cupped wax wad was loaded under the bullet; eventually it was found that the wad did not lubricate the rifle bore, but it did give a desirable sweeping action ("Wads Under Patched Bullets", *The American Rifleman*, November, 1972, p. 90). Factory ammunition, designated "waterproof" in the last listings of U.S. factory patched bullet ammunition, indicate patch lubrication.

Conventional and unconventional lubricants were tried on the paper patch throughout this NRA development, and were found to have an astonishingly great and variable effect. Correct lubrication is necessary to success.

Dry lubricants—graphite, MoS_2, mica, and Teflon in several forms—all failed when used alone. Lithium automobile grease rubbed on the applied patch does fairly well, and a mixture of equal parts by weight of lithium grease and powdered mica does better. This is contrary to NRA staff experience with lubricants on conventional bare grooved cast bullets, on which any admixture of dry lubricant impairs the shooting accuracy.

Unquestionably best has been Teflon sprayed on the patch lightly and evenly—two makes of Teflon spray cans proved to be equivalent here—and allowed to dry. Then put the bullet through a conventional sizer-lubricator with .310" or .3105" die and standard Alox bullet lubricant. Finally wipe any excess lubricant off the patch; if left on it tends to open the groups.

This sizing over the patch turns out to be important also to fit the bullet to most .308 and .30-'06 barrels. Nearly all these barrels have forcing cones of one or the other forms illustrated here. While the two forms differ, the important thing is that both are made to the .310" minimum diameter at rear end of the forcing cone. A bullet of the designed .301" diameter measures about .313" over a tightly applied patch of .0033" paper. This shoots through the .310" forcing cone origin better than might be expected, but rings of hard paper are cut off some patches and these interfere with good grouping. Sizing the lubricated patch to .310" or .3105" prevents this in almost all barrels. A few special barrels are smaller than .310" at this point, and sizing in a .309" die has been satisfactory for these. Even this heavy sizing can be done on properly applied and lubricated patches, in sizer-lubricator dies correctly made with a smooth tapered entrance for the bullet. Most present dies are so made.

So far, so good. But here Lyman threw us a curve. *(This is not to take back the well-deserved compliment to Lyman already expressed.)* The original No. 301620 mold cast its bullets close to the designed .301" diameter, allowing development to proceed without complications. But the next mold tried, for the shorter 301618 bullet, was found to cast a .3035" diameter, and the molds now supplied for both bullets cast this oversize, in accordance with Lyman's long practice. When I objected, Ken Ramage of Lyman pointed out that Lyman already has a standard .301" bullet sizing die, with which these bullets can be brought to .301" diameter. That means first sizing the bullets and then removing the necessary sizing lubricant from them before patching, if the patched bullets are to shoot well; thus it adds not one extra operation but two. Also, it requires the user to possess a Lyman sizer-lubricator or one of another make which can use Lyman dies. Since, however, the available Lyman molds are so made, we had to see what we could do.

Then an important favorable aspect appeared at once—the oversize bullet fits worn barrels better. Most barrel wear is on the lands before the chamber, and some occurs there with very little firing of jacketed bullets and most propellants. Then the exposed forward part of a .3035" patched bullet fits and aligns it in the best possible manner. Wear is greatest on rear ends of the lands and tapers forward to zero; so if the amount of barrel wear is uncertain, it is best to begin with the shorter 301618 bullet. A trial will show at once whether the unsized patched bullet, loaded in the cartridge case, will chamber and enter over the rifling lands. If it will not, it will have to be put through the .301" die before patching. A very little wear will, however, allow it to be used as cast.

I had thought the above would be the only material complication in the use of these paper patched bullets. Then, almost at end of the development, a .30-'06 pressure barrel was found to be chambered so far off-axis that the loaded rounds could not be chambered because of interference between bullet and barrel bore (the ammunition was assembled straight, etc.). Even lathe-turning the upatched forward portion of these bullets down to .296" diameter did not remove the interference completely. It is not noticeable, even in this barrel, with usual jacketed bullets, which in normal loading have very little parallel exposed outside the cartridge case; thus it is a special disadvantage of these patched bullets that they may suffer such interference. A similar situation, though not nearly so bad, was found in a new .308 free rifle also, thus in two barrels of supposed high quality. But nothing of the kind appeared in a variety of .308 and .30-'06 factory rifles used extensively with these patched bullets, so perhaps we may assume that such severe barrel defects are unusual.

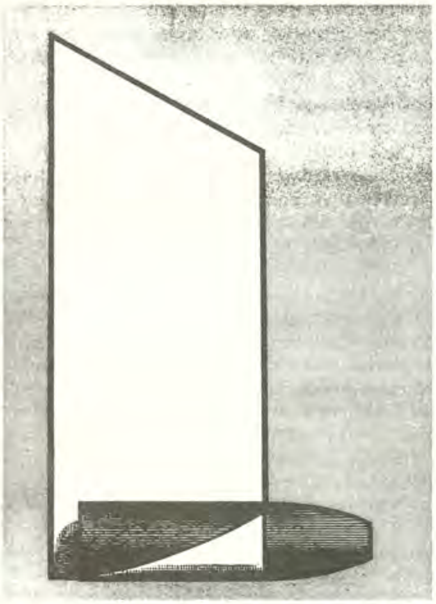
The bullet design

I have been more than a little startled when some persons, on being informed of this development, instantly recommend how it should be done, though they have had no knowledge of it at all. So its principles should be explained.

The most striking feature is that the bullet is of the same diameter from end to end, except for the short point and stepped base. A correct patch then fills the rifling as tightly as practicable, while the unpatched forward length fits on the rifling lands and aligns the bullet. The diameter is chosen to provide for both this forward fit and for patching with the best paper for the purpose. The bullet being a straight cylinder, as much of its length can be patched as accommodated by the cartridge neck (these bullets should not be loaded to extend below the neck) and by the barrel throating and state of wear. The small bullet grooves appear to hold the patch during discharge (at least they have been found necessary to accurate shooting), and they indicate the patch position for wrapping on. The stepped base has been explained.

The short but relatively sharp point was chosen to combine minimum head drag with maximum bore guidance, as well as possible. As the drawings show, it is an old Lyman-Ideal head form. A longer point would give less head drag and thus less velocity loss in flight, but experience with long points in rifle cast bullets has shown their failure to align the bullet reliably in heavy loads.

The design includes an important additional feature. For use in a new barrel the bullet is sized in a .301" die before patching, as explained, while for a worn barrel it is used as cast. Unlike conventional lubricated bullets, the die sizes this cylindrical form also in the ungrooved forward part, which in the loaded cartridge extends over the barrel rifling. The diameter of that part is adjusted, by sizing or not sizing as required, to fit the rifling lands and perform its function of



Starting to roll patch on; direction of winding is immaterial since patch cuts to pieces in firing.

aligning the bullet—something which the conventional two-diameter cast bullet cannot be adjusted to do. Thus the oversize molds, which I objected to when Lyman so dimensioned them, give the patched bullets this important capability, though that was not intended.

Loading and performance

In contrast to all these special bullet features, the loading is almost completely conventional. Fired cases are sized in the usual way, with the standard .3065"–.307" neck expanding plug as for jacketed bullets—not a larger diameter, as the very tight neck left by the standard plug is necessary for best shooting. The case mouth is smoothed and then belled a little to allow the patch to start in without tearing—the only special preparation. The bullet then will seat smoothly, and the patch will not be damaged at all; pull a few bullets and examine them to be convinced. The patched bullets having been lubricated and sized in a .310"–.3105" sizer-lubricator as already explained, seat them in the case necks to a depth which brings the patch against the barrel forcing cone about midway up the exposed paper. This cartridge is stronger and more rigid than most cast bullet loads.

A great many .308 and .30-'06 patched bullet loads were tested over the last four years, and *American Rifleman* staff member Ken Raynor measured the velocity and pressure of 24 .308 full loads. Among all those tried on targets and by ballistic measurement, the three .308 loads in the appended table were the best. The .30-'06 received much less attention, but the two .30-'06 loads in the table are good.

As would be expected in such an untried field, the shooting was at first quite variable. With improved knowledge of fundamental requirements, the results became more regular. During most of 1975 and 1976 there were relatively few .308 five-shot groups larger than 1-1/2 m.o.a. from machine rest in the NRA indoor test range, or 1-1/2" from bench rest at 100 yds., but at the same time almost none under 1 m.o.a. or 1". In the summer of 1976 this picture changed. Groups of 1" and under began to appear, and in September and October, 1976 about half the 100-yd. groups with 196-gr. No. 301620 bullets, shot in two Remington 40-XC position rifles, were under 1". The tests were concluded shortly afterward.

Except for assembling all rounds in a straight-line bullet seater, and on one occasion selecting bullets by weight, all loading of these paper patched bullets was done in the ordinary manner with conventional loading tools. The refinements of weighing bullets, weighing or neckturning cartridge cases, etc., remain in future in the hands of users.

As a matter of interest, *American Rifleman* staff member C.E. Harris in June, 1976, tried a .308 full load with the 196-gr. 301620 bullet, similar to the one in the table, at 100, 200, and 300 yds. The five-shot group at 300 yds. measured 2.80", with its center 21" below the 100-yd. impact. He thereupon offered to shoot this load in regularly scheduled 1000 yd. matches. Due to

(continued from p. 94.)

experienced hunters is likely to be negative. Their reason is that for accurate shooting the bullets must be made of a hard and strong lead alloy, this being one of the most important findings during the NRA development, and so they cannot expand properly on game. Perhaps this view should be examined more closely than it has been.

The article "Bullet Performance on African Game" by George Jacobsen (*The American Rifleman*, April, 1974, p. 26-28) remarks that while practically all American hunters swear by expanding bullets, in almost complete opposition European shooters living in Africa favor full-jacketed bullets for most game. After shooting soft nose ammunition for the first year with poor results, Jacobsen also began to purchase hard nose ammunition. He points out that a hunter on 30-day safari obtains only 15 to 30 head of big game, and even this small number is taken with shots fired only when the accompanying professional hunter judges conditions favorable, thus further limiting the value of the hunter's conclusions. By contrast, the article reports results on nearly 200 head of game of varied size, shot often under difficult conditions which greatly increased the need for bullet performance. Jacobsen concludes that bullets should expand but never shed their jackets. In the cases illustrated in his article, however, full-jacketed bullets were successful even though not expanding.

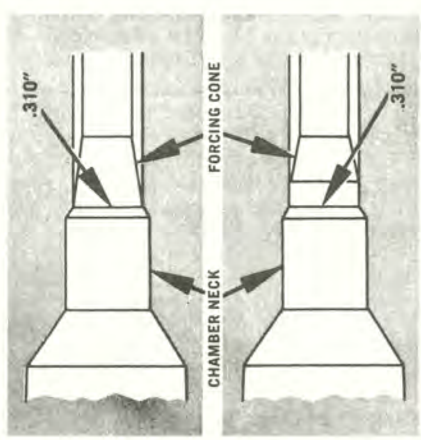
Even very hard cast bullets expand when made hollow-pointed by casting in a hollow-pointing mold. American hunters have objected to this on just the opposite ground, namely that the bullet then expands too much; the forward part blows to pieces to depth of the cavity, leaving only the remaining body to follow through. Americans traditionally have desired that the expanded bullet retain as much of its original weight as possible. It may be remarked that the practice in German hunting bullets, based on study at least equal to ours, provides for expansion and fragmenting of the forward third or so of the bullet, leaving the rear two-thirds intact - which happens to be the action of the hollow-pointed cast bullet. One of the most effective American game bullets, the Nosler partition, has this same action, and some other recent types approximate it. So the old view on this particular requirement may have changed, at least among some riflemen.

But while the above is all worth consideration, the ultimate test is performance on the game, and on that there is not a great deal of recorded information. Reports of cast bullet use on whitetail deer have been received at NRA Headquarters at intervals over the last decade. There never has been an unfavorable comment on them, and the users have remarked on their effectiveness. This has been the case despite hard alloys used. An unusually well qualified NRA Life Member comments that in his experience it is inadvisable to use the Lyman 170-gr. No. 311291 bullet, cast of linotype metal, on whitetail deer at muzzle velocities above 2400 f.p.s. because of the destructive effect. This bullet cast hollow-pointed and loaded to 2300 f.p.s. resulted in destruction of an entire hindquarter of one deer.

On the other hand, the number of reports has been very limited. There is no information on how many other hunters may have used these bullets and whether they have had unreported failures. Shot placement must be of great importance. The handloader who has made up and tested his ammunition with care is likely to use it the same way, and his accurately placed shots give him a tremendous advantage. But what if widespread use were to bring more typical shooting, and deer often were only paunched? Such hits would be effective with hollow-point cast bullets, but it appears these may be undesirably destructive otherwise. Might some of the long-developed factory game bullets, even though no one claims they are perfect, compromise these conflicting requirements better?

The above points out how limited is the information so far available on cal. .30 cast bullets for deer. Also the use of these bullets on deer certainly amounts to only some extremely small fraction of their total use, thus having very little effect over all. It has seemed as well, for the present, to let some of those skilled with cast bullets obtain more information on their use on game.

EHH



Two usual forms of .30-'06 and .308 forcing cones are both about .310" at base of cone, requiring sizing of the patched bullet (see text).

.308 Win. Lyman 301618, 160 gr., 2750 f.p.s. C=.289

Range yds.	Velocity f.p.s.	Time sec.	Elevation m.o.a.	Deflection ins.*
0	2750	0	0	0
100	2433	.116	2.5	1.3
200	2142	.247	5.4	5.2
300	1876	.397	8.9	12.5
500	1428	.765	18.2	39.0
600	1249	.912	20.9	45.7
1000	911	2.136	64.9	186.0

**In 10 m.p.h. cross wind*

.308 Win. Lyman 301620, 196 gr., 2440 f.p.s. C=.354

Range yds.	Velocity f.p.s.	Time sec.	Elevation m.o.a.	Deflection ins.*
0	2440	0	0	0
100	2201	.129	3.1	1.4
200	1979	.273	6.7	5.5
300	1773	.434	10.8	12.5
500	1418	.813	21.2	36.6
600	1270	1.036	27.9	44.6
1000	950	2.155	67.7	166.0

** In 10 m.p.h. cross wind.*

Firing tables for 160-gr. 301618 and 196-gr. 301620 paper patched bullets at .308 velocities.

the comparatively short bullet point (see above explanation of the design considerations for these paper patched bullets, including the reason for the short point) the load would require considerably more wind allowance than normal match loads; but otherwise it appeared quite practical to him, and he is an experienced long range shot.

Accordingly, a similar load was fired at the H.P. White Laboratory, Bel Air, Md., in July, 1976 to determine the ballistic co-efficient for a firing table. Harris did the firing, and the Laboratory measured velocities at 15 and 889 ft. on 30 consecutive rounds. Twenty rounds of these were registered on a paper target at 300 yds., making five-shot groups of 5.00″, 6.35″, 6.09″ and 7.09″. These average 6.13″, or 2 m.o.a., which is larger than other groups at that time even when the development was not yet completed. However, the firer had to contend with a cross wind and also the somewhat distracting presence of photo-electric velocity screens just before the 300-yd. target—though as it turned out the ammunition was reliable and the photo-screens were in no danger.

Velocities of 2474 f.p.s. at 15 ft. and 1811 f.p.s. at 889 ft. yielded, after correction for air temperature and density, a rounded value of .354 for the ballistic coefficient of this 196-gr. 301620 bullet, on the usual Ingalls-Siacci drag function. For the 160-gr. 301618 bullet, which differs only in weight, the ballistic coefficient then is about .289. The corresponding form factor is about .85, which is near enough to unity that firing tables may be made on ballistic coefficients left constant over the velocity range involved. Firing tables for these two paper patched bullets at .308 velocities are given herewith.

Unfortunately I failed to complete the development until October, 1976, too late for ammunition to be made up and used in the season's long range matches, so that opportunity was lost.

The basic .308 development was completed, the .30-'06 less so. The fundamentals were established, leaving experimentation with primers and powders to handloaders who enjoy it, as many do. Some trials here have indicated that considerable experimenting with components may be necessary to obtain results at all comparable with those given in the tabulated loads. So it may be as well first to use the loads shown, verifying in this way that the bullets as used are made correctly.

These bullets, properly patched and sized-lubricated as described, are more forgiving of mistakes than conventional cast rifle bullets. Unlike the latter, the patched bullets can be made too hard; then there will be wild shots, due to insufficient expansion into the rifling. But patched bullets made softer than they should be will open their groups only moderately, unlike the disaster which results from the common mistake of using soft metal in conventional cast rifle bullets. Still, however, it remains possible to make patched bullets poorly enough with grossly soft metal or otherwise to defeat them.

Details applying only in special conditions, such as use of thin patch paper, are omitted here. Nor are smokeless powder calibers included above or below .30. The March, 1972, article, which opened the subject of paper patched bullets, describes how conventional rifle cast bullets not more than .001″ above barrel groove diameter can be patched for use as an interim measure. When molds for bullets of this new design become available in other calibers, it can be expected that small sizes will require development of considerable manual skill to patch, while large rifle bullets, as I have already found, will be easy.

Laboratory-tested loads in .308 and .30-'06

10-shot Strings	Bullet	Powder	Velocity Muzzle	Velocity 15 ft.	Pressure c.u.p.
		In .308: (all with WW 8-1/2-120 primer)			
2	160-gr. 301618 BHN 17	50 gr. WW 760 no fiber filler	2731	2748	47120
4	196-gr. 301620 BHN 19	45 gr. WW 760 no fiber filler	2426	2439	42900
3	204-gr. 301620 BHN 13	30 gr. IMR 4895 1 gr kapok filler	2017	2028	-
		In .30-'06: (both with CCI 250 Magnum primer)			
1	160-gr. 301618 BHN 17	53 gr. WW 760 no fiber filler	2816	2834	46620
1	196-gr. 301620 BHN 19	49 gr. WW 760 no fiber filler	2515	2530	44350

Summary

The above gives a one-time explanation of this paper patched bullet system, as required for an understanding use. The following short directions summarize it and show its essential simplicity:

1. Cast the bullets of hardness according to the load—for full loads, BHN 16–20, or slightly softer than linotype (the softer metal for the shorter bullet); for 2000 f.p.s., about BHN 12–14 which is softer than Lyman No. 2 metal. Hardness is not critical but must be approximately correct for best results. Very unsuitable metal, of course, will fail.

2. Size bullets .301″, provided that is necessary for chambering in the given barrel. Wipe sizing lubricant off before patching.

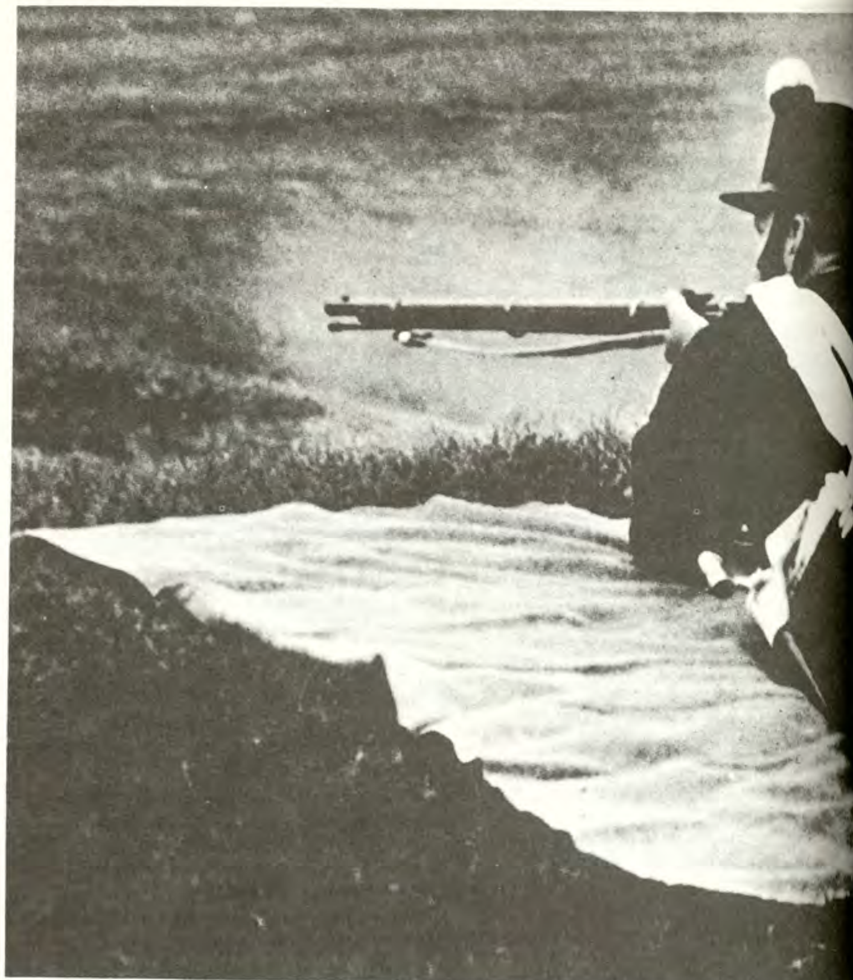
3. Wrap patch as described, allow to dry, and clip dried tail off short but not flush. For most barrels, the patch should cover the second bullet groove. Quality 16-lb. bond paper, 25% cotton fiber, is very nearly best and meets all but the most advanced requirements.

4. Spray applied patch with Teflon, then size in conventional .310″ or .3105″ sizer-lubricator with Alox standard lubricant. If Teflon spray is not available, rub patch instead with Motor Mica (which, like Teflon, is not dirty) before sizing. Wipe off the sized-lubricated patch.

5. Size fired cases and expand case necks as for jacketed bullets, and bell case mouths only slightly. Bullets will seat smoothly, and tight neck is necessary for best shooting. Seat bullets to leave 3/16″ to 5/16″ of patch exposed as required to touch barrel forcing cone on chambering.

6. Start with the tabulated loads.

All the firing tests since 1973 on these bullets—in rifles, machine rest barrels, and pressure barrels—were done by staff members R.N. Sears, J.B. Roberts, Jr., K.C. Raynor, and C.E. Harris, to whom my best thanks.—E.H.H. ■



Fort Henry Guard team competing in authentic uniform at the DCRA 1976 blackpowder matches.

Canadian Blackpowder Shooting Goes A Long Way

By MAJ. DON HOLMES

INTEREST in long-range blackpowder target shooting has grown steadily over the past several years. The availability of many well-made replica blackpowder arms has followed closely upon heightened interest in the colonial and frontier periods.

Nowhere has the revival in long-range blackpowder target shooting caught on more successfully than in Canada. The 109-year-old Dominion of Canada Rifle Association has, since the Canadian centennial celebrations of 1967, held yearly blackpowder Annual Prize Meetings going back to the traditions of DCRA teams which competed in the Creedmoor Matches of the 1870's. Five blackpowder matches are fired, at ranges from 100 to 300 m. Authentic DCRA 1868 gold, silver and bronze medals are awarded in each event, and two large silver trophies, the Loyalist Cup and the Ranger Cup, are awarded for the 100 and 200, and, 200 and 300 aggregates, respectively.

In some matches, only prescribed arms may be used, as in the Snider and muzzle-loader matches. In most matches, however, any breech- or muzzle-loading rifle may be used, if it is of a type authentic to the blackpowder period and does not confer any undue modern advantage upon the user. Breech-loaders must fire cartridges originally intended for blackpowder.

Two excellent arms of current manufacture which satisfy the DCRA blackpowder target rifle requirements are the Browning Model 78 single-shot rifle in .45-70, and the Ruger No. 3 single-shot carbine of the same caliber.

Preparing good .45-70 blackpowder target ammunition is a handloader's dream because of the abundance of superb modern components available. No DCRA restriction exists on choice of blackpowder projectile. Any cast, swaged, jacketed or patched bullet may be used. Blackpowder must comprise the main propelling charge in all matches, but duplex loads (authentic to the late blackpowder periods—see Roberts: *The Muzzle Loading Cap Lock Rifle*, p. 101) may be used.

Many Canadian long-range blackpowder shooters believe that carefully cast, sharp-shouldered and generously lubricated lead bullets are inherently capable of better sustained blackpowder accuracy than typically slope-shouldered, unlubricated jacketed bullets.

Favorite long-range .45-70 cast bullets are the Lyman #457406 hollow-point, gas-check design, and the Lyman #457483 hollow-point gas-check type. These bullets are similar to the highly successful U.S. service 500-gr. rifle, and

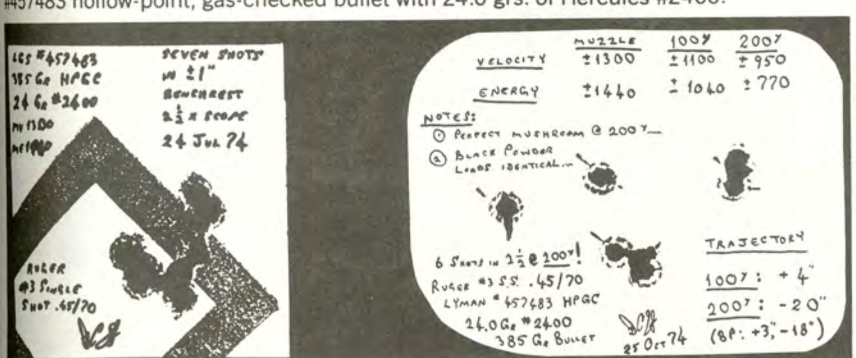
405-gr. carbine bullets, but with a hollow-point and gas-check added.

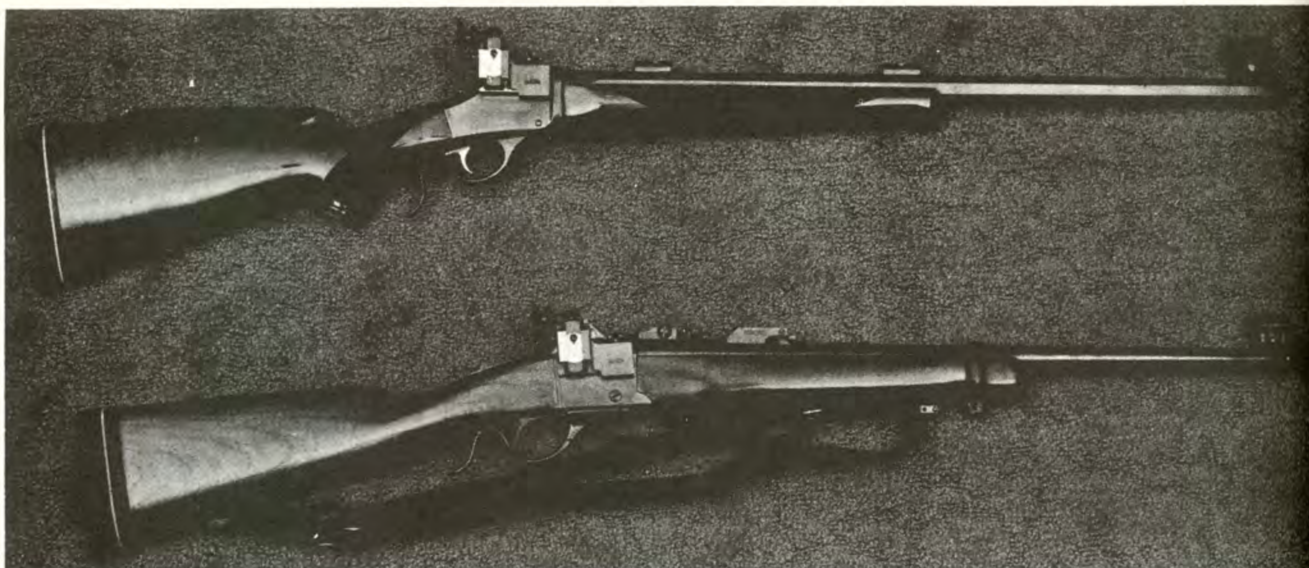
Cast hollow-point bullets, although more demanding to produce, offer for many shooters sufficient advantage to justify the extra pains necessary for their production. Such bullets certainly cannot be cast with the speed of similar solid bullets. The core pin must be tightly positioned and absolutely concentric in the mold; a hotter casting temperature is necessary to ensure against air pockets adjacent to core pin; and more stringent bullet weighing and spinning are necessary to properly select the best hollow-point cast bullets. More bullets are rejected or reserved for practice than when solid bullets are being used.

The advantages of hollow-pointing are threefold. Hollow-point bullets, especially at relatively low velocity, as with blackpowder or at extended range, expand far more reliably for hunting than similar solid bullets. More important from the target shooter's point of view is that hollow-point bullets have a longer bearing surface to guide and align the bullet in its travel down the bore than a solid bullet of the same weight. In addition, the hollow-point bullet, being lighter than a solid bullet of the same head shape and length of bearing, can be fired at higher velocity, and is therefore slightly more stable than a slower, heavier bullet of the same length. Also important for long strings in matches, besides improved accuracy and stability, increased velocity and flatter trajectory, is the fact that you get less recoil.

There is sound reason for choosing a gas-check bullet. Most cast bullets, and all hollow-points, have the sprue on the bullet's base. Dr. Franklin W. Mann, nearly 70 years ago, conclusively demonstrated in *The Bullet's Flight* that bullet base perfection is the single most critical ingredient of cast bullet accuracy. Use of a gas check trues and protects the bullet base, facilitates undamaged loading into the cartridge case, and provides an effective hard, sharp, forward-facing and bore-filling scraping action with every

Two targets shot with the Ruger No. 3 .45-70 rifle at 100 and 200 yds. using the Lyman #457483 hollow-point, gas-checked bullet with 24.0 grs. of Hercules #2400.





Typical DCRA single-shot blackpowder match rifles chambered for the .45-70 cartridge are: (top) Browning Model 78 with high comb stock, recoil pad and Parker-Hale left-hand sights, and Ruger No. 3 carbine with recoil pad and Parker-Hale sights.

shot. The efficacy of copper gas-checks in reducing bore leading and blackpowder fouling is familiar to any shooter who inspects his bore or even a few recovered gas-check bullets.

Bullet alloy hardness is held by many experienced shooters to be an important consideration when muzzle-loading Minie bullets are used. With muzzle-loaders, the hollow base must be soft enough to obturate reliably on ignition, but tough enough to resist deformation from escaping powder gases as it leaves the bore. The first problem, failure to expand sufficiently into the rifling and hence to acquire sufficient spin, is by far the most frequently encountered.

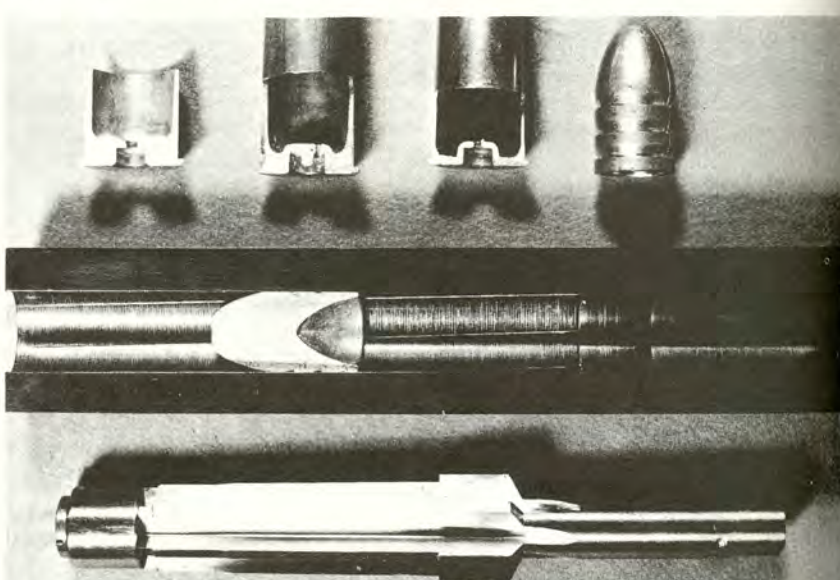
Copious quantities of soft, almost moist bullet lubricant are most commonly used in Canada, with Crisco continuing to be a favorite, in order to keep the blackpowder fouling from caking and then not shooting out from shot to shot. Such moist, generously-lubricated ammunition is subject to rapid deterioration of powder and primer in storage, especially during long, hot summer weather. As Col Townsend Whelen reported in *Small Arms Design And Ballistics* Vol. II, only freshly loaded blackpowder ammunition should be used for serious target shooting. Discriminating Canadian shooters typically avoid hard beeswax-base lubricants, because of their inadequate blackpowder fouling moistening qualities, and generally "shoot down" all remaining unexpended blackpowder ammunition at season's end.

Carefully produced cast-bullet ammunition can produce very impressive accuracy. A light-barreled Ruger No. 3 Carbine in .45-70, won the DCRA 1975 long-range blackpowder match. Sample groups from this 22″ carbine, shooting Lyman cast bullet #457483 HP, were measured: seven shots in 1″ at 100 yds., and six shots in 2-1/2″ at 200 yds.

The .577 Snider is regularly capable of 3″ five-shot groups at 100 yds. (Reported in *The American Rifleman,* Dec., 1973, p. 38 and Aug., 1976, p. 78.) The actual 1867 British acceptance proof diagram of the then-new Snider rifle and ammunition, shows that even this venerable old converted muzzle-loader was capable of holding its shots in a mean deviation of 12.84″, 110 years ago, at the impressive accuracy proof distance of 500 yds.

Those who shoot blackpowder competitively often find it useful to develop a mild smokeless load of equivalent trajectory to their blackpowder match load, for cleaning-free weekly practice.

An excellent .45-70 blackpowder duplex load consists of 8.0 grs. DuPont SR-4759 smokeless under a case-capacity charge, generally about 55-grs., of FFFg.



At top are (l.-r.) sectioned solid-head B.E.L.L. .577 Snider case, semi-balloon head Berdan primed Kynoch case, balloon-head D.C. Co. case, and Lyman #585213 Minie bullet. Below are sectioned .58 muzzle-loader blank correct for the .577 Snider, with sectioned Lyman Minie bullet in bore and .577 chambering reamer by Keith Francis, Talent, Oreg.

The faster burning triple F blackpowder seems to burn more cleanly than single or double F. Handloaders understandably reluctant to contaminate their powder measure with blackpowder dust can easily make scoops for the above duplex load by using an empty 9 mm Luger cartridge case for SR-4759, and an empty .45 Colt case for the FFFg.

A very popular equivalent load of smokeless for virtually any weight of .45-70 bullet is 24.0 grs. of Hercules 2400. Both the duplex and the smokeless load give velocities, with most bullets in the neighborhood of 1300 f.p.s., and produce trajectories generally conforming to the usual military .45-70 sight scales and graduations.

Modern solid-head brass has less powder capacity than original folded head brass, and although I am delighted to report my own continuing occasional use of a few 85-year-old tinned Frankford Arsenal cases, balloon-head .45-70 brass should be avoided whenever possible. Case head separations will be an ever-present possibility otherwise, and a .45-70 separated case extractor (original issue U.S. govt. extractors are still available from Numrich Arms Corp.) may very well be required.

Both Winchester and Remington produce excellent modern .45-70 cases, with many experienced marksmen preferring the uncannellured Remington empty unprimed brass, especially if deep-seated lead bullets are used.

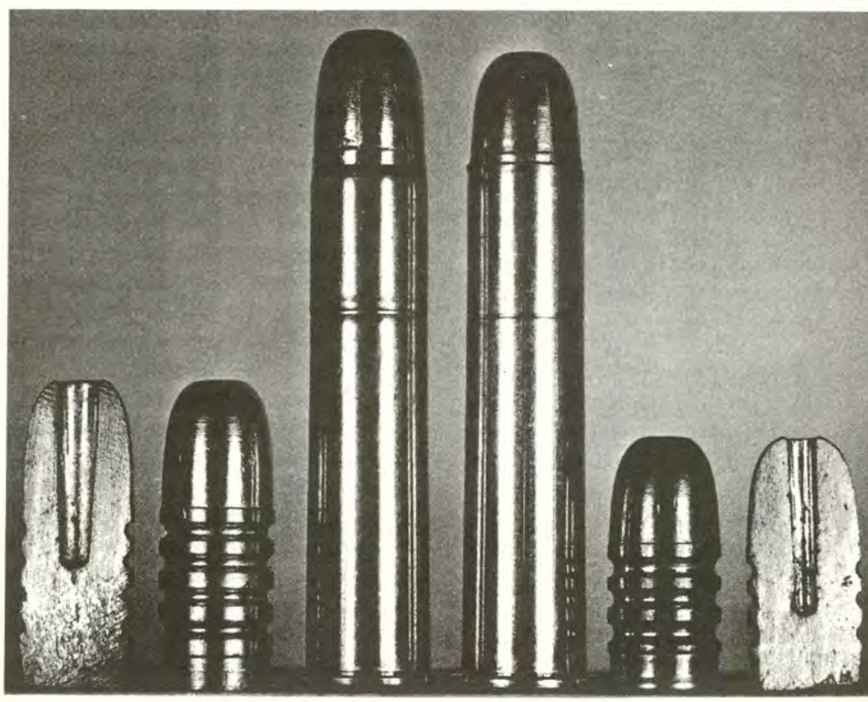
The DCRA blackpowder matches are all fired prone, no rests or slings allowed, iron sights only, except for the 300-m long-range blackpowder match wherein period or modern external-adjustable-only telescope sights are optionally permitted. Abuses in the direction of too modern equipment and unfair cost-escalation are discouraged, and the DCRA blackpowder rules contain abundant authority to prohibit any article of equipment deemed to convey undue modern innovative or technological advantage upon the user. A modern, heavy-barrelled, bolt-action, Canjar-triggered .45-70 target rifle would not be allowed anywhere near the DCRA firing point. Period rifles or replicas of arms generally authentic to the blackpowder period are encouraged.

Each match consists of two sighters followed by seven shots for score. The sighters are convertible, which means that after having fired these two but before the first round for score, competitors may elect to count both, or the second sighter only, for score, and forego the last one or two record shots. The targets used are the standard DCRA fullbore Target Rifle targets, with, for blackpowder only, the 200-yd. target fired at 100-yds., and 300-yds. (There is no such thing as a DCRA 100-yd. target). Targets are separately mounted on a 4 x4 ft. frame, and the DCRA 200-yd. target features a 4-1/2" bull inside a 16" circular black aiming mark. Near-possible scores are frequent occurrences, and tie-breaking rules or shoot-offs must regularly be resorted to.

Many NRA Members participate in the DCRA blackpowder annual matches, to be held this year on Sunday, Aug. 7, at the newly metricated Connaught Ranges near Ottawa. Questions about the matches may be directed to the author, DCRA Director of Planning and Development, 29 Sandwell Crescent, Kanata, Ontario, Canada K2K 1V2. ■

DCRA blackpowder matches are all fired prone with no rests or slings allowed.

Popular Lyman cast bullets used by DCRA shooters in the .45-70 cartridge are shown sectioned, as cast, and in loaded cartridge. They are: (two bullets and cartridge at left) #457406HP, and (at right) #457483HP. Both bullets are gas-check types.



Lead Alloys Age-Harden

It has seemed to me that my cast bullets become harder on standing. Can this be correct? Please explain.

Answer: Your observation is correct. Lead alloys do harden considerably for a time after casting (spontaneous hardening is meant here, not that from heat treatment). This has had almost no mention in the cast bullet information and misinformation published to handloaders for generations. It is remarkable that something which can greatly affect bullet performance, and which is observable and measurable with simple means, has been overlooked so long.

The practical considerations are extent of hardening, which is 50% or more, and the time during which it takes effect. These are brought out in the following Brinell hardness measurements made by the procedure already published in *The American Rifleman,* on a bullet alloy at three-day intervals after casting (0 means the day of casting):

Days	Brinell
0	13
3	14.5
6	15.5
9	20
12	19
15	20
18	19.5

Thus the alloy reached nearly its full hardness by the ninth day after casting, though it will continue to harden further, very slowly, for some time longer.

This takes place in softer alloys also. These measurements were made on another bullet alloy at four-day intervals after casting:

Days	Brinell
4	9.5
8	10
12	12.5
16	13
20	16

The increase then nearly stopped. The metal thus reached almost full hardness by the 20th day. This may be a more usual time than the nine days of the other alloy.

Some age-hardening takes place in this way in all lead bullet metal of any useful degree of alloying. It occurs very little in pure lead. Some of the most expert individual makers of jacketed target bullets like to leave intervals of several days between steps of their bullet assembling operation. So far as known, there is no established connection between the shooting performance of these bullets and a measurable age hardening in their pure lead cores. Stress relief may be a better justification for the practice.

The practical view is that the aged hardness is the normal one, the soft condition after casting being abnormal but temporary. With this information, the handloader knows that for normal performance he simply must hold his cast bullets for at least two or three weeks before using them.—E.H.H.

Sampling Lead For Hardness

Directions for measuring the hardness of lead alloys (The American Rifleman, *December, 1974, p. 63) prescribe indenting samples of the alloy and of pure lead by pressing them in a vise with a steel ball between. A photograph illustrates this with the metal samples in form of 1-lb. ingots, as cast in the ingot molds used by handloaders when melting up their supplies of metal. But I find that shrinkage of the solidifying ingot leaves only a small area on top which is smooth enough to take a sharp indent. A larger useable surface is needed.*

Answer: Your comment is quite correct. The sample of the metal to be tested will be indented only once or twice; but the pure lead standard can continue in use as long as any smooth surface remains on it, so that surface should be large.

When this simplified Brinell hardness method was first published (*The American Rifleman,* Jan., 1959, p. 43) it was illustrated with samples cast in a large pipe cap having the threads bored out and the inside bottom faced smoth, providing the desirable large surface. For many users however, it is not convenient to have such machine work done.

Samples can be cast in aluminum muffin pans instead. These deliver the required thick cakes of metal with an excellent smooth bottom. (Afterward, do not use the pans for any food purpose, since they almost certainly will have taken up some lead, even though invisibly.)

Casting the lead in a tinned-steel muffin pan, instead of aluminum, affords an interesting sidelight on jacketed bullet construction.

The casting will be found soldered in and cannot be removed, not even by cutting and tearing the pan to pieces; they have to be melted out.

This illustrates strikingly the effectiveness of the original Lorenz process of 1884, in which the drawn bullet jacket was tinned inside and the lead core then assembled by pouring in melted lead, or by pressing it in cold and then warming jacket and core together to solder them ("Bullets With Jackets: A European Invention", *The American Rifleman,* Nov., 1976, p. 36). This basic procedure has been adopted in recent years for manufacture of some sporting bullets in this country. —E.H.H.

Thumbnail Hardness Test

Handloaders have long tested their bullet metal with their thumbnail. If the metal can be indented readily, it certainly is soft and according to some directions can be called pure lead. I have found this to be mistaken, since I can thus indent bullet metal containing several percent tin. For guidance, how hard a lead alloy can be distinguished by this procedure? Then, how far is it actually useful?

Answer: Your finding is quite correct.

From curiosity, an attempt was made to measure the effectiveness of this "test." Of course, the result will depend to a considerable extent on strength of the user's thumb and hardness of his thumbnail. But only moderate effort was found necessary to indent and scratch lead alloys up to about Brinell hardness 11. This is more than twice the hardness of pure lead. Surprisingly, it was found also that the thumbnail test could not even serve to estimate reliably the relative hardness of alloys within its marking range.

Bullets which can be marked in this way are much too soft to shoot well in most rifle cartridges. At the other extreme, in muzzle-loading bullets the test does not identify pure lead, as noted above. Pure soft lead is required for correct functioning of Minie bullets, especially the original design, when used without an expanding plug in the base cavity. While the U.S. standard Minie was designed to be so used, only a full charge will expand it into the rifling, and then only when the bullets are pure lead. Investigation has shown that Minie bullets made of salvaged metal, and shot with the reduced loads now employed in competition, do not expand into the rifling at all. The thumbnail thus is of little practical use to test the hardness of bullets for either cartridge rifles or muzzle-loaders.

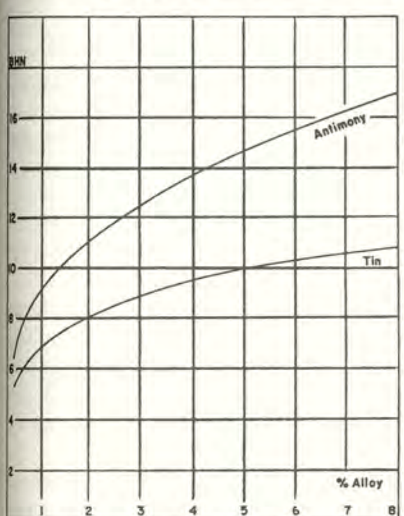
It does distinguish between hard and soft scrap metal. Much or most loading for handguns is done with bullets of soft and unknown composition. For this inexact requirement, the thumbnail test has some usefulness.—E.H.H.

Tin In Bullet Metal

I have been shocked at the high price of tin when I buy it for making up my bullet metal. Has it always been like this? Why is tin recommended as the alloying constituent?

Answer: It has not always been like this. An old Ideal Handbook (apparently No. 4 dating from shortly after 1890) calculated reloading costs on the basis of tin at $.36/lb., lead $.05/lb., and primers $1.20/1000. Tin thus cost at that time about seven times as much per pound as lead.

In May, 1977, the periodical *Iron Age* reported tin prices averaging $4.53/lb., and primary or new lead $.31/lb. Tin thus costs nearly 15 times as much as new lead. Heavy soft lead scrap is quoted at $.13-.15/lb., and tin costs more than 30 times that. These are industry prices, which ultimately control retail prices. Individuals may at times find small amounts of metal priced below retail, but most users cannot count on it. Nor can they count on scrap tin at a low price—as if metals dealers did not know the price of tin! So in general a user of tin must pay.



Hardening effect of tin and antimony used separately. Brinell hardness numbers (BHN) express compressive strength in kilograms per square millimeter.

Besides his advantage from the relatively lower price of tin, the 1890 handloader used comparatively little of it. The 1 part tin to 16 parts lead composition of the Army .45-70 bullet was exceptional. Most handloaders of that still blackpowder era made their bullets 1-30, 1-40, or even 1-60 tin and lead. Under such conditions, tin as the only alloying element worked well.

Then smokeless powder was found to require harder bullets. Adding a little more tin proved adequate in the only limited amounts needed for smokeless loads in blackpowder calibers. But it was not adequate for the more severe requirements of smokeless calibers. The hardening effect of tin is too small. A small amount gives some hardening; 4% tin gives lead alloy a hardness of nearly Brinell 10, which is about twice the hardness of pure soft lead (see illustration, which was published in *The American Rifleman* in January, 1958). But further additions have little effect.

This is unfortunate, since tin's other properties are favorable—availability, ease of melting and alloying casting qualities, and tradition. But some antimony in the lead is necessary to meet anything more than quite modest requirements. Providers of handloading information were for many years unwilling to tell the user this, assuming they knew it. The result was decades of failures with cast rifle bullets.

Tin is still useful in light loads, and in revolver loads which do not have to meet measured accuracy standards, which means most revolver loads. Antimony is difficult to melt with ordinary handloading equipment, but after alloying in any proportion it gives no trouble. Type metals containing desirable proportions of antimony and tin are still found in scrap yards, despite changed use of metal in modern printing. Antimony alloyed half-and-half with lead, for easy further use as desired, can be produced.—E.H.H.

Wear By Linotype Bullets?

A statement has been made that linotype alloy, used to make some cast bullets, may by its hardness wear out rifle and handgun bores. Is this correct?

Answer: It is fantasy.

The hardness of gilding metal, of which most present bullet jackets are made, varies according to its drawn and annealed state but is in the neighborhood of 100 Brinell. This is more than four times as hard as the 22 Brinell of straight linotype metal.

It became evident years ago that bullet jackets do not of themselves wear out smokeless rifle barrels; this requires the high temperature and pressure of burning smokeless propellants. Still less could the far softer linotype metal do it.

Jacketed bullets apparently do wear out the soft barrels of early breechloading rifles. Such rifles are now few and becoming fewer. In any case, most handloading for them probably is done with light charges and soft-alloy bullets to give the blackpowder ballistics for which these rifles were made.—E.H.H.

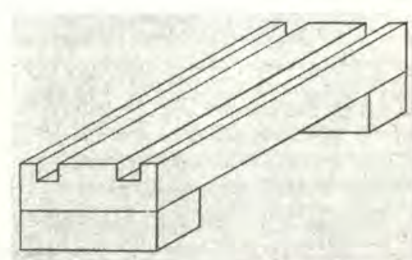
Paper-Patch Lubricant

It is difficult for me to obtain locally the Teflon spray lubricant for applying to paper patched bullets, before sizing with the standard Alox bullet lubricant ("Paper Patched Bullets Come Of Age," The American Rifleman, *March, 1977, pp. 28-32). Can something else be used?*

Answer: In this case the Teflon spray can be replaced with powdered mica. This is Motor Mica, available in hardware stores.

Apply it by hand to the patched bullet, rubbing it on vigorously. Leaving it on the patch, size the bullet with Alox bullet lubricant in a .310" or .3105" bench sizer die, or .309" if required to enter the barrel forcing cone. This is exactly as explained in the March, 1977, article, substituting mica for Teflon.

Wipe any excess of lubricant-off the patched bullet before seating it in the cartridge case, or leave the excess on, depending on firing results.—E.H.H.



Grooves at top of guide clear mold handle screws

Gang Mold Guide

To ease bullet casting in gang molds when a bottom pour pot is used, I made a wooden guide to support the weight of the mold. The guide consists of a piece of 2"x4" lumber and two shim blocks cut so that the top of the assembled guide holds the top of the mold ¼" below the pouring spout. This clearance allows me to slide the mold underneath the spout, yet I can easily pour molten alloy into the individual mold cavities.

In making a guide, plane the top of the 2"x4" smooth and also rout lengthwise clearance grooves for the handle screws of a Hensley & Gibbs four-cavity mold. My guide is made to sit level, but the shims could easily be cut to make the guide lower at one end than at the other.

Using this guide reduces the physical effort involved in handling a heavy gang mold and makes casting a simpler, more enjoyable pastime.

GALE ASCH

Readers Comment On Cast Game Bullets

Recent experiences affirm the effectiveness of molded lead projectiles

Editor's note: Since E.H. Harrison's article "Cast Bullets For Game" *(The American Rifleman,* March, 1977, p. 29) appeared, many NRA Members have written describing their experiences hunting deer with cast bullets. Space does not permit printing all such replies, but the comments given here summarize those of hunters who had opportunities to use such ammunition on more than a single hunt, thus observing its performance on several animals.

Editor:

In reading the March, 1977, issue of *The American Rifleman* I saw your article, "Cast Bullets For Game." I shoot a .30-'06 with a 26" McGowen barrel, and my wife shoots a Model 70 Winchester, also a .30-'06. I find that the load I worked out shoots well in both guns. I use mold #311291 HP with #2 alloy, and the bullets come out 164-168 grs., lubricated and gas checked. I have a lot of H870 so I worked up a load of 42 grs. powder with CCI standard primers. They grouped 3/4" at 100 yds. I don't have a machine rest, just a pillow on a bench.

I shot a two-point blacktail (two points each side) at about 80-90 yds. I wanted to see what would happen so I shot at the shoulder. It went in the left side through the shoulder blade, broke two ribs, took off the tip of the heart, went through the opposite shoulder and broke a piece of bone out of the leg about 3" long and lodged just under the hide but did not break the skin.

The entire hollow-point cavity blew away, and I found three pieces in the heart. It did not knock the deer down; he hopped on three legs about 30 yds. (toward me) and lay down. He was dead by the time I got to him.

I shot an antelope in the spine and the cast bullet took out an entire vertebra. The recoil doesn't bother me, and with that load you can hardly feel the rifle go off.

I don't think I'd take these rounds elk hunting, but they will kill deer and antelope. They are a lot cheaper to shoot, too. These loads should not be considered flat-shooting rounds, nor for long ranges, but if you're not too far away, they're great.

J. E. Dobson
New Castle, Wyo.

Editor:

I noted with interest, the article "Cast Bullets For Game," (*The American Rifleman,* March, 1977, p. 29-31), and I would like to relate my experience with cast bullets for whitetail deer.

The first deer my wife killed was taken with a sporterized 7.65 mm Argentine Mauser firing a 205 gr. gas-check cast bullet, of design #311299, cast from wheel weights, bar solder, and scrap lead to approximate #2 alloy. This bullet was propelled by 20.5 grs. of #2400 powder with an estimated velocity of 1800 f.p.s.

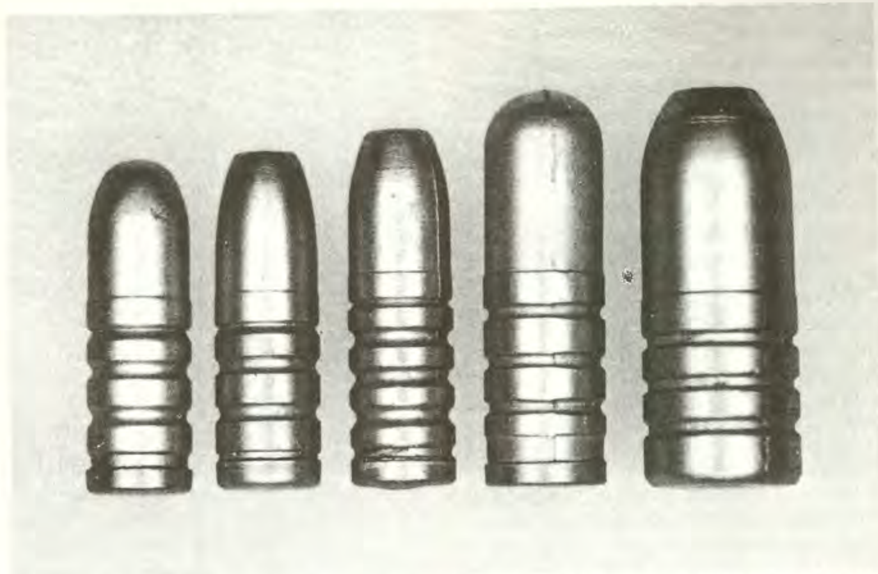
She shot her buck at about 45-yds. range, striking him through the front shoulders. The buck traveled about 70 ft. before dropping. The 205-gr. bullet passed through both shoulders, breaking both, and creating a wound channel which was very impressive. The diameter of the exit wound was about 1½" and the blood trail was excellent.

The second deer was a medium-sized doe taken by my youngest son during doe season. The rifle was a cal. .303 British Lee-Enfield No. 4. The bullet was a 155-gr. gas-check #311466, cast of the same alloy as above, propelled by 24.5 grs. of IMR 4227 powder with an estimated velocity of 2000 f.p.s. My son shot his deer at about 30-yds. range. There was an easy-to-follow blood trail and the deer was found dead about 50 ft. from the point where it was hit. The bullet had penetrated in a forward direction starting at a point midway in the chest cavity, passed through the heart and lungs, broke a rib on the offside and lodged on the inside of the opposite front leg. The bullet had expanded to approximately two diameters and shed about half its weight. The heart and lungs showed a very favorable amount of destruction in view of the fact that no bone was struck on the entrance side.

A third deer was harvested by my oldest son the following year. The rifle used was a Springfield .30-'06. The bullet was a 170-gr. gas-check flat-nose, cast from a Lee mold #309170F. This bullet was propelled by 20.5 grs. of Hercules 2400 powder with an approximate velocity of 1800 f.p.s. My son was presented with a standing shot on a medium-sized buck at about 110-yds. range. He assumed a prone position to steady his aim, and struck the buck just behind the shoulder blade in the center of the chest cavity. The blood trail was excellent, and the buck was found about 40 yds. from where it was shot. The cast bullet passed through the near side, broke one rib, pulped the large vessels above and forward of the heart, collapsed the lungs, and broke a rib on the exit side. The exit wound was about 1/2″ in diameter.

I have concluded that if the range is moderate and the bullet is placed in the boiler works, cast bullets of cal. .30 function very well for whitetail deer, even at moderate velocities. The wound channels are almost equal to the wound channels of high velocity jacketed bullets, and the ability of a young shooter is enhanced by the light recoil and lessened muzzle blast of the moderate loads.

STANLEY B. SMITH
Easton, Pa.

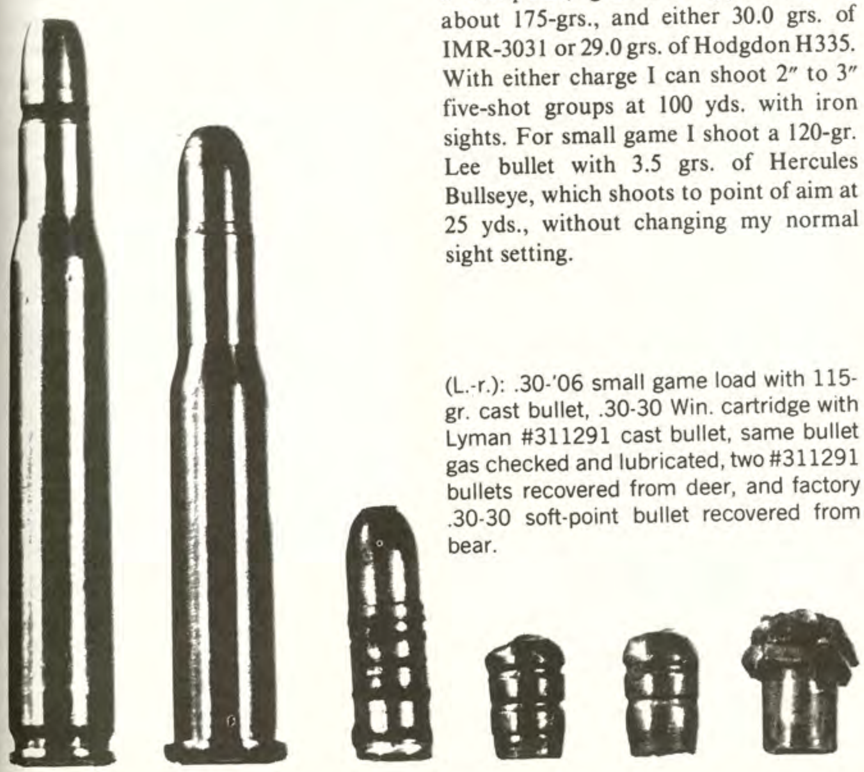


Successful cast game bullets have usually been of cal. .30 or larger, having a long bearing surface, reasonably heavy for their diameter, with a flat or blunt point. Some popular cast bullet designs having these characteristics are (L.-r.): Lyman #311291, #31141, RCBS 30-180F, Lyman #3589 and Lee 457-450 bevel base.

Editor:

The remark was made in the March, 1977, issue of *The American Rifleman* that there isn't much information available on the performance of cast bullets for game shooting. I wish to shed some light on this subject.

For several years I have hunted with a Savage Model 24V, having a .30-30 rifle barrel above a 20-ga. shotgun. My deer loads consist of the Lyman #31141 bullet, a flat-point, gas-check type weighing about 175-grs., and either 30.0 grs. of IMR-3031 or 29.0 grs. of Hodgdon H335. With either charge I can shoot 2″ to 3″ five-shot groups at 100 yds. with iron sights. For small game I shoot a 120-gr. Lee bullet with 3.5 grs. of Hercules Bullseye, which shoots to point of aim at 25 yds., without changing my normal sight setting.



(L.-r.): .30-'06 small game load with 115-gr. cast bullet, .30-30 Win. cartridge with Lyman #311291 cast bullet, same bullet gas checked and lubricated, two #311291 bullets recovered from deer, and factory .30-30 soft-point bullet recovered from bear.

The #31141 bullet is cast of wheel-weight metal, or harder, and with these powder charges it develops velocity and energy equivalent to factory .30–30 loads. I've killed five deer with this bullet over the years, two were large bucks. Only one animal took a second shot—an angling shot in which the bullet traveled downward between the shoulder blade and rib cage without penetrating. That deer ran about 200 yds. before I finished it off.

Another buck was shot in the spine, killing it instantly. A doe was neck shot and ran 15 yds. before it collapsed and died. I have only recovered one of these bullets. It appeared to break up, shedding pieces at 4″ intervals as it coursed through the deer. The base, which I recovered, was only about ⅜″ long, and was still about cal. .30.

I've never shot .30–30 jacketed bullets at deer, but I think they would have achieved almost identical results with the cast bullets described above. I've shot many deer with a .270 Win., and consider it a nearly perfect deer cartridge for the serious hunter. Of course, the .30–30 can't compare with it.

However, I get more satisfaction from shooting deer with a single-shot rifle and a fussy cartridge which is complicated to load and limited in range. The Savage Model 24V is a handy little gun, and if I were really honest with myself, I could use it with these loads and dispose of the other 20-odd guns in my closet.

WILLIAM BEHRENDS
Worland, Wyo.

Zinc Bullet Pistol Loads

Houston, Tex.

Editor:

The trend in handgun ammunition seems to be toward lighter bullets at higher velocities. One way to do this is to have special molds made for casting extra-light lead bullets. The result is a stubby bullet with poor ballistic shape and short bearing length. Even when cast of hard lead alloy and well lubricated they often lead the bore if loaded to high velocities.

By using zinc die-casting alloy instead of lead, one can cast, in standard molds, bullets that weigh only 60% of their lead alloy equivalents. They need no lubrication or gas checks.

My first experiment was with the Lee 105 gr. SWC mold which produced a 9 mm bullet weighing only 64 grs. Loaded with Unique powder, five rounds from my Astra 600 made a 1 7/8" group from rest at 25 yds.—acceptable, I thought, for most purposes.

After this, I decided to try a round-nose bullet, since many 9 mm pistols don't feed semi-wadcutters as well as the Astra. The Lyman 358242 121 gr. mold produced a zinc bullet weighing 74 grs. Unique powder seemed to be a little slow for such light bullets, so Bullseye was used with improved results.

The next step was zinc loads for .45 ACP. Using two Lee molds—the 452-228-1R and the 452-190-SWC—I was able to cast bullets weighing 140 and 115 grs. Bullseye proved to be the best powder for these also. Groups at 25 yds. were 5" to 6", nothing to write home about. Most of this is probably due to my rather loose Llama .45.

Zinc bullets don't expand—ever. But if you have done much gelatin block testing of hollow point lead .45 bullets, you know that they seldom open up either. The energy of most .45 loads is too low to provide reliable expansion. The higher velocity achievable with zinc bullets at close ranges should produce considerable wounding effect by cavitation. All the loads described in this article punched through .093" sheet steel. On the other hand, zinc bullets have very low sectional density, and will not hold their velocity beyond short pistol ranges. Their extreme range is much less than that of lead bullets.

There are tricks to casting zinc bullets, but they have all been described in past *American Rifleman* articles, and no handloader should have much trouble with process. The cost of zinc bullets is less than that of type-metal bullets. Type-metal and zinc die-casting alloy both cost about $.50 a lb. and a lb. of zinc alloy makes almost twice as many bullets. LEON DAY

Smoking Bullet Molds

It has long been claimed that smoking the cavities of bullet molds helps in making good bullets. Is this still true? How does smoking the mold produce this result?

Answer: It still is quite true. The procedure helps especially with long rifle bullets, which otherwise may be difficult to cast well every time.

Experience of *The American Rifleman* staff has developed further information which considerably extends old directions on the subject. Those directions prescribed smoking the mold cavity and brushing it out before use; if that was unsuccessful the mold was to be smoked again and used without brushing out. Recent experience here indicates better casting without any brushing out. Best of all is to smoke the mold several times, sooting the cavity heavily. It seems the heavy, irregular-appearing deposit would interfere with the mold filling, but it then fills most smoothly and reliably.

Wooden or paper matches possibly may be better for smoking than a candle, which might leave a greasy soot.

How this functions is another matter. It does appear that the soot slows the transfer of heat from the molten alloy, preventing a sudden and thus irregular freezing of the thin layer first touching the mold walls. But the important thing is that it works.—E.H.H.

Bullet Patch Paper

Is the Crane 100% rag paper described in The American Rifleman *("Paper Patching Comes of Age," March, 1977, pp. 28-32) still the best for bullet patching? Can it be made readily available? Perhaps also something could be learned from the paper used with the old-time patched bullets.*

Answer: *The American Rifleman* staff has found that Crane paper is still the best for patching bullets in full-power smokeless calibers. It has to meet the requirements of such ammunition, which are quite unlike those of the blackpowder ammunition and barrels in which the old patched bullets were fired.

The search did result in considerable new information, generously provided by Edward Lazarus of New York. We are indebted to him for this authoritative information.

When the first description of this modern paper-patched bullet development appeared (*The American Rifleman,* March, 1972, pp. 18-22) Lazarus through his extensive connection with the paper industry was kind enough to send me a number of paper samples for consideration as bullet patch paper. The Crane paper mentioned proved to be best among those tried.

The thought of having the old patch paper again manufactured occurred to Lazarus, and it actually can be done. But under present conditions, Crane & Co. have set a mininum of 5000 lbs. of that paper for a production run, at $250 per 100 lbs. This unfortunately would rule it out for any ordinary requirement.

Crane discovered some of the old patch paper manufactured before 1870 in their mill. Lazarus sent me a sheet of this, together with a sheet of regular Crane's Bond also manufactured before 1870. It was an understandable pleasure to examine items of such interest, still in perfect condition.

In the way of practical help to handloaders, Lazarus has provided the following.

"In Crane's Bond the watermark always reads right with the grain direction and in wrapping a bullet the watermark should go around the circumference of the bullet. In other types of paper, the grain is indicated on the wrapper. However, generally the watermark reads right across the grain. —E.H.H.

Bullet Casting Safely

Spring City, Tenn.

Editor:

Recently, while casting lead bullets, I had a dangerous experience that I would like to tell my fellow NRA members about. After casting several bullets, the metal handles of my mold became too hot to hold, so I stopped casting and ran water over the handles to cool them off. I then resumed casting. The first bullet cast in the cooled mold brought very unexpected results. At the instant the molten lead entered the mold, hot lead flew everywhere. It was as if an explosion had occured.

Recovering from the initial shock, I found lead splattered all over the casting area and small droplets on my clothing and skin. It was only by the grace of God that none hit my eyes. Studying the situation, I determined that when cooling off the handles I had allowed water to get into the mold cavities. This caused steam to form which blew the lead back out into the ladle, splattering it all over the place.

From this experience I learned the following:

1. Use molds with heat-resistant handles so water cooling will not be needed. If a mold has metallic handles, either let them air cool or make wooden sleeves to fit over them so that they may be comfortably handled during the casting operation.

2. *Always* wear eye protection. Safety goggles as worn in chemistry labs are excellent for this purpose as they are sturdy, well-ventilated, fit over prescription eye-glasses, and have a good field of view.

3. Always wear heavy-duty clothing and shoes.

Molten lead splatters easily and with potentially tragic effect. So take care.

FRANK M. BAILEY

Bullet Base Edges

Please tell me how I can cast bullets with clean, unfinned bases. I am following the directions of the bullet mold manufacturer. But fins persistently appear around the bases. Lead also collects under the cut-off plate, requiring that it be cleaned off.

Answer: These troubles are prevented by making the cut-off plate lie flat, by not allowing the mold to become too hot, and by smoking the mold cavity heavily.

It is useless to try to make the plate lie flat by tightening its hinge screw down, whether the screw has a lock washer or not. With most molds, tightening the screw tilts the plate up slightly. You can see the wedge-shaped gap by holding mold and plate up to the light. Bullet metal runs into this gap, making a fin, and the tilted plate forms the bullet base correspondingly out of square with the bullet body.

Instead, loosen the screw until the plate swings of its own weight when the mold is turned on its side. The casting dipper then can press the plate down flat. Keep the dipper thus connected long enough to fill the mold completely. Then give the remaining puddle of lead time to solidify, so as not to drag molten metal across the mold top which is what causes lead deposits there.

Keep the mold considerably cooler than the molten lead. Of course the melt should be kept at the lowest temperature which produces acceptable bullets. But fins can also result from lowering the pot temperature while allowing the mold to become as hot as it will. In that condition the bullet bases will be undesirably sharp-edged at best. This is prevented by pressing the cut-off plate against a wet sponge for each bullet or so, as found necessary, and by smoking the mold cavity as heavily as practicable. The mold then fills as well or better, while bullet bases will be smooth and with edges very slightly and evenly rounded, the desirable condition.

Cooling the cut-off plate in this way requires a compensating slight increase in the pot temperature, but not enough to bring on undesirable drossing.—E.H.H.

Micro-Groove Leading

I own a Marlin Model 1894 .44 Magnum rifle which shoots very accurately with jacketed bullets, but it doesn't shoot well with cast bullets, unless I use very light loads. I would like to use cast bullets in a large caliber rifle for deer hunting, but full-power cast bullet loads lead the Micro-Groove rifling heavily. Would the Marlin Model 1895 rifle in .45-70 give better results for hunting with cast bullets?

Answer: Your experience with cast bullet loads in your Marlin .44 Magnum carbine is not unusual. The Micro-Groove rifling, although capable of very good accuracy with jacketed bullets, does not give good performance with cast bullets except with light loads, not over about 1000 f.p.s. I believe you should be able to develop satisfactory cast bullet loads for the .45-70 Model 1895. The sample Model 1895 rifle evaluated by the NRA (see *The American Rifleman*, Oct., 1972, p. 40) had 8-groove conventional rifling. Marlin Model 1895 rifles of current production are advertised as having 12-groove modified Micro-Groove rifling which gives good performance with both cast and jacketed bullets. The sample Model 1895 rifle evaluated by the NRA produced average five-shot groups at 100 yds. from a sandbag rest of less than 3″, using standard factory loads with the 405-gr. soft-point bullet. This is excellent accuracy for a large-caliber sporting rifle shooting factory cartridges.

—W.C.D., Jr.

Watch Ladle Moisture

Concord, Calif.

Editor:

Even though I have been reloading both jacketed and cast rifle and pistol bullets since 1949 without incident, I recently experienced a serious molten lead explosion. An estimated 4-6 oz. of lead was blown over two-thirds of my 5-ft. long loading bench and some equipment. The explosion was not a case of "familiarity breeds contempt" but rather of an "unknown" being introduced.

I have always exercised extreme care with molten metal to preclude the possibility of a live primer being introduced. Equal caution has been exercised to prevent the possibility of water from any source, including perspiration or a sneeze, entering the pot.

Although I lacked previous experience or observation of lead pot explosions, I felt the cause of this eruption was moisture. But the source was a mystery, until the actual preparation of this particular "melt" was mentally reconstructed.

It was clear the explosion occurred immediately upon insertion of the ladle into the molten metal. Fortunately, the open side of the inverted ladle and pour spout were facing away from me. The ladle deflected the eruption onto the bench and equipment rather than against my body. Even though I always wear heavy clothing, heavy leather gloves, ankle-height shoes and glasses when casting, the volume and violence of the lead ejected would have caused serious burns over at least the front upper half of my body, had it sprayed toward me. It could possibly have ended a lifetime hobby.

Now for the culprit; it was about 30° F. in my garage loading area. The ladle was also at that temperature. For the first time in my many casting sessions, I had failed to lay the ladle on top of the lead during heating. Upon realizing this, when I was ready to start casting, I merely passed the ladle very briefly over a propane torch flame and the cold cast-iron ladle became wet with condensation.

To check this supposition I later cooled the ladle to the same temperature and repeated my careless preheating. Sure enough, results confirmed the reasoning; the ladle was wet with condensatation, particularly within the dip cavity.

CARL H. OEDER

Casting dipper must be preheated before use to evaporate condensed moisture which reacts violently with molten lead.

Paper Patched Bullets Work in .300 Magnum

Test results prove cast bullets can approach 3000 f.p.s. with fine accuracy.

By E. H. HARRISON

AFTER the use of paper-patched cast bullets in .308 Win. and .30-'06 full power loads had been developed ("Paper Patched Bullets Come of Age," by this author, *The American Rifleman*, March, 1977, pp. 28–32), it appeared there was nothing to prevent their similar employment in magnum rifles. This was tried, and when experimentation had established details of the load, it was confirmed.

The .300 Win. Mag. was convenient because a new rifle of that caliber had just been tested ("Steyr-Mannlicher Mod. S," *The American Rifleman*, April, 1977, pp. 42–43). As there reported, the rifle delivered the following average group sizes for five consecutive five-shot groups with each of the following factory ammunitions:

.300 Win. Mag. Cartridge	Vel. at 15 ft. (average)	100-yd. group (average)
150-gr. W-W Power Point	3245 f.p.s.	1.85"
180-gr. Peters Core Lokt	3018 f.p.s.	1.22"
180-gr. W-W Power Point	2979 f.p.s.	2.55"
220-gr. W-W Silvertip	2602 f.p.s.	1.82"
Group average overall 1.86"		

It remained therefore to make up corresponding paper-patched bullet loads and test them in the same rifle for comparison.

The 1976 Winchester-Western loading information for the .300 Win. Mag. prescribes 76.0 grs. of W-W 785 Ball powder for the 150-gr. Power Point and Silvertip bullets, giving them 3150 f.p.s. muzzle velocity at 51,000 c.u.p. For the 168-gr. hollow-point bullet, 72.0 grs. of the same powder gives 2960 f.p.s. at the same pressure. One of the two NRA-developed paper-patched bullets, Lyman No. 301618, weighs 160 grs. when cast of suitable hardness for such loads.

160-gr. No. 301618 paper-patched cast bullet.

Conditions at the time of this test prevented establishing a charge for it to laboratory-measured velocity and pressure, as normally would be done. However, from the above information one might expect 74.0 grs. of this powder to give the 160-gr. patched bullet about 3055 f.p.s. muzzle velocity, at a pressure somewhat lower than with jacketed bullets, in accord with past experience. The 74.0-gr. load proved to give this bullet 3025 f.p.s. in the Steyr rifle, measured at 15 ft., corresponding to about 3040 f.p.s. at muzzle—almost exactly as expected. The 74.0-gr. load therefore was taken as standard. Slightly reduced loads of 70.0 and 72.0 grs. also were tried as refinements.

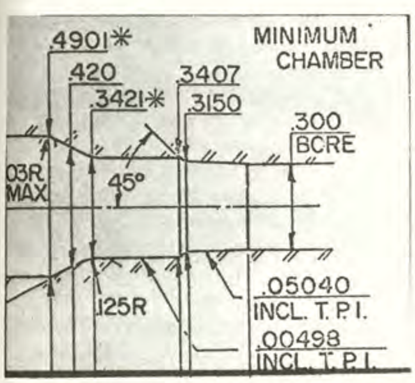
Besides obviously large powder capacity, some magnum rifle cartridges have special features which affect paper-patched bullet use.

One is the short case neck. This tends to weaken the heavy bullet pull which has been found desirable with paper-patched bullets. Therefore, these .300 Win. Mag. cases were left with their case necks unexpanded after sizing, to provide the tightest possible assembly. The case mouths were belled with a .314" plug deeply enough for the bullets to seat very smoothly. This was entirely successful. Extracting and examining seated bullets showed them to be undamaged.

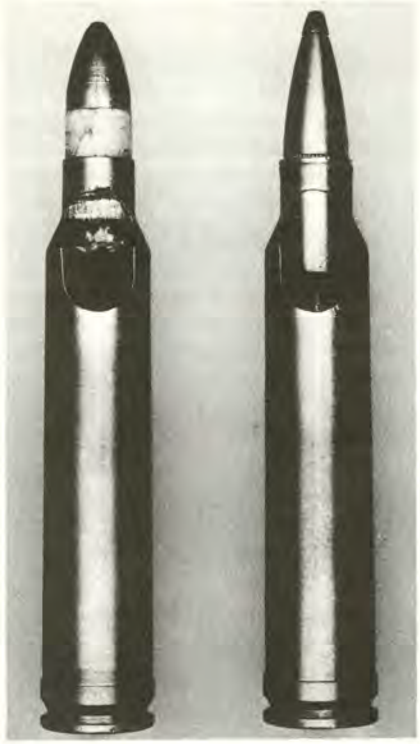
A second peculiarity, happily beneficial in this case, is the forcing cone of the .300 Win. Mag. chamber. The fundamental article of March, 1977, on paper-patched bullets points out that present standard .308 Win. and .30-'06 forcing cones, whether of stepped or simple conical form, are of about .310" diameter at rear, and in custom barrels often as small as .309". This requires sizing the patched bullet that small or smaller, which is rather inconvenient. In contrast, minimum diameter of the .300 Win. Mag. forcing cone is .3150" at that point. It could take patched bullets unsized. However, accurate shooting requires sizing over Alox bullet lubricant after the applied patch has been sprayed with Teflon, as detailed in the March, 1977, article. Sizing in a .3105" Saeco die worked well.

The first load to be made up spread more than 6" in a 10-shot group at 100 yds. Clearly something was very wrong, and it was found to be inadequate fit of the seated bullet in the barrel forcing cone. Since the rifle was not then at hand, the bullets had been patched and seated in cases deeply enough to insure chambering, which left them with 1/8" jump before reaching the rifling. Paper-patched bullets cannot tolerate that. The best fit was obtained by seating the bullet so as to place its bare ogive against the barrel rifling, and patching the bullet over its first groove, thus simultaneously fitting the patch into the forcing cone. Similar fitting also was successful with the .308 Win. and .30-'06. The need for this fit does constitute a distinct limiting factor in paper-patched bullet loading.

Lubricating the bullet involved the only basic change found necessary from the loading procedure which had been established in .308 and .30-'06. In that procedure, after the applied patch was sprayed with Teflon and the patched bullet then sized over Alox bullet lubricant, all surplus lubricant was wiped off the bullet. But thus wiping off the lubricant in these .300 Win. Mag. loads opened the 100-yd. groups to nearly 5" with the 70.0-gr. powder charge. Groups of 5" and then wild shooting occurred with the 74.0-gr. full load. Leaving the lubricant on the bullet as it comes from the sizer, including the band of lubricant deposited over the recessed gas-check shank, corrected this. It was also useful to make the Teflon spray as heavy as practicable. Evidently the severe conditions in the magnum make more lubrication necessary. Probably for the same reason, the bullets had to be of harder alloy than for the .308 and .30-'06.



Minimum dimensions at front of .300 Win. Mag. chamber. Note .3150" diameter at forcing cone.



160-gr. paper-patched bullet (l.) and 180-gr. factory .300 Win. Magnum load. Case necks are cut away to show bullet bases.

Testing was done in the Steyr rifle referred to above, and by the same firer who tested the rifle originally—R.N. Sears of the *American Rifleman* staff. Thirteen loads, differing in details which have been mentioned, were tested between February 19 and July 7, 1977. All were loaded by this author. The last three embodied the final results, as follows:

Five consecutive five-shot groups at 100 yds., with 70.0-gr. W-W 785 Ball powder and bullets of 19 Brinell hardness, measured 1.50", 1.19", 2.20", 1.27", and 1.21". These had to be shot in a crosswind gusting to 25 m.p.h., unavoidably opening some of the groups laterally. But still they averaged 1.47", materially smaller than the 1.86" average of the factory ammunition, so this was considered very good. However, 70.0 grs. is slightly reduced from the 74.0 gr. full-power load.

Five groups with the full 74.0 grs., with bullets from the same lot, measured 2.63", 2.43", 3.69", 1.17", and 3.09", averaging 2.60"—considerably larger than the factory ammunition. Four groups of the five contained one bad flier each (these were included in the group sizes given here), lending an appearance of inadequately strong bullet metal.

Accordingly the full-load test was repeated with bullets cast of new linotype metal. It turned out to be of only 19½ Brinell hardness, thus very little harder than the 19 Brinell of the preceding test. The first group was centered at the target edge, three shots forming a .51" group but losing two off the paper. After sight adjustments, the remaining four groups measured 1.84", 1.60", 2.21", and 3.14", to average 2.20". (A single flier in the last group increased this four-group average from 1.75" without the flier.) Thus the very slightly harder bullet alloy was not quite enough for correction.

The development was ended at that point. Regrettably, it was impracticable to test the 200-gr. No. 301620 bullet, which has always shot better than the 160-gr.

It is of some interest to consider whether these results indicate that the paper-patched bullets have here reached their practical limit in power. Possibly they have. One of the intermediate tests was with 76.0 grs. of W-W 785 powder and the 160-gr. patched bullet. This was an obvious overload, giving hard extraction and slight longitudinal stretch marks on cases, and it is not recommended. But five consecutive five-shot groups with it averaged 2.94", only moderately larger than groups from the 74.0-gr. full-load. With jacketed bullets also it is no new thing for overloads to deliver poor grouping, nor for somewhat reduced charges to yield smaller groups.

The results of paper-patched bullets at 3000 f.p.s., remarkable as they are, obviously could be refined with experience. It seems that in the .300 Win. Mag. the pressure limit of the cartridge limits the attainable power with paper-patched bullets, as it does with jacketed bullets.

What are we to think of these results? Perhaps magnum rifle enthusiasts are an unlikely group to take up loading of this kind, though, of course, it is available to everyone. Nor were these magnum paper-patched bullet loads developed with game shooting in mind; their action on game is not even known, though almost certainly it would be violent. They do make it clear that the full-power loads with paper-patched bullets in .308 Win. and .30-'06 are well under the inherent power capability of these bullets. Improvement in their accuracy at the 3000 f.p.s. level could doubtless be made with further experimentation in other cartridges and rifles. ■

Lyman No. 2 Alloy

In reading articles on cast bullets, I find frequent references to Lyman No. 2 bullet alloy. What is this alloy's composition and its approximate Brinell Hardness Number? Handbooks vary as to its composition, some calling it 90% lead, 5% tin, 5% antimony; while Lyman's current Cast Bullet Handbook *lists it as 10 parts lead to one part tin to one part antimony. Which is correct?*

Answer: The discrepancies you noted in describing Lyman No. 2 alloy apparently result from different descriptions of No. 2 alloy in different Lyman Handbooks.

The *Lyman/Ideal Handbook Number 38*, published in 1951, and all earlier editions I have seen, describe No. 2 alloy as being 90-5-5 (lead-antimony-tin), as do the *44th Edition* (1967) and the current *45th Edition* (1970). Lyman/Ideal No. 2 alloy always has been so described in *The American Rifleman.*

However, the *Lyman/Ideal Handbook No. 40* (1955), their *Handbook of Cast Bullets* (1958), and their current *Cast Bullet Handbook* (1973) describe the composition of their No. 2 alloy as 10-1-1 (lead-antimony-tin).

The two compositions are not equivalent. A 90-5-5 alloy is 90% lead, 5% antimony and 5% tin. A 10-1-1 alloy is 83.33% lead, 8.33% antimony and 8.33% tin.

The 90-5-5 alloy is only moderately hard, producing a BHN of about 15. The 10-1-1 alloy, however, has a BHN of about 22, practically the same as linotype metal, which would be preferable to 90-5-5 alloy when used for high-velocity cast bullet loads.—W.C.D., JR.

Sizing Lubricant Pressure

I am annoyed by grease deposits on the bases of my cast bullets. I use a Lyman 450 lubricator-sizer and NRA formula Alox/beeswax lube. Usually I must wipe the bullet bases clean before loading them. Is anything wrong with my equipment or technique?

Answer: I suspect your problem is caused by putting too much pressure on the lubricant reservoir.

Before pushing a bullet into the sizing die, turn the lubricant pressure up just enough to feel resistance on the ratchet handle, if using a Lyman 450 or RCBS lubricator. Place a bullet into the die and force it down. Hold pressure on it with the ram for an instant at the bottom of the stroke. While holding the bullet down, turn the ratchet slightly to increase pressure on the lubricant reservoir, then quickly raise the ram, pushing the bullet out before grease can flow under the bullet base.

Grease pressure required will depend on the size and number of lube grooves. Bullets using large quantities of grease may require a quarter turn or more on the ratchet with every bullet. The same pressure may be enough to grease three or four bullets of smaller caliber, or when filling only one or a few grease grooves.

Clean bases are obtained most easily when minimum lubricant pressure is used, but this may require that the bullet be pushed into the die twice to evenly fill the grease grooves. With good quality lubricant, however, it isn't always necessary to completely fill the grooves for best results. In mid-range target loads for cartridges like the .38 Special or .45 ACP, accuracy is sometimes improved by incompletely filling or filling only the bottom grease groove of bullets such as

the H&G No. 50, Lyman 358495, Lyman 452460 or Saeco 290451 when using Alox/beeswax lubricant.

Using either of the above techniques, bullet bases should be almost completely clean and not require wiping. If you continue to get grease on the bullet bases, clean the inside of the base punch of all grease and foreign matter, so as to get a good fit against the base of the bullet. As grease pressure diminishes with succeeding bullets, some grease grooves will come out unfilled. As that occurs, again push the bullet into the die and gradually increase the pressure until you feel the slightest resistance. Withdraw and examine the bullet, then carry on as necessary—E.L.

More on Cast Bullets

Burnt Lake, B.C.

Editor:

I read with great interest the two articles regarding cast bullets on game (*The American Rifleman*, March, 1977, p. 29, and Sept., 1977, p. 52), but they left out an important reason that justifies this practice. I have used cast bullets in my rifles for years, to permit more shooting for my money, and I use them for shooting camp meat such as grouse or marmots.

Pointed cast bullets may not be as accurate at low velocities as blunt ones, but they destroy less meat on small game. For best results, I keep velocity down to about 1400 f.p.s. for small game loads in my cal. .30 rifles. Heavier loads used on grouse result in an explosion of feathers, with nothing left to eat.

Cast gas-checked cal. .30 bullets of conventional form (not paper-patched) driven at their maximum practical velocity (about 2000-2200 f.p.s) give power equal to .30-30 factory loads, which is adequate for deer and some larger game, if the bullet is placed right.

Hollow-pointed cast bullets made of hard alloy do not expand, but the front portion weakened by the hollow-pointing stem shatters. I discovered this after using the Lyman #311284 hollow-pointed bullet and 30 grs. of IMR-3031 powder in my .303 SMLE rifle with 22" barrel. The bullet was placed well and killed the deer, but it blew up on striking, leaving only the base intact. The #311407 180-gr. solid, flat-point bullet cast only moderately hard, driven about 2100 f.p.s. performs well on most Canadian game up to moose if the range is short, not over 100 yds. Most old time bush rovers admit power in excess of the .30-30 is not needed, and I agree. Of course, the bullet must be placed correctly, but that goes for any rifle.

The big advantage of cast bullets in rifles is that it lets you get practice in the field, on small game, shooting offhand, under actual hunting conditions. That beats shooting from a bench-rest at paper every time. By using cast bullets and light loads on small game you become a better woodsman and hunter when the big game season opens. When guiding I have known hunters who would attempt shots at ridiculous ranges, out where their rifle doesn't' strike the killing blow it does up close. That's asking too much of fate. Instead, learn to approach to reasonable range.

THOMAS RIDLER

Grooves In Patched Bullets

Has some consideration been given, in The American Rifleman's *development of paper patched bullets, to shape of the bullet grooves? Perhaps sloping the back of each groove might help to hold the patch in place without damage.*

Answer: Grooves of that form were used early in this development. Their performance generally was good, although there were a few unexpected failures.

As reported in the original announcement of this paper patched bullet development (*"Paper Patched Bullets Come Of Age,"* March, 1972, p. 18-28) the first trial bullets were obtained by lathe-turning conventional cast rifle bullets to the desired diameter, eventually .301", for patching. These were successful. Then a bullet mold of that diameter was obtained to order from Lyman. Its bullets, which were ungrooved and smooth like those of blackpowder patched bullets of the past, did not perform well in .30-'06 and .308 rifles. It became clear that the success with turned-down conventional cast bullets was due to remains of the lubricant grooves left on them after turning. When small grooves were turned on the smooth bullets, they then generally shot well. From just the consideration you mention, these grooves were cut with back faces sloped at 30° to the bullet length. The point, however, did not appear decisive, and when a new design was made and molds obtained, it was with grooving of simple form (illustration p. 28 of March, 1977, article). These bullets have been highly successful.

At one time it did seem that sloping grooves might be very useful, when rings of hard paper were found to be cut off patches occasionally in firing, producing off shots. This did not always happen, but it continued despite machining the rear face of existing grooves to a 30° slope, and trying a variety of extreme lubricants. It was caused by the barrel forcing cone, about .310" diameter at its rear edge in most .308 and .30-'06 barrels. This hardly can admit undamaged the paper patches of .313" outside diameter as applied and shrunk on .301" bullets, or even larger on larger bullets. This was the necessary though not the only reason for sizing the patched bullets, which then was adopted as standard procedure. The other reason was that best grouping required spraying the applied patch with Teflon, then sizing the patched bullet with Alox lubricant.

But a sloped groove really might be a desirable refinement, and it should be tried. It has happened repeatedly in *The American Rifleman's* cast bullet developments that experimental features have not worked out as expected. So a changed groove should not be announced until after a genuinely thorough test.—E.H.H.

Reamed Case Mouths

Belling case mouths to avoid damaging cast bullets adds an operation to the loading procedure and reduces case life. Is there a way around these disadvantages?

Answer: One alternative is to ream the case mouths so bullets may be started by hand.

This may be done with inside neck reamers such as the Forster or Wilson. The reamer is first used on fired cases as they come from the chamber to insure clearance between the bullet and the neck. The case is then sized and the reamer run into the case mouth for a distance of about one-fourth of the bullet's diameter. This second use of the reamer allows the bullet to be started in the case by hand. It is then seated to the desired depth in a die.

The neck reaming operation needs to be done only once. After that, fired cases require outside sizing only. Eliminating belling of the mouth and expanding the neck over a plug both increase case life.

Reaming sized .45-70 case mouth to .460" diameter to a depth of about .11" allows hand starting of .459" diameter cast bullet.

Reamers may be special ordered for any diameter. Standard ones generally work very well, however. A reamer intended to provide clearance for .308" jacketed bullets usually allows hand starting of cast bullets sized to .310".—R.N.S.

Age-Hardening Of Alloys

The cast bullet information in "Lead Alloys Age-Harden," (The American Rifleman, *August, 1977, p. 66) is certainly revealing. In that connection, an experimenter (the only one who has done anything on this that I know of, except for the above report) states that alloys containing only tin and lead do not age-harden, and some even soften in time. Is this correct?*

Answer: It is correct. The August, 1977, report you refer to should have added that age-hardening of bullets depends on the antimony content. Without that, the hardening does not take place.

Unlike the extensive technical literature on lead-tin antimony alloys there is very little (except as to solders) on alloys of only tin and lead. One investigation, however, established that such an alloy containing 5% tin showed no measurable hardness change during observation for four months, while the hardness of a similar alloy with 10% tin actually decreased slowly through most of that time.

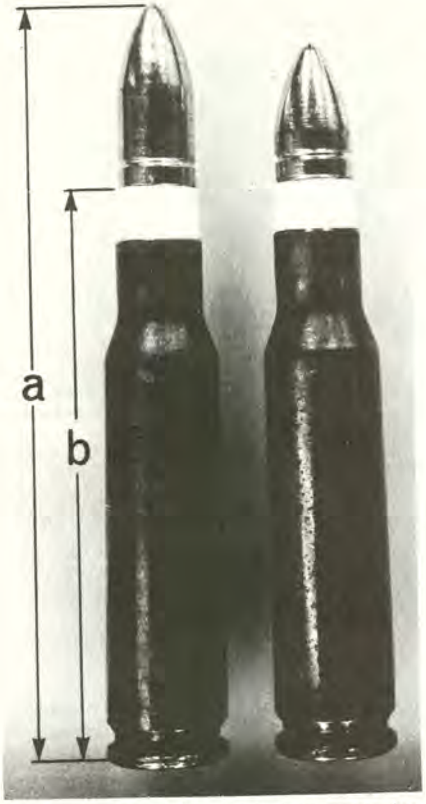
This brings out a further disadvantage of the costly, ineffective 1-10 tin-lead alloy that was recommended to handloaders for so long. On the other hand, users of the more reasonable low-tin mixtures are seldom concerned about exact hardness. They can assume that their bullets will remain practically unchanged after casting.—E.H.H.

Paper Patched Bullets

A remark in the article "Paper Patched Bullets Work In .300 Magnum" (American Rifleman, *Dec., 1977, p 44-45) points out that both patch and bullet ogive should fit into the barrel rifling before discharge. Please give the loading procedure to obtain these fits.*

Answer: A good fit at both points is necessary for best shooting with these paper patched bullets. To obtain it:

a. Forward fit. Drop an unpatched bullet into the chamber, and with a dowel or short rod press it very



Cartridge dimensions *to secure engraving by the rifling* **(a)** *and to place patch into forcing cone* **(b)**, *before discharge, as explained in text. Note rifling engraving ahead of patch.*

firmly into the barrel. Holding it there, pass a rod from the muzzle to the bullet nose, and carefully mark the rod at muzzle. This indicates the desired position of the bullet in the loaded cartridge.

The bullet should then show rifling engraving well back along its forward parallel, or at the very least on the ogive. If molds for bullets of slightly different diameters are available, or different diameters can be produced by sizing (Lyman has a .301" bullet sizing die), try these for the one that is best engraved. That is the one to use.

If worn rifling will not thus engrave the bullet, it will still provide some guidance, and the patch fit (see just below) is still effective.

b. Patch fit. To place the patch against the rifling, prepare several of the chosen bullets with the patch variously placed. On the standard bullets (Lyman Nos. 301618 and 301620), the patch may allowably cover three, four, or all five of the bullet bands, and its front edge may fall on or between bands, as required by the barrel.

As already explained ("Paper Patched Bullets Come of Age," *American Rifleman*, March, 1977, p. 28-32), most .308 and .30-'06 barrels have forcing cones of about .310" diameter, with some as small as .309". The patched bullet therefore must be reduced to let it enter such forcing cones without injury. After sizing and lubricating the patched bullets *in a .308" die* (see explanation below), try the experimentally patched bullets by pushing them into the barrel as done in **a.** The correctly patched and sized bullet will go all the way to the position found in **a,** while requiring some additional force to bottom the patch in the forcing cone.

Thereafter, regularly patch and assemble bullets to provide this close fit at both points as described. Dummy cartridges made up in this way help to preserve the dimensions found.

Sizing the patched bullet. The March, 1977, article prescribed reducing the patched bullets in a .310" sizer-lubricator die for barrels having .310" forcing cones, and a .309" die for .309" cones. Continuing experience has shown that these reductions often fail to prevent some cutting of the patch on the cone edge. The best practice found so far (late 1977) is to put the bullets through *a .308" sizer-lubricator die* for .308 and .30-'06 barrels, to assure the patch entering the forcing cone without interference. That is done without trouble in a well-made die with Alox/beeswax bullet lubricant, after spraying the patch as prescribed with Teflon. This .308" die requirement specifically modifies the .310"-.309" die direction given in the March, 1977 article.—E.H.H.

Calcium In Lead Alloys

Bullet casters occasionally salvage lead from discarded automobile batteries. I understand that the new maintenance-free batteries contain calcium alloyed with the lead. Is anything known about the effect of calcium on bullet alloy?

Answer: The trend in making automobile batteries is to make thinner plates, reducing the weight and increasing the energy density of the cell. Since discarded batteries are likely to be heavily oxidized, only a small amount of lead can be salvaged. Because of the small yield, risk of chemical burns from sulphuric acid, and the labor involved, salvaging battery plates isn't very practical.

The addition of calcium to battery plates is another reason not to attempt salvaging the lead from them. While calcium alone strengthens lead, it is unsuitable for cast bullets, and its addition to bullet alloys actually reduces the antimony content by forming an intermetallic compound with antimony, which in turn causes heavy drossing. If this dross is skimmed off and discarded in the presence of moisture, it releases small quantities of a colorless, poisonous, flammable gas—stibine (SbH_3).

These changes in battery manufacture remove any reasonable justification for attempting to salvage battery lead for bullet metal.—C.E.H.

Ringed Chambers

Recently, several single-shot rifle shooters at our club have noticed rings in the forward portion of their rifle chambers which cause hard extraction. All rifles were fired with plain-based lead bullets at low velocity, in fixed ammunition in calibers such as the 8.15×46R mm and .32-40, with loads having a fiber filler inserted lightly over the powder charge. The rings are observed at the approximate location of the bullet bases. Does use of the filler entail a risk of chamber ringing?

Answer: Other reports of chamber rings when firing straight walled cases with low velocity cast bullet loads and a filler over the powder charge have been received. (See *American Rifleman*, Feb., 1978 p. 73). Several instances of this occurring in .458 Win. Mag. rifles with cast bullet loads are believed to have been caused by inserting a hard cardboard wad over the powder charge. A test furnished the *American Rifleman* by B. J. Obermeyer Brass Extrusion Labs, Inc. indicated that use of a cardboard wad over the powder charge in .470 N.E. when certain canister powders were used which left much airspace in the case, caused a significant and undesirable increase in pressure. *American Rifleman*, Sept., 1975, p. 93 reported chamber ringing in a .38 Special revolver in only 150 rounds when a .08" cardboard wad was seated over the powder charge.

I knew a group of Schuetzen shooters some years ago who claimed to have seen barrels ringed at the position of the bullet base of their breech-seated bullets when cork or fiber wads were seated on top of the powder charge. Seating the wads just inside the case mouth, against the bullet base in their separate loaded ammunition eliminated the problem.

I have a Winchester Hi-Wall .38-55 with No. 4 barrel that has been fired many thousands of rounds with the Lyman #375272 Hudson bullet, breech-seated ahead of the chamber, charged with 18.0 grs. of SR-4759 or 32.0 grs. of IMR-4320 and a blotting paper wad pressed onto the powder, which shows no evidence of ringing in the barrel or chamber. I have also seen many rifles chambered for bottleneck cartridges such as the .30-'06 that were fired extensively with cast bullet reduced loads using fiber fillers which show no signs of ringing. The "Speer Reloading Manual No. 9" states a fiber filler was used over the powder charge for all reduced loads for jacketed bullets therein, and no problem seems to have arisen from use of these loads.

The evidence is not clear. It appears that ringed chambers caused by wads or fiber fillers pressed down on the powder charges have occurred in some instances, but not in others. The weight of the wad is apparently of some significance, as is the fact of whether it is loaded so as to touch the base of the bullet, or is pushed down so airspace exists between the wad and base of the bullet. Handloaders should be aware that while there is evidence that tufts of Dacron or kapok over the powder charge often improve the uniformity and accuracy of many reduced loads with cast or jacketed bullets, some risk of ringing exists. They must balance this in their own judgement against the benefits derived from such wads or fillers in reduced loads.—W.C.D., Jr.

Antimony For Bullet Metal

Tin has become so extremely expensive that even some long-time users of it may find they have to reconsider. (A little tin remains necessary for good casting quality.) Antimony is the only practicable alternative. Also, antimony is necessary in many cast bullets where tin alone does not give adequate hardness and strength. I bought some antimony, but it merely floated on the lead in my electric furnace. What it the secret in using it?

Answer: The difficulty with antimony is its melting point of 1167°F., which is a low red heat and above the operating range of the usual handloader's electric melting pot. Antimony can be alloyed with lead at a lower temperature, very slowly, but handloaders may find that impractical. On the other hand, antimony once alloyed with lead melts without difficulty and can be used in bullet metal as desired. Accordingly, the best way to procure it is when already alloyed half-and-half with lead. The user then buys and pays transportation on new lead in only the same small amount as antimony, obtaining all the rest of his metal locally. Unfortunately, antimony alloyed in this simple way has not become widely available.

This antimony supply can be prepared in any melting pot which can be raised to the required heat. The essentials are only an iron pot over a coal or charcoal fire, and a gentle blower.

For occasional use, a hollow cinder block, bound with wire or a steel band to prevent eventual splitting, works well. A square of hardware cloth (coarse wire screen) placed underneath and covered with a layer of small stones, supports the fire. A small fan provides the draft and is adjusted by moving it forward or back. Charcoal briquets make a hot fire.

Installation must be outdoors, to avoid danger of fire and especially of carbon monoxide poisoning. There will also be some vaporizing of metals at the temperature involved, but carbon monoxide from the fire is a controlling consideration in any case.

Put equal weights of lead and antimony into the pot, and cover with a thin layer of powdered charcoal to prevent oxidation. When the metal can barely be seen to be a dull red when screened from the sky (wear eye protection!), it is hot enough. To insure homogeneity, stir it with the end of an iron rod which has been dried in the fire. Take the pot from the fire and allow it to cool somewhat, then skim and pour the metal into molds. Handloader's ingot molds which make 1-lb. ingots are convenient. Similar full ingots of 50-50 lead-antimony will weigh about .8 lb., containing .4 lb. antimony and .4 lb. lead.—E.H.H.

Forcing Cone Polish

It has been pointed out by the American Rifleman *that both patched and conventional bare cast bullets may be cut by the edge of the forcing cone in .308 and .30-'06 barrels. To prevent this requires making the bullet definitely smaller than the cone opening. Would it be desirable to eliminate this trouble by enlarging the cone?*

Answer: There is no doubt that forcing cones as small as .309" are too small for either patched or conventional cast bullets. For both these types, enlarging the cone to at least the standard .310" would be advantageous. Cones of only .309" opening normally are found only in custom barrels, and users of custom barrels tend to have them made or altered as required.

The great majority of riflemen, however, use factory barrels as manufactured. Fortunately for cast bullet shooters, the factory barrels can shoot correctly made cast bullets of both kinds very well.

But most barrels can be improved for this use by polishing the forcing cone and smoothing its edge. Any qualified gunsmith can do it. Conventional cast bullets larger than the usual .310" cone opening, for example bullets of the traditional .311" diameter, necessarily are sized by the cone edge on discharge. (It is remarkable that this remained unmentioned in the cast bullet information and misinformation published through so many decades.) Smoothing the cone eases this action.

Paper patched bullets have shot most reliably when sized .308" over the lubricated patch, and then loaded so as to enter positively in the forcing cone before discharge ("Fitting Paper Patched Bullets," March 1978, p.68). But even then there are indications that the cone should be smooth.—E.H.H.

Patching Bullets

I have obtained a mold for casting paper patched bullets, but am having trouble patching the bullets. Would something be helpful which could hold the patch in place until it can be wrapped? A practical method must be available if these patched bullets are to be used generally.

Answer: Your comment is quite correct. Several artifices tried here for sticking the patch down during application have not succeeded or have produced poor bullets. Instead, some details in the standard patching operation have been improved, making it much easier.

To note these, review the patching operation. Provide a semi-soft base on which to work, most suitably a bit of thick sheet rubber. Wet the patch with saliva on both sides. Lay it down pointing away from you, with the near corner turned up. Lay the bullet in place, press the upturned corner onto it, and pull the patch tight. While pressing down hard, roll the bullet away from you. When the patch is all rolled on, pinch the paper tail into as fine a stem as possible and then twist it in the direction of rolling. After it has dried hard (drying can be speeded with gentle heat, if desired), clip the tail off short.

The only serious difficulty is that the applied patch may be loose and thus useless. This will be because the corner did not stay down until the bullet could be rolled over it. These improvements help greatly to prevent this. They are:

- Wet the corner thoroughly; it is

limpness which allows it to stay down. The rest of the patch can be only damp, allowing the tail to be twisted snugly without wringing off.

- After the first half-turn of the bullet, roll it back far enough to make sure the corner is under your fingertip again; then roll it forward to completion. This, done routinely, eliminates failure and in fact makes the patch so tight it cannot be turned on the bullet even while still wet.
- After this half-turn reversal, complete the application while pressing down at point and base of the bullet. This leaves the patch leading edge exposed to view; the direction of rolling then can be corrected during the operation, making it error-free and fast.
- About 1/16" can be cut off that near corner, making it stick down most easily. This expedient should not be needed very long.

Patching these bullets does require some skill and practice. But with the above details, which were developed in long experimentation here, it is simple and straightforward.—E.H.H.

Paper Patches In Light Loads

Except for a single .308 load at 2000 f.p.s., all current information in the American Rifleman *on the new paper patched bullets has been for loads of full power ("Paper Patched Bullets Come Of Age", March, 1977, for .308 and .30-'06; and "Paper Patched Bullets Work In .300 Magnum", December, 1977, for .300 Winchester Magnum). Why is this? Are these bullets unsuitable for light loads?*

Answer: The NRA development of paper patched bullets began in light and medium loads. But unlike conventional bare cast bullets, they did not seem to require such loading to shoot well. This was most interesting, since the conventional cast bullets can shoot very well when made and loaded in accordance with their requirements, which now have been made known; but they cannot approach full power in modern cartridges. So the paper patched bullet development in its eventual form was devoted to loads of full factory power, with the published results which you note.

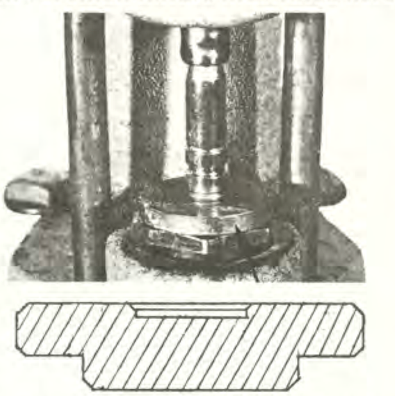
There appears to be no reason these patched bullets could not succeed in light loads as well, when made and patched as detailed in the two articles you refer to. For light loads they have to be cast of softer alloy to expand properly into the rifling on discharge. That is an advantage, requiring less expensive lead alloys than conventional cast bullets in corresponding loads. The patch also provides the bullet with immunity to gascutting and the accompanying slight bore leading to which conventional bare cast bullets remain subject in some degree even in best loading. I have not yet worked out in detail the requirements for light loading of patched bullets, as was done for full power loading and explained in the two articles you refer to; but preliminary tests in late 1977 indicate that patched bullets can perform in light and medium loads.

Still, the conventional cast bullets now are doing well, and in some cases extremely well, in their own lower power range. So present reasons for trying paper patched bullets in that range appear to be only the handloader's curiosity, and certain advantages of the patched bullets mentioned above. —E.H.H.

Gas Check Seater

Only the Saeco lubricator-sizer seats gas checks as a separate operation before sizing and lubricating bullets. Can you suggest some simple way this can be done using the more common lubricator-sizer tools?

Answer: One way is to make the kind of small fixture illustrated here.



Easily made fixture (arrow—section view below) allows separate seating of gas checks with an ordinary lubricator-sizer.

It fits inside the sizing die nut of ordinary tools such as the Lyman and RCBS. Gas checks are set into the recess at the top of the fixture and are seated squarely onto the bullet bases by downward pressure of the top punch on the bullet noses. The fixture is then removed and the bullets sized and lubricated in the usual manner.

When gas checks are seated as part of the lubricating-sizing operation, inward pressure of the sizing die can crimp the gas check onto the bullet shank before the gas check is seated firmly and squarely against the bullet base. This is particularly true if the shank is tapered, and most are. Eliminating resulting irregularities is the principal advantage of seating gas checks as a separate operation.

The gas check seating fixture is easily turned on a lathe from 1" dia. bar stock. The recess at the top is made about .035" deep and about .005" larger in diameter than the gas check. The bottom is turned down to about ⅝" diameter to fit inside the nut which holds the sizing die. No change in the normal tool setup is required to use this fixture.—R.N.S.

Contaminated Lead Supply

I have found it impossible to cast good bullets from a quantity of lead I recently obtained. The American Rifleman *has stated that lead may be contaminated by zinc or aluminum. What can be done to correct this, or prevent it if possible?*

Answer: Small amounts of zinc or aluminum do destroy the casting quality of lead.

Consultation with a highly qualified source brought out that there is no simple, ready means for detecting the presence of zinc or aluminum in lead. The reloader, therefore, may find it wise to test the casting quality of lead or lead scrap before he adds expensive tin and antimony to it, or mixes it with good metal. Even supposedly good pig lead has at times been found to be seriously contaminated. Zinc and aluminum diecastings now appear almost everywhere, and it would take very little of either of these to spoil a whole batch of lead.

If a practical casting test shows bad casting quality, the user should reject the metal if possible. If it must be used, the following can be a guide in making the best of the situation.

Some years ago the *American Rifleman* found that a purchase of pig lead drossed almost endlessly when melted. No other lead being at hand, attempts to use it continued, and after many fluxings and skimmings the metal did become usable though never really good. For information, the "phase diagram" of aluminum with lead shows that these two metals alloy at all temperatures above 1218°F.; but below that and all the way down to 621°F. (the melting point of lead), there is little or no alloying, and the two metals are in only a mechanical mixture. Aluminum being so much the lighter (.097 lb./cu. in., lead .41 lb./cu. in.), it might be expected to rise to the top of the melt, and that is what happened in this case. Accordingly, if extreme drossing is experienced, the metal should be given time to settle. Fluxing minimizes the loss of sound metal in the dross, but the stirring required in fluxing prevents the desired separation. It appears best to let the melt stand quietly an hour or more, until it eventually remains clear after skimming.

Defect caused by severe zinc contamination. Less contamination may show only frosting on bullet bands and grooves.

Zinc contamination presents a much more difficult problem. The lead-zinc phase diagram shows the two metals alloying at all temperatures above the melting point of lead. The expert advice mentioned above included some suggested means for separating them, but not a simple, readily applied procedure which would be practicable in connection with bullet casting.

The illustration shows typical casting defects in what apparently is a zinc-contaminated alloy. The "frosted" spots are depressed below the surrounding normal areas because of the contaminated metal's high surface tension, which kept it from filling the mold completely. Not touching the mold, the sunken spots cooled abnormally slowly, and this caused their frosted appearance. The situation can be improved by raising the temperature of mold and metal considerably, but this is only partly effective and is undesirable in itself. Adding tin, which normally would improve casting quality, has little effect here.

Metal contaminated in this way is best thrown away. If it must be used, it can be added to a larger quantity of good metal, with great caution of course, and thus saved. Add a little at a time, and after each addition check by casting sample bullets to make sure that the result is not too degraded for the use intended. Despite care, it is likely that too much will be added, since it is hard to perceive just when the unsatisfactory condition is approached. So fill the melting pot only half full of good metal and make the additions to that; then when a little too much of the bad has been added, as revealed by a casting check, fill the pot the rest of the way with good metal which will restore the whole to usability. In such a case, I added some apparently zinc-contaminated lead, ½ lb. at a time, to half a pot of good metal, stopping after putting in 4 lbs. when the product became unsatisfactory. Then filling the 11-lb. pot the rest of the way with good metal produced 11 lbs. of alloy usable for an undemanding requirement.

All this is a great deal of trouble and annoyance, worth going through only if one is stuck with a quantity of lead contaminated in one of these two ways. In that case, it can be salvaged as described.—E.H.H.

Fit In Forcing Cone

The description of newly developed paper patched bullets for loading in modern rifles ("Paper Patched Bullets Come of Age," American Rifleman, *March, 1977, p. 28-32) explains that the patched bullets must be sized to a diameter suited to the barrel forcing cone. Now that this point has come up, might it apply to other bullets also?*

Answer: It applies to conventional cast bullets also. As the March, 1977, article points out, present .30-'06 and .308 Win. factory barrels have forcing cones of about .310" opening. The paper patched cast bullets measure larger than that and so are sized to a diameter which can enter the forcing cone undamaged.

While it appears never to have been pointed out clearly before, the same consideration must apply to conventional cast bullets when, as is usual, they are of .310" diameter or larger. The illustration shows the situation.

In the .308 load **a**, a bullet of .312" body diameter has been seated in a barrel which has a forcing cone opening of about .310" (though reamer chatter marks in the cone leave its exact diameter uncertain). The cone has a sharp edge, which, with the given dimensions, inevitably cuts into the bullet as the illustration shows. While this bullet was a little larger than the traditionally recommended .311", obviously no bullet larger than .310" could enter this forcing cone without being cut. Even a .310" bullet would be undamaged only if perfectly centered by being pushed into place before discharge. Otherwise, nothing above .309" has any reasonable chance of getting through unharmed.

The .30-'06 load, **b**, exhibits a more favorable condition. A bullet of .3105" body diameter has been seated in a barrel having .310" cone. The bullet is only a trifle larger than the cone opening, the edge of which also is excellently smooth and rounded. With this smooth edge, and the bullet, before firing, pushed into the cone as shown, the given dimensions work well—though no better than a .309" bullet pushed farther into the cone. If this edge were sharp, the .309" diameter of bullet would be necessary for reliable accuracy.

The effects of severe (left) and slight interference (right) of the forcing cone with cast bullets as described in text.

The following points are thus evident:

1. Barrels made for cast bullets should have forcing cones which are smooth and smooth-edged and larger than the bullets used.

2. Factory barrels to be used extensively with cast bullets should be adjusted at these points, unless they have already worn to this condition (wear, thus, is favorable in this use).

3. Otherwise, the bullets should be cast or sized to a diameter freely entering the existing forcing cone.

4. With the bullet body fitted to the forcing cone as described, the bullet's forward parallel should fit tightly on the rifling lands, as shown by the engraving.

These conditions are readily checked by examining bullets assembled to different depths in the cartridge case, and seated in the barrel.—E.H.H.

Patched Light Loads

The American Rifleman's *development of new paper patched rifle bullets has been almost entirely in loads of full factory ammunition power. On the other hand, some experienced users find certain advantages in the more limited velocities of bare gascheck bullets—moderate recoil and hence pleasant shooting, and excellent accuracy* *which now is possible. It seems the paper patched bullets would share these qualities when loaded the same, plus the freedom from any bore deposits with patched bullets, and perhaps further accuracy possibilities. Accordingly, any directions you can give for light loading of paper patched bullets would be welcome.*

Answer: The NRA investigation of light loads with these new .30 cal. patched bullets was relatively brief. However, some basic points became clear:

Detailed directions for these bullets in full power loads ("Paper Patched Bullets Come Of Age," March, 1977, p. 28-32) govern in light loads also. They include adequate hardness (for this see below), patching with high grade paper of correct thickness, lubricating the patched bullet with Teflon spray, then sizing it on standardized Alox bullet lubricant to a diameter entering the barrel forcing cone, and seating it in a tight case neck to a depth fitting the bare forward bullet part onto the barrel rifling and the patched body into the forcing cone ("Paper Patched Bullets," March, 1978, p. 68). The patch should enter the forcing cone, not merely be pushed against the cone's rear edge; sizing to .308" makes this possible.

Light loads require less bullet hardness than full power loads. But do not overdo this. Excessively soft bullets appear to expand prematurely during discharge, destroying the paper patch and shooting poorly. Except possibly for the lightest loads, a hardness of about Brinell 13 appears best to start with, corresponding to an alloy of equal parts linotype metal and pure lead. Make the bullet as hard as will still expand reliably into the rifling on discharge, rather than as soft as will not shoot too badly.

For the same reason, a propellant of moderate burning speed should be chosen, to move the bullet undamaged into the rifle bore. Fast-burning pistol and reduced load powders are unsuitable. Propellants no faster than IMR 4198 are initially appropriate.—

E.H.H.

Battery Plates: Bad News for Bullet Casters

Bullet casters have often salvaged lead from storage batteries, but this is no longer safe or practical. Manufacturers have reduced the amount of lead in batteries, so the quantity of metal obtained is hardly worth the effort or risks of explosion, acid burns, or environmental pollution.

These disadvantages apply to all batteries, but the advent of the "maintenance free" battery has raised another far more serious hazard. All or part of the antimonial alloy is being replaced in these batteries by other alloying elements such as calcium. The danger comes when calcium alloys are melted with those containing antimony and arsenic. Intermetallic compounds are formed in the melt which become mixed with the dross. When the dross is discarded, these can react with moisture to release highly toxic gases.

Let us consider what happens when a calcium alloy is mixed with wheel weights. At normal casting temperatures, either alloy alone exists as a homogeneous solution in which all of the alloying constituents are dissolved in the lead; gravity segregation cannot occur. The drossing behavior of the two alloys is very different. The surface of a freshly fluxed antimonial alloy is bright and oxidizes slowly, but lead-calcium alloys dross more rapidly than pure lead, forming a silvery scum which becomes thick and gray as casting proceeds. The dross clings tenaciously to the casting ladle and often ends up inside the bullet mold. Calcium alloys are ill-suited for cast bullets.

If the two metallic solutions become mixed, (or the alloys are melted together), the antimony and arsenic will react with calcium to form small crystals in the melt. While the reactions may vary in accordance with the composition of the melt, the two most commonly accepted reactions are:

$$2Sb + 3Ca \rightarrow Sb_2Ca_3$$
$$2As + 3Ca \rightarrow As_2Ca_3$$

Sb_2Ca_3 and As_2Ca_3 are intermetallic compounds which have very limited solubility in lead melts at normal casting temperatures, and no amount of fluxing or stirring will cause them to return to the melt. Since neither compound will dissolve, and both are less dense than molten lead, they will gravity segregate to the surface and become mixed with the dross. The danger lies in what can happen to the discarded dross.

In metallic form, calcium is easily oxidized. In fact, calcium's affinity for oxygen is so strong that it will actually pull the oxygen from water, whether in liquid or vapor form. In the case of the above-mentioned intermetallic compounds, water oxidizes the calcium to form lime while the hydrogen combines with antimony or arsenic to produce the poisonous gases stibine and arsine respectively. The chemical reactions are:

$$Sb_2Ca_3 + 3H_2O \rightarrow 3CaO \text{ (lime)} + 2SbH_3 \text{ (stibine)}$$
$$As_2Ca_3 + 3H_2O \rightarrow 3CaO \text{ (lime)} + 2AsH_3 \text{ (arsine)}$$

Both gases are considered acute poisons and are approximately equivalent in their effects on the system, but somewhat more is known about the toxicology of arsine. This is probably due to the fact that industrial deaths have occurred as a result of arsine poisoning. For example, aluminum, which is commonly used in tin refining, combines with arsenic impurities to form As_2Al_3 which when wetted produces arsine.

Owing to their high density relative to air, both gases tend to accumulate in low lying places. Around the home, the two most obvious areas of concern are basements, where much casting is done, and garbage cans, where the dross is usually discarded. Of the two, the basement is probably the lesser worry. The reaction with damp basement air is relatively slow and would tend to be diluted by air. However, if the quantity of dross is large, or if the dross accidentally becomes wet, significant amounts of gas could be generated and may contaminate the entire basement of an average size home.

Garbage cans where dross is discarded are perhaps the most dangerous area. The interior is usually wet with residue or rain water which can cause a large amount of gas to be generated quickly in a restricted volume. Inasmuch as light helps to decompose stibine and arsine, the dark interior of the can prolongs the life of the gas. Once a quantity of gas is produced, anyone lifting the lid to deposit material could easily inhale a concentrated dose.

Physical effects due to poisoning depend on how much gas is absorbed by the body. Some sources indicate that as little as 50 parts per million (p.p.m.), $^1/_{20,000}$ dilution, of arsine is injurious to the system, impairing the function of the blood or causing pulmonary edema. A few breaths of the concentrated gas may be fatal.

Calculations show that 1 lb. of wheel weight metal of the above-mentioned composition will ultimately produce 0.1 cubic feet of poisonous gas, stibine plus arsine. If a bullet caster were to obtain six used maintenance free batteries, the six batteries should yield about 44 lbs. of calcium alloy which is sufficient to react all the antimony and arsenic in 3 lbs. of wheel weights. If three or more pounds of wheel weights are mixed with the calcium alloy, enough Sb_2Ca_3 and As_2Ca_3 will be trapped in the dross to generate 0.3 cubic feet of gas.

The volume of a typical 30 gal. garbage can is about 4 cubic feet; therefore, 75,000 p.p.m. of these poisonous gases could be trapped for some finite period of time in the garbage can. This is 1500 times more than the amount indicated to be injurious to the system and certainly approaches a concentrated dose. Even if it were determined that this theoretical calculation predicts a volume of gas several times more than would be found in a real life situation, the concentration is still high enough to cause injury, particularly to small children.

Three-tenths cubic feet of the gas will also contaminate the air space of a basement. A basement measuring 24 ft. × 40 ft. with a 7 ft. ceiling has a volume of 6,720 cubic feet. Three-tenths cubic feet diluted 6,720 times still gives a concentration of about 45 p.p.m. which is near the injurious level.

It is important to emphasize that these concentration estimates are based on mixing 44 lbs. of calcium alloy and three or more pounds of wheel weights. Someone processing a larger quantity of alloy can expect a correspondingly larger problem with the dross material.

The simplest solution to this poisoning problem is to avoid using batteries, no matter how good the price is. And if you're entertaining thoughts about separating the "good batteries" from the "bad batteries" you're out of luck. In addition to the fact that external markings in no way define alloy content, manufacturers are presently marketing batteries which utilize both alloys (antimonial and calcium) in the same container.

DENNIS MARSHALL

A Casting Technique That Works

New cast bullet shooters are often frustrated by their inability to cast well-filled bullets, without defects, which are uniform in weight. It takes experience and a good casting technique to get good bullets. I hope the following procedure will work as well for you as it has for me.

Preheat the mould as the pot heats up. An electric pot should be about 700°F. Let your mould get well preheated before starting to cast. Heating the mould by casting 25-50 bullets and discarding them is a waste of time and labor.

Fluxing: When the lead is up to temperature, flux the pot vigorously. I prefer Marvelux for this. Reflux again every half hour and whenever you add new metal to the pot.

Pour a generous sprue: When filling the mould from a bottom pour pot, put the sprue recess of the mould up against the pot's spout and open the valve. In a moment when the cavity is filled, drop the mould down an inch without stopping the flow of lead and pour the largest button of lead you can get to form on the top of the sprue plate before shutting off the flow. You want the bullet to harden before the sprue does, to minimize the effects of lead alloy shrinkage.

Time the sprue's hardening: Watch the sprue button as it solidifies. A ten-second interval should give enough time for the sprue to harden before you cut it and avoid lead build-up on the bottom side surface of the plate.

Refill the mould: Immediately after releasing the casting.

Dropping the bullets: I drop the bullets out of the mould onto a folded bath towel which is on a flat surface. While waiting for the sprue of the next bullet to harden, I scan the bullets already cast for imperfections.

Too cool a casting temperature, or oil contamination of the mould, causes bullets to be wrinkled and not filled out.

Segregate double cavity bullets: If yours is a double cavity mould, segregate the bullets; drop bullets from #1 cavity in one pile and those from #2 cavity in another . . . unless you have proved the castings are identical in size and weight. They rarely are.

If you have two single cavity moulds, you may alternate their use: while the sprue is hardening on mould A, dump B and refill it. While B is hardening, dump A . . . etc.

Final inspections: When they're cold, inspect all bullets, looking for *any* imperfections. A 2X eyeglass helps tremendously in this important culling process. You want to minimize the probability of having a flyer at the target. Discard all castings that show any imperfections; these go back into the pot.

Weigh all bullets: You want to find those that depart in weight from most of the others. Again, trying to minimize the probability of flyers at the target. The main objective of bullet weighing is to eliminate the occasional very light bullet which has a void, not visible to the eye. A weight variation of as much as ± 0.2 gr. among 170-gr. .30 cal. bullets which appear perfect otherwise has little or no effect at the target, and is adequate for serious competition. — SID MUSSELMAN

Frosting of the casting is caused by too hot a casting temperature. Uniform frosting does no harm, but avoid "hot spots."

STRONGER BULLETS WITH LESS ALLOYING

The real characteristics of lead alloys make better performance practical at far less cost

By Dennis Marshall

CAST lead bullets provide an enjoyable extension of the possibilities open to the handloader. Among their advantages are greatly reduced cost and extended barrel life.

Once bullets of the proper geometry and quality are obtained, the most important requirement for their success is sufficient hardness and strength. The common practice is to add large amounts of tin and antimony to provide this. But the cost of these alloying elements is very high. *In lieu of such costly materials, bullets of equal or superior strength can be made from lead containing as little as 2½% antimony, by a simple heat treatment.*

To understand how and why, consider the effects of the loads and especially the bullet metals used.

Because of poor target accuracy obtained by many handloaders with their cast bullets, The *American Rifleman* has published the results of its own research to identify the requirements for accuracy *(see references).* The most important conclusions were: (a) cast bullets must be strong enough to prevent deformation in firing, and (b) moderate charges of medium to slow burning rifle powders are required for any but very light loads, for the same reason. In support of these findings, Richard Lee provided graphic evidence of the problems caused by soft alloys and fast burning powders (7).

The most widely successful alloy has been linotype metal, which contains 12% antimony, 4% tin, and 84% lead. The metals literature indicates a Brinell hardness of about 22 for this material. Brinell values as high as 34 are attainable, but only by copious further additions of antimony and tin, at additional expense. And these metals being lighter than lead, they decrease the bullet's sectional density.

Reduced availability and increased cost of these alloying elements are providing ample reason for the bullet caster to use less of them. To this end, here we explain the real characteristics of lead alloys, to inform the handloader on techniques for producing bullets superior to linotype metal and with far less alloy content.

The modern abandonment of "hot type" printing also is drying up the supply of type metals, so this development is timely. Ed.

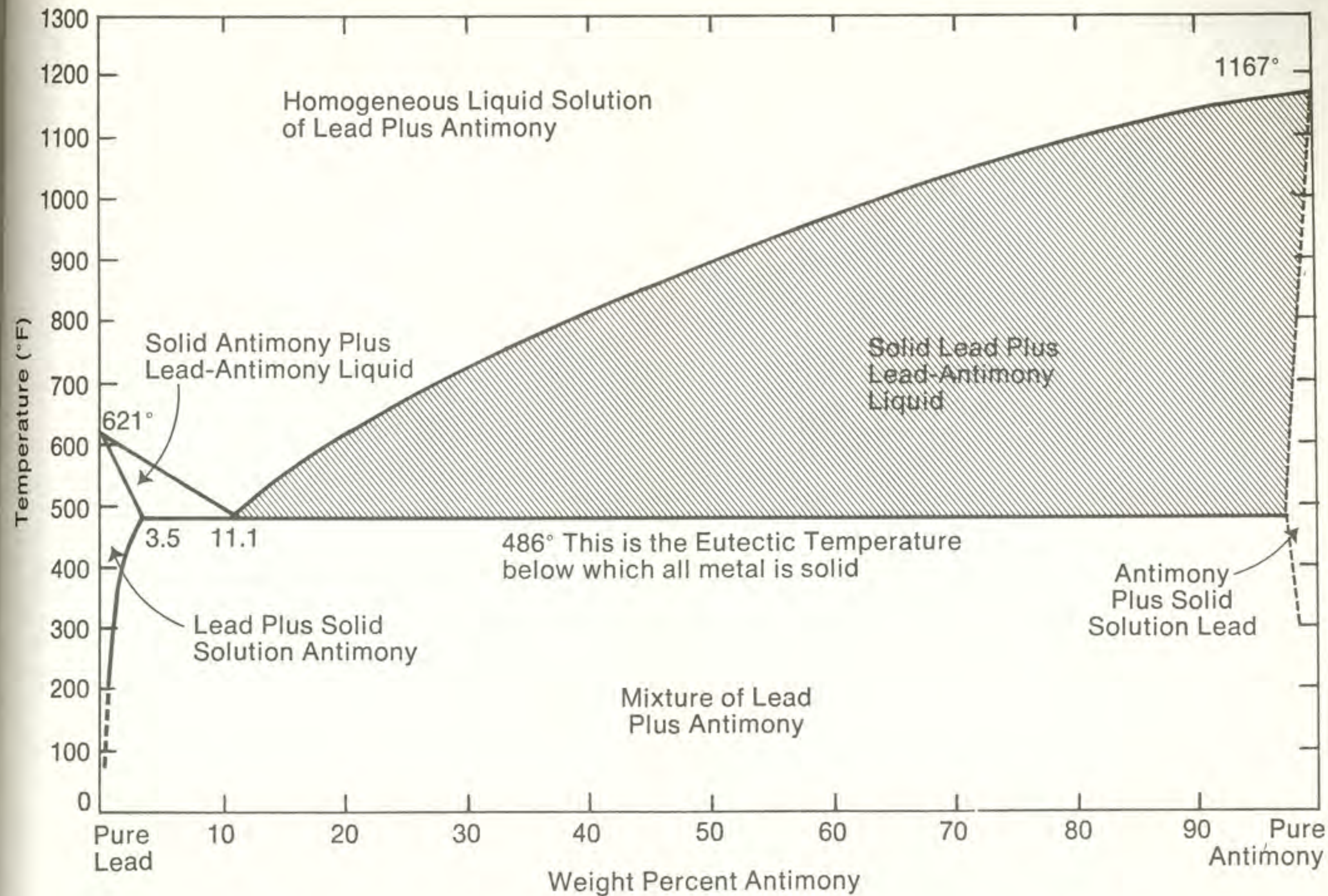


Figure 1. The phase diagram for lead-antimony alloys according to Hansen (10). It defines the liquid and solid regions of the system in terms of temperature and composition.

The characteristics of lead alloys

Metals commonly are regarded as unvarying materials. But lead, whether pure or alloyed, actually is in a high state of thermal activity even at room temperature, and in that state is subject to change. The reason is quite simple and is readily understood in terms of an absolute (Rankine) temperature scale.

The melting point of pure lead is 621° F. But on the Rankine scale (made by adding 460° to the Fahrenheit value since 0° Rankine, the absolute zero, is 460° below 0° F.), lead melts at 1081° R. Room temperature is about 70° F, or 530° R which is half-way to the melting point of lead. Looked at in that way, its high state of activity becomes understandable.

Lead is not unusual in this respect; it is only behaving like any other metal halfway to its melting point. For example, iron melts at 3257° R. One-half of this is equivalent to 1169° F, at which the iron is red hot and not far below the usual range of heat treating temperatures for steels. Being "hot" at room temperature thus is not unique with lead. Other elements are in a similar state of activity, while mercury is actually molten. Therefore, when you think lead, think hot.

This "hot" behavior of lead does give rise to many changes in its alloys which are not normally encountered in other materials.

By itself, lead lacks the necessary strength for bullets in modern rifles. While there are several materials which may be added to lead to improve its strength, tin and antimony are at present the only practical alloying elements for cast bullets. When either of these is added to molten lead, a metallic solution is formed. It is a common misconception that because they are less dense than lead, antimony and tin may undergo gravity separation from the melt. Nothing could be farther from the truth. The solution formed in this case is like that when sugar, salt, alcohol, or antifreeze is dissolved in water. In the absence of oxygen or oxidizing materials, melted lead alloys will remain stable and mixed virtually forever.

If a lump of sugar is placed in a glass of water and left undisturbed, it eventually dissolves. Likewise, a piece of antimony immersed in molten lead also dissolves. To show that this could be accomplished without any special equipment, a 130-gram lump of technical grade antimony (melting point 1167° F) was added to a preheated pot containing 2250 grams of commercially pure lead. A coarse screen held the antimony under the surface of the molten lead to maximize contact and minimize oxidation of the antimony. At 900° F, approximately the upper operating temperature for most bullet casting pots, the antimony dissolved in about 30 minutes. The alloy produced was entirely suitable for casting and was used to make the bullets for the photomicrographs in Figures 3 and 4.

It is important that this alloying be done *with generous ventilation.* When the antimony was added to the lead in this demonstration, a whitish vapor evolved from the molten surface. A portion collected by allowing it to condense on aluminum foil proved to be antimony in the form of an oxide (Sb_2O_3). Sax (9) equates the toxicity of antimony with that of arsenic, so it is advisable to treat this material with a little respect. Fortunately, once the antimony has dissolved the rate of evolution drops dramatically.

Molten lead alloy exposed to air soon oxidizes. This oxidation affects all the constituents, including the lead. (The chemistry of tin and antimony dictates that they oxidize at a higher rate, which accounts for their gradual depletion from the melt.) Thus, the scum which forms on

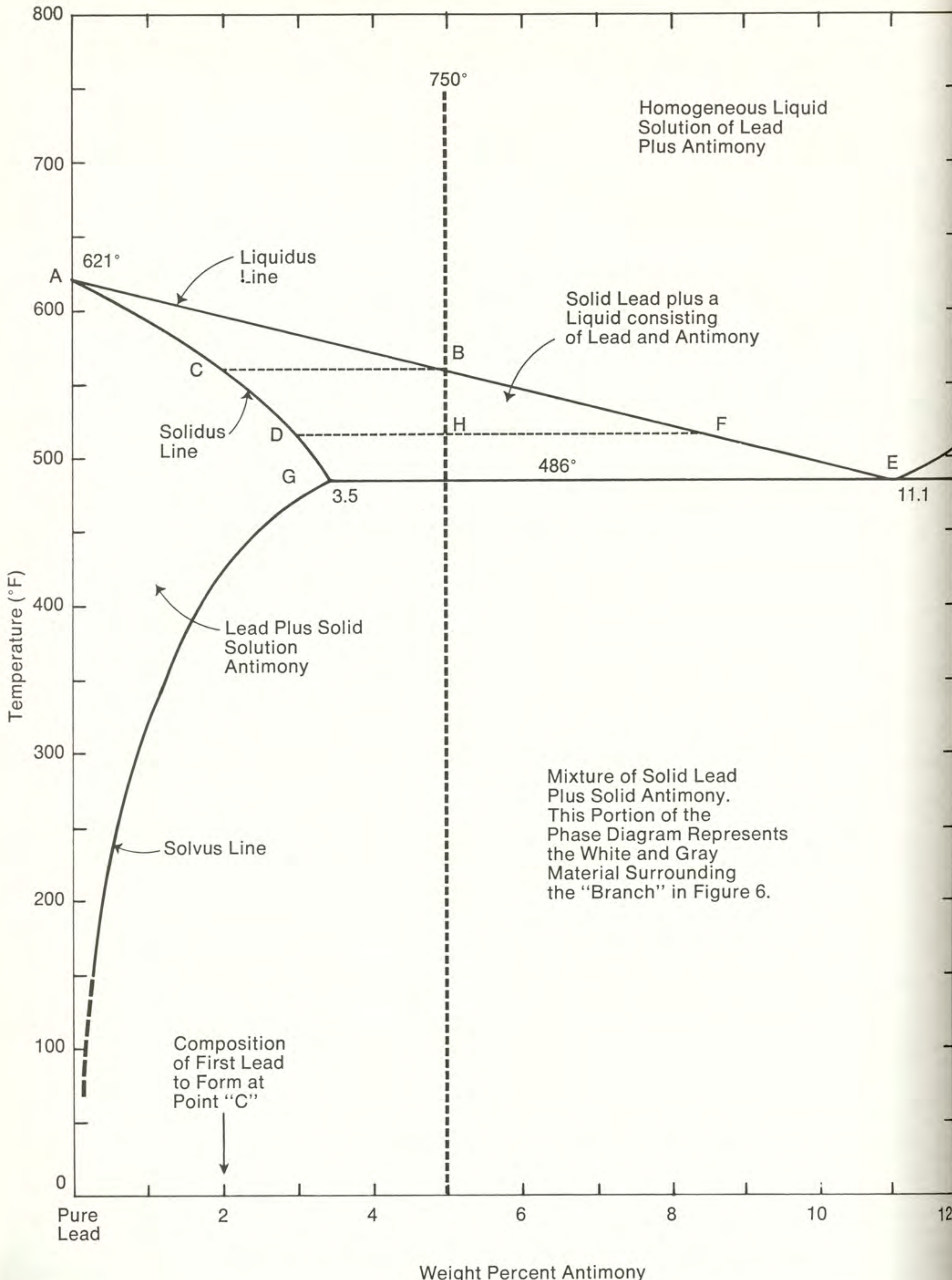


Figure 2. Enlarged view of the lead rich side of the lead-antimony phase diagram shown in Figure 1. In conjunction with the text, it is useful for explaining the solidification and heat treatment of lead-antimony alloys.

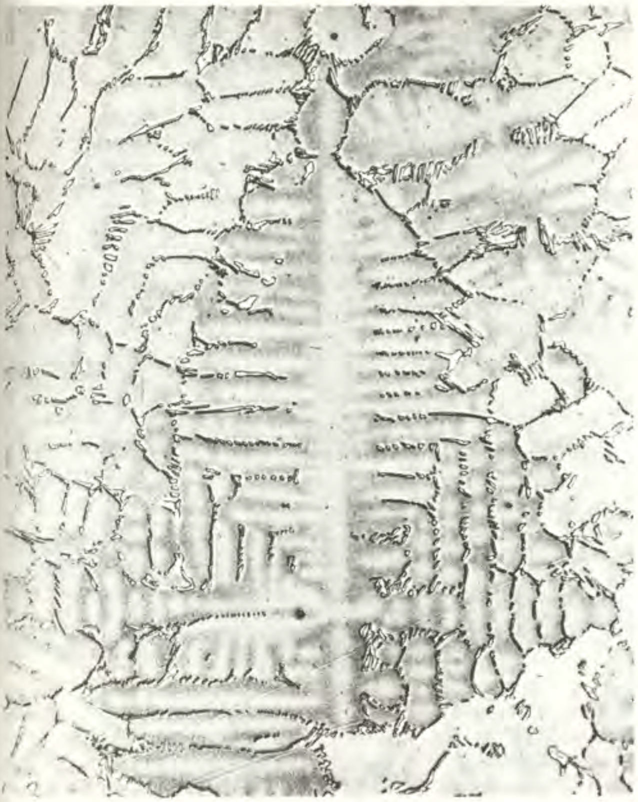


Figure 3. (500X) Photomicrograph of a cast bullet made from a lead-5% antimony alloy. The "tree-like" structure is representative of those which form during solidification of lead-rich alloys (less than 11.1 % Sb). The "tree" is nicely outlined by the eutectic which freezes at 486° F.

Figure 4. (100X) At this lower magnifications, this micrograph shows at least twelve "trees" in various orientations. The photograph was taken about 1/10" from base of a lead-5% antimony bullet. The small black spot near top of the picture is a shrinkage cavity formed when the eutectic material contracted on freezing.

the surface of the melt is a mixture of metal oxides, not tin or tin oxide only.

Fluxing returns much of the oxidized metal to the melt. Fluxes used by the bullet caster are usually some carbonaceous matter such as beeswax or oil and sawdust. Two things happen in fluxing: 1) the carbonaceous material chemically reduces a portion of the oxides, allowing the metal to return to the melt, and 2) any oxides remaining are separated from the metal. During casting, the oxides formed are wetted by the metal, giving the appearance of a lumpy surface. If the surface is skimmed before fluxing, as much as 90% by weight of the material removed will be metal. After fluxing, the oxides which remain are more flocculent and much easier to remove.

Since heat accelerates oxidation, it is best to operate the pot at the lowest temperature which gives reliable casting.

The behavior of the alloy when it solidifies in the mold is best understood in terms of a phase diagram. For example, Figure 1 is the phase diagram (10) for lead-antimony, and illustrates the relationship of the liquid and solid phases in both temperature and composition. Note that only three compositions have a sharp freezing point: 1) pure lead, 2) pure antimony, and 3) the lead-antimony eutectic composition, 11.1% antimony. All other compositions solidify progressively.

Since we wish to use less alloy, we focus on the lead end of the diagram. Figure 2 is an enlarged view of Figure 1 for compositions up to 12% antimony. Suppose we have an alloy containing 5% antimony, indicated by the vertical dashed line in Figure 2. At 750° F the alloy exists as a homogeneous solution of antimony and lead. It begins solidifying as soon as it cools to point B on the liquidus line AE. At this temperature solid crystalline lead nucleates and begins to grow, with a composition indicated at point C (approximately 2% antimony). As the casting continues to cool, the composition of the solid lead follows line CG while that of the liquid follows BE. At point H, for example, the compositions of the lead and remaining liquid are shown by points D and F.

At slightly above the eutectic temperature of 486° F, the last lead to form has a composition at point G of 3.5% antimony, while the remaining liquid contains lead plus 11.1% antimony. Just below the eutectic, the remaining liquid freezes and partitions to form two discrete solids, lead and antimony.

It is interesting that during solidification, the lead grows in the shape of tree-like structures with a trunk and branches. One such tree is shown in Figure 3 which is a photomicrograph of a bullet cast from a 5% antimony alloy. Figure 4 is a lower-magnification photomicrograph of another bullet of the same alloy. Examining it carefully, you can find at least a dozen trees. Metallurgists call these structures dendrites owing to their tree-like shape.

One or more lead trees, all growing in a cluster with the same orientation, constitute a single grain. Grain boundaries result wherever tree groups of different orientations impinge on one another. An example of the grain texture common to cast bullets is shown in Figure 5. This is a soft lead (plumber's lead) bullet sectioned and polished to reveal the microstructure. The high contrast between grains was devel-

Figure 5. (2.7X) Macrograph of a soft lead bullet (Lee C309-190F) sectioned to half diameter and polished. The grain sizes and shapes are representative of those found in alloyed bullets although alloying generally produces a more uniform grain size.

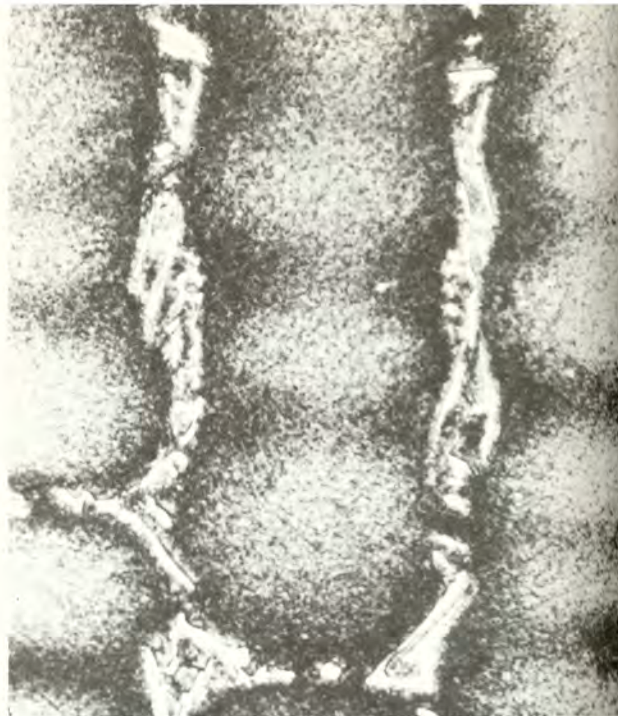


Figure 6. (1000X) A branch of a lead dendrite, surrounded by eutectic material which has split into two discrete solids, lead (gray) and antimony (white). If the temperature of this alloy were raised to 486° F, the eutectic material would melt causing the alloy to lose all strength. Metallurgists refer to this condition as hot short.

oped by a special chemical etchant followed by slow surface oxidation.

The last liquid to freeze, the eutectic, occupies the spaces between the branches and within the grain boundaries. This appears in Figure 3 and again in Figure 6 as the white and gray material surrounding the grayish lead dendrite (a branch of a "tree"). Figure 6 shows how the eutectic has split into two separate entities; the jagged white particles are antimony and the dark are lead.

The eutectic liquid contracts in freezing. When this comes after the pouring sprue has solidified, a shrinkage cavity is left within the bullet. Liquid metal supplied to the shrinking area prevents this and thus it is desirable that the sprue area solidify last. Just how prevalent shrinkage cavities are is not well documented, but based on the findings of this research they are fairly common, as they were found in almost every bullet which was sectioned and polished (see Figure 4). Although these imperfections can occur anywhere within the bullet, they are usually near the center where they have the least influence.

Another consequence of eutectic shrinkage is "frosty" bullets. These occur when the mold and/or pot temperature is too high. The long freezing time then results in exaggerated grain growth with very large dendrites. When the eutectic liquid contracts, the dendrites are in effect left standing out from the surface, and these give the frosty appearance. The same effect appears on the surface of a solidified pot of lead alloy, where it is common to see dendrites as large as ½" on the slowly cooled surface. Actually the effect is always there, it's just not visible to the unaided eye on bullets cast at lower temperatures.

Tin has acquired an undeserved reputation as necessary in lead-antimony alloys. It has been stated (11) that in its absence, solidified alloys will exist as antimony grains surrounded by lead. This is very wrong as you can see from the preceding explanation and photographs. In all lead-antimony alloys with less than 11.1% antimony, lead grains are surrounded by the eutectic mixture of lead and antimony. For compositions greater than 11.1%, antimony crystals grow in place of the lead and are surrounded by the same eutectic material, not merely lead. A certain amount of gravity separation can occur with this high percentage of antimony, since the growing antimony crystals are less dense than the alloy melt, but they will still be surrounded by eutectic.

There are, however, two valid reasons for adding some tin to lead-antimony alloys. For printing purposes, tin is added to form a ternary eutectic; that is, a three-component alloy with a single sharp melting point like the lead-antimony eutectic though at a still lower temperature, 464° F. The composition of this three-component eutectic is 12% antimony, 4% tin, and 84% lead which is linotype metal. This possesses exceptional casting qualities, due in part to its very high fluidity. The alloy does not expand on freezing as many believe, in fact it contracts about 2% (8).

The other reason for adding tin is oxidation protection. Pure lead-antimony melts form considerable dross, especially if the surface is agitated as when using a ladle. As little as 0.25% tin will greatly reduce the quantity of dross by forming a tight layer of tin-rich oxide over the surface.

What hardens the bullet

Two mechanisms provide strength in cast bullets: precipitation hardening which occurs within each of the lead grains, and eutectic hardening which occurs when a substantial portion of the bullet microstructure consists of eutectic. In this latter case the eutectic forms a rigid matrix around the grains. Bullets with low alloy content derive most of their strength from precipitation hardening since there is little eutectic material available. Those of high alloy content obtain their strength from both mechanisms.

Precipitation hardening is by far the more important — especially since heat treatment provides a means for optimizing it. To understand its operation, we look at Figure 2 more closely. For temperatures above 486° F, the composition of the lead grains is represented by the solidus line AG. This gives the proportion of antimony which dissolves at a given temperature in solid lead. Below 486°F, the solvus line GI represents the solubility of anti-

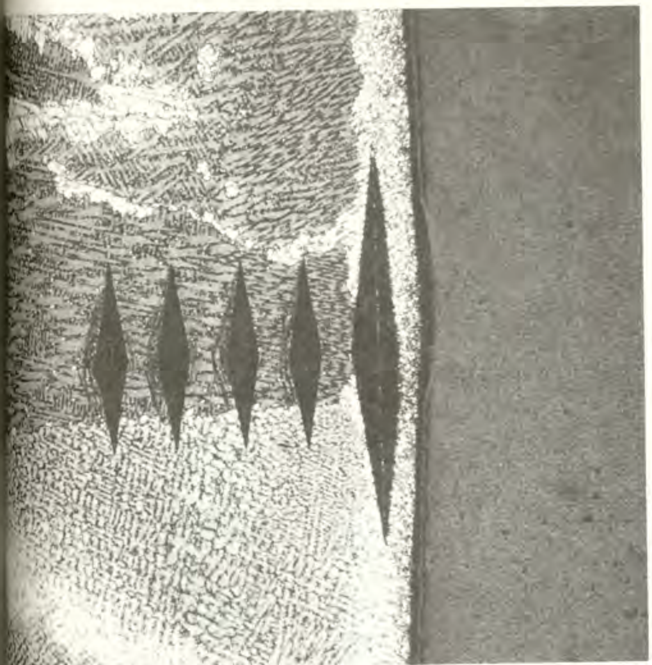


Figure 7. (200X) Polished and etched cross-section (normal to major axis) showing the smeared metal at the periphery of the bullet (light band on the right). Knoop identations show the difference in hardness: the four smaller impressions average 36.7, the one in the smeared metal is 8.8. This latter value is lower than those in Table 2 due to edge effects.

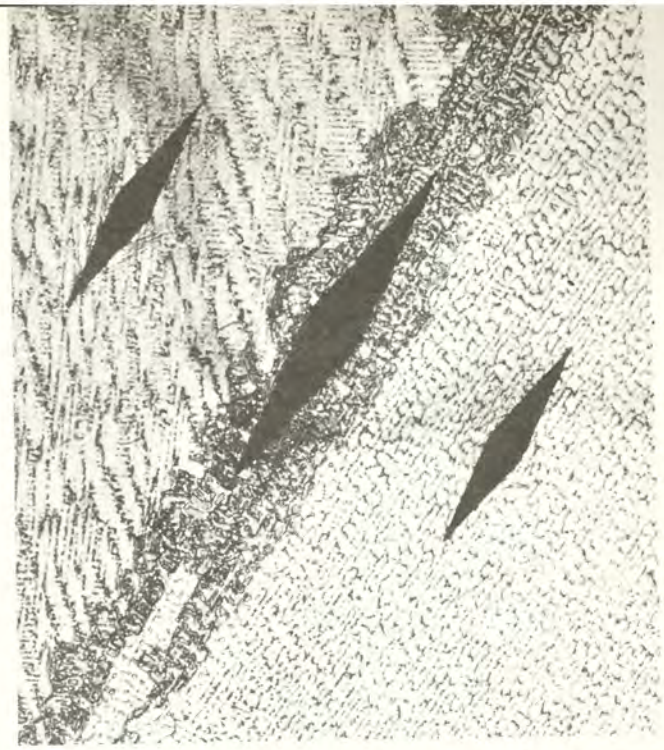


Figure 8. (200X) Photomicrograph of two hard grains which slid relative to one another generating the dark band of deformed metal between them. The Knoop hardness numbers are, from upper left to lower right, 38.8, 15.2 and 36.7.

mony. When a bullet cools to room temperature, we see that lead will no longer dissolve much antimony, acceptin only about 0.2%. Anything beyond 0.2% is forced out of solution and precipitates as small antimony crystals, much the same as sugar crystalizes out of soution from water. These crystals are shaped something like flakes of shotgun or pistol powder though they are about 100,000 times smaller. With the antimony thus forming in solid lead, its motion is constrained and it becomes trapped. Since metals deform by the movement of imperfections (called dislocations) within the grains, the precipitates block movement and thus strengthen the alloy.

But though formed in a solid material, the precipitates are by no means dormant. Remember, lead is "hot" at room temperature and as a result the antimony is mobile, which gives rise to changes in the size of the precipitates with time. Most important, there is an optimum size which provides the highest strength, *and this can be controlled in a predictable manner.*

To understand how, we focus once more on Figure 2. Since line GI gives the composition of the grains, we see that if the bullet is heated above room temperature, antimony will again dissolve within the grains. This means the solid precipitate of antimony, along with some of the eutectic antimony, will go into solid solution with lead. The temperature must not exceed 486° F since that is the melting point of the eutectic material surrounding the lead (melting the eutectic would cause the alloy to lose all strength and fall apart). If the bullet is held at an elevated temperature for sufficient time, the grains will tend to become homogeneous in dissolved antimony. To be hardened, the bullet now is simply quenched in water. This quench is extremely important and it must be as rapid as possible.

At this point it might seem as though we had merely duplicated the original cooling after casting, but there is a remarkable difference. Very rapid cooling causes the antimony to precipitate in a finer and more evenly distributed manner which greatly enhances the strength. By analogy, when sugar water is cooled rapidly the crystals formed are smaller and more evenly distributed than from a slowly cooled solution, which produces larger and fewer crystals.

We will now describe the most effective method for heat treatment in detail. The best time and temperature were found by an experiment statistically designed to optimize these. We will also discuss the role of an element which greatly increases the hardening action.

While heat treatment may sound like a novel approach, metallurgists have done it with a variety of lead alloys to improve their strength or other mechanical characteristics (12). Of particular interest to handloaders is its use with very dilute antimonial alloys (13). In this case, the metal was cast to the desired shape, heated for 30 minutes at 455° F., and immediately quenched in water. This produced a Brinell hardness of 21.6, about the hardness of linotype metal, in an alloy containing only 2% antimony and 1% tin.

Special attention is given to including a seemingly insignificant amount of arsenic in the bullet alloy which, in combination with antimony and heat treatment, produces a 50 to 60% increase in hardness over conventional linotype metal.

Earlier, we discussed the mechanism responsible for strengthening a lead-antimony bullet, namely precipitation hardening, wherein minute antimony crystals precipitate within solid lead to block the movement of imperfections. What makes all this possible is the increasing solid solubility of antimony at higher temperatures. When a cast bullet is heated, additional antimony (over and above that which is soluble at room temperature) dissolves in the lead grains just as hot water dissolves greater amounts of sugar. When the temperature is again lowered, the antimony in solution precipitates to harden the lead. *From the standpoint of hardness, the significant difference between hard and soft bullets is the size and distribution of the precipitates, and these are readily controlled by the heat treating time and temperature.*

The heat treating variables

For maximum hardness cast bullets should be heat treated at the highest possible temperature, since that maximizes the amount of antimony that will go

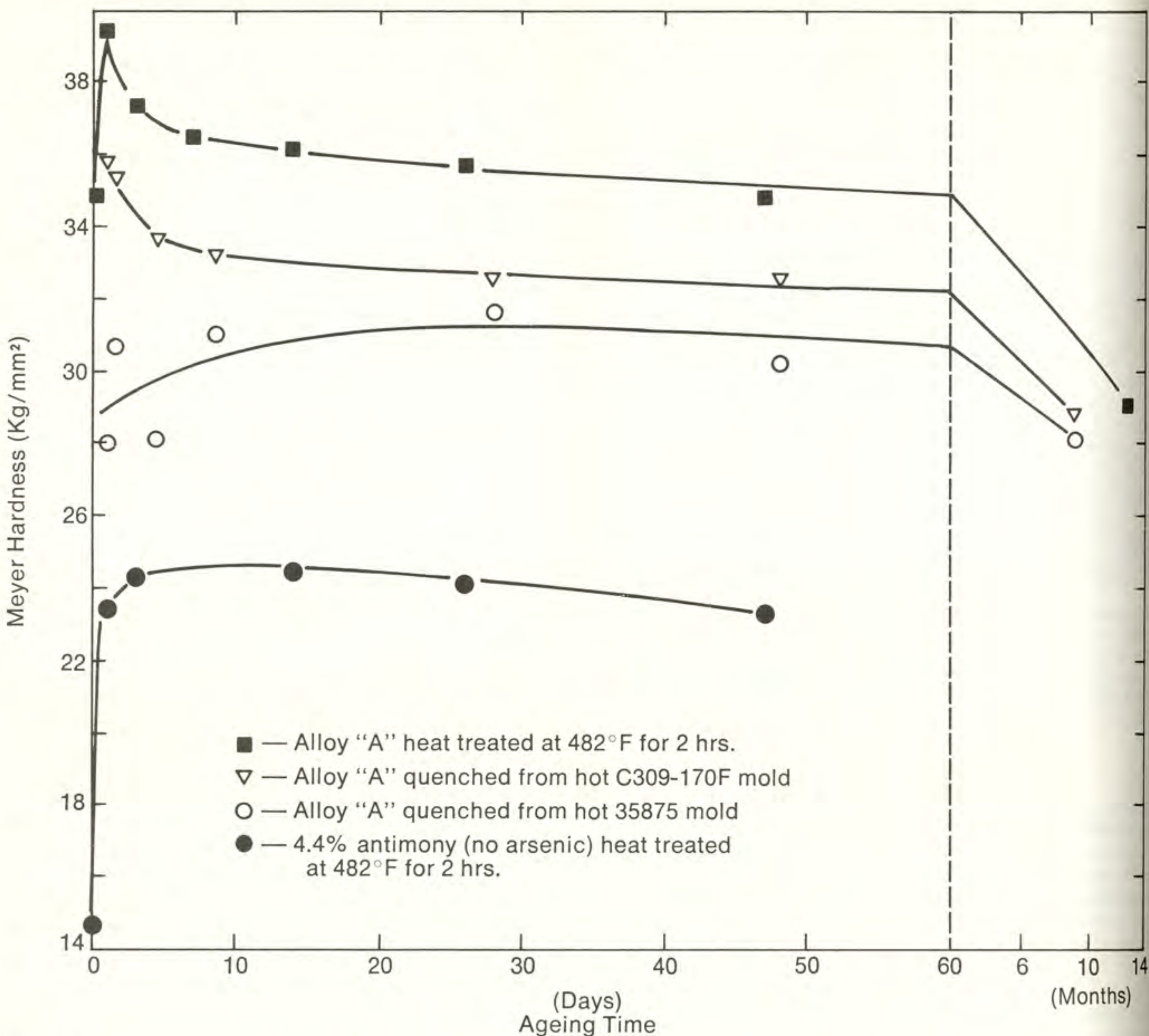


Figure 9. Ageing response of bullets heat treated by both methods. The hardness of bullets without arsenic are shown for comparison.

into solution. It also speeds up the movement of atoms and thus hastens the process.

The upper temperature limit is determined by the melting point of the material surrounding the grains, the eutectic. For all the alloys composed primarily of lead-antimony, this upper limit is 486° F. If the tin content of the alloy exceeds about 1%, the upper limit will depress toward the lead-tin-antimony eutectic at 464° F. In either case, when the upper limit is reached the eutectic material melts and the bullets fall apart. This is readily apparent as the alloy surfaces become wrinkled and a bullet standing on end slumps to one side before completely melting.

Some time is required to get the antimony into solution. Remember, the thing we wish to control is the movement of atomic antimony within solid lead, and atoms don't move fast under these circumstances. As an example, let us suppose you have placed a batch of bullets in the oven at 482° F. If it were somehow possible to insert an "atomic chronograph" into one of the bullets, it would record a velocity in the order of 10^{-8} f.p.s. (1/100,000,000 f.p.s.) for the antimony atoms moving through the grains. You could walk the circumference of the earth in less time than it would take one of these atoms to move four inches.

So if the heating time is too short, little antimony will dissolve in the solid lead and strength will suffer. But since heat speeds up atomic movement, the heat treating time is shortened by higher temperature. Fortunately, the distances atoms must move to accomplish solutioning in lead are very small and consequently the times become entirely reasonable.

Assuming a batch of bullets has been heating for sufficient time, they must receive an adequate quench; failure to give this will nullify an otherwise good heat treatment. The key word in quenching is speed. An air quench is much too slow and would allow the antimony to initiate a coarse and ineffective pattern of precipitation; in fact, there is a good chance that air cooling will actually soften a cast bullet. But nothing more than tap water is required for quenching these bullets. Water as it comes from the tap or at room temperature is adequate. Icewater offers no significant advantage — the benefits of lower temperature are offset by the poorer heat transfer in cold water.

The heat treating investigation

For heat treating to be useful to the average handloader, it must be workable over a practical range of temperatures. A typical kitchen electric oven, the most likely heat source around the house, fluctuates about the temperature at which it is set; so the user has to set it at somewhat below 486°F to avoid melting his bullets. How much hardness then is sacrificed by operating at a lower temperature? To answer this question, as well as determine the effects of heat treating time, an experiment was run in which time and temperature were varied over broad limits and the effect on bullet hardness recorded (see Table 1). Ingots were not used here since preliminary tests indicated they could not be heat treated to the same hardness as bullets, their larger mass slowing the quench.

Test samples for each of the 16 cells in Table 1 were cast from an alloy containing 5% antimony, 0.5% tin, and 0.17% arsenic, referred to here as alloy "A". The mold was a Lee C309-170F, selected for its flat nose which was convenient for hardness testing. Bullets were heat treated in an industrial oven with a temperature control of ±2°F, quenched in room-temperature water, and tested after 24 hours of storage.

The standard Brinell test for lead alloys was unsuitable here, the usual 10 mm. ball indentor being much too large for the nose flat of a C309-170F bullet. Substituting a 1.17 mm. ball and using a 4 kg. load, it was possible to run several tests on the nose of one bullet. Hardness numbers were calculated according to Meyer's formula,

$$H_m\ (kg/mm^2) = L/\pi(d/2)^2$$

where L is the load in kilograms and d is the diameter of the indentation measured in millimeters. The data in Table 1 are easy to compare with other known alloys, since in this hardness range the Meyer and Brinell values differ by only one number, i.e., $H_m = H_b + 1$. So if an alloy has a Brinell hardness of 22 it will have a Meyer hardness of 23.

Referring to the row means in Table 1, it is obvious that temperature has had a pronounced effect on hardness. This was expected for the reason stated earlier, that more antimony dissolves at high temperature and thus more of it takes part in the hardening. More importantly, the data show that good hard bullets are obtained at nearly 60° F. below the eutectic temperature, and that's well within the control capability of almost any kitchen oven.

The only thing Table 1 doesn't tell us is the effect of temperature cycling on hardness. As an example, suppose a batch of bullets has been heating at 464° F. for 1 hour during which the temperature fluctuated ±18°F. What then, is the final hardness value — 32.8, 35.0 or 37.7? While this effect was not considered in the experiment, it is a fair guess that the final number will be close of 35.0 and in any case the worst one could expect is about 32.8 — not bad for an alloy with only 5% antimony, since it is 50% harder than straight linotype metal!

Temperature (°F) \ TIME (HRS.)	1/2	1	2	4	Row Means
428	1 28.8 ± 1.0	10 31.0 ± 0.8	9 31.3 ± 0.8	14 30.2 ± 1.2	30.3
446	11 34.2 ± 1.0	16 32.8 ± 0.8	4 33.0 ± 0.7	3 32.7 ± 0.8	33.2
464	15 36.5 ± 0.4	6 35.0 ± 1.7	8 35.4 ± 1.0	5 35.6 ± 0.9	35.6
482	7 39.7 ± 1.4	2 37.7 ± 1.3	13 39.3 ± 1.2	12 36.9 ± 1.0	38.4
Column Means	34.8	34.1	34.8	33.8	

Table 1. Results of a controlled experiment in which bullets were heat treated for the times and temperatures shown, quenched in room temperature water, aged 24 hours, and subjected to a hardness test. The numbers in each cell are average and standard deviation of five Meyer hardness readings in kg/mm². The number in upper right hand corner of each cell indicates the order in which the data were taken.

In contrast to temperature, the column means show that time has not influenced bullet hardness, even though a comparison of individual cells might lead one to believe otherwise. From the bottom row in Table 1, it is tempting to conclude that the bullets in Cell 7 are harder than those in Cell 2. But it is invalid to judge the differences between number groups solely on the basis of their averages; overlap must be considered also. This is clear in Table 2, which is the raw data for Cells 2 and 7. These provide a visual indicator of overlap, the high value for Cell 2 exceeding the low value for Cell 7. This overlap was evaluated statistically by a "t" test, which indicated these two averages are not significantly different, a result which also is representative of the remaining data within each row with only a few minor exceptions.

For the bullet caster, this means that if a batch of bullets is not pulled from the oven at a specified time there's no harm done. Thus time variations from one batch to another are unimportant provided the time is sufficient and the temperature remains the same.

In addition to supporting the claims about time and temperature, the analysis showed there was something unusual about Cell 1 when compared with the general trends of Table 1. While one-half hour was enough time at higher temperatures, it was not adequate to heat treat a bullet fully at 428°F. To determine whether this was indeed the case an additional set of bullets was heat treated at 428°F. for only 15 minutes. These gave a Meyer hardness of 25.7 ± 0.6 which is substantially lower than Cell 1 and definitely showed that one-half hour was the beginning of a downward trend in hardness. While it is likely you could get away with something less than one-half hour at higher temperatures, a few extra minutes in the oven provide insurance of a proper heat treatment and really don't represent any inconvenience.

Arsenic increases hardenability

Because lead is a material of great commercial importance it has been the subject of many investigations, having been alloyed with nearly half the elements in the periodic table. Still, out of the countless variations and combinations tried, antimony and tin remain the only practical major alloying constituents for cast bullets. However, metallurgists have found that very small additions of arsenic, from 0.05% to 0.5% enhance the hardenability of antimony alloys by a quite disproportionate amount — even though arsenic alone is of little value for strengthening lead. The intentional use of arsenic for cast bullets in fact represents something of a turnaround, since it is generally regarded as a nuisance or an impurity at best. But in combination with antimony

Cell 7	Cell 2
41.4	38.9
40.5	38.7
40.0	37.7
38.9	37.3
37.9	35.7
39.7 ± 1.4	37.7 ± 1.3

Table 2. Here the raw data for Cells 2 and 7 provide a visual indication of the overlap between them. On the basis of a statistical "t" test, the overlap was enough to nullify the difference between averages.

As Cast	Heat Treated at 482° for 2 hours	Composition by weight Percent	
16.2 ± 0.3 After 6 days	37.2 ± 1.1 after 3 days	5.0 Antimony 0.5 Tin 0.17 Arsenic	Alloy "A"
14.3 ± 0.2 after 6 days	24.3 ± 0.5 after 3 days	4.4 Antimony Trace of Arsenic	Alloy "B"

Table 3. The contrast between "A" and "B" illustrates the beneficial effects of arsenic on bullet hardness. Each average and standard deviation is based on a minimum of four Meyer hardness determinations.

and heat treatment, arsenic provides the capability to harden lead much beyond present bullet casting standards.

Table 3 provides an excellent comparison of arsenic's benefits. It is obvious that the arsenic here has greatly magnified the effect of heat treatment. Had alloy "B" containing almost no arsenic been used in place of "A", the hardness in Table 1 would have been displaced downward approximately 13 hardness units. (But if an alloy does not contain arsenic, and is treated at higher temperatures, one can still expect something approximately as hard as linotype.)

A good source of arsenic alloy is available in wheel-weight metal. Four lots of wheel weights examined during this study had the compositions shown in Table 4. The precise composition doesn't matter so long as there is enough antimony and arsenic to harden the lead. Bullets cast from the 1974 lot and heat treated at 482°F. for 45 minutes yielded a Meyer hardness of 39.6 after ageing 5 hours, and this agrees perfectly with the data in Table 1.

If you are unable to obtain wheel weights or prefer making the alloy from scratch, there is a best compositional range, based on mechanical and economical constraints. At the lower end, there must be enough antimony and arsenic to harden the lead. Judging from the performance of the wheel-weight metal shown here and other published results on heat treated lead alloys (12, 13), 2.5% antimony and 0.1% arsenic are practical lower limits. The upper bound is a little less definite. It makes little sense to add hardening alloys beyond the amount required to do the job, since that gains nothing in strength and serves only to increase cost and reduce sectional density. However, there is one practical consideration: if you anticipate remelting the alloy several times, there must be enough of these constituents to make up oxidation losses. Based on these arguments, 6% antimony and 0.3% arsenic can be regarded as practical maximums. Also, 0.25% to 0.5% tin should be added to reduce drossing. If you add much more tin than this, the eutectic temperature will be depressed which will limit the maximum heat treating temperature that can be used and hence limit its effectiveness.

There are two commercial babbitt metals which can provide arsenic for your alloy. One is arsenical lead babbitt (SAE 15) which contains 15% antimony, 1% tin, and 1% arsenic, the rest lead. The other is arsenical lead "G" babbitt, containing 12.75% antimony, 0.75% tin, and 3% arsenic. Both of these alloy readily with lead and provide a safe means for handling arsenic.

NEVER UNDER ANY CIRCUMSTANCES attempt to alloy lead directly with elemental arsenic or any of its compounds. Under normal atmospheric conditions, strongly heated arsenic sublimes; that is, it transforms directly from the solid to the gaseous state, emitting a highly toxic smoke. Leave this to the experts, and buy your arsenic in alloyed form such as the above babbitt metals.

Details of heat treating

To obtain the hardest bullets, you will wish to operate your kitchen oven at the highest temperature practicable for your alloy. That point is readily determined by using the alloy itself as a thermometer. Stand a few scrap bullets upright in the preheated oven and increase the temperature in increments from 425°F. At the first sign of melting, back off in small increments until you can repeatedly leave a batch of bullets in the preheated oven without any risk of melting. Then mark or record that thermostat setting so you can return to it. Note that very few home ovens have forced draft circulation and consequently hot spots are common. To avoid problems from these, place the bullets in the same location each time.

As explained, heat the bullets for a minimum of 30 minutes, then plunge them rapidly into a bucket of water. To insure proper quenching the bullets should be loosely stacked in a basket fashioned from heavy wire cloth. Be sure the stack isn't too high as this will impede cooling of bullets near the center.

Depending on the time, temperature, and alloy composition, a microscopically thin layer of lead oxide will form on the bullets. This tarnish has absolutely no effect on hardness or performance and, for all the benefits afforded by heat treating, the only thing you'll have to sacrifice is possibly a standard of aesthetic excellence.

Another method is also practical, that of hardening cast bullets by dropping them from the mold directly into water.

In 1958, James V. King published a short article (14) describing a method for heat treating cast bullets in which they were dropped directly from the mold into water. The advantage of this technique is obvious to any bullet caster; since the mold replaces the oven in conventional heat treating, the need for additional processing is eliminated. Furthermore, when used in conjunction with a lead-antimony-arsenic alloy, the bullets can attain a Meyer hardness in excess of 30.

Convenience is not the determining factor for using this method. Previous work published in the *American Rifleman* (2) indicates that sizing does not improve cast bullets and may even damage them. Even the least amount of sizing involves some metal movement and any part of the bullet so worked will soften, defeating the heat treatment. Thus, *oversize bullets must be sized first and then heat treated.*

Quenching from the mold

Conventional heat treatment provides a simple means for hardening cast bullets. The purpose of the additional heat and quench processing is to make up for the inadequacies of normal casting by causing antimony to precipitate more efficiently. But, if a bullet is quenched while still hot from the mold, very much the same result is accomplished as with normal heat treatment.

The temperature from which a bullet is quenched has a remarkable effect on its hardness. Once the bullet is cast, its temperature attempts to approach that of the mold and the rate at which it does this is proportional to the temperature difference between the two. A bullet will cool faster in a mold at 300° F than one at 400° F, and for equivalent times, it will be cooler when ejected from the 300° F mold. This means precipitation will be more advanced prior to quenching, detracting from the bullet's ability to harden. If the mold is maintained hot, more antimony will be retained in solid solution for hardening.

To demonstrate the influence of mold temperature on hardness, an experiment was devised in which bullets were cast under two temperature extremes, very hot and very cool. While instrumentation was available for recording mold temperature, this option was not utilized. Instead, temperature was judged in exactly the same way any bullet caster would do it, by looking at the bullet. For the "cool" condition, the mold was kept just warm enough to permit a reasonable fill with the bullets coming out shiny. A "hot" mold condition was judged to exist when the bullets became frosty over their entire surface. (To suggest that handloaders intentionally cast frosty bullets will likely raise a few eyebrows. But remember, frosting merely represents exaggerated grain growth and large grains can be made every bit as hard as small ones.) Once these conditions were attained, the casting rate was held relatively constant. These conditions and the molds selected are shown in Table 5.

All bullets were cast from alloy "A", consisting of 5% antimony, 0.5% tin, 0.17% arsenic, and the remainder lead, quenched in room temperature water. For safety, the bucket was located such that it was necessary to turn around, back to the pot, while ejecting the bullet. Done in this fashion, the probability of water splashing into the pot is remote and even if it does, metal cannot strike the face. The bullets were stored at room temperature and test samples were selected at random from each batch.

The results of the hardness testing are shown in Table 5. Bullets cast under cool conditions show no improvement over those allowed to air cool from the mold. Bullets cast hot, however, attain a hardness similar to those obtained by conventional heat treatment. As stated earlier, casting temperatures were judged. However, in a separate study, a thermocouple was attached to a single cavity mold to record its temperature during casting. Beginning at 205° F, casting speed was increased until the mold reached 430° F, at which the bullets became partially frosted. Thus, at least for this one case, the mold temperatures producing the desired hardness are on a par with those used in conventional heat treatment, emphasizing the importance of casting hot.

Table 5 also shows different bullets cast under hot conditions do not always attain the same hardness, in spite of every attempt to keep conditions the same. This, too, is a temperature effect indicating the onset of frosting varies from one mold to the next due to differences in casting technique, bullet geometry and mass, and the general thermal properties of the mold.

Due to the large number of bullet designs and mold types available, no attempt was made to examine a large number of molds. The data in Table 5 simply indicate that differences may arise. You should begin quenching your bullets after establishing a casting rhythm. If you break to flux the melt, return the first dozen or so bullets to the pot until rhythm and proper operating temperature are achieved.

Chemical Analysis of Various Wheel Weight Samples

Sample date and origin	Composition (weight %) Antimony	Tin	Arsenic
scrap, 1970	5.08	0.44	0.12
scrap, 1974	2.54	0.21	0.26
scrap, Jan. 1978	3.06	0.25	0.17
new, April, 1978	3.03	0.23	0.17

Table 4. Compositions of four lots of wheel weight metal obtained from gas stations. All provide a convenient, ready to use source of alloy for making hard bullets.

Lee C309-170F Cool Cast	Lee C309-170F Air Cooled from Mold	Lee C309-170F Hot Cast	Lyman 35875 Hot Cast
16.9 ± 0.1 @ 24 hrs.	16.2 ± 0.3 @ 24 hrs.	35.8 ± 0.8 @ 15 hrs.	28.0 ± 1.1 @ 15 hrs.
18.1 ± 0.5 @ 4.9 days	18.7 ± .1.2 Age unknown	33.2 ± 0.1 @ 8.6 days	31.0 ± 0.4 @ 8.6 days

Table 5. Illustrates the effect of mold temperature on the hardness of bullets water quenched directly from the mold. Quenching from a cool mold is no more effective than normal air cooling. Each average and standard deviation represents a minimum of four Meyer hardness readings.

Lead work softens

Sizing is an operation of fundamental importance to handloading. But while its hardening effect on cartridge brass is well-known, few handloaders are aware of its marked influence on the strength of lead.

For metals with high melting points; e.g., steels, brass, titanium, etc., working (within limits) imparts additional strength. Metallurgically, work hardening is caused by the generation of defects (called dislocations) within the metal's crystal structure. To remove the defects, the metal must be heated to a point known as the recrystallization temperature where new soft grains grow at the expense of the old hard ones. For cartridge brass this is 660°F which is sufficiently above room temperature that defects will remain in the metal unless it is intentionally annealed. But for lead, the recrystallization temperature is about -74°F (13), which means any part of a bullet worked at room temperature will soften spontaneously.

This phenomenon is readily demonstrated with a bar of pure lead about ½" in diameter. If the bar is bent sharply, there will be a pronounced increase in the force required to reverse the bend. If the bar is layed aside for about 10 minutes and again bent, there will be a noticeable drop in the resistance to bending, indicating that it has recrystallized and softened. Makers of hand-made benchrest bullets utilize this property to their advantage, letting core material stabilize between stages of the forming operations. This permits using minimal force to form the bullet, a factor important for best accuracy.

Work induced softening carries through for alloyed lead as well, the extent of which depends on the original hardness, alloy composition, time after casting and a host of other variables. Knowledge of this phenomenon is of general importance for an understanding of the metallurgy of cast bullets and is particularly relevant to this study since it determines the method of heat treatment used.

Hardness measurements and metallography were used to determine the extent of work induced softening for heat treated bullets subjected to increasing amounts of sizing. Specimens were cast from alloy "A" using a special set of oversized molds (Lee C-309-190F) supplied by Richard Lee of Lee Precision, Inc. All bullets were heat treated as a single batch at 464°F for one hour and sized in a Lyman 450 Lubrisizer using a 0.310" die. Since alloying tends to delay recrystallization, sized bullets were stored a minimum of five days before testing.

Hardness measurements were made on the driving bands and polished crossections of the bullets, precluding the use of a ball indenter of any practical size. A more suitable test for this experiment was the Knoop hardness test. The Knoop indenter is a diamond ground to the form of a pyramid which produces a diamond-shaped impression like those shown in Figure 7. Knoop hardness numbers are calculated as follows:

$$KHN\ (Kg/mm^2) = L/0.07028^2$$

Where L is the load in kilograms, l is the length of the long diagonal in mm and the constant, 0.07028, relates to the projected area of the impression. The load in this study was 0.050 kilograms.

How bullets deform

Assuming the handloaders is using a properly fitted nose punch and is careful not to ram the bullet against the depth stop thus damaging the base, sizing deforms bullets in two ways: (1) the surfaces of the driving bands are smeared due to die wall friction, and (2) the reduction in diameter broadens the driving bands and causes the bullet to elongate.

any sizing operation. In the case of cast bullets, lead is smeared over the surfaces of the driving bands and, in cases of extreme reduction, a thin ring of metal may be sheared from the bullet in spite of the use of tapered dies. Even where sizing is minimal, die wall friction represents a drastic form of deformation since it is localized to the surface. The hardness of this layer was measured on heat treated bullets subjected to various amounts of reduction and the results are shown in Table 6.

Surprisingly, the extent of softening bears no relationship to the amount of sizing and is equally damaging (in terms of hardness) for even small amounts of deformation. Under the microscope, it appears as a region of grossly worked metal varying from 0.001 to 0.002" in thickness, depending on the degree of sizing. This is illustrated in Figure 7 along with a series of indentations used to differentiate the hardness of worked and unworked metal.

A cursory examination of unheat treated bullets as well as some cast from linotype indicates smearing is a general phenomenon leading to softening in every case.

The second form of deformation is associated with the actual reduction in diameter. Since the metal is not compressable, it must move somewhere during sizing. Part of the movement is taken up in the driving bands which broaden by forward (toward the nose) displacement of lead. The remaining deformation causes the bullet to elongate in proportion to the amount of sizing as shown in Table 6. Depending on bullet hardness, metal flow is accomplished in two ways. Relatively soft bullets absorb the deformation more or less uniformly in the region of the driving bands, causing the grains to recrystallize over a period of time. But in hard bullets quite a different mechanism persists. To visualize it, imagine a large number of small stones glued together and fashioned into the shape of a bullet. When sized, the individual stones resist deformation and instead, slide across one another leaving a layer of rubble in the boundaries. Similarly, the grains of hard bullets resist deformation and slide across one another leaving a layer of highly worked metal in the boundary which recrystallizes shortly thereafter. The result is a bullet made up of hard grains bound together by soft lead and is a little better than if it had not been heat treated at all. Figure 8 illustrates this effect along with the hardness measurements used to differentiate between hard and soft material.

Of course the stone analogy is valid only to a point. In reality a small amount of deformation is borne by hard grains, a portion of which is permanently retained and causes them to soften over a longer time period. The remainder is absorbed by the spring in the metal and is regained when the bullet is ejected from the die, just as cartridge brass springs back upon ejection from a sizing die. Because of the mechanical characteristics of hardened lead and the short times involved in sizing, the amount of spring is relatively the same independent of reduction. Thus, as shown in Table 6, all the sized bullets had a finished diameter about 0.001" greater than the die used. Moreover, the effect is not unique to heat treated bullets but is proportional to the hardness of any cast bullet; consequently, soft bullets show very little spring.

By now it is probably obvious that a bullet's size, as it comes from the mold, has a direct bearing on the method of heat treatment used. *Bullets which do not require sizing may be hardened by dropping them directly into water; those which are too large must be sized first and then heat treated in an oven.* So long as the bullet's shape is not damaged, almost anything may be done to it prior to heat treatment. In fact, a bullet which has been heat treated and sized may be treated again to regain every bit of the original hardness. For convenience, a sizing press may still be used to seat gas checks and lubricate the bullet, but it is advisable to use a die which is about 0.001" larger than the bullet to preclude smearing.

Hardness changes during storage

The mechanism responsible for hardening bullets continues to operate during storage, causing the antimony precipitates to grow past the optimum size. Barring prolonged exposure to high temperatures, this growth is slow, leading to a gradual yet tolerable decrease in hardness.

This is illustrated in Figure 9 for bullets heat treated by both methods described in this investigation. For bullets cast from alloy "A", even the most conservative

As-Cast Diameter	Reduction Due to Sizing in 0.310" Die	Increase in Length	Knoop Hardness of Smeared Surface Layer
.312"	Not sized	0	37.7 ± 1.7 (Kg/mm^2)
.312"	0.0010"	0.001"	12.7 ± 0.7 (Kg/mm^2)
.313"	0.0020"	0.003"	12.7 ± 0.7 (Kg/mm^2)
.315"	0.0040"	0.006"	12.1 ± 1.0 (Kg/mm^2)
.3175"	0.0065"	0.009"	11.8 ± 0.3 (Kg/mm^2)
.3185"	0.0075"	0.011"	11.9 ± 0.4 (Kg/mm^2)

le 6. Some effects of sizing hard bullets are shown here. Within the statistical scatter of the ness measurements, softening of the driving band surfaces is independent of the amount eduction. Each average and standard deviation is based on a minimum of four Knoop surements made directly on the unpolished surface of the driving bands.

extrapolation of the data show it will take about two years for the hardness to fall into the range of linotype regardless of the heat treating technique.

To retain maximum hardness, bullets should be stored in a cool place away from large thermal fluctuations. You can even store them in a freezer, in which case softening will be subdued considerably. Just remember to let them warm up to room temperature before loading to preclude trapping moisture inside the case.

In shooting for tight groups at the highest cast bullet speeds, you may want to avoid using very old bullets. Since heat treatment takes less time than casting and is convenient in small batches, the problem is overcome by casting and sizing (only if necessary) and storing the unlubricated bullets as-cast. Bullets may then be heat treated, lubricated and loaded shortly before shooting. Also, should you ever be uncertain about the hardness of long-stored bullets, they can always be heat treated again.

The following summarizes the major aspects of this paper.

1) The properties of lead and its alloys are best understood if the metal is always thought of as being hot, even at room temperature.

2) Each of the alloying metals, antimony, arsenic and tin has a specific purpose:

a) Antimony is the principal hardening agent and is most useful in amounts not exceeding about 6%.

b) Small amounts of arsenic, together with antimony, improve hardenability. Arsenic should only be used in prealloyed form; e.g., wheel weight or bearing metal.

c) Tin contributes little to strength but helps reduce dross during casting. Too much tin increases alloy cost and reduces the maximum heat treating temperature.

3) Lead hardens by the precipitation of minute crystallites, in this case antimony, within the grains. A bullet's strength is directly influenced by the size and distribution of the precipitates and these are controlled by proper heating and quenching.

4) The hardest bullets are obtained at the highest temperatures. In conventional heat treatment, the oven must be as hot as the alloy will permit; quenching from the mold requires the hottest casting conditions practicable. In either case the bullets must be rapidly quenched in water.

5) Sizing softens hard bullets. Therefore, oversize bullets must be sized first, then heat treated; those which cast to proper dimensions may be heat treated by either method.

6) Long-term softening is gradual enough to make heat treated bullets practical and cost effective when compared to those made with linotype. ●

ACKNOWLEDGEMENTS

The author wishes to give special thanks to Richard Lee, of Lee Precision, who contributed equipment and materials used; Dr. Guy McDonald and Anthony Matuszewski for their comments and suggestions, and to A. Ortiguera for the metallography.

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The Tin In Your Cast Bullets

(12X) The stainless steel ball used for hardness testing, shown here on the nose of a Lee C309-170F bullet. The indentation shown is 0.39 mm. in diameter and with the 4 kg. load corresponds to a Meyer hardness of 33.5.

By Dennis Marshall

Since the *American Rifleman* first published in 1957-58 its findings on factors affecting cast bullet accuracy in rifles, handloaders have become aware of the question of lead alloy strength. The once traditional, low strength lead-tin alloys have been replaced with lead alloys strengthened primarily by antimony. Yet tin is still an important ingredient in cast bullets, and it is interesting to compare tin's role in lead-tin alloys with that in presently used compositions such as wheel weights or linotype.

Maximum hardness of lead-tin alloys is 17 BHN at 37% lead and 63% tin, the eutectic composition. Mixtures generally used by bullet casters range from 9 to 12 BHN, depending on casting conditions and impurities. But these values can be misleading, since a breakdown in the precipitation hardening process causes the bullets to soften shortly after casting.

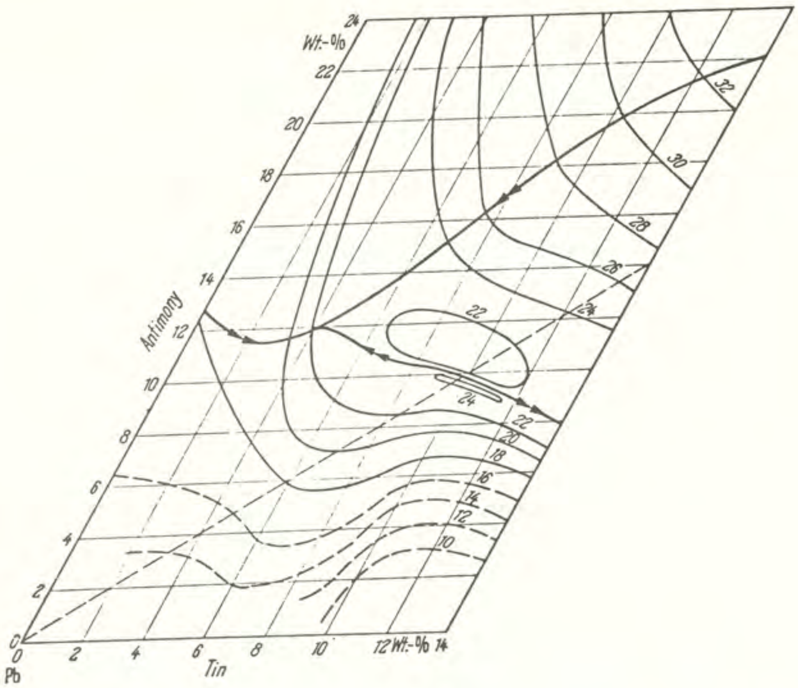
During casting, the tin portion of a lead-tin alloy divides; part of it is retained within the lead grains which make up the bulk of the bullet while the remainder segregates to the grain boundries as lead-tin eutectic. While the lead grains are still hot, immediately after casting, they dissolve a large amount of tin. However, the solubility of tin in the solid lead decreases with temperature, and when a bullet cools its lead grains are left with an excess of tin which must be rejected from solution. In the process of being rejected, tin is trapped inside the lead grains and is unable to make its way to the grain boundries. Thus constrained, tin forms particles or precipitates in the midst of the grains.

Permanent deformation, such as engraving a bullet by the rifling, and upset through obturation, occurs by movement of imperfections through the grains. Lead can be made stronger if the movement of these imperfections can be blocked. Tin precipitates act as barriers to the movement, and thereby help the bullet resist deformation.

Precipitation hardening depends on a number of complex factors. An important one of these is the strength of the precipitates; stronger precipitates harden better. Unfortunately, the strength of tin is only on a par with lead. Published hardness figures of lead vary from 4.2 to 5.0 BHN, but the differences are of little consequence. Imperfections moving through the lead grains meet relatively weak tin obstacles. Strength imparted is due to other factors such as the shape of the precipitates.

For a short time after casting a bullet, the tin precipitates grow, hardening the alloy to a level roughly twice that of pure lead. But as they grow, internal strains are generated within the bullet which cause the lead grains to recrystallize, a process analogous to annealing case necks. During recrystallization the tin in the lead grains forms new, overly large precipitates by a process called cellular precipitation, and these are unable to strengthen the bullet. Since this process occurs randomly throughout the bullet, some grains soften before others and the overall result is a gradual reduction in hardness.

The accompanying graph illustrates the



Brinell hardness of lead-tin-antimony alloys is complicated by the fact that tin combines with antimony during solidification to form an intermetallic compound, which contributes to the strength of the alloy.

age softening of two compositions in the as-cast condition. It points out in specifying the hardness of a lead-tin alloy that age after casting must also be considered. The rate of hardness decline is less for lower compositions since there is less tin dissolved in the lead grains, and consequently less precipitation and strain. Time did not permit continuation of the study to determine when the hardness stabilizes. However, a computer prediction based on these data indicates it will take 372 and 854 days respectively for the 1/16 and 1/10 alloys to soften to about 8 BHN. Changes beyond the limits of the graph are likely to be small.

Unlike lead-antimony alloys, this lower strength condition cannot be improved by heat treatment. In fact, heat treating actually makes matters worse for higher compositions, causing bullets to soften even faster than those left in the as-cast condition.

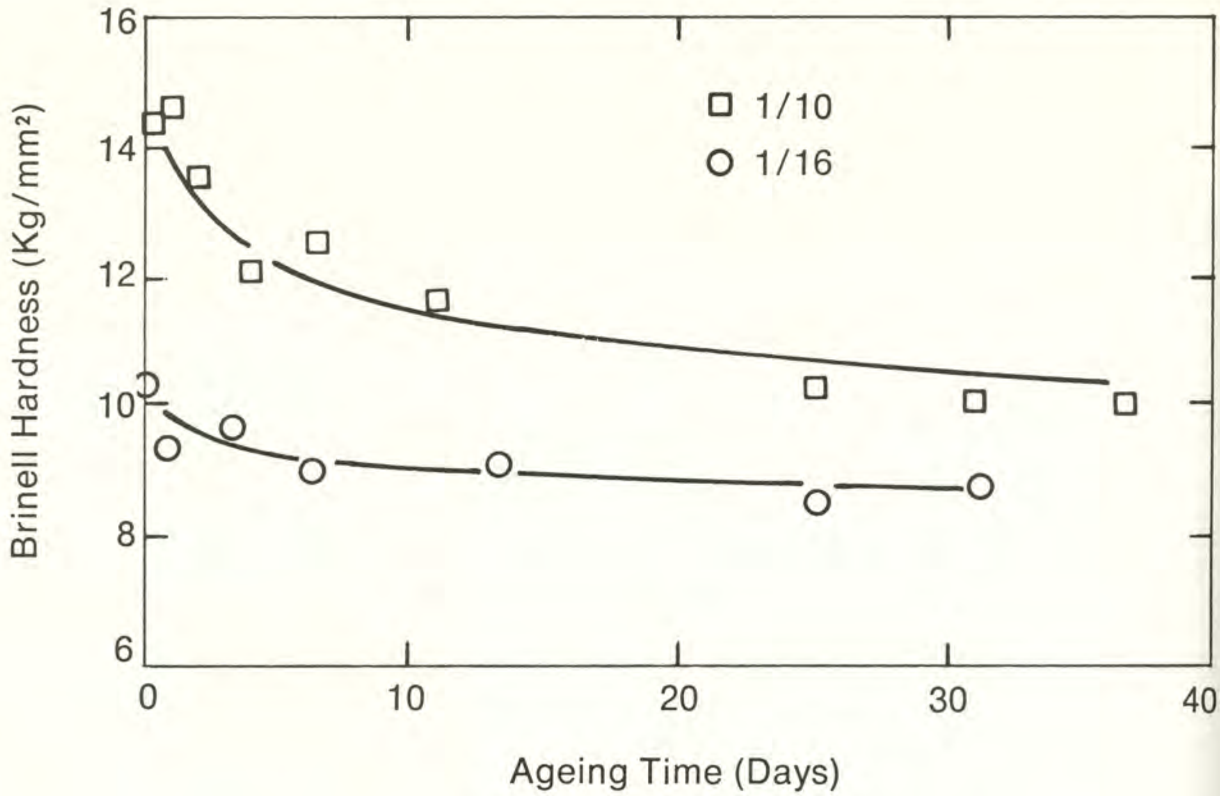
Recrystallization and subsequent softening in lead-tin alloys is entirely spontaneous. There is no practical way to stop it. The process could be slowed by storing the bullets in a freezer, but the benefits would hardly be worth the effort.

Tin plays a considerably different role in type metals, improving not only the casting properties but also contributing to the strength. Unlike lead-tin alloys, the microstructure of type metals does not contain weak tin precipitates. Instead, tin combines with antimony during solidification to form an intermetallic compound, SbSn, which is approximately the same hardness as antimony, as noted in the table.

SbSn is one of three possible constituents in the microstructure of type metals; the other two are lead and antimony. For alloys like linotype, part of the strength is attributed to precipitation hardening of the lead constituent; i.e., hard antimony and SbSn precipitates form within the lead to strengthen it. Compared to tin, these hard precipitates are very effective in hardening lead. The remainder of the strength is imparted by large antimony and SbSn particles.

Within certain constraints, raising the tin and antimony content increases hardness. However, the greatest hardness increase per unit alloy addition occurs when antimony and tin are added in equal proportions. The effect is most noticeable when the combined antimony and tin content exceeds about 12%. The microstructure of such alloys consists of precipitation hardened lead and hard SbSn particles; there are no antimony particles present. If cost were no object, the tin content of linotype could be increased to 12%, matching the antimony content, and increasing the hardness about 2 Brinell numbers.

For tin/antimony ratios greater than one, SbSn is the principle hardening agent, but a fraction of the tin will precipitate as in the lead-tin alloys. As the tin content increases, so do the tin precipitates with no corresponding improvement in strength. It is for this reason, as well as cost, that type metals never contain more tin than antimony. Alloys with higher tin contents are usually



This illustrates the softening of bullets made from lead-tin alloys. Both alloys were cast in a Lyman 35875 mould and the hardness measurements made directly on the bullet meplat. Each data point is the average of five measurements. Test conditions: 4Kg load/1.17mm ball/30 sec.

classified as solders or tin based babbitts.

Hardness of type metals is relatively stable. They do not show the sharp decline in strength associated with lead-tin alloys. Instead, they soften slightly with time as the antimony and SbSn precipitates grow past their optimum size within the lead grains. Cellular precipitation in type metals or other lead-antimony alloys has not been reported.

Casting qualities of type metals have contributed much to their popularity with bullet casters with linotype being the all-time favorite. Antimony has often been credited for imparting good castability. Some older references state that antimony expands on freezing. This is probably what led to the fallacy that linotype casts well because it expands when it solidifies to fill the mould details. It is now known that antimony does not expand on freezing, in fact it contracts 1.23%. Likewise all type metals contract on freezing; linotype, for example, contracts about 2%.

The real credit for castability should go to tin. Tin's first and most general contribution is that it minimizes surface tension by inhibiting oxidation of the metal entering the mould, allowing better fill-out. The second benefit pertains principally to linotype. Linotype possesses exceptional fluidity; i.e., under a given set of conditions, it will flow better than all the other type metals. Tin's function here is that it places the composition of the alloy in a unique position among lead-antimony-tin alloys. The composition 84% lead, 12% antimony and 4% tin corresponds to the ternary eutectic which means it melts and freezes at a single temperature (464° F). Thus, it is the high fluidity, in combination with oxidation protection, which accounts for linotype's ability to produce such beautifully formed cast bullets.

Tin is also present in small amounts in wheel weight metal where its principal benefits are dross protection and castability. A pure lead-antimony melt drosses considerably and the few tenths of a percent of tin present reduces this by forming a tight tin oxide layer on the melt surface which is most effective up to about 750° F. (This also applies to type metals.) In the pot, the tin oxide layer helps prevent excessive oxidation of the more important antimony constituent, and in this sense tin plays a sacrificial role. This is not to say antimony, and lead, are not oxidized in the presence of tin; the rates are simply reduced. As with the type metals, this oxidation protection mechanism also operates while the metal is filling the mould to improve castability.

Most wheel weight metal contains sufficient tin to provide these benefits. However, if you have recycled your alloy a few times it is often beneficial to add .25% (¼ of 1%) tin to the melt to maintain oxidation protection. Some bullet casters report that as much as 2% tin must be added to wheel weights to get good castings. Personal preferences regarding the amount to add are probably influenced as much by casting technique and mould geometry as anything else. Suffice to say, you should add the minimum amount which provides good bullet production. Start with .25% and work up as casting dictates.

Bullets cast from wheel weights derive most of their strength from the precipitation of antimony within the lead grains. The amount of tin present is usually too small to precipitate and remains dissolved in the lead grains. If excess tin is added; e.g., to modify casting behavior, it will react with the antimony, just as in type metals, to form SbSn.

In conclusion we find that while tin alone is of limited value for hardening lead, it still has benefits when added in proper measure to bullet metals containing antimony. Dross protection, strength (principally in type metals) and castability are all favorably influenced. And even if this were not the case, most of us would still add a pinch or two for tradition's sake. •

The Truth About Wheel Weights

Dennis Marshall

Wheel weights provide an economical and convenient source of raw material for cast bullets. They can be used as-is for most applications, or easily modified for improved casting by small additions of tin for the more exacting requirements of rifle target shooting. Yet there remains much misunderstanding regarding composition and dirt inclusions which cause many shooters to shy away from this source of material. What follows here will help to clear the air about wheel weights.

The wheel weight composition of 9% antimony listed in older editions of the *Lyman Reloading Handbook* is very much out of date. Manufacturers have reduced the alloy content through the years. This has not caused any problems in using this material for cast bullets. However if you are using the Lyman formula which includes wheel weights for making No. 2 alloy, the resulting alloy is deficient in antimony. Lyman has revised the formula for No. 2 alloy in the latest edition of the *Lyman Pistol and Revolver Handbook* to reflect the change in wheel weight composition.

Compositions of four different batches collected over an eight-year period are listed. Agreement between the last two analyses suggests the composition of wheel weights has stabilized in recent years. Unless you have altered the composition of your wheel weight metal, you can assume antimony is the principle alloying element. If you have an old batch, it may contain as much as 5% antimony, but recently obtained wheel weights will average about 3%.

Each element in wheel weight metal has a purpose. Antimony precipitation hardens the alloy, tin provides dross protection for the melt up to about 750° F and also improves castability, and arsenic, in combination with antimony, improves strength. In the as-cast condition arsenic raises the hardness about one or two Brinell numbers, providing a benefit normally requiring larger amounts of antimony. Arsenic alone is a poor hardening agent for lead, but its inclusion in antimonial alloys improves the efficiency of antimony precipitation and, consequently, increases the strength.

There is no advantage in trying to increase the arsenic content. In addition to being very dangerous, the mechanical properties are not improved by arsenic contents in excess of 0.1%, thus wheel weights contain all that is needed.

On learning that wheel weights contain arsenic, the skeptic may conclude that such a "contaminant" renders the alloy unsafe. SURPRISE! Antimony is every bit as toxic as arsenic and there's lots more of it in the alloy. Those who mix up their alloys from elemental metals should take special note of antimony's toxicity and should observe especially good hygienic practices. Fortunately, alloying dilutes the toxic effect to a point where handling bullet casting alloys is reasonably safe. But remember to wash your hands, keep your work area clean, and provide adequate ventilation during casting.

Table I
Chemical Analysis of Various Wheel Weight Samples

Sample date and origin	Composition (weight %) Anti-mony	Tin	Arsenic
scrap, 1970	5.08	0.44	0.12
scrap, 1974	2.54	0.21	0.26
scrap, Jan. 1978	3.06	0.25	0.17
new, April, 1978	3.03	0.23	0.17

Table II
Results of adding tin in the form of bar solder to the Jan., 1978 wheelweights

Composition	Brinell Hardness*	Casting Quality
wheel weights + 0% tin	12.4 ± 0.6	Fair
wheel weights + 0.5% tin	12.4 ± 0.6	Good
wheel weights + 2.0% tin	13.6 ± 0.1	Good

Table 2 shows the effects of tin additions to the Jan. 78 lot of wheel weights. Tin was added as 63/37 bar solder so the antimony content was diluted somewhat by the addition. While the higher tin content improved casting, there was no real effect on strength; the hardness increase for the 2% tin addition is not statistically significant.

If you add tin to improve casting, its content should not exceed the percentage of antimony in the alloy. Judging from the composition of present day wheel weights this means 3% tin should be the maximum. If you need more tin than this to get good castings, you are doing something wrong.

Opponents of wheel weights often claim dirt inclusions are a disadvantage, suggesting grit in the cast bullet may damage the bore. These claims come primarily from those who have not used wheel weights rather than those who have. I personally have fired thousands of cast bullets made from wheel weights through various rifles and handguns and have never noted any loss of accuracy or visible bore damage. If dirt was a significant factor, one would expect abnormal abrasion over the entire length of the bore, premature rounding of the lands and increased metal fouling, which could be observed with an interior borescope, but none of these appear.

Admittedly, wheel weights are dirty when purchased, but they are easily cleaned. Liberal fluxing during the initial melt-down and again during casting separates impurities from the melt, and leaves a bright surface which readily reveals the presence of foreign matter. It is also advantageous to scrape the walls of the pot during fluxing to dislodge particles trapped beneath the melt surface. From then on the metal is no more likely to have significant dirt inclusions than any other source of bullet casting alloy.

Microscopic examination of both the cross section and surface of cast bullets indicates dirt from the surroundings is a far more likely source of contamination, and one which affects all alloys. Sweeping the floor of your loading room with an uncovered box of lubricated bullets on the bench is a real no-no! Handling the bullets with dirty hands is also bad practice. Lead alloy surfaces are quite soft and will pick up dirt from just about anything they rub against. After all, embeddability is one of the primary reasons for using lead alloys in bearings.

Metallurgically or otherwise, there is no justifiable disadvantage to using wheel weights. When properly prepared and handled, they provide all the flexibility needed for a variety of cast bullet needs and permit more shooting for your dollar.

Cast Bullets Must Fit The Bore

Size is More Important than Shape

By Robert N. Sears

Cast bullet shooters often buy a succession of molds. The hope is always that the bullet of the next design will give fine accuracy in their particular rifle. Repeated disappointments can be avoided and the chances of success greatly improved when it is recognized that a cast bullet's dimensions are more important than its form. The bullet must fit the bore.

Proper fit is necessary to maintain the bullet's alignment in its travel down the barrel. Any tilt of a bullet's axis relative to that of the bore is accentuated during its flight through the air. Reliable grouping is then impossible.

Cast bullets, probably because they are relatively soft, require a longer bearing length than jacketed bullets to provide proper alignment. The most successful cast bullets for use in rifles firing fixed cartridges have a bearing length of at least twice their diameter. The driving bands at the rear of the bullet are always larger than the bore diameter so they always form part of the bearing length. But the driving band portion of most bullets is less than two diameters long, leaving the cylindrical bore-riding portion to make up the difference.

To contribute effectively, this cylindrical portion between the foremost driving band and the nose ogive must ride on and be guided by the tops of the rifling lands. In other words, its diameter must be at least as large as the bore. Too often it is not. In many .30 cal. bullets it measures .299" or less while the rifle bore measures at least .301".

Unfortunately, more attention is usually given to the diameter of the driving bands which are sometimes sized and measured to within .0005". This can be futile when the diameter of the bore-riding portion is ignored. The driving bands contribute to the bearing length in any event, but the forward cylindrical portion contributes only when it fills the bore.

A most revealing check of a bullet's fit can be made by simply placing it nose first into the rifle muzzle. If it drops in of its own weight up to the driving bands no more than mediocre accuracy can be expected. The lands should, at least, provide felt resistance to thumb pressure. This very effective check requires no measuring devices and provides instant preliminary information on a bullet's

Cylindrical part of the bullet is expanded to fit the bore as the driving band portion is sized and lubricated. The driving bands are always large enough to contribute to the bullet's bearing length but the cylindrical portion is often too small in diameter.

suitability for that rifle.

If it passes the muzzle check, test the bullet's fit at the breech. This is the critical point. Many barrels have bore diameters larger at the breech end than at the muzzle. Some leave the factory so tapered. Erosion tends to wear them all that way. Seat the bullet in a sized empty case and chamber it in the rifle. A slight resistance felt as the breech is closed gives an indication of proper fit even before the extracted bullet is examined.

The lands should mark the bore-riding cylinder evenly to the point where it joins the nose portion. The farther rearward the marks extend the better. Any amount of interference which does not result in leaving the bullet in the bore when a loaded cartridge is extracted does no harm. Cartridges which debullet when extracted are unacceptable in the hunting field, but often give splendid accuracy for target shooting where it is unnecessary for loaded rounds to be extracted from the chamber.

Molds which cast the cylindrical portion of the bullet smaller than the bore by only .001″-.002″ can often be improved by lapping. This can also help to correct out-of-roundness present in many molds.

An alternative which does not require modification of the mold is to expand the cylindrical portion of bullets after they are cast. This has been successfully done with ordinary lubricator-sizer tools adjusted so that pressure is exerted on the bullet nose at the end of the sizing stroke. The driving bands are then fully supported in the sizing die so the resulting compression expands only the unsupported cylindrical portion. No addition to the tool or change in the usual lubricating-sizing operation is required. Expansion is controlled by feel.

More uniform expansion is possible when the tool is provided with a positive means of controlling ram travel. A dial indicator may be set up to measure its stroke while the bullet is being compressed. Another method is to attach an adjustable stop collar over the upper part of the ram.

The special top punch shown here was made to positively limit expansion of a .30 cal. bullet's bore-riding portion to .302″, and to keep this diameter truly cylindrical. Ordinary top punches cover only the bullet nose which allows metal to move at its point of least resistance. This often results in a bulge at some point along the bullet's bore-riding section.

Use only enough force to barely expand the bullet. Excessive force not only causes the bullet to stick in the special top punch described here, but can also break the toggle linkage of the lubricator-sizer. Hardness of the alloy and the volume of metal displaced are the two factors limiting the use of ordinary lubricator-sizers for expanding or "bumping up" cast bullets. The yoke of one tool which had expanded several thousand .30 cal. bullets broke after expanding only a few .45-70 bullets of the same hardness. For the more demanding applications it is worthwhile to make special expander dies threaded ⅞″-14 for use in standard reloading presses. This requires that expanding be done as a separate operation after lubricating and sizing the bullet, but the problem of tool breakage is completely eliminated.

A very favorable result of expanding cast bullets is that it tends to improve their quality while correcting a critical diameter. This is quite opposite from the effect of sizing them down which never helps, and if excessive greatly detracts from, a bullet's shooting performance.

The requirement for an effective bearing length of at least two diameters applies mainly to cast bullets loaded in fixed cartridges. Bullets loaded from the muzzle with a guide starter are aligned with the bore by the loading procedure. Even conical shaped "picket" bullets having a bearing length of less than one-half their diameter give outstanding accuracy when their alignment is properly established in a false muzzle and maintained while being pushed down the bore with the ramrod.

Breech seating the bullet into the rifling with a guide starter as a separate operation before chambering the powder-charged cartridge case as allowed by American Single Shot Rifle Association rules can provide the same kind of initial guidance.

With fixed ammunition, as required by Cast Bullet Association rules, the bullet's alignment is always subject to influence of the cartridge case. Even when the inside of case necks are uniformly concentric with the outsides, misalignment of the chamber with the bore or case body within the chamber will tilt the bullet at the critical moment it starts down the bore. An effective bearing length of at least two diameters (three is much better) serves to overcome unwanted influence of the case.

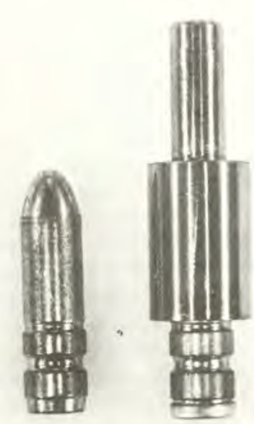
The Lyman #311335 shown here is typical of the two-diameter bullets used successfully in .30 cal. fixed cartridges. Its total bearing length (including the gas check) is 3.2 diameters. More than half of this length is in its cylindrical bore-riding portion.

At the 1978 Cast Bullet Association National Matches, I used this bullet in a Remington 40X rifle. 7.62 mm Match cases loaded with 24-grs. of Reloader 7 powder and Federal match primers gave the 202-gr. bullet an instrumental velocity of 1907 f.p.s. The four 10-shot targets (two at 100 yds. and two at 200 yds.) which won the open class. Group Grand Aggregate averaged .876 m.o.a.

This and other bullets designed 75 years ago perform splendidly if their dimensions are correct. Success with cast bullets does not depend upon minor variations in shape, but rather upon how well their diameter and bearing length align them in the bore.

10-shot group at 100 yds. measures .580″. Fired by the author Sept. 16, 1978 at the Cast Bullet Association National Matches.

Cylindrical part of a cast bullet must not enter the rifle muzzle. This simple check for bore fit requires no measuring devices.



Specially bored top punch controls expansion of cylindrical bore-riding portion of the bullet when it is sized and lubricated.

Casting Pistol Bullets

BY C. E. HARRIS

CASTING bullets to use for competition pistol loads is far different than making them for informal plinking. Although carefully selected and loaded cast bullets can approach the accuracy of factory wadcutter loads, I have seen many shooters use cast bullets which could only be described as abominable. The most important aspect affecting accuracy of pistol loads is bullet quality. If you use cast bullets for match loads, you must be especially careful to inspect them for defects. Those with even the slightest imperfection should be culled out for practice, and any with obvious wrinkles, voids, etc., should be returned to the pot.

Bullet casting, in spite of its drawbacks, is one of the best ways for pistol shooters to shoot more for their money. If you prefer to use factory swaged lead or jacketed bullets of proven accuracy for your match loads, you still may want to use cast bullets for practice, to save money.

Bullet casting is not the awesome task it might seem to the novice. You can learn to cast good practice bullets in a short time, and experience makes the task easier and the product better. You need at minimum, a bullet mold, lead, a wooden or rawhide mallet to open the mold with, a cast iron pot to melt the lead in, heat source, such as a gas stove, and a sizer-lubricator to render the finished castings into a completed projectile. Other things you will accumulate as you gain experience.

Although single-cavity molds are adequate for the occasional shooter, the target shooter needs a higher production rate than the single cavity provides. Double-cavity or four cavity molds are reasonably priced and serviceable. Commercial casters and serious competitors will prefer Hensley & Gibbs gang molds. Their casting qualities are outstanding. If you can find a second-hand H&G mold in good condition, don't pass it up!

Four-cavity gang moulds make fast production easy. Hensley & Gibbs, Lyman, Saeco and NEI are popular suppliers of pistol gang moulds for target shooters. A bottom pour pot of large capacity is desireable to get best performance from multicavity moulds.

Casting should always be done with good ventilation; outdoors is ideal. In the winter I cast in my basement in front of an open window with an exhaust fan running the whole time, and another window cracked for draft.

A gas stove, such as a single-burner Coleman, used with a cast-iron pot and dipper works satisfactorily for bullet casting, but I prefer an electric furnace which permits controlling the temperature. Among the lower priced furnaces the Lee Production Pot works well, but I find it awkward to use a dipper with it, and it is somewhat more inconvenient to clean, as you should do occasionally. Lyman, Saeco and RCBS sell electric furnaces which work very well. The Lyman and standard Saeco pots hold 11 lbs. of alloy and permit use of either a dipper or the bottom pour spout. Saeco also makes a larger 20-lb. utility furnace for use with a dipper. I find it particularly convenient for melting down large batches of metal to mix alloy and cast ingots. You can lift it by the bail and pour ingots directly from the pot. The RCBS pot, made by Ohio Thermal, was formerly sold under the name Pro-Melt, and is an excellent furnace with large 22 lb. capacity. Although this is larger than many shooters would need, it doesn't take as long to empty this monster when using a .45 gang mold as you may imagine. Serious bullet casters will find the RCBS-Pro Melt excellent, though I have used all of the above brands and find them entirely satisfactory for the money.

Your bullet alloy deserves some consideration. Uniform, repeatable accuracy from batch to batch of handloads requires bullets of the same weight, quality and hardness. Therefore, you must find an alloy which casts well and which you can duplicate time after time. Although revolver bullets loaded below 800 f.p.s., as for .38 wadcutter ammunition, can be made of almost any alloy which will cast well, automatic pistol bullets must have suitable strength and hardness to avoid leading in the shallow-groove rifling of .45 automatic pistols, and to minimize feeding problems caused by the bullets' stubbing against the feed ramp.

The minimum hardness which I have found completely satisfactory for .38 or .45 wadcutter loads for use in automatic pistols is about 12 BHN. This is the

Knock off the sprue with a wooden mallet after giving it enough time to harden completely. Premature cutting of the sprue smears semi-molten metal across the blocks and damages bullet bases. Drop the sprue into a box for easy recovery and subsequent remelting.

hardness of straight wheelweight metal of current composition, consisting of about 3% antimony, 0.25% tin and 0.17% arsenic. Swaged lead factory bullets are usually softer, about 10 BHN. Older wheelweights contain higher percentages of antimony and tin. An analysis of a sample obtained as scrap in 1970 revealed them to contain 5.08% antimony, 0.44% tin and 0.12% arsenic, which is about 14 BHN, or slightly softer than Lyman No. 2 alloy.

If you obtain your wheelweights as scrap metal from service stations, the hardness will vary, since there will be some old weights and newer weights mixed randomly in the same batch. Best uniformity is obtained by combining wheelweights into as homogeneous a batch as possible, using a plumber's pot to melt all the metal at once before cleaning, fluxing and casting into ingots. You can also melt it in smaller batches in the electric furnace, recombining the ingots from the different melts in a second cleaning and mixing operation. There is no risk of bore abrasion from use of properly cleaned wheelweight metal.

Once wheelweights are cleaned and remelted, the small amount of tin originally present in them is usually lost through drossing. It is usually necessary to add additional tin to get good castings. As little as ½% will do if you keep the pot temperature below 750°F to minimize drossing and if you don't cool down and subsequently remelt the alloy. If you mix all your alloy ahead, as I do, you should use a bit more tin to be sure there is enough left in the alloy to provide good castings after subsequent remelting. I usually add 1/3 bar of 50-50 solder to a potfull (11 lbs.) of wheelweights, which comes out to about 1½% tin added to the basic wheelweight metal. This works very well for most pistol bullets and raises the hardness about one Brinell number. As a check on your alloy, pick out five of your most perfect bullets, weigh them, and record the average as a reference. If subsequent bullets from another melt, using the same mold, cast significantly lighter, say more than 2% from the previous average, add some pure lead to the mix and check the weight with another sample. If they cast heavy, add tin or antimony in the form of solder or linotype metal to increase the alloy content accordingly until they come out right. Usually only a small amount of metal is needed, perhaps only a ½ lb. to 10 lbs. in the pot to make a satisfactory adjustment.

A common mistake many bullets casters make is to cast with the metal too hot, or with the mold overheated. If you must heat your metal above 750°F to get good castings, you are doing something wrong. If the mold is too hot you may get "hot spots" or frosty areas on the casting. Provided the bullet is lightly and *uniformly* frosted, hot casting doesn't do any particular harm, but frosted bullets generally cast somewhat smaller than shiny ones. If the frosting is not uniform, the bullet will usually be out of round.

I like to start casting with the metal around 700°F until the mold is heated enough to produce well filled out bullets, then I turn it back to the lowest temperature which produces good castings, usually about 625-650°F with my wheelweight and tin mixture. I always alternate between two molds, filling one and setting it down to let the sprue cool completely while I open and refill the other. This prevents the mold from overheating and permits a more uniform casting condition. Using this technique, I can cast good, full shiny bullets until the pot runs dry or my arms get tired. Using a pair of four-cavity molds and two 11-lb. furnaces (letting one warm up to temperature while you cast from the other), an expeienced caster can turn out 1000 good .45 ACP or .38 wadcutters between breakfast and lunchtime.

Good castings require you keep the metal clean and fluxed; otherwise, there is risk of getting dross into the mold if you are using a dipper, and you will otherwise lose alloying elements through oxidation. I like to flux about every 15 minutes, or whenever I add metal to the pot. Bullet lubricant, or any wax will do, but non-smoking fluxes such as Marvelux are more effective and far more pleasant to use. If casting outdoors where smoke is not a problem, I keep a few rejected lubed bullets and drop one in the pot once in a while to flux the alloy. Always scrape the sides and bottom of the pot well to dislodge impurities for skimming.

The basic technique of bullet casting is easily learned with a bit of practice and soon becomes natural. The mold must be clean and free of any oil or grease. I like to clean new molds by boiling in water with Ivory flakes or Oakite. Cleaning them in Cascade with an automatic dishwasher also works well. Remove the mold blocks from the hot water and shake dry, being sure they are *completely* dry before using them, since any latent moisture is potentially dangerous when combined with molten lead! To avoid constant recleaning and degreasing, don't oil your molds for storage, but store them in an air-tight container, wrapped in VPI paper to protect them from rust.

Resting your mold blocks on top of the furnace while the metal heats up helps preheat the mold, reducing the time necessary before getting good castings. I routinely reject the first ten or so castings from each cavity, as it usually takes this many before the bullets come out perfectly filled and sharp. I knock the sprue and rejected bullets into a large wooden box for later remelting, and to keep from littering the bench. Good bullets are dropped gently on a folded towel, to prevent damage, and are removed to a box as soon as they are cool, so they aren't damaged by having subsequent bullets drop onto them.

As you fill the mold, overflow it to leave a large puddle, keeping the sprue liquid as long as possible to reduce shrinkage voids. Allow plenty of time for the sprue to harden, and never knock off the sprue until it is completely solid. Cutting off the sprue prematurely smears semi-molten metal across the blocks and bottom of the sprue plate, and causes damaged, out-of-square bullet bases. If using only one mold, wait at least 10 seconds before cutting the sprue, once the mold is up to casting temperature.

After knocking of the sprue, inspect the bullet bases before opening the mold. Any bullets with rounded, ragged, imperfect bases, or with pinholes which indicate a void underneath, should be rejected. Then open the mold, check the sides of the bullets, making sure they are clean, sharp and well filled out. Drop the best ones onto the towel into the "keeper" pile. When the pot gets down to half full, fill your mold and leave it, to retain as much heat as possible, then return the sprue and rejected castings to the pot. While waiting for these to melt, I again inspect the castings, looking for those with only minor imperfections which go into a "practice" box, while those which are perfect go into the "match" box. Any with gross defects I missed before go back into the pot for remelting. In the time it usually takes to inspect the castings and sort them, the scrap is melted and the pot is ready for fluxing. Once the metal is fluxed and hot enough to pour freely, you are ready to start casting again, usually within five minutes.

After opening the mould, inspect the bullet bases to be sure they are clean, sharp and well filled out, without any wrinkles, voids, caused by not having the mould or metal hot enough; or frosting, smears or fracturing caused by having mould and metal too hot.

Drop the bullets from the mould onto a soft surface, such as a folded towel or piece of old carpeting, to prevent damage. Remove them to a box as soon as they are cool enough to permit inspection and culling. This minimizes damage by dropping bullets on them.

After casting, the bullet still isn't ready for loading, since it must be sized and lubricated. Ideally, the bullet should cast perfectly round and the correct diameter. It should require very little or no sizing, the die only serving to true it up and rub the large spots slightly. It is best to slug your pistol barrel to determine the proper sizing diameter but generally .45 ACP bullets should be sized .451", .38 Spl. bullets for semi-automatic pistols .357", and for most revolvers, .358". If you slug your barrel, size bullets no smaller than the groove diameter. It is best to size them .0005" larger, but not more than .001" larger than groove diameter, unless the mold casts very large. In that event, it is better to shoot a bullet which is somewhat oversized than to size it excessively. You should not size the bullet down more than .0015" from the as-cast diameter if you desire best accuracy. This is not always possible. Some Lyman molds may cast as large as .360" in .38 Spl. or .454" for .45 ACP, leaving you no choice but to shoot a somewhat oversized bullet, such as .359" in a .38 Spl., or .452" in the .45 ACP. Many shooters use such bullets with satisfactory results, but I feel sizing generally does nothing to enhance a bullet's accuracy. The least sizing necessary is best.

As I size and lubricate my bullets, I inspect them once again. First I check the base, being sure only perfect, cleanly cut square bases go into the "match" box. Although minor dents and imperfections on the nose of the bullet affect accuracy very little, seemingly minor base defects wreck accuracy potential. After checking the base, I roll the bullet around, checking for well-filled bands and freedom from wrinkles and voids, hoping to eliminate that last imperfection I might have missed.

At the lower velocities of target wadcutter loads used for .38 Spl. and .45 ACP, lubricant quality isn't usually a problem. But the best, most effective and economical lubricants to use are those based on a 50-50 mixture of pure yellow beeswax and Alox 2138F, as are sold by Javelina, Hodgdon, Lyman, RCBS, Tamarack and others. For the .38 Spl. with 2.7 grs. of Bullseye and wadcutters like the H&G No. 50, it is necessary to lube only the bottom grease groove to prevent leading and give best accuracy. Excess lubrication increases smoke, which can be particularly objectionable on indoor ranges, often impairs accuracy, and cruds up the gun more quickly. With .45 ACP bullets like the Lyman #452460, 452389, 45266, the RCBS #45-200SWC or the Saeco 290451, you similarly only need to lube the bottom groove with Alox if using moderate charges up to about 4 grs. of Bullseye or 4.5 grs. of Green Dot, or 5 grs. of W-W 231. If using less effective lubes like the old black Ideal lubricant or Saeco Lube B, you may need both grooves full to prevent leading. With bullets having a single large grease groove like the H&G 130, you may get slightly better groups with Alox lubricant using slightly heavier charges than the traditional 3.5 grs. of Bullseye which gives best results with other lubes. The difference in recoil is hardly perceptible, but a 4.0-gr. load bucks the wind better at 50 yds., and operates the gun more positively to reduce malfunctions.

Cast bullets can give fine accuracy for target shooting, but only if you exercise care in their casting, selection and preparation. If you have the patience to do the job right, you will find the expenditure of time worthwhile.

The Importance of Gas Checks

BY CARL JOHNSON

Correctly fitted gas check (left) is seated fully against base, tight and square with minimal deformation of the base. It cannot be pulled off with the thumbnail. If bullet shank is too large for the gas check chosen, the base is deformed and lead is scraped from the bullet (arrow). This is often accompanied by an out of square base from gas checks crimping before being fully seated. If the gas check shank is too small, proper fit cannot be achieved without upsetting the base in a die to fill the gas check. Otherwise the attachment of the gas check will be insecure, causing it to fall off in flight, causing poor accuracy.

MANY cast bullet shooters ask if I think one brand or another of gas check is better. This question can't be answered with a direct positive statement. I have used both Lyman and Hornady brands with good results. Each has its own place and can give excellent results when properly loaded.

Lyman gas checks have a base metal thickness of about .015", varying from .013" to .016" on the lots I've checked. The I.D. of the open cup averages .275" in .30 cal., but also varies somewhat. The sidewall that bears against the shank of the bullet has an average height of .087", but has some variation.

Hornady gas checks have a base metal thickness of .020" plus or minus a few thousandths of an inch on lots I've measured. The I.D. of the open cup is about .280", but varies slightly from lot-to-lot, and the sidewall, or bearing surface, has a height of .078" on the average.

Hardness of the metal, brass for Lyman gas-checks and gilding metal for Hornady, varies from batch to batch. Variance also results from tool wear, state of anneal of the metal when cupped and how good the manufacturer's quality control is. Bench-rest shooters have sorted bullet jackets for years to obtain uniform, accurate bullets. I'm convinced that the cast bullet shooter who wants half-minute-of-angle groups should do likewise with his gas checks. I shot three bullets with gas checks of one lot, and two from another to make a 5-shot group. Each five shots made two distinct groups, one from each lot of gas checks, about .500" apart at 100 yds.

Gas checks must be seated firmly against the bullet base. Quality of the base is very important. It must be flat and absolutely square and true. If the base has a sharp edge, more seating pressure is needed to make sure the gas check is bottomed out. The inside contour of the gas check is not square, but has a small radius at the corner which will interfere with a sharp edge on the bullet.

The fit of the gas check on the shank of the bullet is also very critical. For example, on the Ohaus 30-170FN from my mold the shank tapers from .285" to .280" when cast of linotype metal, a tight fit for either brand of gas check. When cast of 50% linotype and 50% pure lead, the shank measures .283" to .278" along the taper, and stands a much better chance of taking the gas check without deforming the base and destroying accuracy.

We all accept that a bullet must be of correct size, but few of us ever measure the diameter of a gas-check seated and sized on the bullet. I picked ten gas checks from four different lots of the same brand. After seated and sized, their O.D.s varied by .0005" to .0015". Driving bands of all bullets miked .310" after sizing, and the bullet was one which had proven capable of outstanding groups.

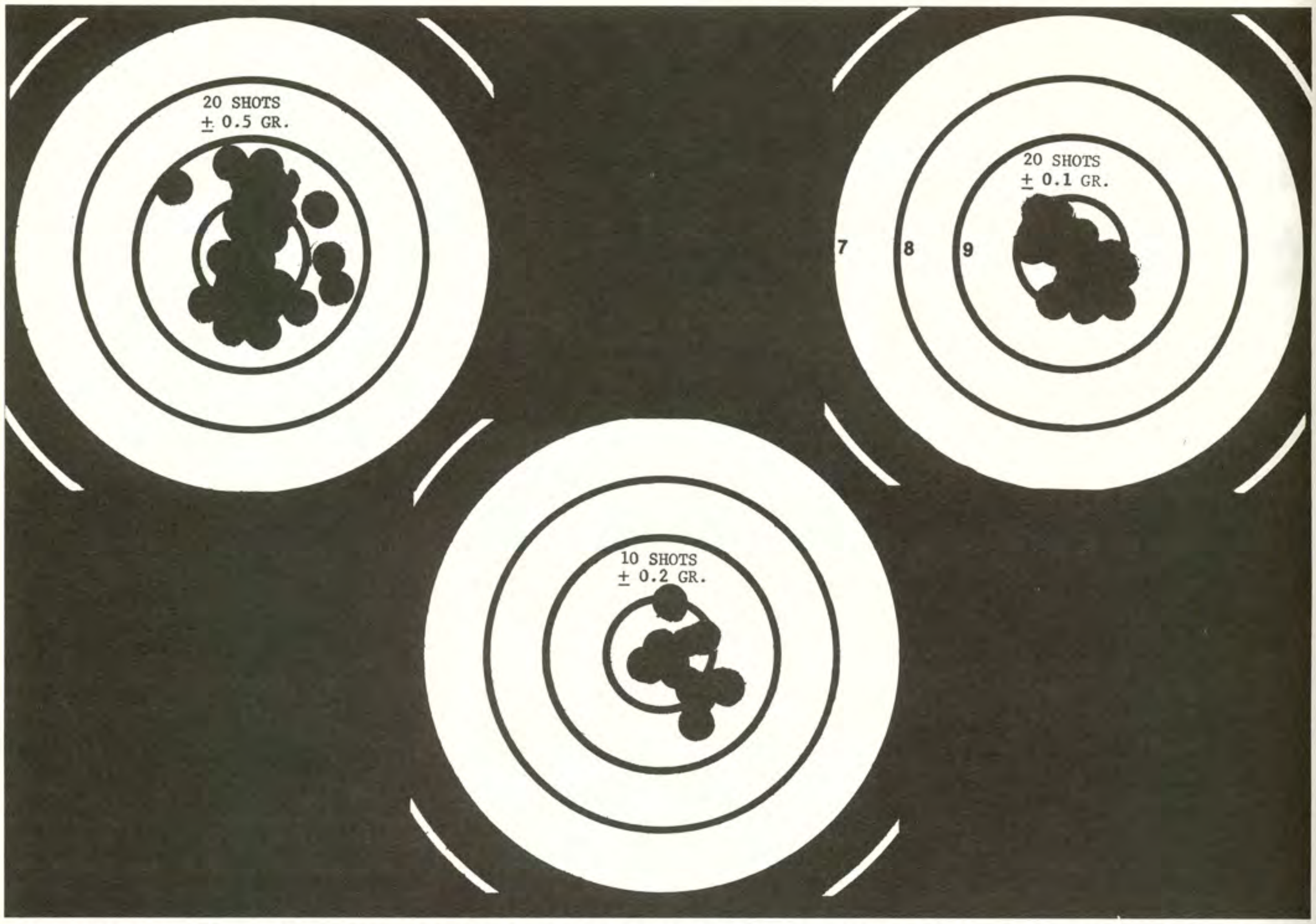
You might think the sizing die would bring the gas check down to whatever size the die is, but this isn't true. The two materials have vastly different physical properties and each has a different amount of spring back. If the driving band is smaller than the O.D. of the seated gas check, the gas check will come off in flight most of the time.

If a bullet sheds its gas check in flight, it will not group in the same place as bullets of that batch which have retained their gas check. Also, if all bullets of a batch shed their gas check, they still won't shoot into a tight group.

How do you correct this condition? Measure the gas check shanks of several bullets from one lot of casting, making sure they are all the same, sort out any that aren't. With the size of the shank in mind, select a gas check with inside cup measurement as close as possible to the shank diameter. The cup should not be more than .001" larger than the shank.

Size one or two bullets with the gas check seated, and measure them to determine if the diameter of the driving bands and gas check are the same. If they are, try to remove the gas check from the base with a small amount of force. If it comes off, there is a mismatch, or the gas check shank has too much taper. You may find that some bullets and gas checks do not permit a correct match of the shank with the gas check.

The average cast bullet shooter, having only normal handloading equipment and little in-depth knowledge of the subject, is probably better off with Lyman gas checks. I say this because crimping-type Hornady gas checks must be seated absolutely square and bottomed out against the bullet case before crimping. Otherwise they will crimp onto the shank before being seated, often making the base out of square. This can be avoided by using a separate gas check seater. •



Composite targets (left to right) illustrate the effect of weight variation and orienting bullets upon accuracy. Bullets with ± 0.5 gr. weight variation averaged 1.4" extreme spread for 20 shots with slight vertical stringing. Those with ± 0.2 gr. were capable of "possibles" on the 1" ten ring used at 100 yds. in CBA matches, but typical 10-shot groups show fliers and some vertical stringing. Author's best loads with only ± 0.1 gr. weight variation easily stay in the 1" ten ring as this 20-shot composite shows.

Orientation and Selection: Two Keys to Accuracy

BY FRANK MARSHALL JR.

When shooting cast lead alloy bullets, we can only seek to *approach* perfection, since subsequent sizing and loading operations have no appreciable effect in reducing flaws inherent in the casting. Much effort is exerted in trying to cast "perfect" bullets, but this can discourage the would-be cast bullet shooter, since true perfection in the as-cast bullet is nearly impossible to obtain. The mold which casts a perfectly round bullet of correct size on nose and bands, with a concentric, square base with gas check shank of ideal proportions, is an extreme rarity.

However, there is much which can be done in the way of selecting and loading cast bullets which minimize the effect of their inherent imperfections. Best accuracy is obtained by inducing uniformity in the effect of these flaws so they all have the same effect on the target! This is done by segregating bullets carefully by weight, while eliminating all those with any obvious physical defects, and orientating the bullet by an index mark as it comes from the mold, throughout the entire sizing, loading and firing sequence. The best method of orientating the bullet is by placing a small prick punch mark in the cavity near the nose of the bullet, where it does least harm. This leaves a small bump, which is easily noticed, so it may be placed in the same position each time as the bullet is sized, seated, and the rifle loaded. An alternate method is to file a small notch on the edge of the mold cavity, also near the nose, which leaves a similar small projection for reference. This can be removed with the thumbnail before firing, if desired, and does no harm.

Despite the widespread use of these techniques by cast bullet shooters for 100 years or more, there is little documented data on the performance of oriented cast bullets compared to those which aren't, and the effect of normal weight variations on group size within a rifle's normal grouping ability. Over several years I have maintained careful records of over 1000 shots, all using the same rifle and load, which yield some pertinent observations on this subject.

The test rifle is a pre-war Winchester Model 70 target rifle in .30-'06 with original factory bull barrel. Although this rifle is not super-accurate by current benchrest standards, it has been a consistent performer for many years. It is regularly capable of ¾ m.o.a. groups with carefully handloaded Sierra match bullets. The barrel is .300" bore diameter, and .308" groove diameter with four lands and grooves, right twist, one turn in 10". The barrel is free floated and the action is still perfectly bedded into the wood as it originally came from the factory in 1939. All shooting was done from a sandbag rest with Lyman 20X Super Targetspot scope.

Throughout I used the Lyman #311284 bullet, which weighs 219 grs. with Hornady gascheck and all grease grooves filled with 50-50 Alox 2138F and pure yellow beeswax. My alloy is 87% lead, 10% antimony and 3% tin, slightly softer than new linotype. As a standard, I already had developed a cast bullet load with the above bullet, and 21 grs. of SR-4759 powder in National Match cases with Remington 9½ primers which would consistently equal the accuracy of my best jacketed bullet loads, if weight variation of the bullets was held within 0.2 gr. maximum, and the bullets were oriented throughout and carefully loaded. From a typical batch of 100 cast bullets, weighed and visually inspected, only 20 would be of "match" quality, visually perfect and of correct weight. These were capable of ¾ m.o.a. groups at 100 yds. on calm evenings. I used the other 80 bullets to compile data on the effects of differences in bullet weight and orientation under the same conditions on each day's firings.

A typical batch of 100 cast bullets yielded 20 bullets of 0.2 gr. maximum weight variation; 20 within 0.4 gr.; 20 within 1 gr.; 20 within 2 grs. and 20 which were rejected and remelted. I shot the first three weight divisions only for this test. Each weight group was fired both oriented and not oriented. I also shot bullets which were not weighed, but which were visually inspected only, both oriented and unoriented. These didn't include any obvious culls or rejects. These bullets were perfect to visual inspection, but simply weren't weight segregated. Only 100 of these unweighed bullets were shot for comparison.

The targets shown are reproduced composites of test targets as well as some fired in Cast Bullet Association matches over a two-year period, all using the same load of 21 grs. SR-4759 obtaining about 1600 f.p.s. with the #311284 bullet in .30-'06. Test conditions were better than match conditions, but the overall average shooting conditions are realistic. The targets reflect a selection of a few examples which clearly represent the effect of these factors. No unusual results are revealed which aren't commonly known to the experienced cast bullet shooter. The degree to which accuracy is affected, however, is useful as a guide, assuming other factors are compatible and equal.

The author used a pre-war Winchester Model 70 target rifle in .30-'06 with original factory bull barrel for his tests, and Lyman 20X Super Targetspot. His loads were assembled in National Match cases with Remington 9½ primers and 21 grs. of SR-4759 with the Lyman #311284 bullet, cast of 87-10-3 lead-antimony-tin, with Alox lubricant.

Best method to orient the bullet is to file a small index mark on the edge of the mould cavity, which leaves a small bump on the bullet, near the nose where it does least harm. This is indexed at 12:00 for each shot, and can be removed with the thumbnail.

The effects of weight variation and bullet orientation might well be accentuated with a heavier load than I use. My results indicate this bullet is not perfect and, in fact, it may not even be up to average. Its good performance is due more to conscientious application of the above techniques than to the inherent excellence of the bullet itself

The above averages are approximate, rounded to the nearest ¼", but they still illustrate the obvious advantages of bullet selection and orienting the bullet. The fact that oriented bullets consistently outshot

Average Extreme Spread
(ins. @ 100 yds.)

Bullet Wt. (grs.)	Bullets Oriented	Bullets NOT Oriented
219 ±0.1	¾	1½
219 ±0.2	1	1¾
219 ±0.5	1¾	2½
NOT WEIGHED VISUAL INSP ONLY	2½	3¼*

*(Voids gave occasional wild fliers)

the unoriented bullets reinforces the suspicions of many shooters over the years, regarding the roundness, or lack of it, and the squareness of the base of most cast bullets.

In conclusion, a cast bullet which has been carefully selected by weight, inspected closely for surface defects and consistently oriented in the chamber the same way each time, can equal the accuracy of jacketed bullets, subject to the effects of range conditions and human error. The elusive "perfect" cast bullet does not exist, and probably never will from a practical standpoint. There is no shortcut to cast bullet accuracy. Innovation may result in better percentages of good bullets, or molds which cast bullets more closely to their ideal dimensions, but the selection process and the variables which affect grouping ability will remain the same. Weighing and orienting your cast bullets greatly minimizes the effect of their imperfections and permits surprising results, considering the basic simplicity of the process. Those seeking the ultimate accuracy will find the expenditure of effort highly rewarding.

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Footnotes

Cast Bullets in Rifles, Part 2, Page 15

[1] Not quite correct, though it is correct as to freedom from leading in lumps or streaks. Examination shows an inconspicuous lead wash left in the rifle bore by bare lubricated gascheck bullets even in the best light loads. This apparently does not affect the performance of proper loads.

[2] Lyman has published two different compositions for "No. 2 Metal." For information on these, see "Lyman No. 2 Alloy" in this handbook.

[3] Linotype alloy has become less available in recent years because of changed printing methods, but it still is found in metals scrap yards. The handloader can make it up himself — see "Antimony For Bullet Metal" in this handbook.

[4] For further information on zinc and aluminum contamination in bullet metal, and practical means of dealing with it, see "Contaminated Lead Supply" in this handbook.

[5] Desirable non-smoking fluxes now are available.

Cast Bullets in Rifles, Part 3, Page 19

[1] This was true for the bullet lubricants of that time. Continuation of this development program eventually produced the Alox-beeswax lubricant now used. For a comprehensive account, see "Bullet Lubricants" in this handbook.

[2] Continued testing brought out that former waterpump greases, and calcium greases in general, break down in the high temperature of discharge and leave a bore deposit which is difficult to remove. Other greases are far less subject to this. See "Bullet Lubricants" in this handbook.

[3] Old type sizing dies which cut bullets off-center have since that time been taken off the market, after criticism of them by *The American Rifleman.* Present dies which have a smoothly tapered lead-in, and are well made, can reduce lubricated bullets by .002" or so without damage.

[4] This was written in reaction to directions which called for sizing bullets to .311" diameter in the poor dies described above. Those directions were meant partly to accommodate variably dimensioned cal. .30 barrels at beginning of this century, and partly to compensate for bullet mold form reamers made oversize to allow for wear. Cast bullets when correctly produced can shoot well at .001" to .002" above the barrel groove diameter.

[5] The following explanation of dimensional requirements for both body and forward part of the bullet remains correct.

[6] Mercury also is a dangerous poison when incautiously used.

Cast Bullets in Rifles, Part 4, Page 23

[1] Powders marked are no longer listed, and other changes in availability of course can be expected with time. The types shown, however, indicate the practical relationship between burning speed and successful .30-'06 cast bullet loads.

Refinements in Cast Bullets, Page 37

[1] That 1958 Lyman handbook is now out of print, and its contents are no longer necessarily representative in this respect.

[2] Best up to that time (1963). Continuation of this development eventually produced the Alox-beeswax now in use — see "Bullet Lubricants" in this handbook. It gives better results over all than any other so far tried.

[3] Continued experience indicates that linotype alloy, BHN 20-22, generally improves the reliability of target grouping in even these very light loads.

[4] In these light loads, the filler of kapok or Dacron fiber (up to 1 or 1½ grs. has been found practicable) may not improve target grouping. The fiber filler however is highly desirable in loads carried in the field. In loads for the target range, it should be used where safety considerations do not permit elevating the muzzle of the loaded rifle before firing.

[5] While the various cartridge space fillers here described gave the results stated, all of them except kapok and the later Dacron were dropped from this development after continued testing.

Bullet Lubricants, Page 43

[1] There is no advantage in using either Alox 350 or Alox 2138F straight. The Alox 2128F-beeswax bullet lubricant has proved best for target accuracy as well as workability in sizing-lubricating machines.

[2] Further use has shown 1 to 1½ grs. kapok or Dacron fiber to be generally practicable.

Accuracy and Power with Cast Bullets, Part 1, Page 61

[1] This type of sizing die was taken off the market about 1963.

[2] Tin has since that time become even more expensive. See "Tin In Bullet Metal" in this handbook.

[3] Even the best loads with bare lubricated cast bullets leave a light lead wash on the rifle bore, which appears to do no harm.

[4] Also reproduced in this handbook.

[5] In very light loads, unconsumed Dacron may leave a deposit in cartridge case or bore. Kapok seems always to be consumed or to be blown out leaving no deposit, so can be used in such loads.

Caution: All technical data, especially for handloading, presented in NRA publications reflects the experiences of individuals using specific equipment and components under specific circumstances. Such information is intended solely as a guide and should be used with caution. NRA accepts no responsibility for results obtained using these data.