A Bullet Casting Journey

By

Tim The Idahoan

Introduction – Bullet Casting Basics

Having been fascinated with firearms and everything associated therewith from a very young age, it was inevitable that I would get into bullet casting eventually. Even as a child I often picked up spent brass cases and fired bullets when I chanced to find them, usually in the course of tagging along with my father on various adventures in the great outdoors. I was probably about nine years old when I first tried melting down some salvaged bullets in a tin can over a camp stove. However, it was not until I was in college that I bought my first actual bullet mould and tried casting bullets for my own use. My first mould was a Lee .44-caliber round ball mould, which I used to cast balls for a replica "New Army" cap & ball revolver that I purchased at about the same time. A few years later, I picked up a minie ball mould in the hope of casting bullets for a homemade .50-caliber muzzleloader. Initially, I didn't get very good results casting minie balls. I followed the instructions in the user manual to the letter, including lubricating certain parts of the mould with beeswax, smoking the mould cavity, and fluxing the melting pot, but most of the bullets came out with surface defects and often failed to fill out the mould completely. Disappointed, I set bullet casting aside for a few years until my elderly neighbor happened to bring up the subject one day. When I told him about my experience with the minie balls, he expressed surprise that I wasn't able to cast better-than-factory quality bullets and invited me over for a lesson in bullet casting. In a morning spent with my neighbor we cast, sized, and lubed about 750 handgun bullets and I learned that there are four basic factors that affect the quality of home-cast bullets:

1) The quality of the equipment used. Better equipment will yield better results, or at least make better results easier to achieve. My neighbor insisted that Lee moulds are of relatively low quality, and Lyman's aluminum moulds should also be avoided. He said RCBS makes decent quality bullet moulds, and Saco molds are excellent. The best bullet moulds are made of mehenite cast iron. Similarly, a better melting pot will regulate the temperature of the lead more closely and dispense it more evenly. My neighbor considered RCBS melting pots to be the cream of the crop. That said, cheapskate that I am, I'm still making due largely with Lee equipment, and with careful attention to the other relevant factors, it can indeed be used to good effect.

2) The surface condition of the bullet mould. The mould should be properly cleaned and treated with a good release agent. Some sources recommend smoking the mold with a lighter or beeswax candle, but I find that this tends to result in a dirty, sooty mould that will cast wrinkly bullets and is very difficult to clean. My neighbor treats his moulds with a release agent made of graphite powder in isopropynol. I tried using a Lock-ease graphite-suspension lubricant on my moulds, but it did not produce the same results. I tried some other concoctions and found that a homemade release agent made from 1 part permanent red chalkline chalk dust to 2 parts denatured alcohol by volume produces acceptable results. It can be applied with a cue-tip. Typically, the first couple of bullets cast after coating the mold will have a furry texture and a redish tint from the chalk, but after that they come out clean. Later, I tried spraying my molds all-over with CRC Dry Moly Lube, which creates an adherent layer of molybdenum disulfide that can act as a dry lubricant and works at least as well as chalk for a release agent, if not better. To make sure the layer of moly wouldn't materially reduce the size of the as-cast bullets, I applied several layers of the coating to both sides of a scrap of aluminum plate, and measured its thickness with a micrometer before and after coating. Within the measurement capabilities of my micrometer, the plate measured the same before and after coating, so the coating thickness is much less than a thousandth of an inch; as such, it shouldn't have any appreciable effect on bullet dimensions.

3) The composition of the base alloy. Using an appropriate alloy is important for casting high-quality bullets. For muzzle-loader bullets (which should be quite soft) I found that an alloy made by mixing 5% pewter with 95% pure lead by weight produced excellent results.

4) The temperature of the mold and the metal. The pouring temperature of the lead should be close to 650ºF. The mould temperature should be close to 350ºF. If temperatures are too low, the metal may not completely fill the mould cavity, or the bullet may have a wrinkled appearance due to premature solidification. If temperatures are too high, it will take longer for bullets to solidify and may be more prone to stick in the mold and usually have a frosty appearance due to large grain size of the solidified metal. As a side note, I used an infrared thermometer during my initial measurements of melting pot and mould temperature, and thereafter for monitoring temperature to keep the temperature in the optimal range. The emissivity of molten lead is too low for its temperature to be measured accurately with an infrared thermometer, but with the emissivity set to 0.75 it is possible to get a reliable reading on blued or oxidized steel surfaces. Thus, when casting I keep a cast-iron lead dipper in the pot and when I want to measure the temperature of the lead, I invert the dipper and take a reading on the bottom of the dipper, which will be at the same temperature as the lead it was immersed it.

The discovery of these factors reinvigorated my interest in bullet casting, and it wasn't long before I felt the need to undertake a more involved experimental study of the various aspects of homespun cast-bullet technology. Thus it was that I conducted a series of tests in an effort to further develop my expertise in the area of bullet casting and in hopes of producing the best possible bullets for my own target practice. I used two firearms for this testing: a Smith & Wesson model 629 revolver, and a Marlin model 1894 lever-action rifle, both chambered for .44 magnum.

Benchmark Load

As a benchmark against which to measure the performance of my hand-cast ammunition, I selected a mid-power .44 magnum load consisting of 18.5 grains of Alliant 2400 smokeless powder behind a Nosler 240-grain jacketed hollow-point bullet. This load generates minimal fouling with no barrel leading. Based on a 12-shot group fired from a bench rest, it delivers about 14 MOA accuracy in my revolver ($3^1/_2$ inch group at 25 yards) and 3 MOA accuracy in my rifle (3 inch group at 100 yards).

Bullet Sizing

Most sources report the diameter of a .44 magnum bullet as either 0.430 or 0.429 inches. I measured several .44 caliber jacketed bullets made by Nosler and Hornady and found that the Hornady bullets were all very close to 0.4300" in diameter, while the Nosler bullets ranged from 0.4290" to 0.4295" in diameter. Next I pounded a .50-caliber soft lead round ball through the barrel of each of my test firearms to get an imprint of the bore. Measuring the resulting lead slug indicated that the Marlin's bore had a groove diameter of almost exactly 0.430" and a land diameter between 0.423" and 0.424". The Smith & Wesson had a 5-groove rifling pattern, which made it difficult to precisely measure the land and groove diameters; its average diameter (measured from one land to the opposite groove) measured 0.4225” while its groove diameter (measured from the corner of one groove-ridge left on the lead slug to the corner of the one opposite it) measured between 0.428” and 0.429” implying that the actual land diameter was about 0.417”. Conventional wisdom has it that the ideal diameter for a bullet is 0.001 inches larger than the groove diameter of the bore, as this slight interference fit will provide a good gas seal without being so tight as to obstruct the bore and create excessive pressure.

In order to put the conventional wisdom to the test and assess the influence of bullet diameter on accuracy, I cast some test bullets using a Lee 429-214-SWC bullet mold and Lyman #2 bullet alloy, which is nominally 90% lead, 5% tin, and 5% antimony. As cast, I found that the diameter of these bullets was only about 0.429 inches, and I wanted to test diameters both above and below this value so I powder coated them with Eastwood “Pastel Blue Hot Coat” to increase their effective diameter. After coating, most of the bullets measured about 0.433 inches in diameter, although a few came out as large as 0.436 inches. I then made a series of sizing dies for my reloading press and sized the bullets to diameters of 0.423, 0.428, 0.430, and 0.432 inches, respectively. After sizing them, I proceeded to load them into primed .44 magnum cases along with 18.5 grains of Alliant 2400 smokeless powder, after which I tested them in both my rifle and my revolver.

The 0.428, 0.430, and 0.432 inch diameter bullets yielded practically identical results. These three sets of test loads all functioned normally in both guns, and none of them produced any appreciable barrel leading in either the rifle or the revolver. These three bullet sizes all delivered about 14 MOA of accuracy (~3$^1/_2$ inch groups at 25 yards) when fired from my revolver, and about 6 MOA of accuracy (~6 inch groups at 100 yards) when fired from my rifle. The point of impact for these three loads was also quite similar, though it shifted noticeably relative to my baseline jacketed bullet load.

The 0.423 inch loads, however, delivered inferior performance in every respect. To begin with, the bullets were sufficiently undersized that during initial loading they would sink down into the case until they rested on the powder charge, reducing the overall length of the cartridge. They were not so loose as to fall out if a cartridge was simply turned upside down, but if the bullet were grasped by the nose with thumb and forefinger, it could be pulled out of the case with ease. In the revolver, the cartridges had to be loaded one at a time, as the recoil would pull un-fired bullets out of their cases. In the rifle, the tubular magazine kept enough pressure on the cartridges to keep them from coming apart due to recoil, but feeding was unreliable due to the rim of the bullet being depressed below the mouth of the case. Ammunition management aside, the 0.423 inch diameter bullets performed reasonably well in my revolver, producing an extreme spread of 28 MOA due to a couple of outliers, but with most of the shots grouping within about 14 MOA (~3$^1/_2$ inches at 25 yards) just as the other test rounds had. In the rifle, however, accuracy was noticeably poorer. When shooting 0.423 inch bullets out of the rifle, I was unable to measure their extreme spread due to the difficulty of getting hits on my target. After firing several rounds at a distance of 100 yards without scoring any hits on the target, I moved it up to 50 yards for the remainder of the testing. I found that some shots would strike very close to my point of aim, but that most would miss the target entirely. Since the shortest distance from the point of aim to the edge of the target was a little over 5 inches, this implied that the group size had to be at least 10 MOA, although I suspect it was much larger. It is worth noting given my earlier bore measurements, the 0.423 inch bullets would just barely touch the rifling lands in the rifle, but would engage the rifling lands in the revolver to about half their depth. This may explain why I observed a severe degradation of accuracy with the rifle, but only a marginal decrease in accuracy with the revolver. Interestingly enough, the 0.423 inch bullets also produced slight but noticeable barrel leading, particularly in the revolver.

Thus, based on the results of this test I concluded that the bullet diameter should be approximately equal to the groove diameter of the bore, but that variations within a few thousandths of an inch from this value are relatively inconsequential in terms of their effect on bullet performance. However, as bullet diameter is reduced to the land diameter of the bore or smaller, performance begins to degrade rapidly.

The realization that, within a few thousandths of groove diameter, bullet size has little impact on performance led me to wonder whether sizing bullets is even worthwhile. I hypothesized that the sizing process might still improve the consistency and concentricity of the bullets and thereby improve accuracy, irrespective of the exact diameter to which they were sized. To test this hypothesis, I loaded up three more batches of test ammo, using powder-coated bullets cast from Lyman #2 alloy. For one batch, I refrained from sizing the bullets at all. For another, I sized the bullets to 0.432 inches after powder-coating them, as I had done before. For the third batch, I sized the bullets to 0.428 inches before powder-coating, and then sized them again after powder coating, this time to 0.430 inches.

When I fired the test rounds through my rifle, all of functioned normally, none produced any appreciable leading of the barrel, and they all delivered approximately 6 MOA accuracy (6-inch groups at 100 yards). If anything, my double-sized "precision" bullets seemed to scatter slightly more than the bullets that I didn't size at all, although the difference was not statistically significant. Thus, I concluded that, at least for powder-coated bullets cast from Lyman #2, bullet sizing is a largely superfluous operation that has negligible influence on bullet performance – unless bullets are sized so small that they no longer engage the rifling securely, at which point their performance degenerates.

Alloy Hardness

The next parameter that I experimented with was bullet hardness. Based on internet discussion forums and word of mouth, I gathered that the prevailing opinion among DIY bullet casters is that bullet lead should be an alloy with a Brinell hardness of about 12 – comparable to the hardness of lead wheel weights (which are no longer readily available, having been supplanted by the supposedly more environmentally friendly zinc ones). I surveyed the available hardness testing devices on the market and found that a variety of lead hardness testers or hardness testing kits were available for prices in the range of $50 to $100. However, most of these devices relied on some kind of calibrated spring for operation, and according to their reviews, these springs are not always in calibration and calibrating them yourself is not necessarily straightforward, if it is even possible. For this test, I felt I needed something more reliable than these economy-grade bullet hardness testing kits. However, commercial hardness testing machines start at around $1,000 which was well beyond my budget for this project. Thus, I resorted to building my own Brinell hardness testing machine, using a hydraulic jack and some scrap metal to build a manually-operated hydraulic press. I tapped a pipe-threaded hole into the bottom of the hydraulic jack so that I could install a pressure gage, allowing me to monitor the pressure inside the cylinder, which allowed me to calculate the applied force. Next, I made a jig to hold an indenter point and a dial indicator, allowing me to easily measure the depth of indentation to within a thousandth of an inch. For an indenter, I brazed a 10-mm carbide ball bearing to a steel shank, as this is the standard indenter for Brinell hardness testing. Pictures of my hardness testing equipment are presented in Figure 1 and Figure 2. With this apparatus, I proceeded to measure the hardness of several available lead alloys, as well as a couple other materials that I had lying around, just for context. The results of my measurements are presented in Table 1.

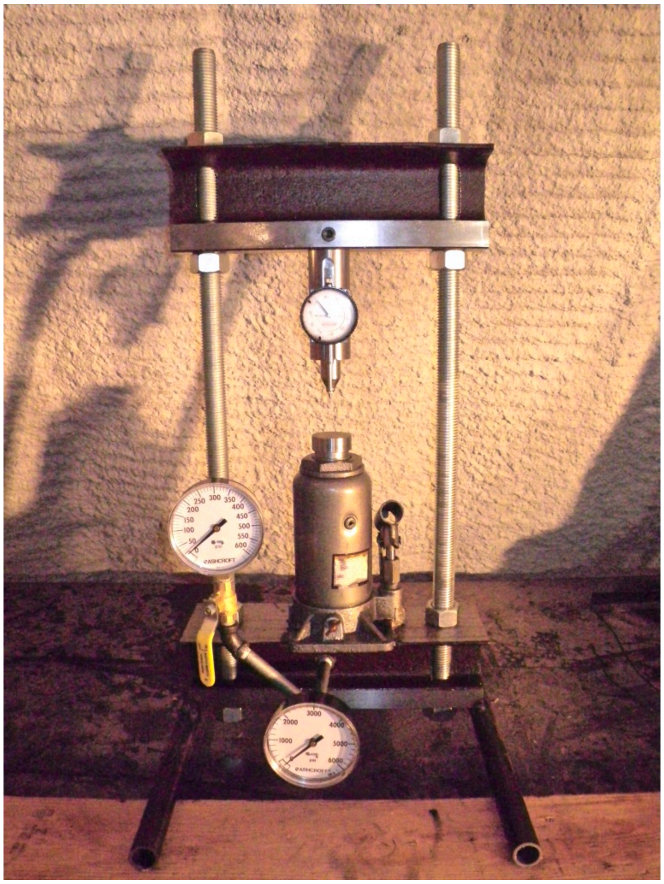


Figure 1: Photograph of my homemade hardness testing machine, consisting of a hydraulic press with pressure gages to measure applied force and a hardness testing jig mounted at the top of the press.

Figure 2: Closeup of my homemade hardness testing jig.

Table 1: Hardness Comparison	
Material	**Brinell Hardness**
Type 1018 flat steel bar	125
Steel file	563
Lyman #2 bullet casting alloy: 90% Lead 5% Antimony 5% Tin	16 – 17
Linotype alloy: 84% Lead 12% Antimony 4% Tin	20
1:25 Bullet Alloy: 96% Lead 4% Tin	7
Custom Alloy: 94% Lead 4% Tin 2% Antimony	12

I proceeded to cast bullets from each of the lead alloys in Table 1 using the Lee 429-214-SWC bullet mold. I ran all the bullets through a 0.430" sizing die, although since the as-cast diameter was already 0.429" to 0.430" this served only to trim off any flashing around the base of the bullet. Then I powder coated the bullets with Eastwood "Pastel Blue Hot Coat," and loaded them into cartridges with 18.5 grains of 2400 powder.

When I tested these loads, they gave similar results in both my rifle and my revolver. When fired through my revolver, the Lyman #2 bullets (hardness 16) performed better than usual, producing about a 10 MOA group (2.5" at 25 yards). The linotype (hardness 20) bullets produced a typical 14 MOA group (3.5" at 25 yards). Neither the Lyman #2 nor the linotype bullets produced any appreciable barrel leading. However, both of the softer alloy bullets generated slight to moderate barrel leading and their group sizes opened up to about 16 MOA (4" at 25 yards). When fired from my rifle, the Lyman #2 bullets (hardness 16) produced about 6 MOA groups, just as I expected they would based on previous testing. The linotype bullets (hardness 20) produced a group that was slightly larger – about 7 MOA overall, but that appeared decidedly bimodal, visually resembling two separate 3-MOA groups. The bullets cast from the custom alloy with 2% antimony (hardness 12) spread out to produce about an 8-MOA group, and the 1:25 lead-tin alloy bullets (hardness 7) spread out even more, to the point where only about half of the rounds were hitting the paper target at 100 yards, implying a group size somewhat greater than 10 MOA. The 1:25 alloy bullets also produced slight but noticeable barrel leading in the rifle, while the other bullets produced no appreciable leading.

Thus, the results of this initial test indicated that for best accuracy and minimal leading, bullets should not be too soft. Moreover this test seemed to indicate that, contrary to popular opinion, bullets with a Brinell hardness of 12 are still a little too soft to deliver maximum accuracy and minimum barrel leading. Based on this test, bullets seem to require a Brinell hardness of about 16 for best performance. Interestingly enough, despite delivering slightly inferior accuracy in both the rifle and the handgun, my custom-alloy bullets with a Brinell hardness of 12 produced noticeable barrel leading in my revolver but not in my rifle. Because the bullets achieve higher velocity in the rifle, I would have expected the rifle to be more prone to barrel leading. However, this proved not to be the case in testing. Instead, perhaps the more aggressive rifling profile in the revolver makes it more susceptible to barrel leading.

The bimodal distribution of the linotype bullet holes in the target intrigued me. It occurred to me that I had cast the bullets in a 2-cavity mold. What if the two cavities were not quite identical and the slight difference in bullet geometry was resulting in a slight deviation in the bullets' point of impact? That could explain the bimodal distribution. To test this hypothesis, I cast four more batches of bullets, filling the front and rear mold cavities separately with linotype and Lyman #2 respectively. When I loaded these bullets into cartridges and fired them from my rifle, however, they all gave essentially the same performance I had been seeing before, yielding approximately 6-MOA groups at 100 yards. As such, I concluded that the bimodal distribution I had seen with the first linotype group was simply a statistical anomaly.

Lubrication Methods

There are a number of methods by which cast lead bullets can be lubricated so as to reduce their potential for barrel leading. The traditional method involves extruding a wax-based lubricant into the bullet's lube grooves using a lubrisizer. Alternatives to traditional lubricating include powder coating, treating bullets with liquid Alox, or spraying them with a coat of molybdenum disulfide. In order to assess and compare the effectiveness of these methods, I cast a large number of bullets from Lyman #2 (Brinell hardness of about 16) using the Lee 429-214-SWC bullet mold. I then separated these bullets into test batches and lubricated them in different ways.

I lubricated two test batches in the traditional way, using Lyman "Ideal" bullet lube for one batch and Lyman "Super Moly" bullet lube for the other. Another batch I lubricated with Lee liquid Alox, applying it to the bullets in a plastic container, swirling them around to disperse the lubricant, and then dumping them out on a sheet of wax paper and allowing them to dry overnight, as prescribed by the directions on the bottle. Yet another batch of bullets I carefully placed standing upright on their flat noses and applied two coats of CRC Dry Moly Spray to coat them with a thin, adherent layer of molybdenum disulfide. By this point in my testing, I had already fired enough powder-coated bullets of this type to know that they would generate no appreciable leading and produce 6-MOA groups from the rifle and 14-MOA groups from the revolver, so I did not consider it necessary to powder-coat a separate batch of bullets specially for this test. I did, however, include in the test a batch of bullets that I loaded into cartridges without applying any kind of lubrication at all to serve as a control group. As usual, I loaded all cartridges with a powder charge consisting of 18.5 grains of Alliant 2400 smokeless powder.

As expected, the bare lead bullets produced severe leading of the barrel in both the rifle and the revolver. In the rifle, the bare lead bullets were also quite inaccurate: out of a 12-shot group, only 3 holes appeared on the 8x11 inch target, implying a group size much larger than 10 MOA. Most likely, the poor accuracy was the result of the lead accumulation in the barrel. In the revolver, the accumulation of lead seemed to have only a minimal impact on accuracy: despite the severe leading, the group size only opened up to about 16 MOA – just slightly inferior to the typical 14-MOA performance of most other rounds. The performance of the bullets that were sprayed with dry moly lube was functionally indistinguishable from that of the bare lead bullets. Based on visual assessment during cleaning, the amount of lead accumulation in the barrel may have been slightly less, but the accuracy was identical, with enough lead accumulating in the rifle barrel to seriously compromise accuracy.

In the rifle, the bullets lubricated with Lyman "Ideal" bullet lube performed the best, producing approximately a 5-MOA group, and leaving only minimal leading in the rifle barrel. Meanwhile, the bullets lubricated with Lyman "Super Moly" bullet lube produced approximately a 6-MOA group, and also generated slightly more leading. The bullets lubricated with Lee liquid alox bullet lube delivered a level of performance that was intermediate between the bullets with traditional extruded lube and the bullets with no lube at all: they produced a significant amount of barrel leading, enough that the group size opened up to an estimated 8 to 10 MOA, although only about half of the shots were captured on paper.

In the revolver, the "Ideal," "Super-Moly," and "Liquid Alox" lubes all gave virtually identical results, producing a moderate amount of barrel leading and delivering typical 14-MOA accuracy.

Thus, in terms of their ability to prevent leading of the barrel, all of the lubrication methods tested proved inferior to powder coating. That said, the traditional extruded lubricants were successful in keeping leading down to a level at which it had no detrimental effect on accuracy, and the bullets with Lyman "Ideal" bullet lube actually produced a slightly tighter group than the typical 6-MOA accuracy that I would have expected from powder-coated bullets.

Bullet Geometry

Finally, I conducted an experiment to assess the effect of bullet shape on the performance of cast bullets. I cast some round-nose bullets using a Lee 429-240-2R mold and two different styles of semi-wadcutters using Lee 429-214-SWC and TL430-240-SWC molds respectively. I also prepared custom bullet molds to cast tapered flat-point and double-tapered bullets of the nominal dimensions shown in Figure 4. A photograph of my homemade bullet mold with a few finished custom bullets is presented in Figure 3. I cast all the bullets from Lyman #2 alloy, and powder coated them with Eastwood "Pastel Blue Hot Coat" before loading them into cartridges with my usual 18.5 grains of Alliant 2400 smokeless powder.

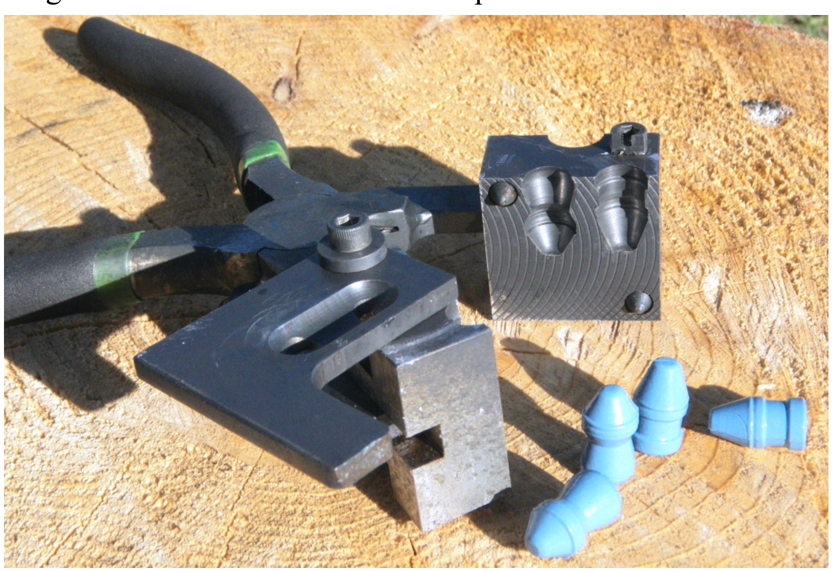


Figure 3: My homemade bullet mold with a few powder-coated bullets.

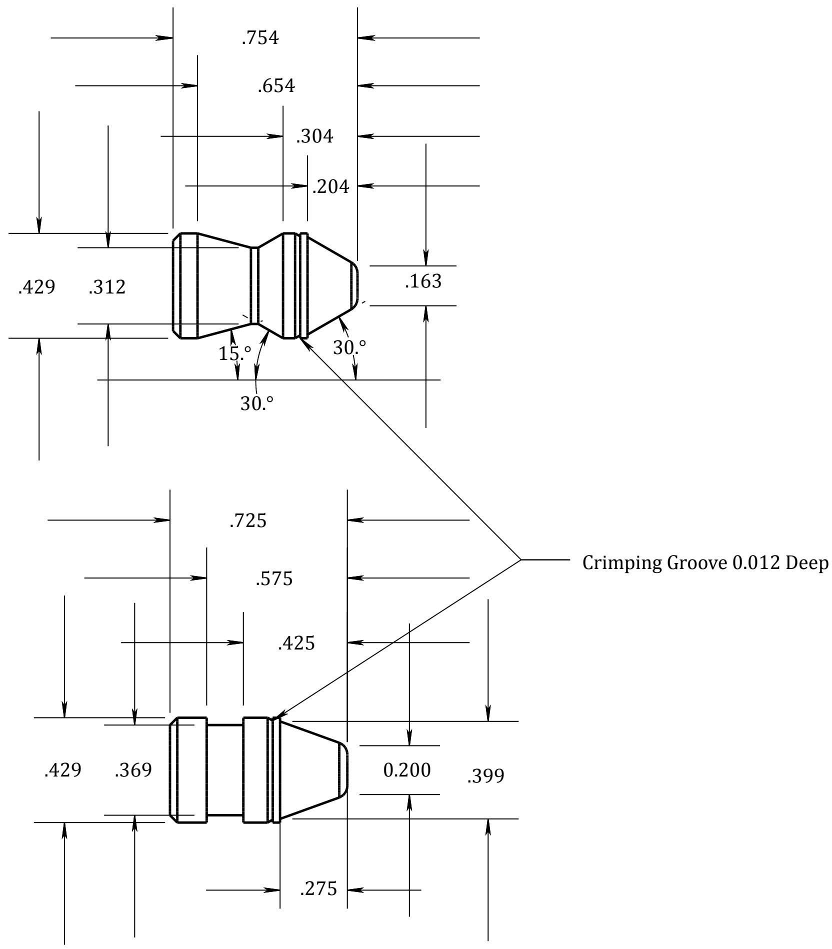


Figure 4: Design dimensions of my custom double-taper (top) and tapered flat-point (bottom) bullets.

When I tested my experimental ammunition, the SWC bullets cast with the Lee 429-214-SWC mold produced approximately a 6-MOA group when fired from the rifle. The SWC bullets cast with the TL430-240-SWC seemed to disperse slightly more, although if a few clear outliers can be neglected, they still produced a 6-MOA group. Meanwhile, the round-nose bullets cast with the Lee 429-240-2R mold produced a slightly tighter group measuring close to 5-MOA. None of these rounds produced any appreciable leading in the rifle barrel. My custom bullets were a different story. Accuracy with the tapered flat-point bullets was so bad I couldn't get enough shots on paper to provide any meaningful measure of group size. My double-tapered bullets performed a great deal better, but still not nearly as well as any of the bullets cast in Lee molds: fired from the rifle, the double-tapered bullets produced about a 22-MOA group. Moreover, I observed occasional examples of keyholing with both types of bullets from my homemade mold, and on top of that, they produced mild but noticeable barrel leading.

I observed much the same trend in accuracy when testing bullets in my revolver, with the TL430-240-SWC bullets producing a group just slightly larger than the 429-214-SWC bullets, and the round nose bullets producing a group just slightly tighter than the 429-214-SWC bullets. In prior testing, powder coated bullets cast with the Lee 429-214-SWC mold from Lyman #2 alloy had generated no appreciable barrel leading in my revolver and produced groups of about 14-MOA. Yet, the barrel leading produced by non-lubricated bullets in other testing was so severe that I was unable to completely remove it prior to this test, despite much scrubbing of the bore with strong solvents and repeatedly firing strings of jacketed bullets in hopes of scraping the lead out. In this test, the identical 429-214-SWC bullets spread out slightly more than usual and generated mild but noticeable barrel leading, both presumably because of the existing lead residue in the bore. Likewise, the other SWC and round-nose bullets generated mild but noticeable barrel leading, likely with an attendant detrimental effect on accuracy, though no baseline existed against which to assess it. Proportionately, my custom bullets performed somewhat better in the revolver than they had in the rifle, although the tapered flat point bullets still spread out to about a 40-MOA group, and the double-tapered bullets only managed about a 25-MOA group.

Conclusions

Based on the testing documented heretofore, it may be concluded that cast bullets intended for use in .44 magnum (and presumably most other modern smokeless-powder cartridges) should be cast out of a lead alloy with a Brinell hardness of at least 16, such as Lyman #2 which is 90% Lead, 5% Antimony, and 5% Tin.

Bare metal cast bullets should not be used in ammunition, as they will produce severe barrel leading with attendant detrimental effects on acracy. Powder coating of cast lead bullets was found to be the most effective method of preventing barrel leading.

Sizing of cast bullets (either before or after powder coating) was found to have little to no effect on bullet performance, provided that the as-cast diameter of the bullets was within a few thousandths of an inch of the groove diameter of the gun barrel through which they will be fired. However, if the bullets are sized all the way down to a diameter approaching the land diameter of the barrel, accuracy degrades severely.

When using bullet molds of a given manufacture and level of quality, the particular style of bullet chosen seems to have only a minimal effect on accuracy. In this test it was found that a round-nose bullets delivered marginally better accuracy than semi-wadcutters. However, while the difference in performance between different bullet styles cast in molds of comparable quality is minimal, the use of inferior-quality molds can have a catastrophic effect on accuracy. Furthermore, while it is certainly possible to make homemade bullet molds for casting custom bullets, producing homemade bullet molds of comparable quality to entry-level molds such as those manufactured by Lee proved unexpectedly difficult.

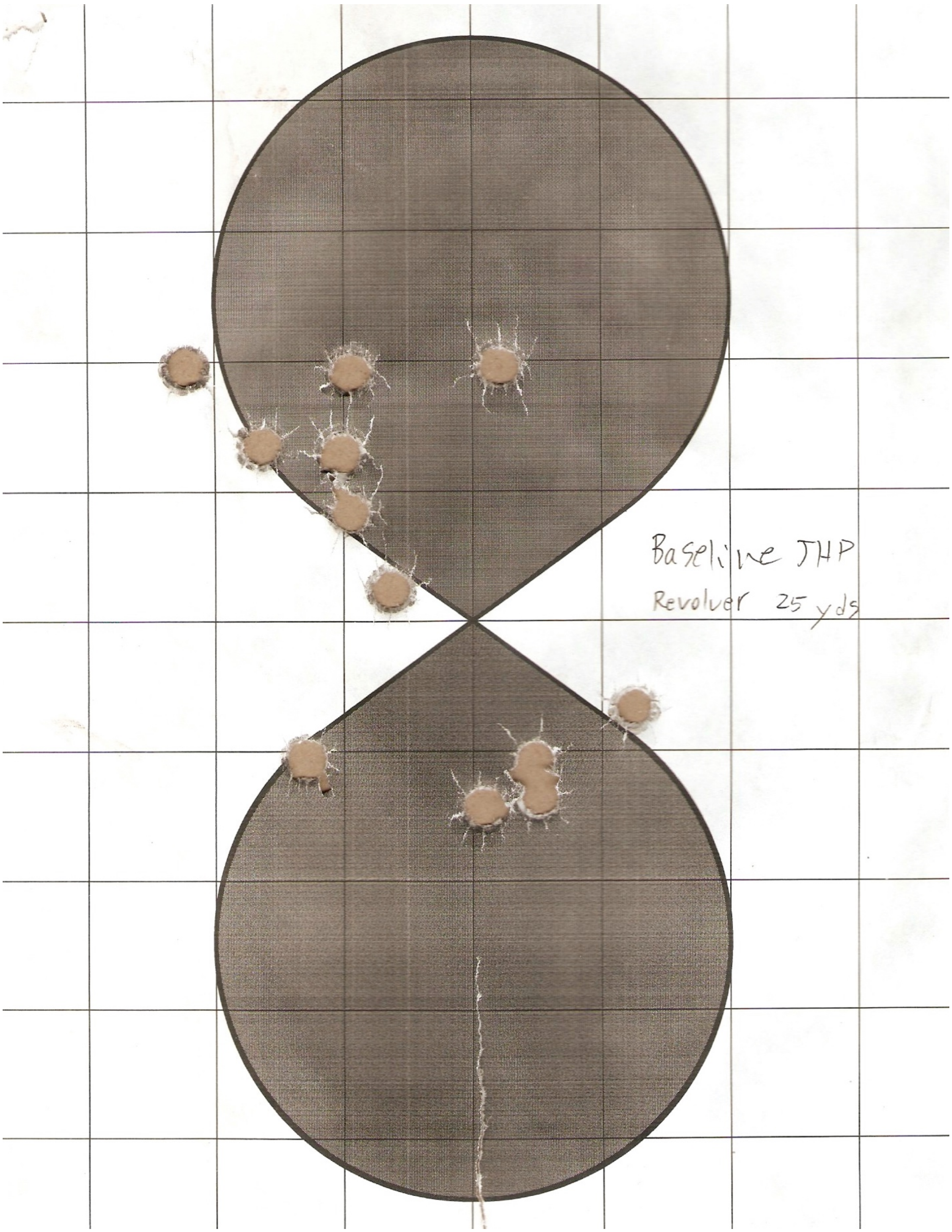
Applying the above conclusions, .44 magnum ammunition produced with powder-coated bullets cast from Lyman #2 alloy using a Lee 429-240-2R bullet mold was found to deliver about 5-MOA accuracy. While this level of accuracy is adequate for many applications, it remains slightly inferior to the accuracy that may be achieved using factory-made jacketed bullets.

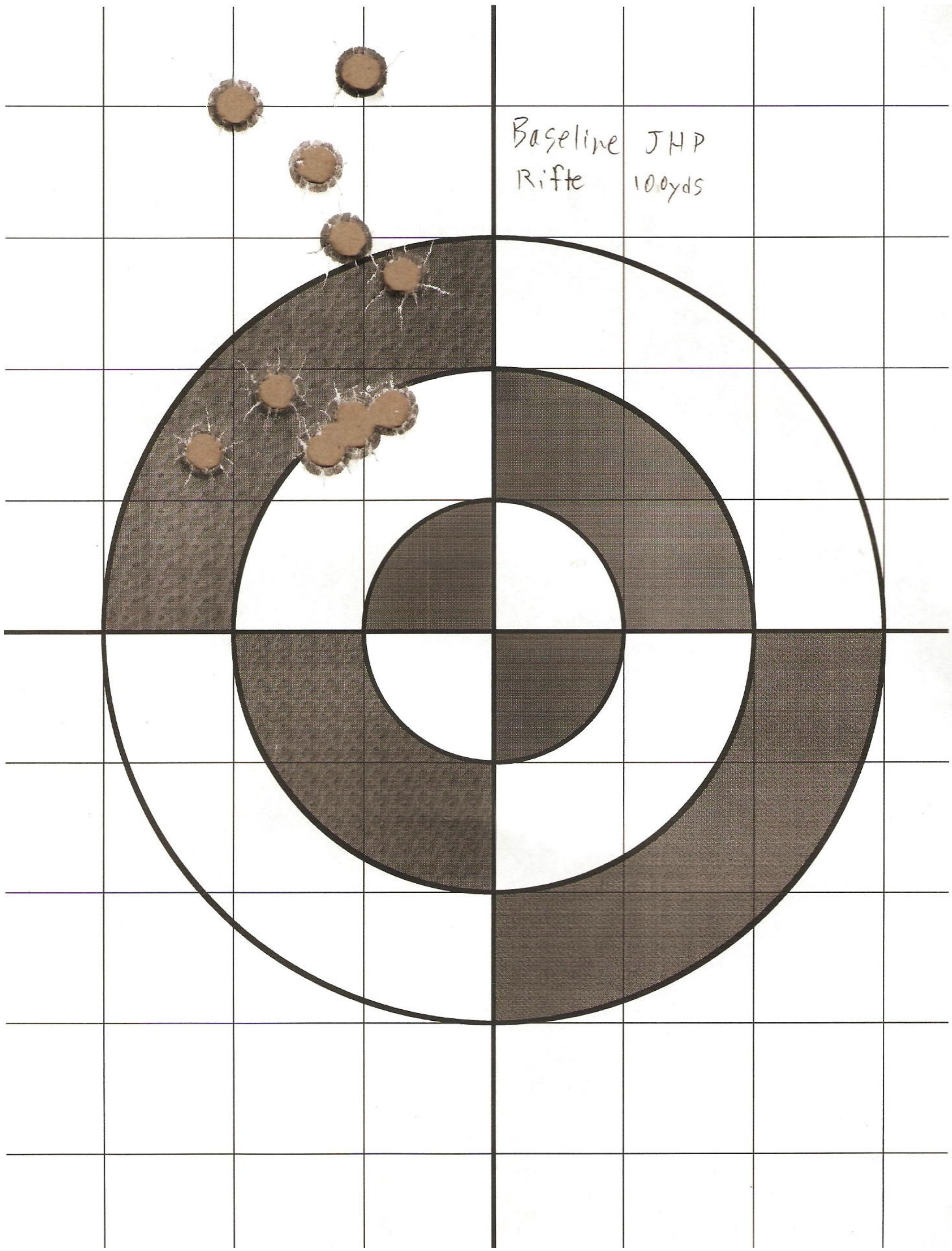
Future Work

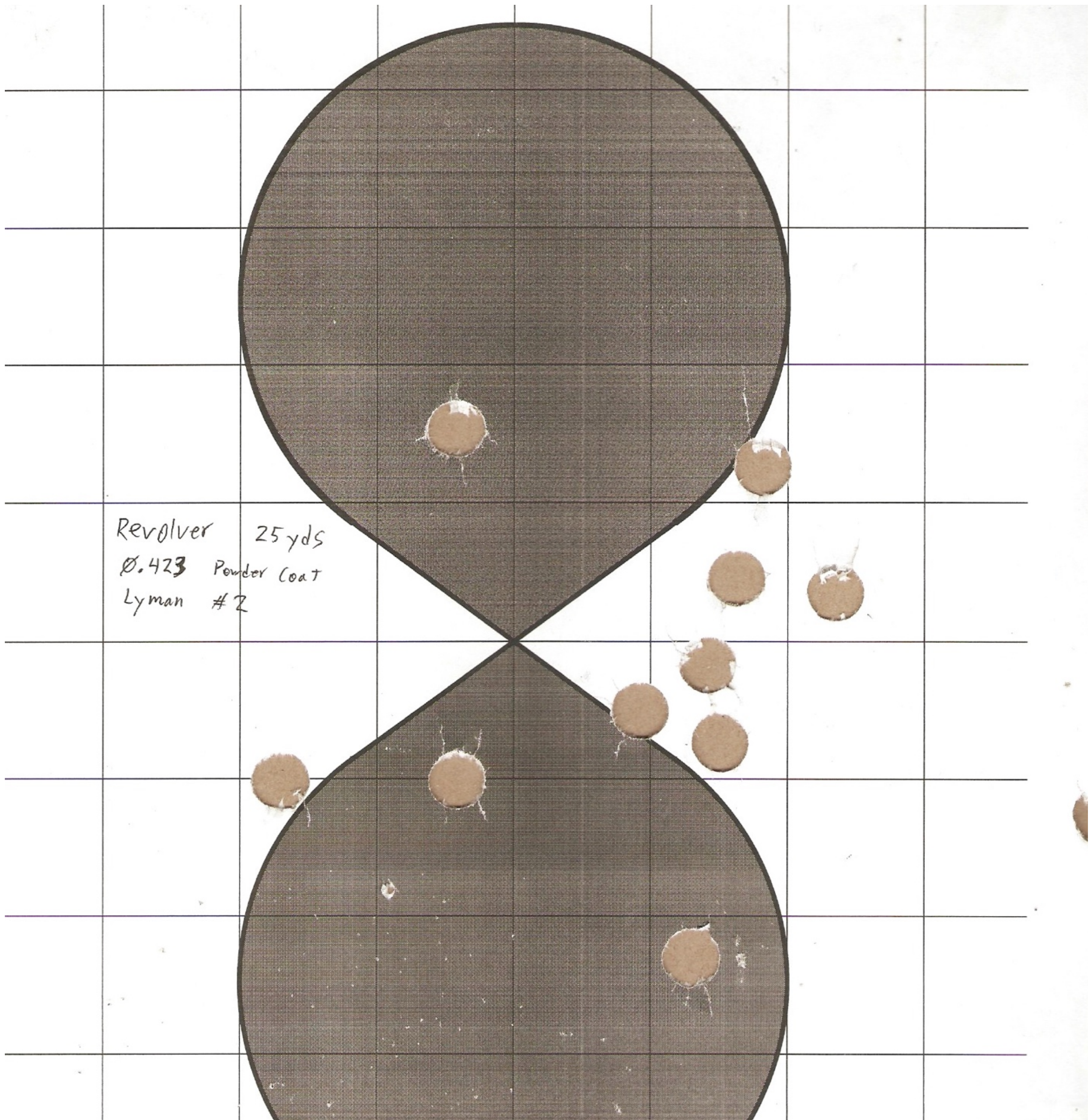
Although this investigation into factors affecting cast bullet performance was illuminating in many regards, there is substantial work that still remains to be done. For example, I did not evaluate the effect of gas checks on bullet performance, nor did I include any hollow-point bullets in my comparison of bullets of varying style and geometry. In this study, I gaged performance primarily in terms of barrel leading and accuracy, without regard to the performance of the bullet after striking the target. It would doubtless be instructive to extend the study into the realm of terminal ballistics, particularly when comparing hollow point bullets to round-nose bullets and semi-wadcutters. Insomuch as I was unable during the course of this testing to produce a cast bullet capable of delivering the same level of accuracy as commercial jacketed bullets, and given that jacketed bullets are produced by a swaging process, it might also be worth investigating whether it is possible by simple means to produce swaged, jacketed, and/or hybrid bullets at home. Perhaps in lieu of a drawn copper jacket, a copper jacket could be produced by casting a coil of copper wire onto the periphery of a bullet. These would all be interesting factors to consider in the course of further experimentation, but my available time and funding for such experimentation has for the moment been exhausted, and so I must adjourn here for now.

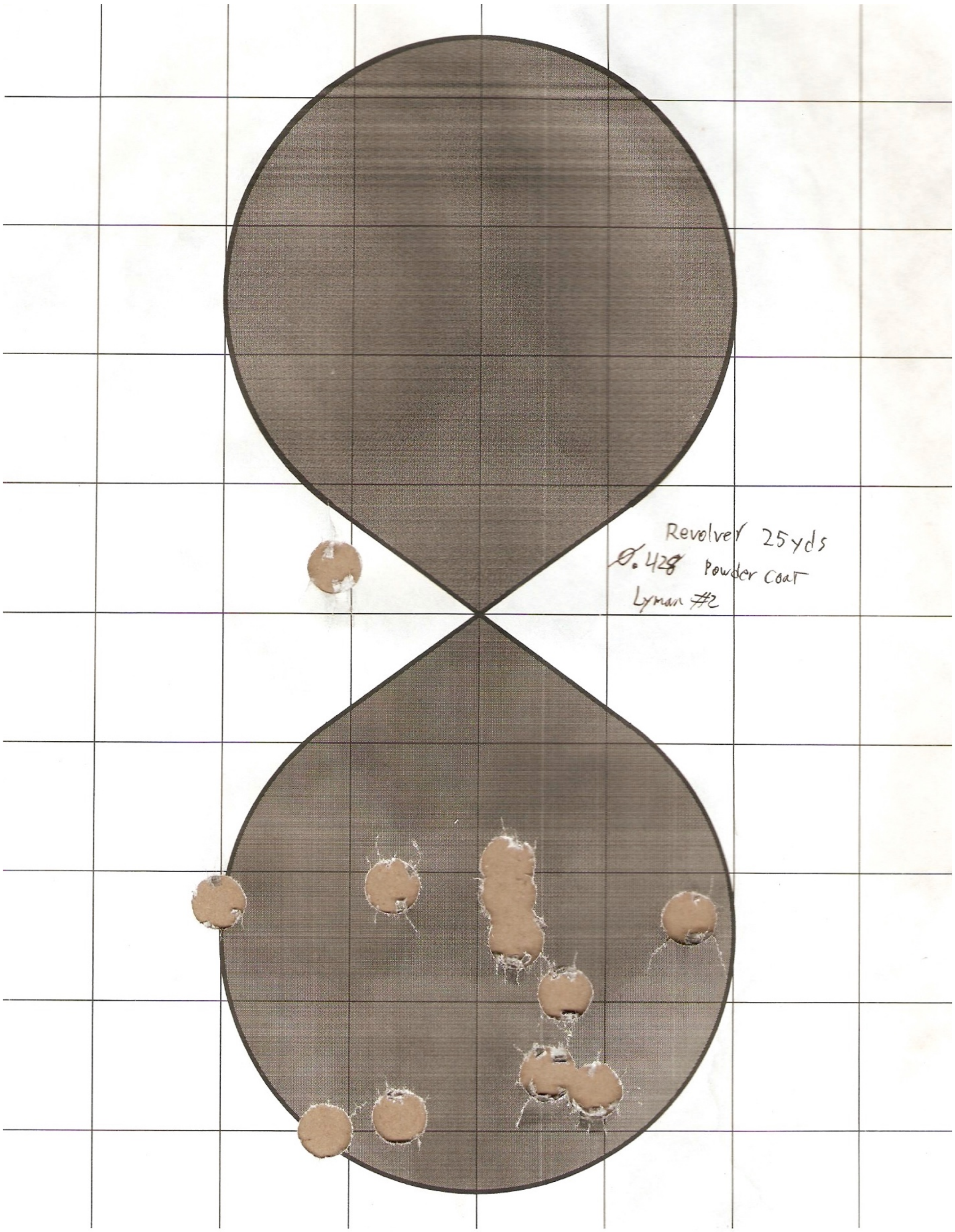
Appendix A: Targets

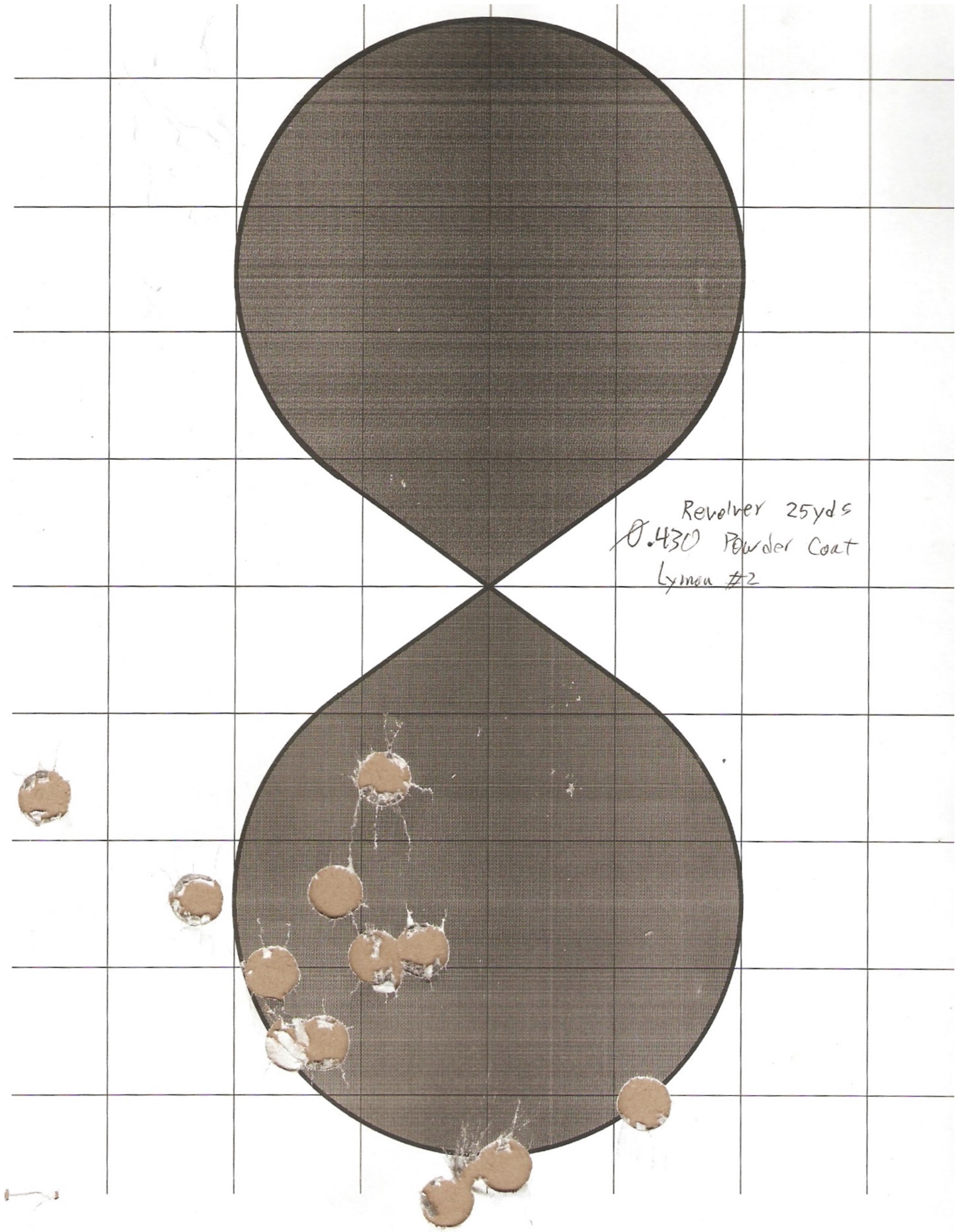
Note: Scale of scanned images may vary.
All targets have a 1-inch grid pattern to expedite measurement of group size.

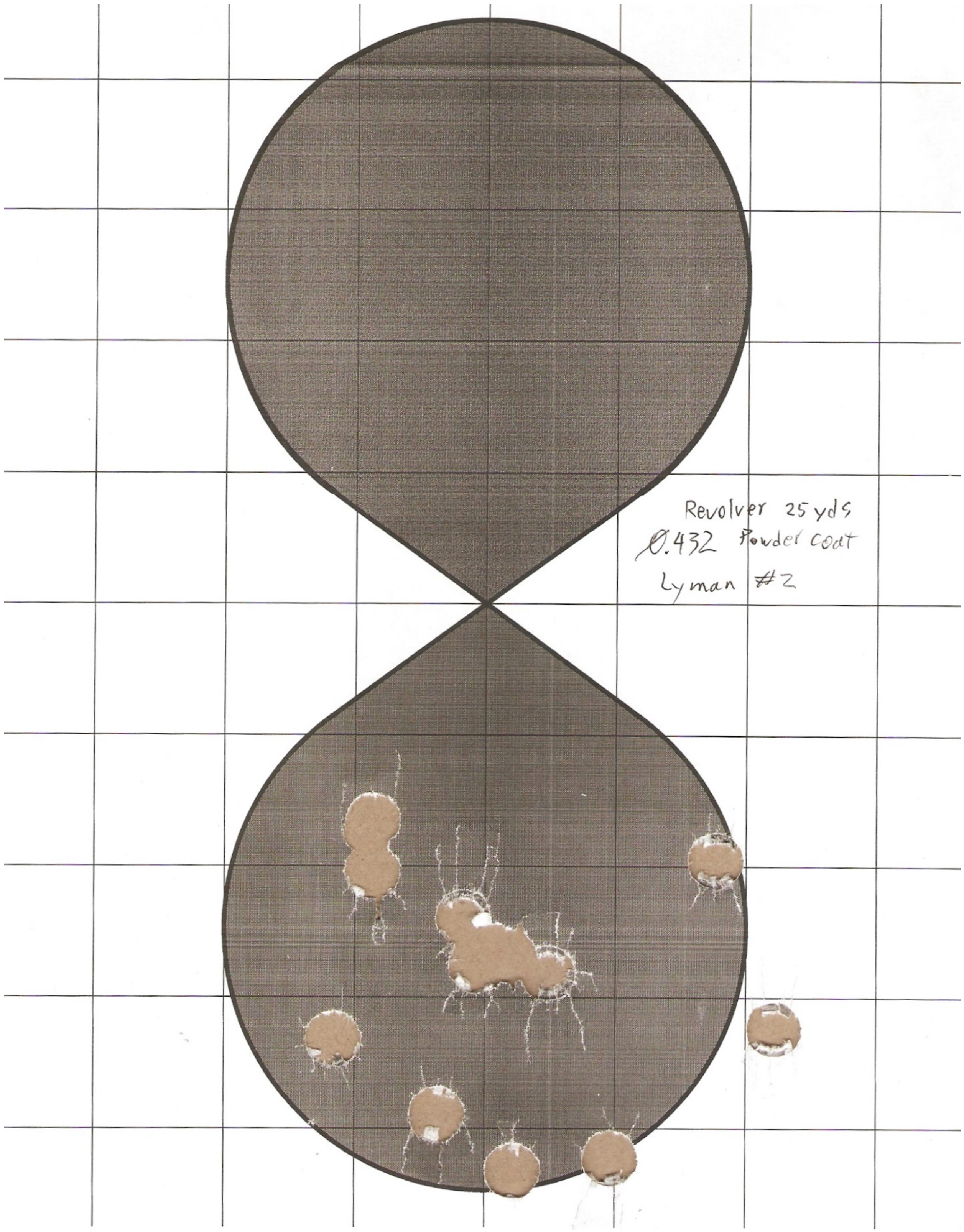

Baseline JHP
Revolver 25 yds


Baseline JHP
Rifle 100yds

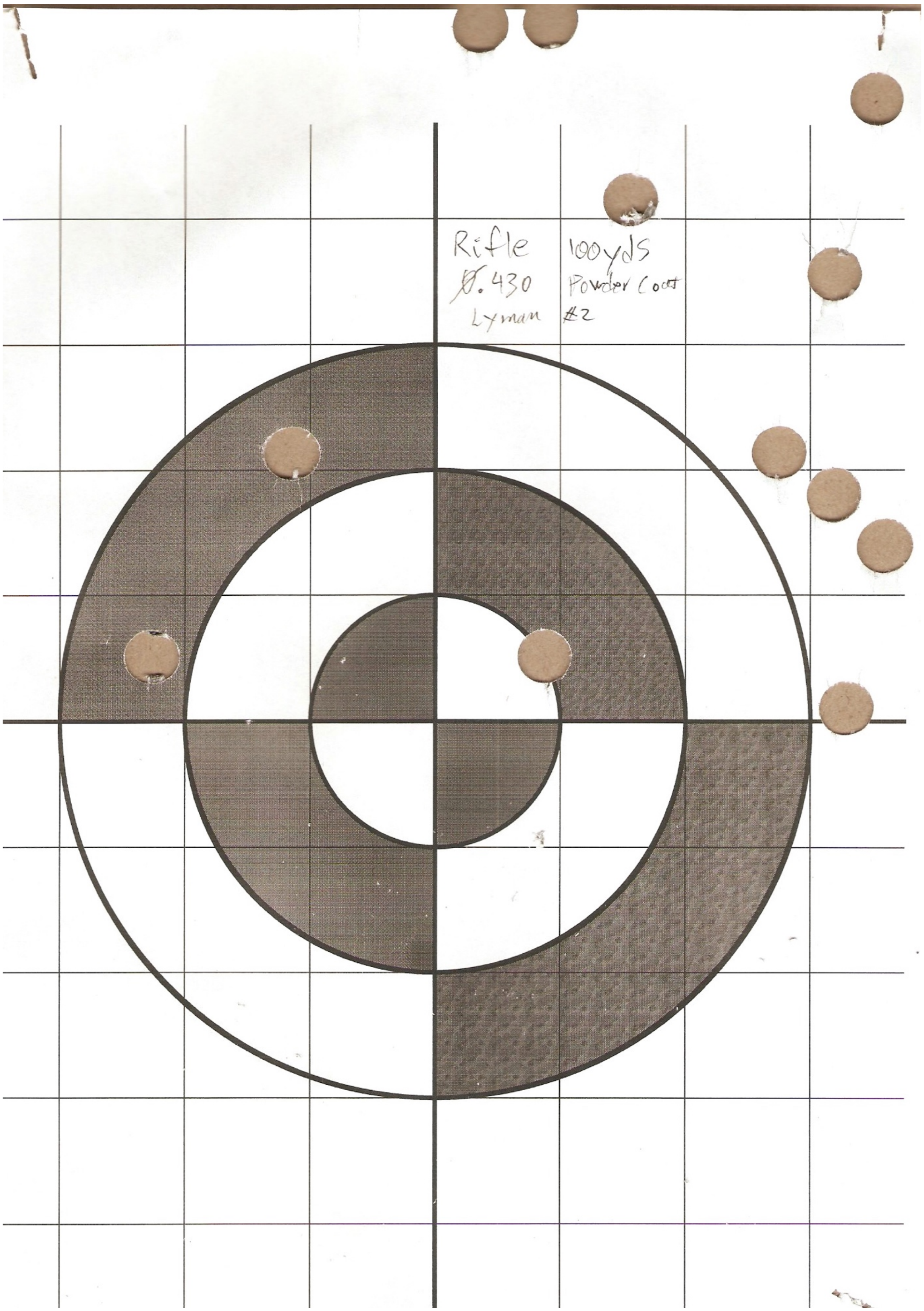

Revolver 25yds
Ø.423 Powder Coat
Lyman #2

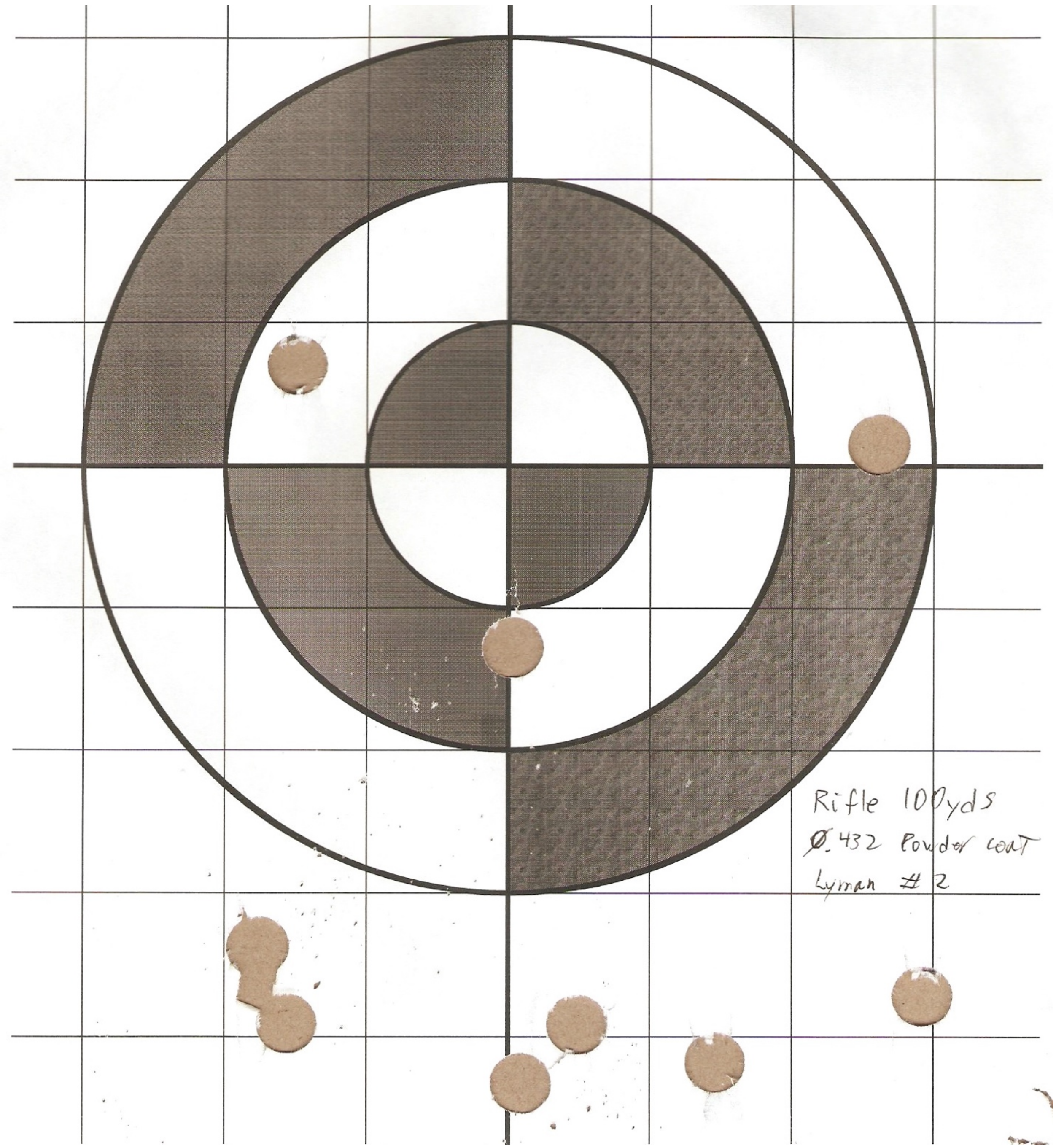

Revolver 25yds
Ø.428 Powder Coat
Lyman #2

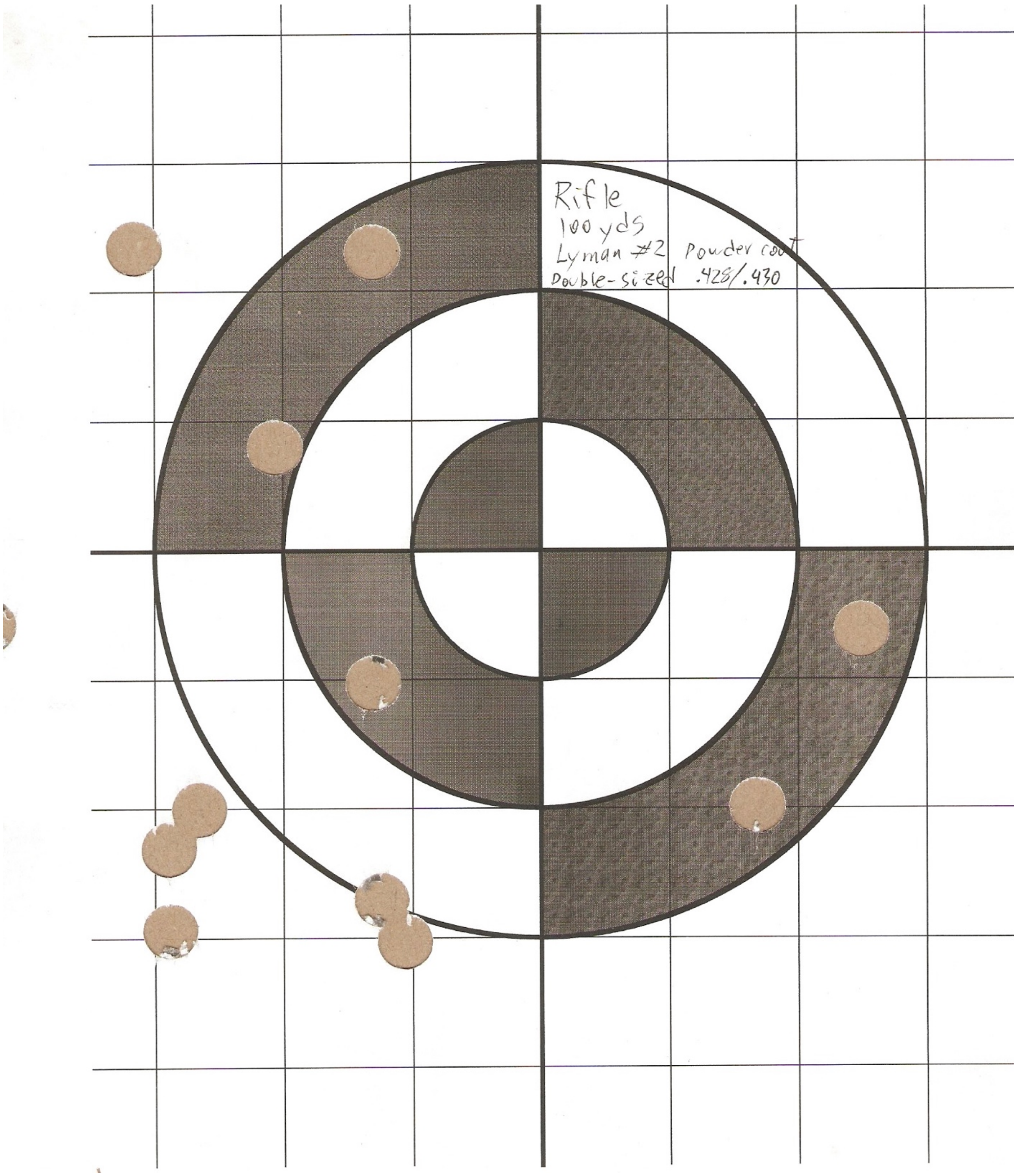

Revolver 25yds
0.430 Powder Coat
Lyman #2

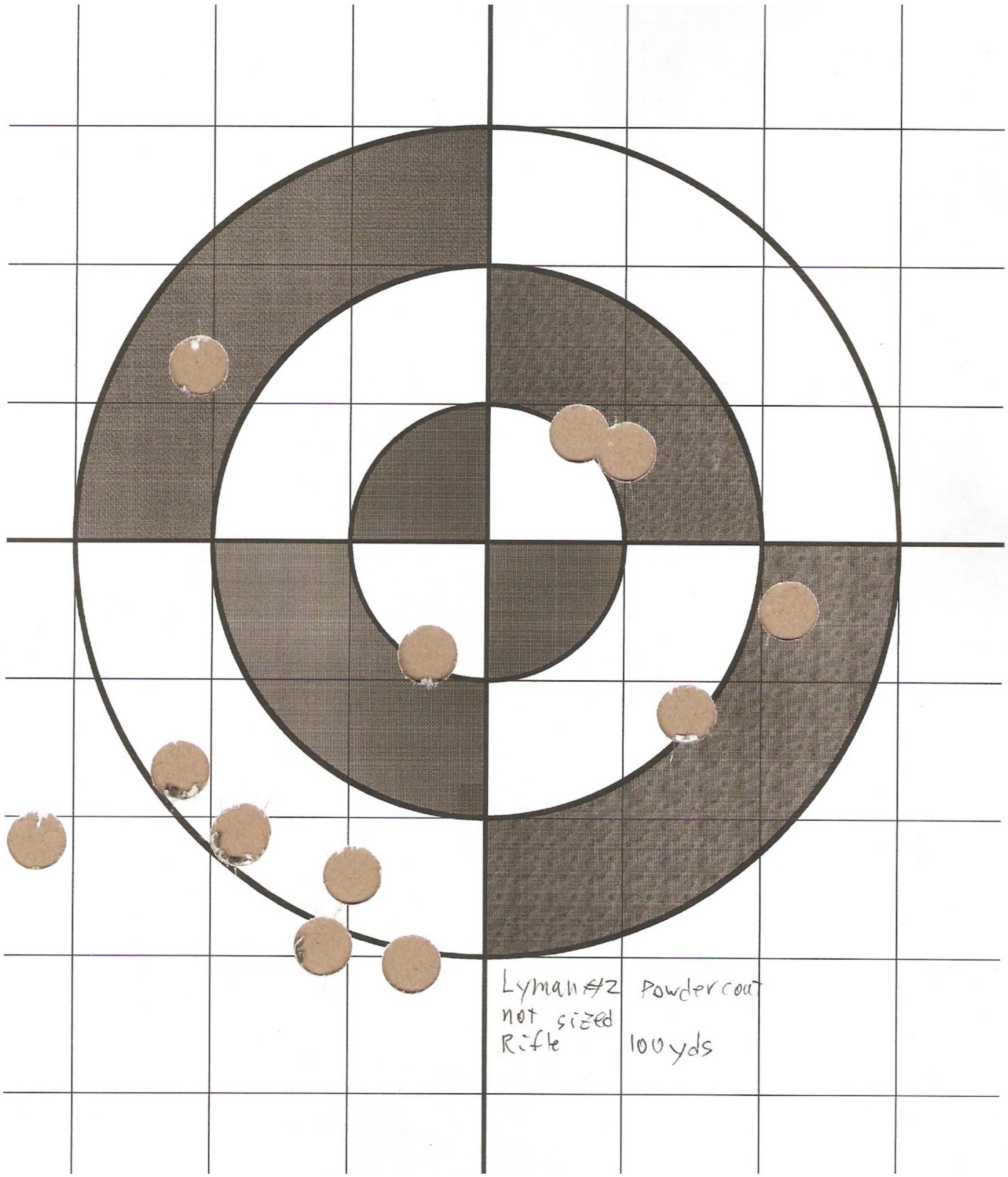

Revolver 25 yds
Ø.432 Powder coat
Lyman #2


Rifle 100yds
Ø.428 Powder coat
Lyman #2

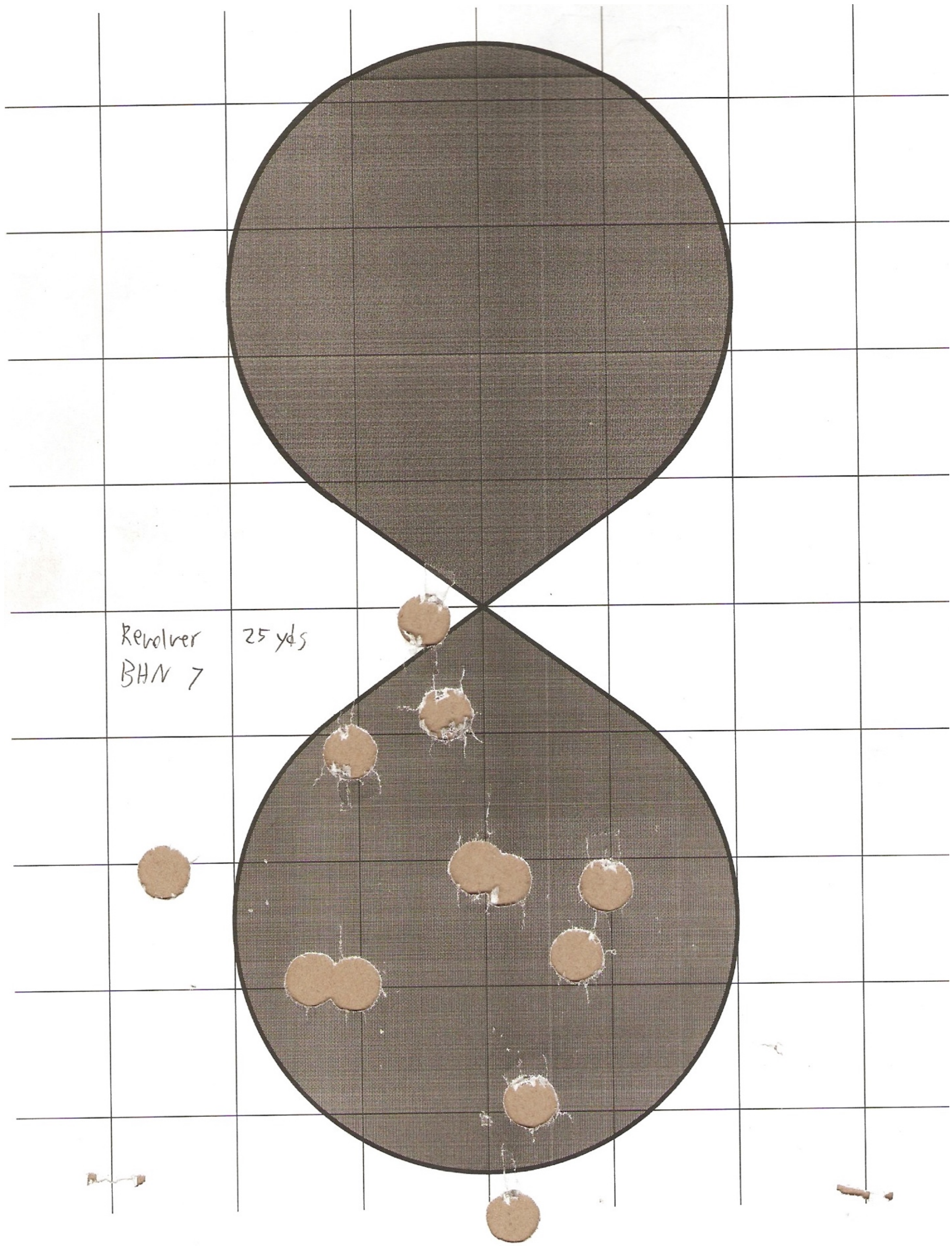

Rifle 100yds
Ø.430 Powder Coat
Lyman #2

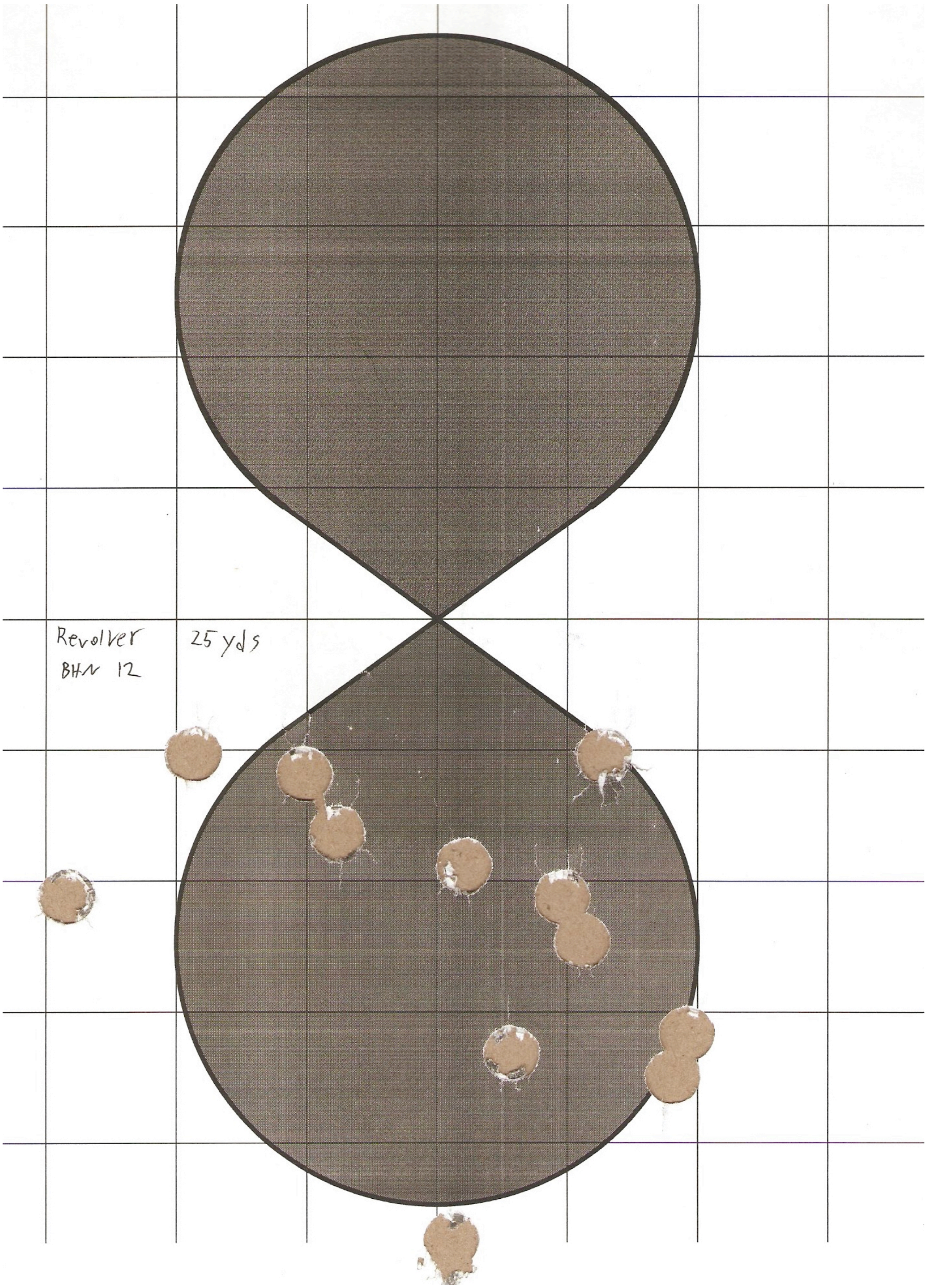

Rifle 100yds
Ø.432 Powder coat
Lyman #2

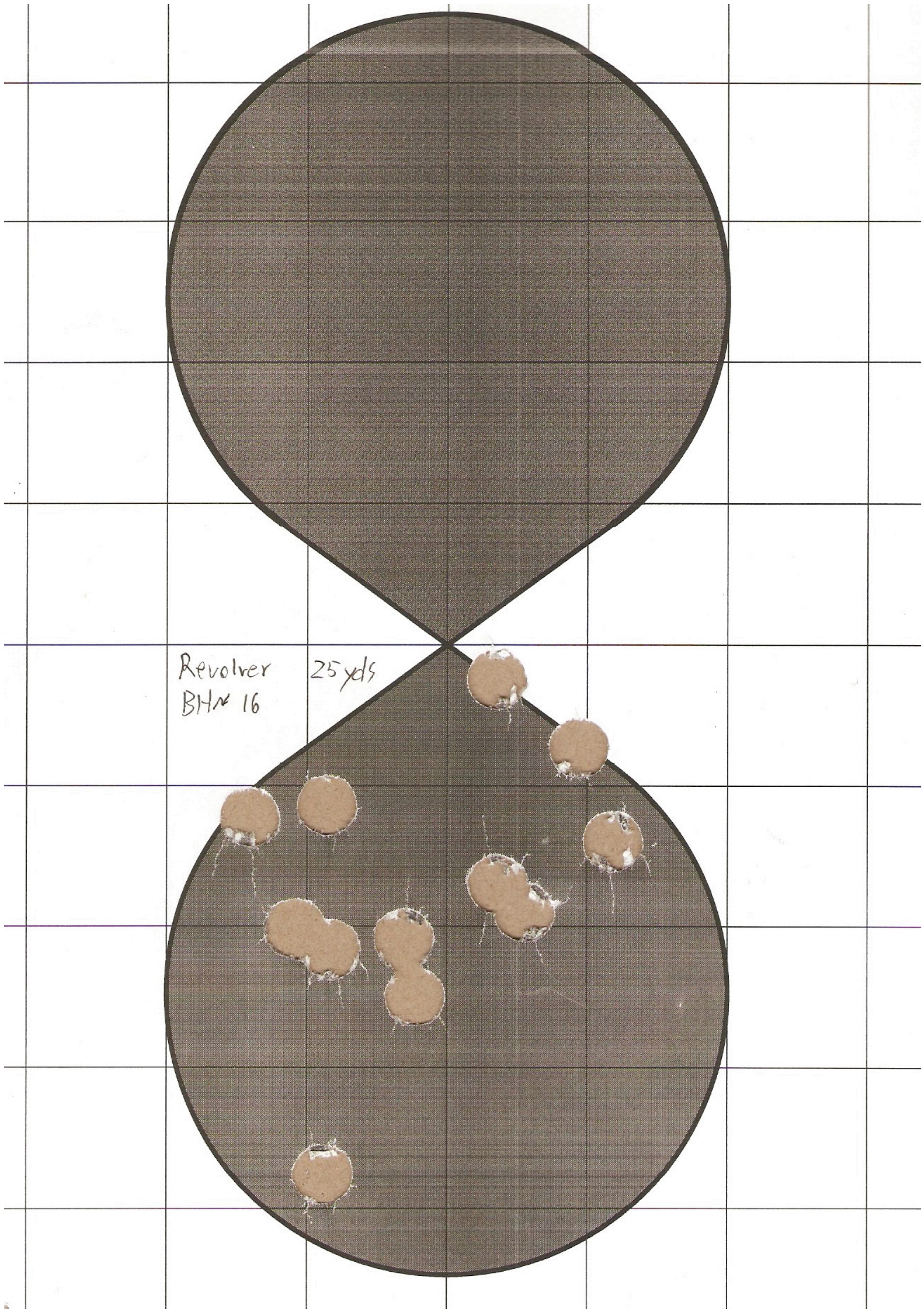

Rifle
100 yds
Lyman #2 Powder coat
Double-sized .428/.430

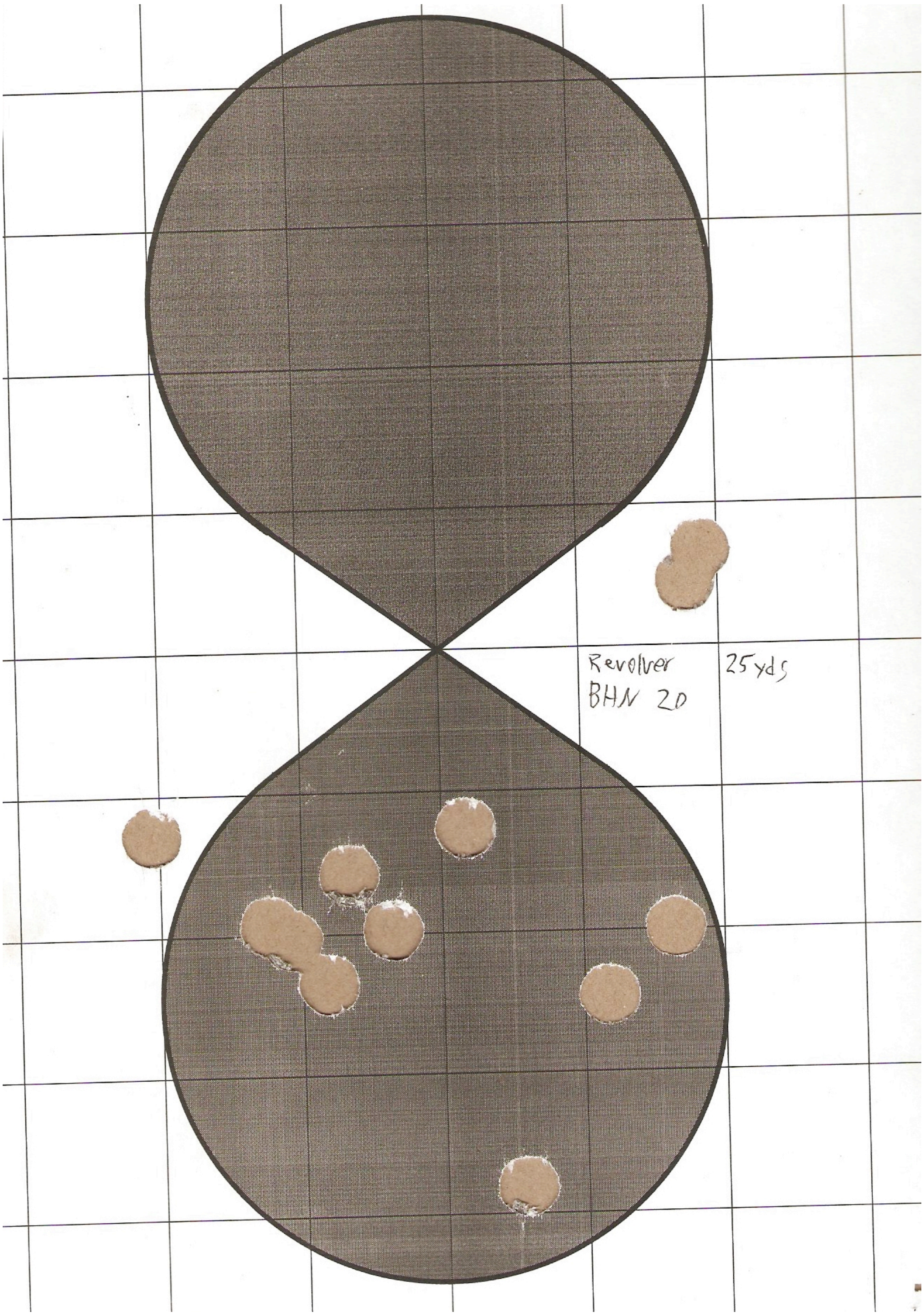


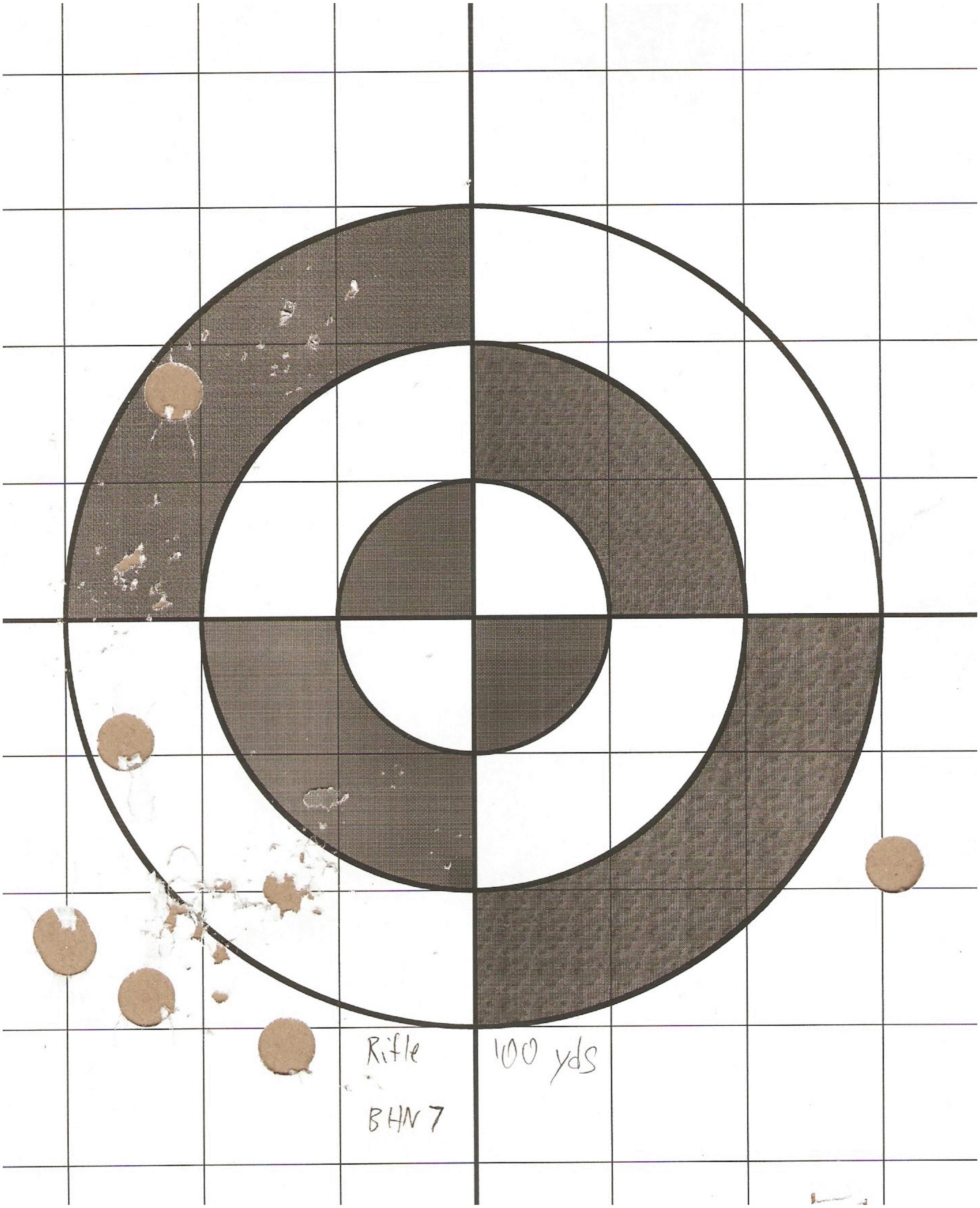
Lyman#2 Powdercoat
not sized
Rifle 100yds

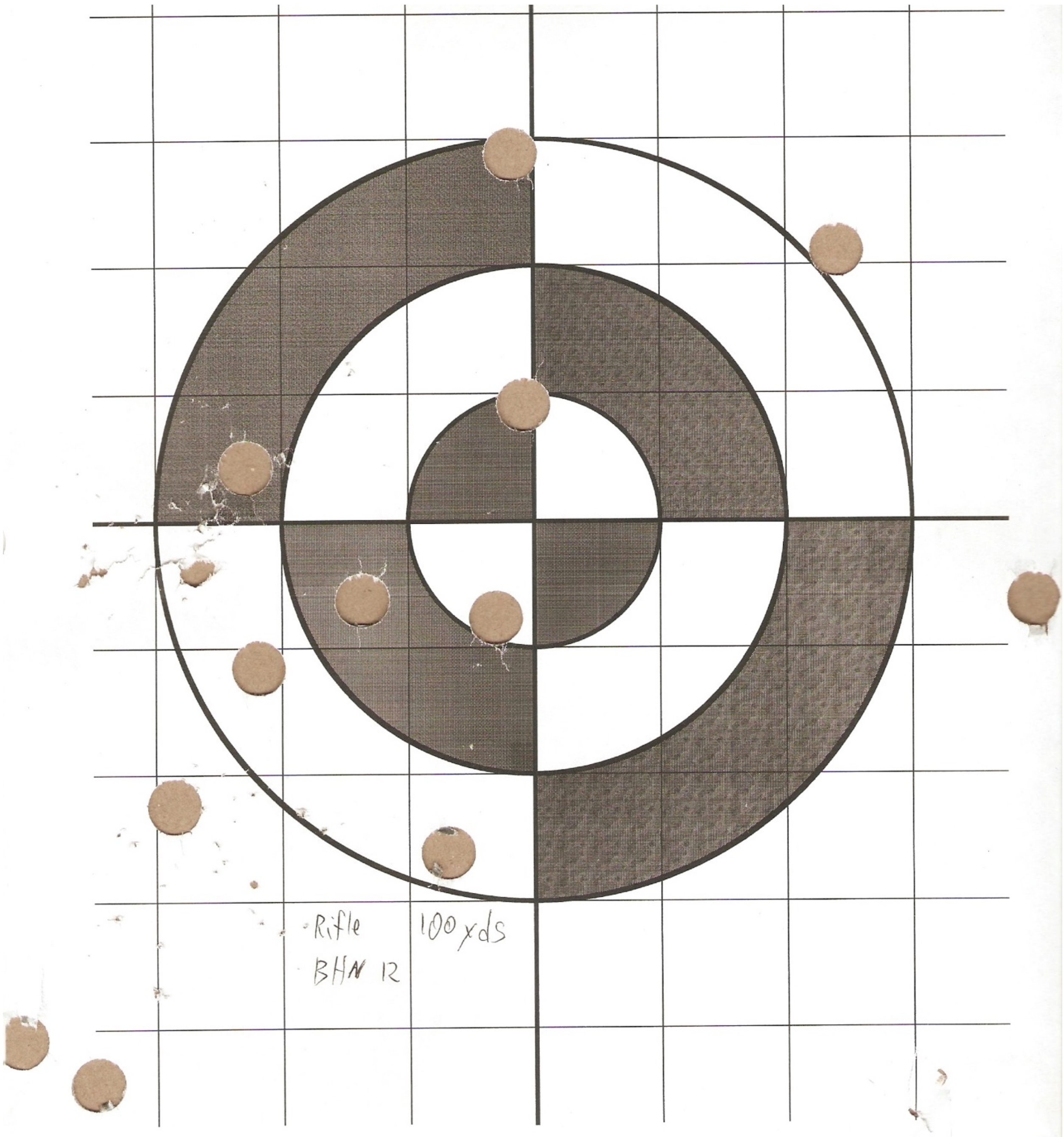

Revolver 25 yds
BHN 7

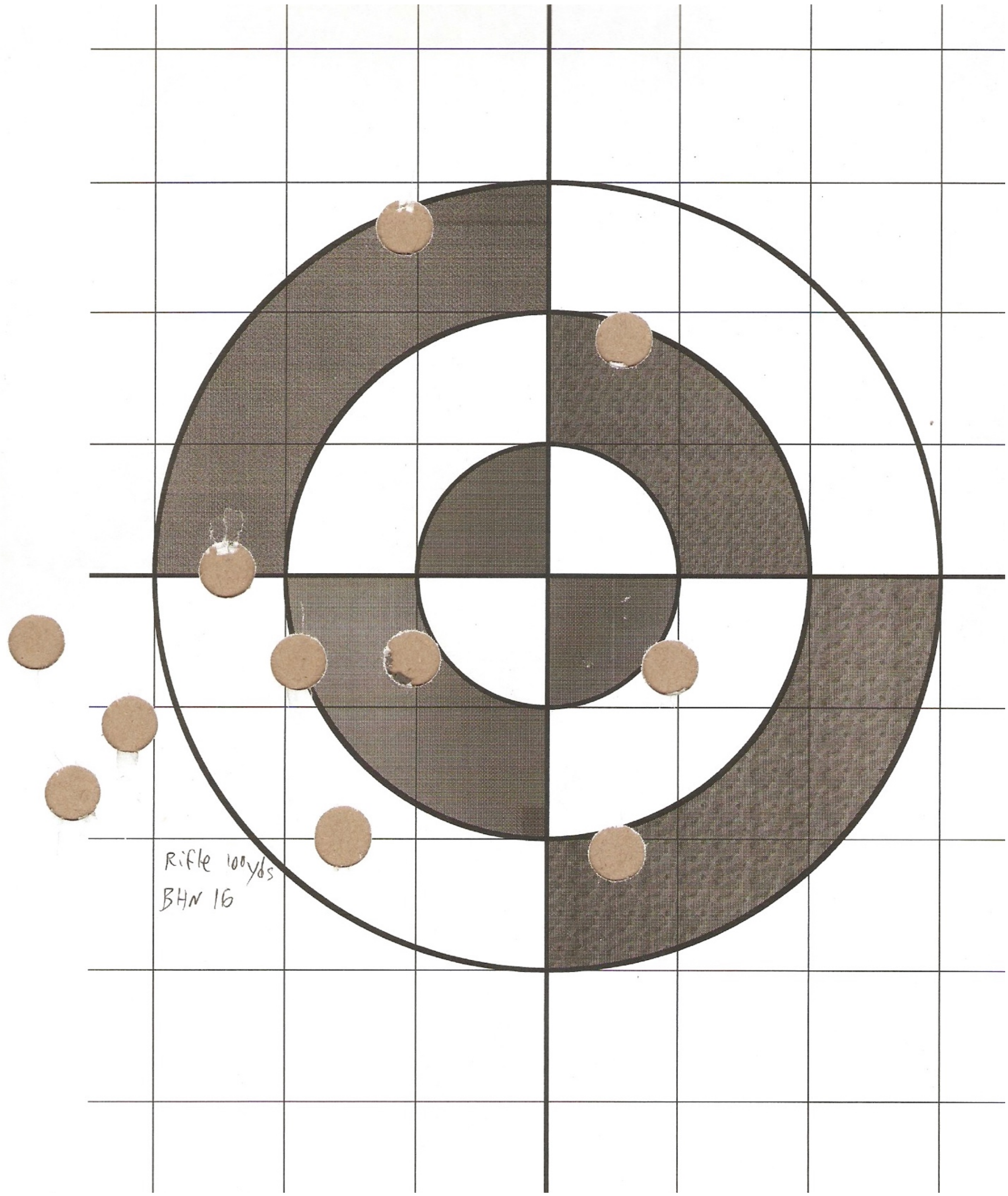

Revolver 25 yds
BHN 12

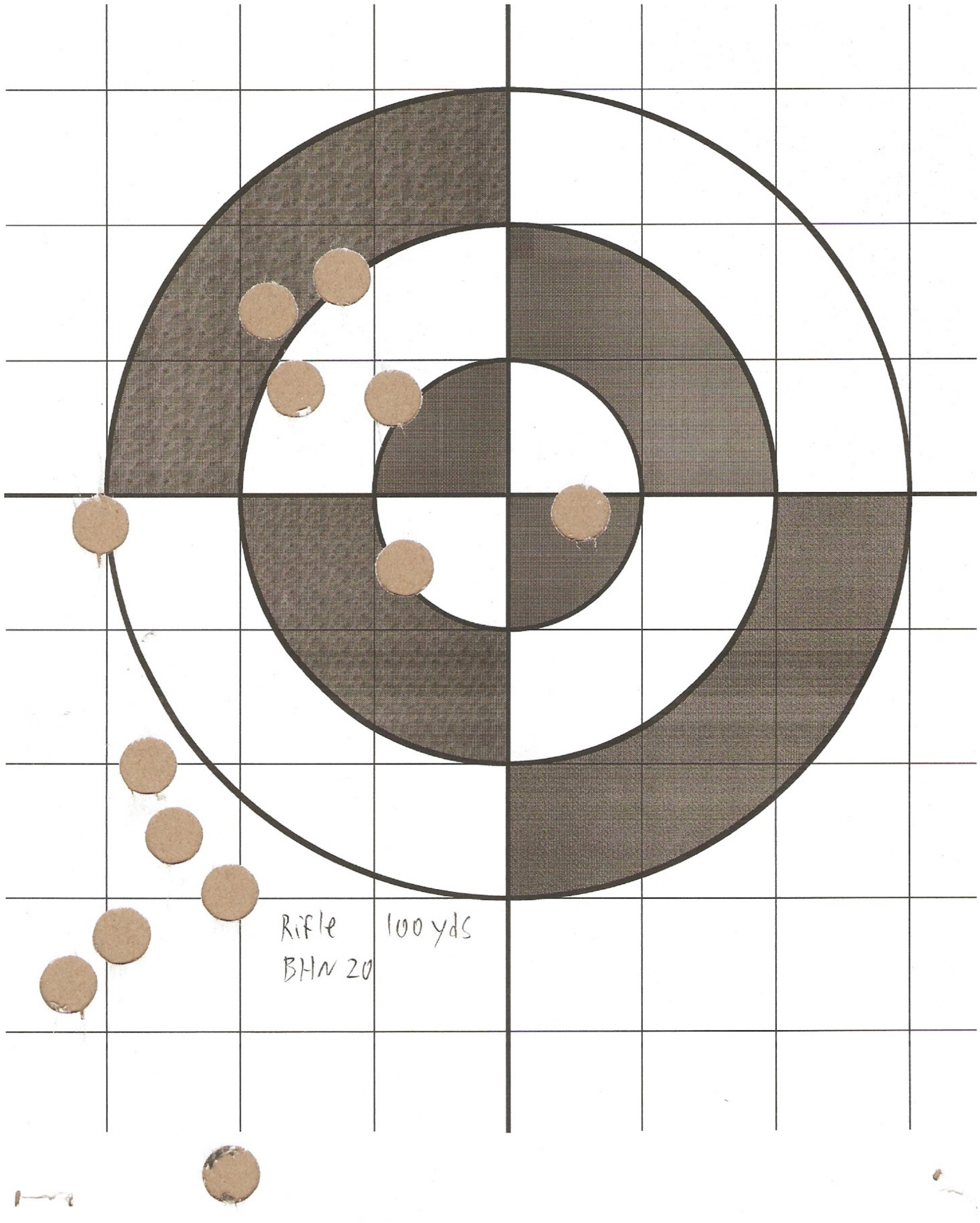

Revolver 25yds
BHN 16

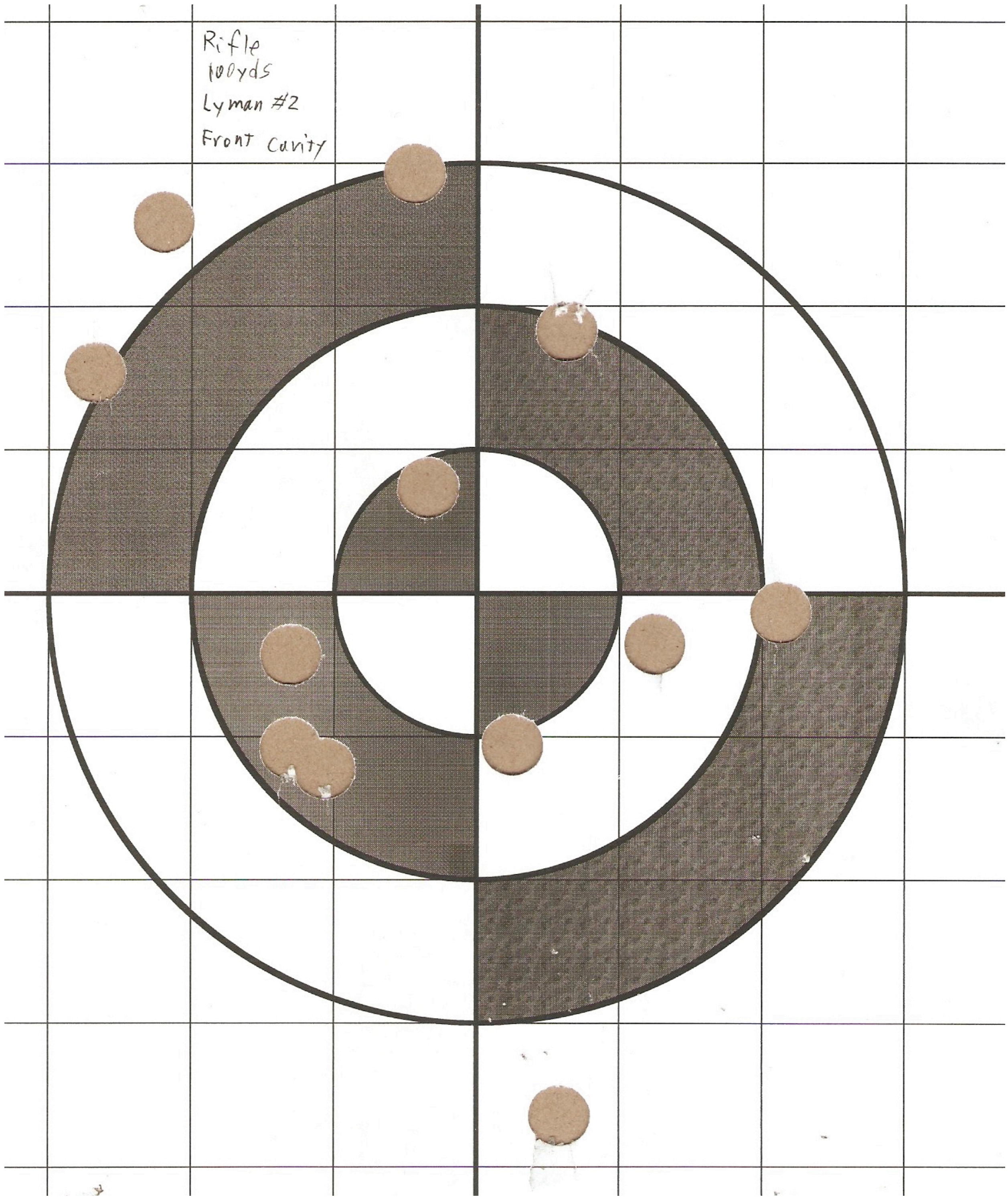

Revolver 25yds
BHN 20

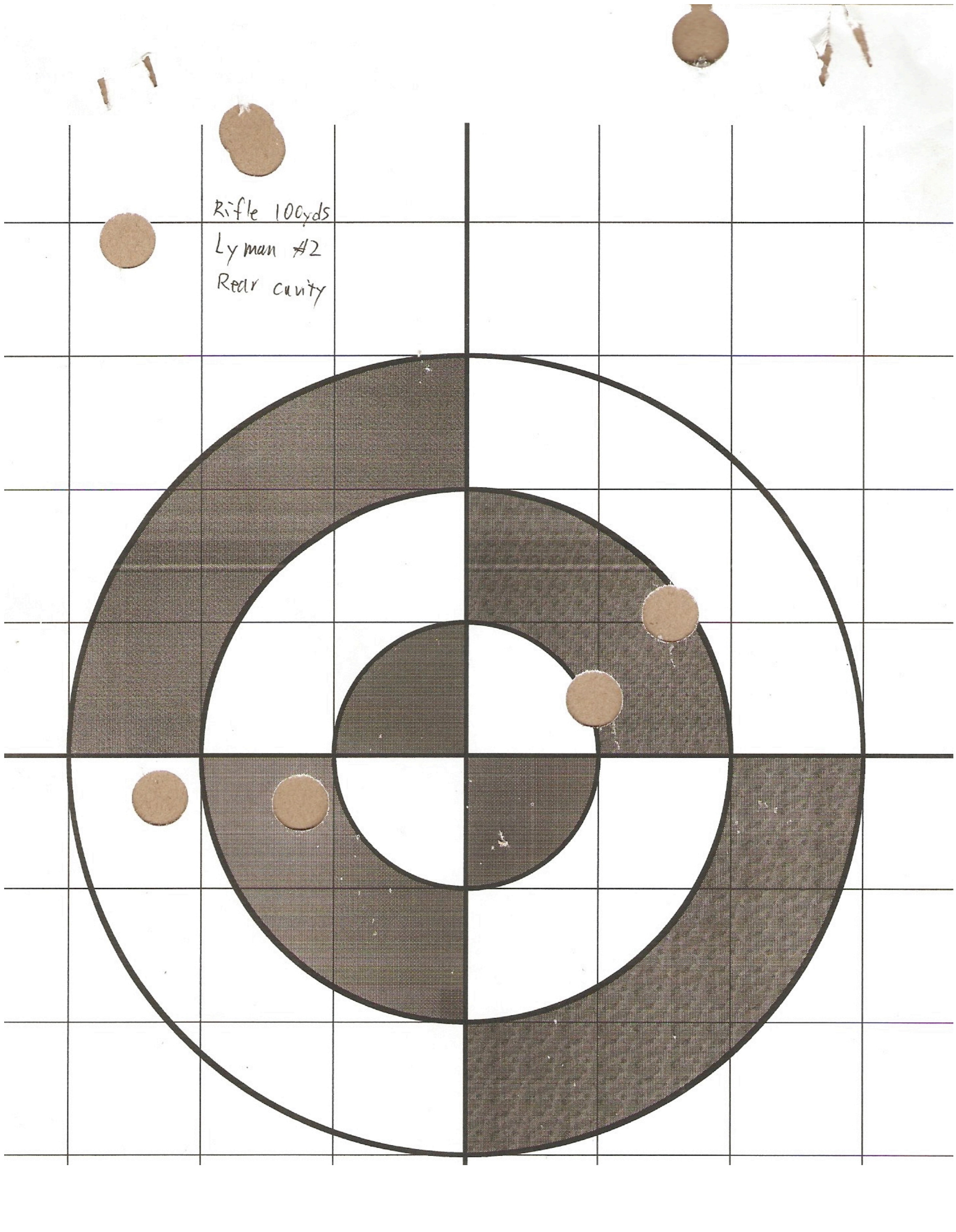

Rifle
100 yds
BHN 7

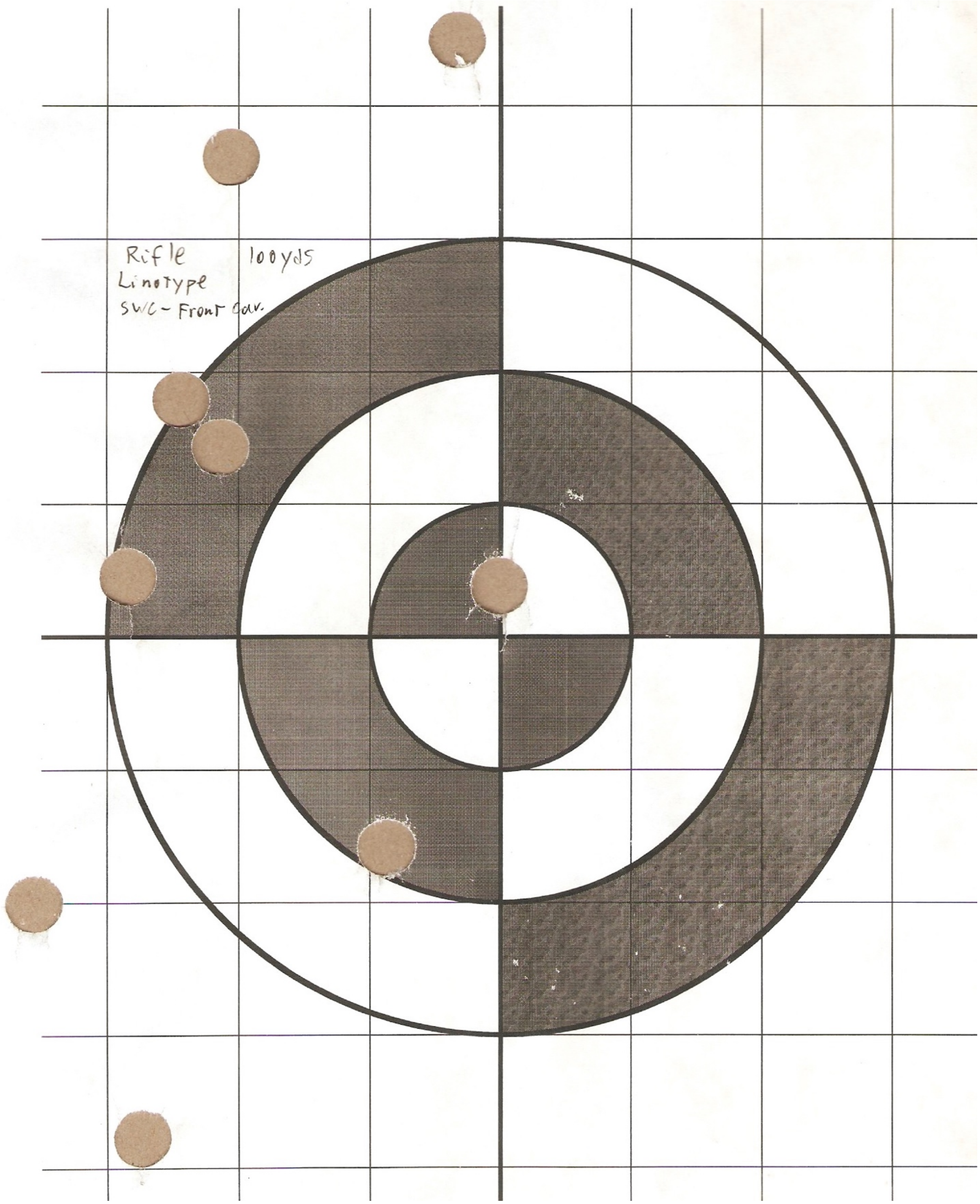

Rifle 100 yds
BHN 12

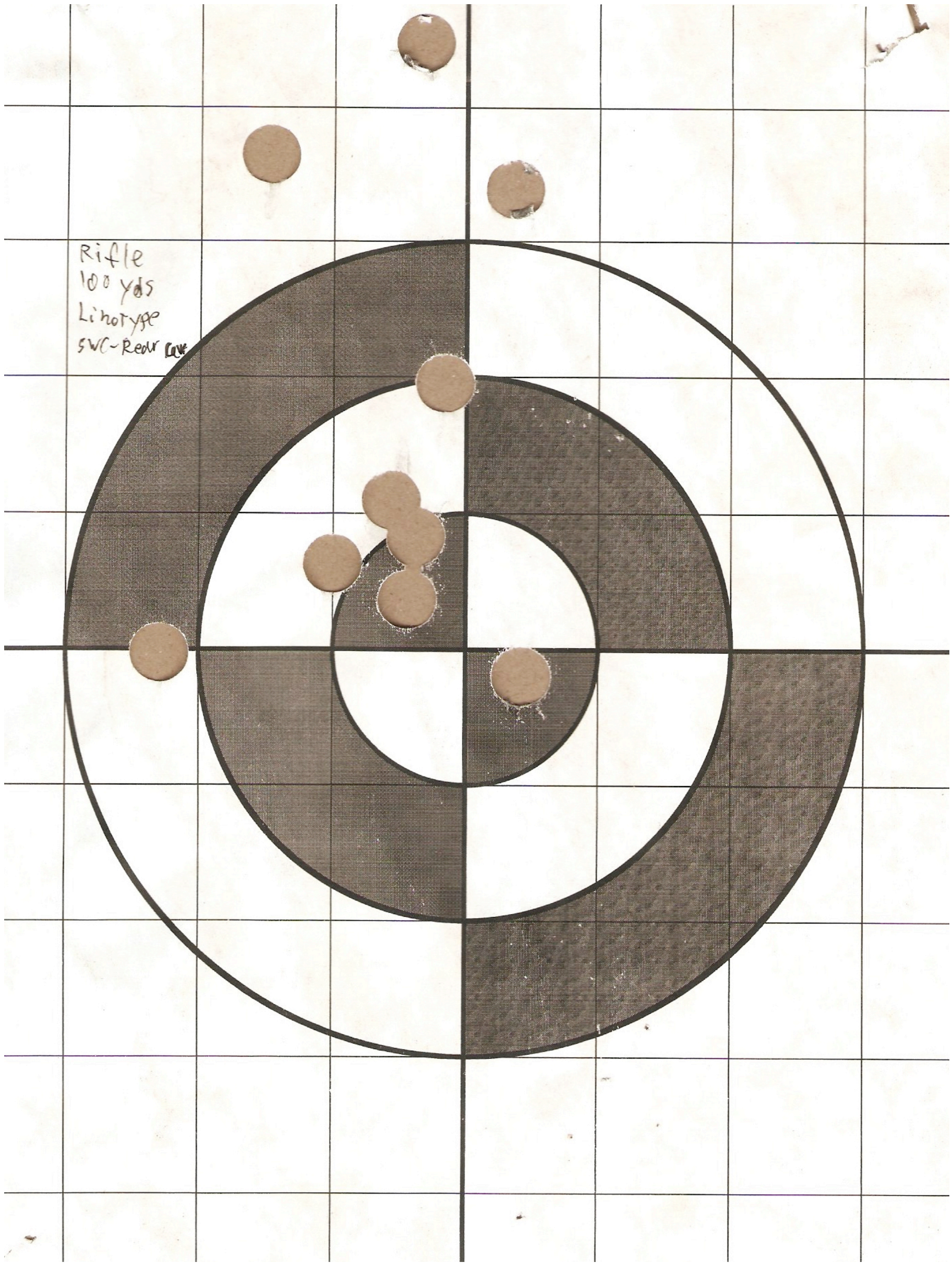

Rifle 100yds
BHN 16

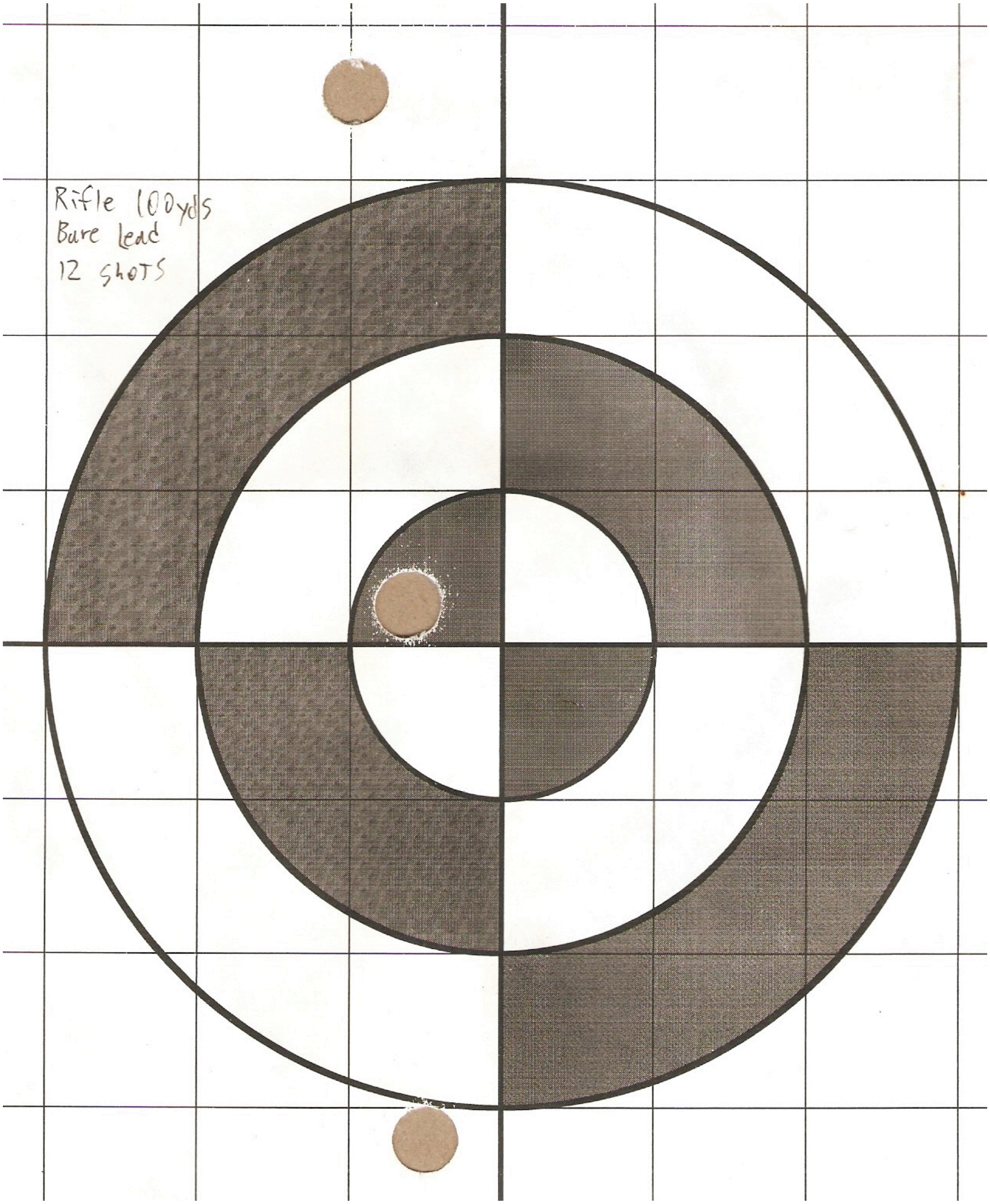

Rifle 100 yds
BHN 20

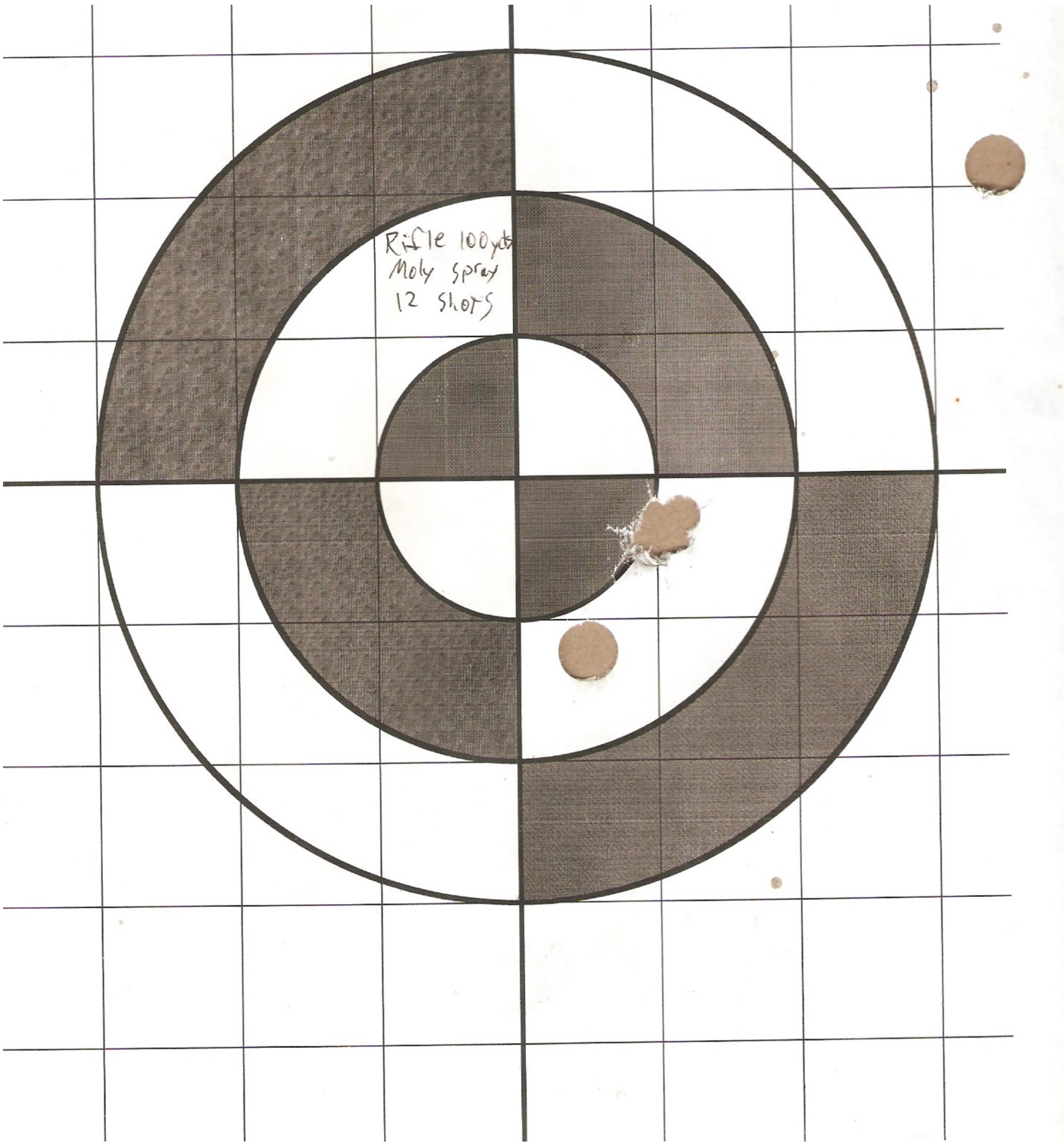

Rifle
100yds
Lyman #2
Front cavity

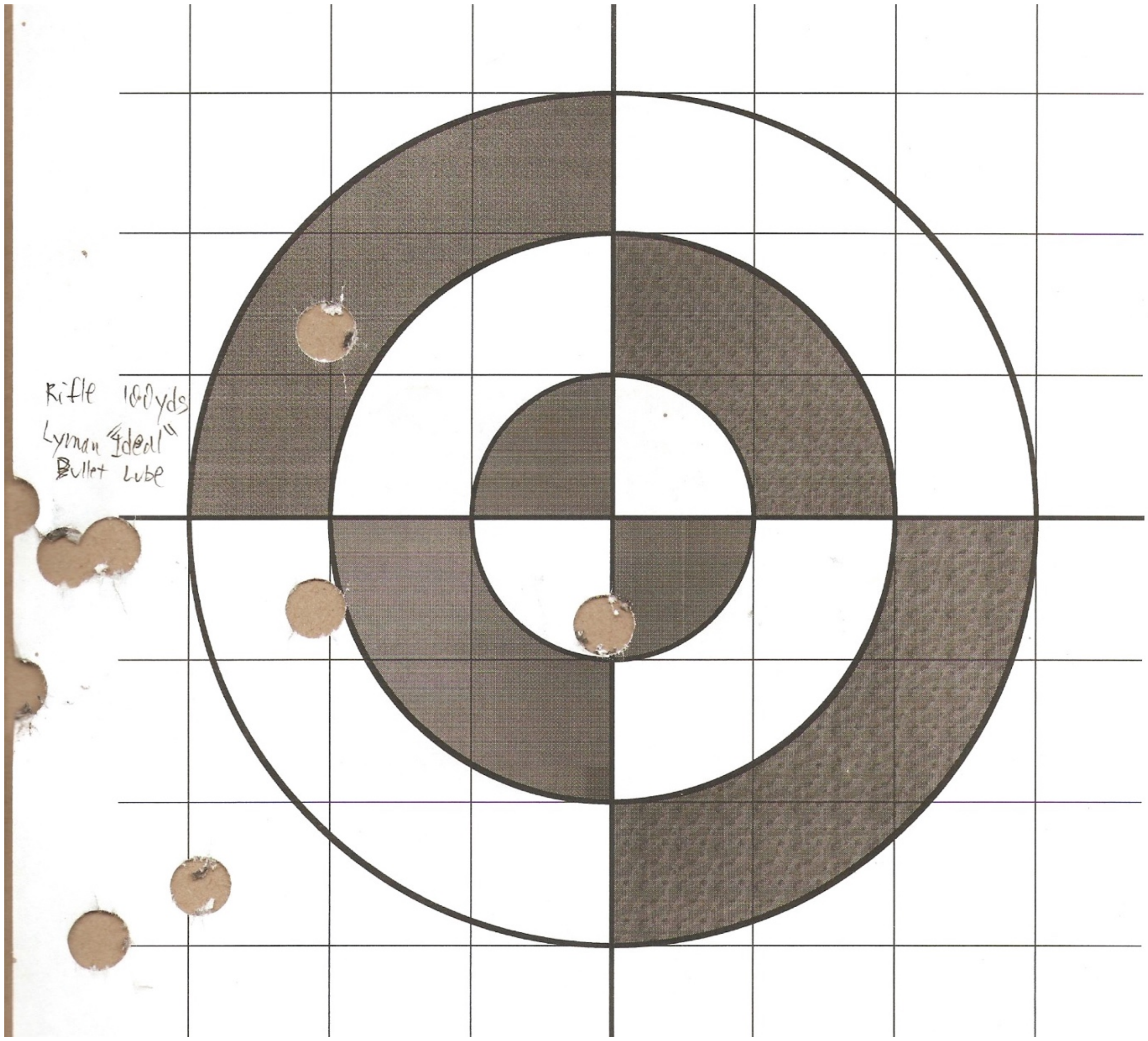

Rifle 10 yds
Lyman #2
Rear cavity

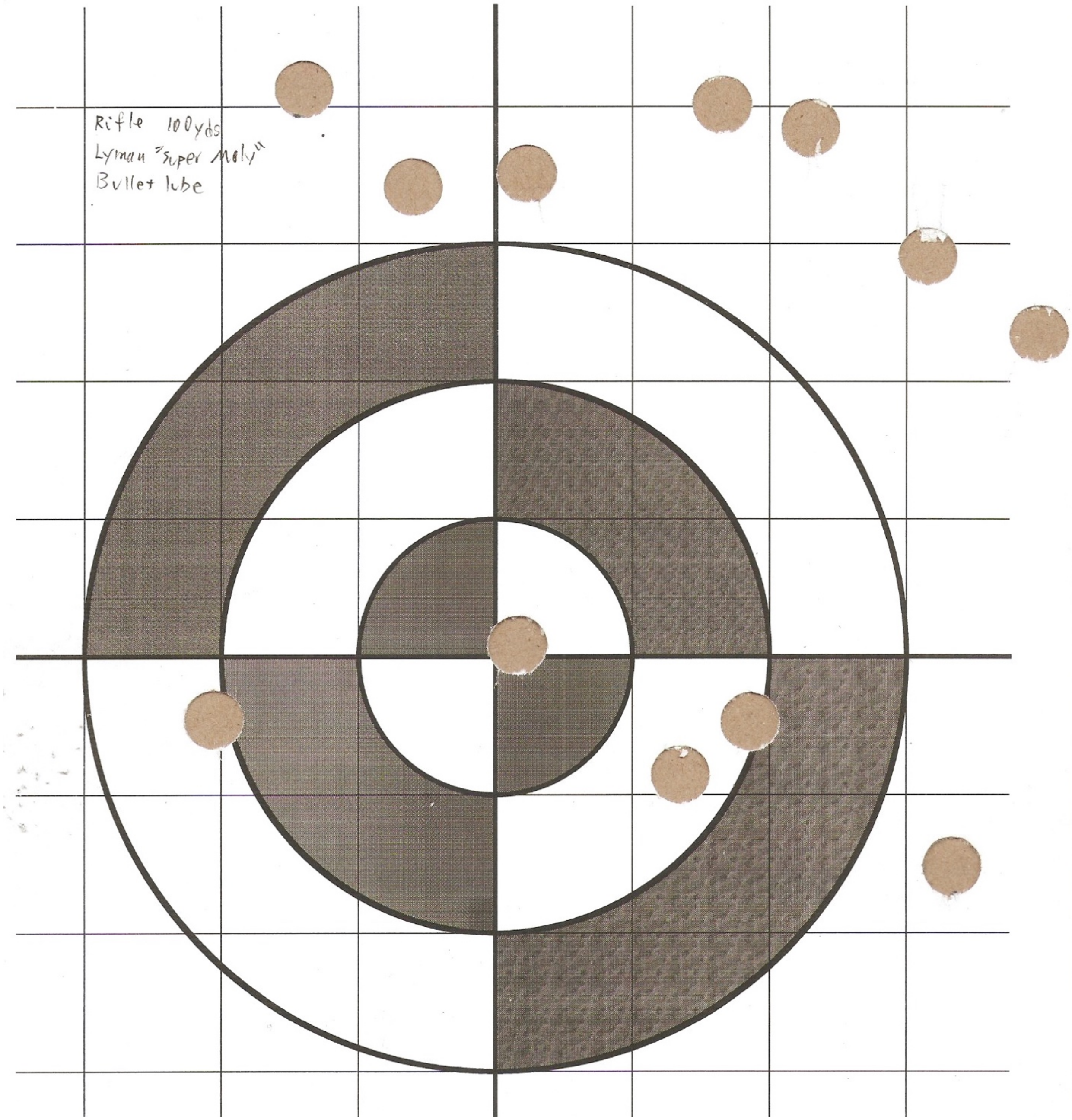

Rifle 100yds
Linotype
SWC - Front car.


Rifle
100 yds
Linotype
SWC-Redr

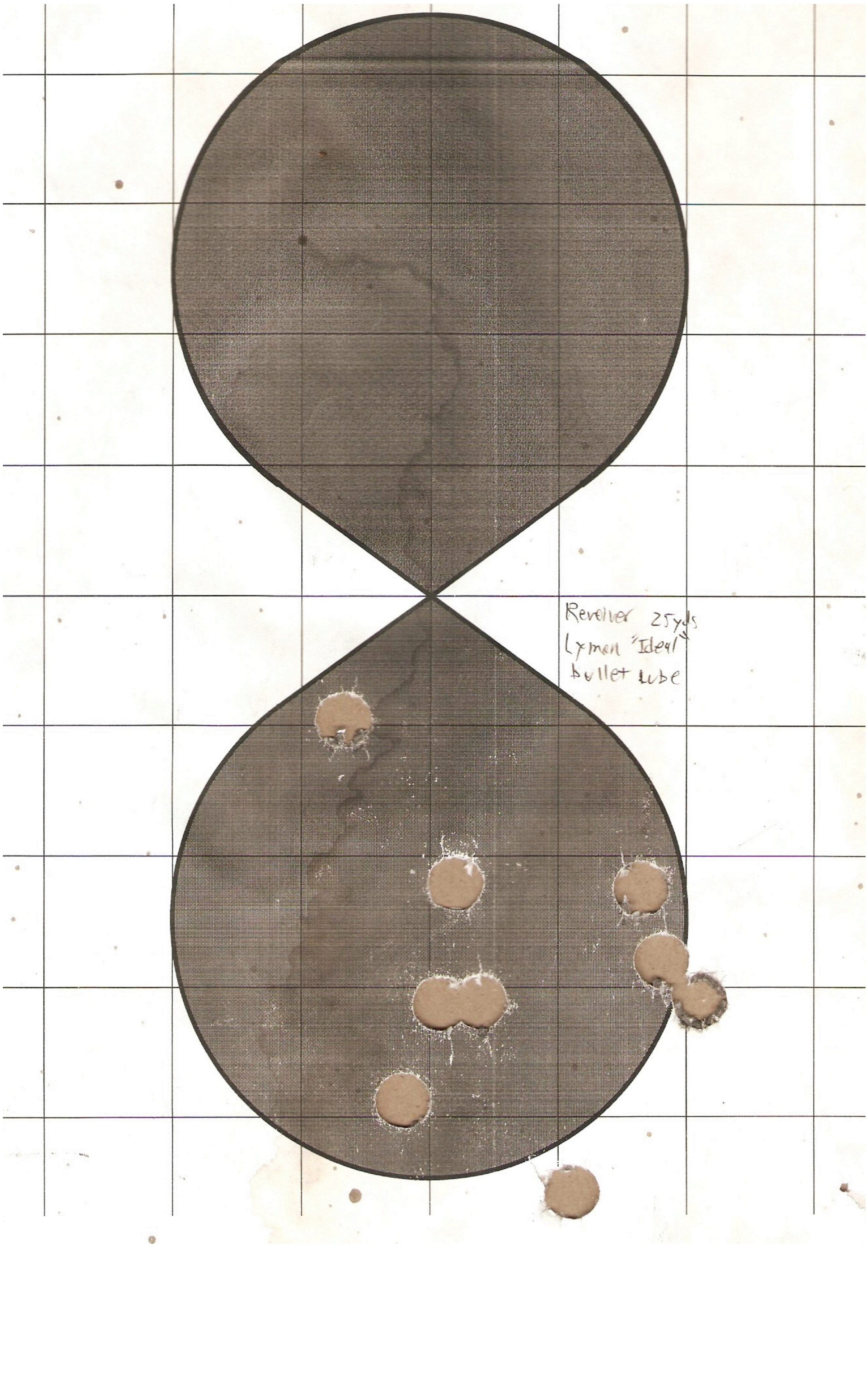

Rifle 100yds
Bare lead
12 SHOTS

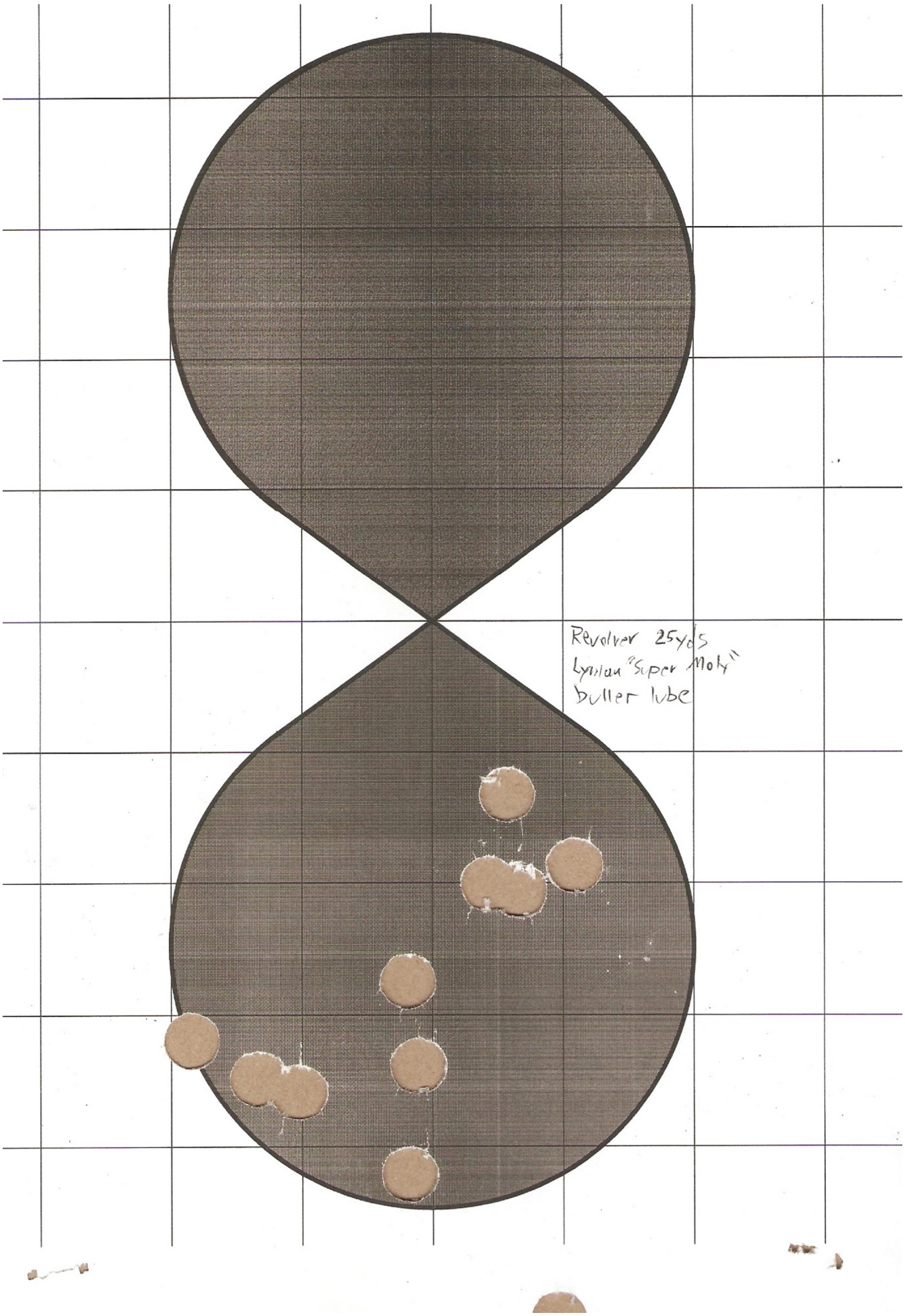

Rifle 100yds
Moly spray
12 shots


Rifle 100yds
Lyman "Ideal"
Bullet Lube

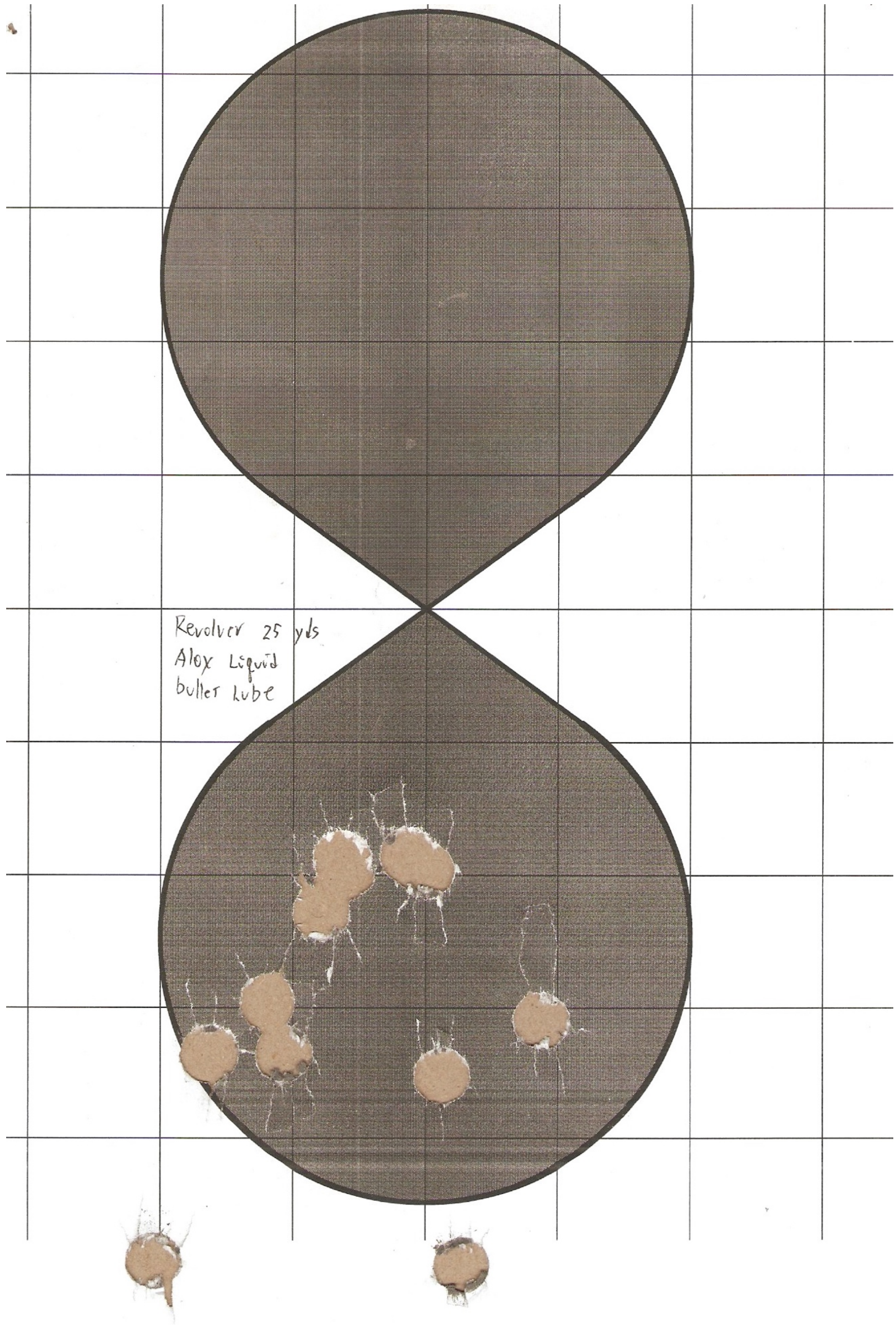

Rifle 100yds
Lyman "super Moly"
Bullet lube

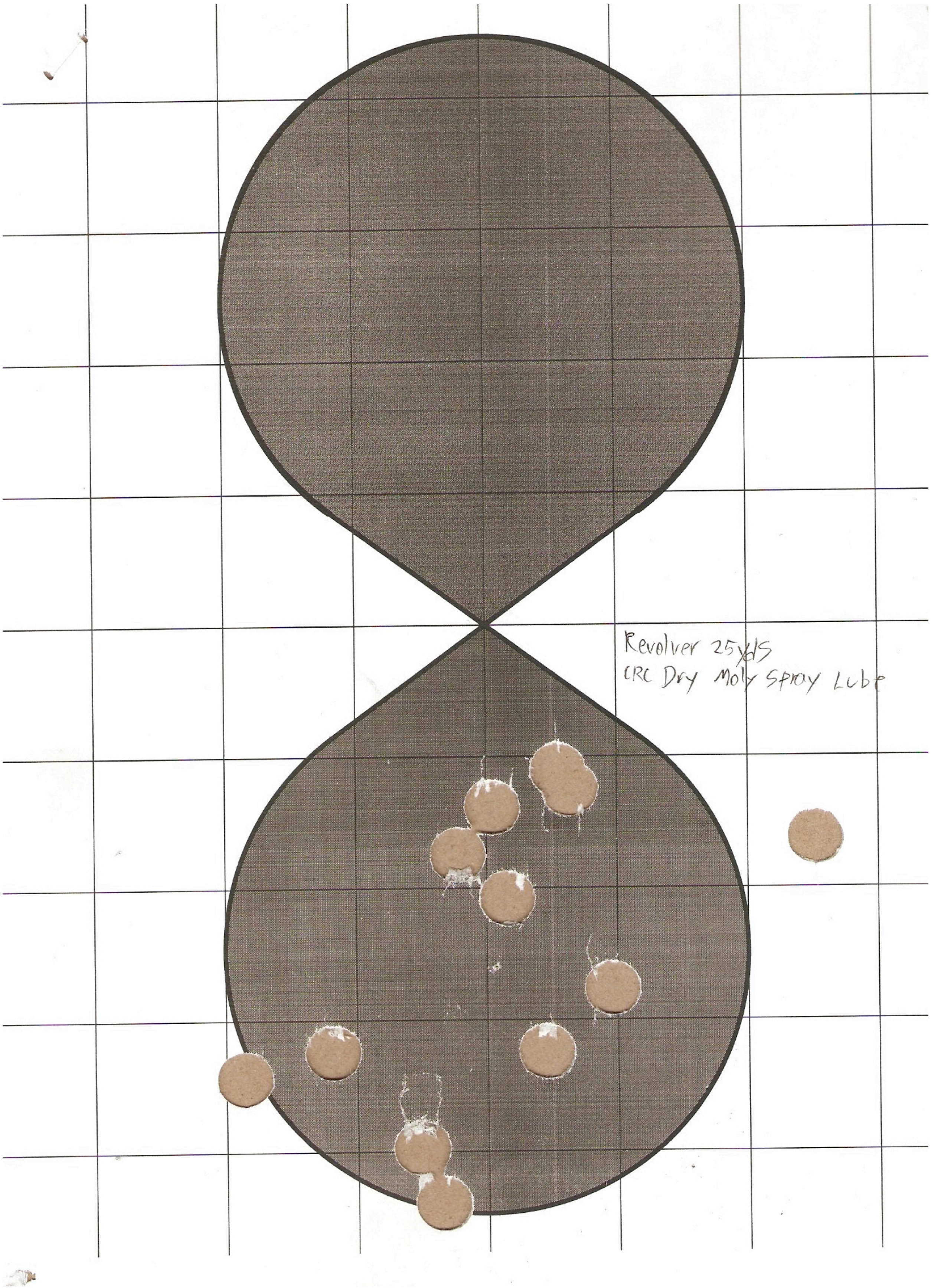

Rifle 100yds
Alox bullet lube


Revolver 25yds
Lyman "Ideal"
bullet lube

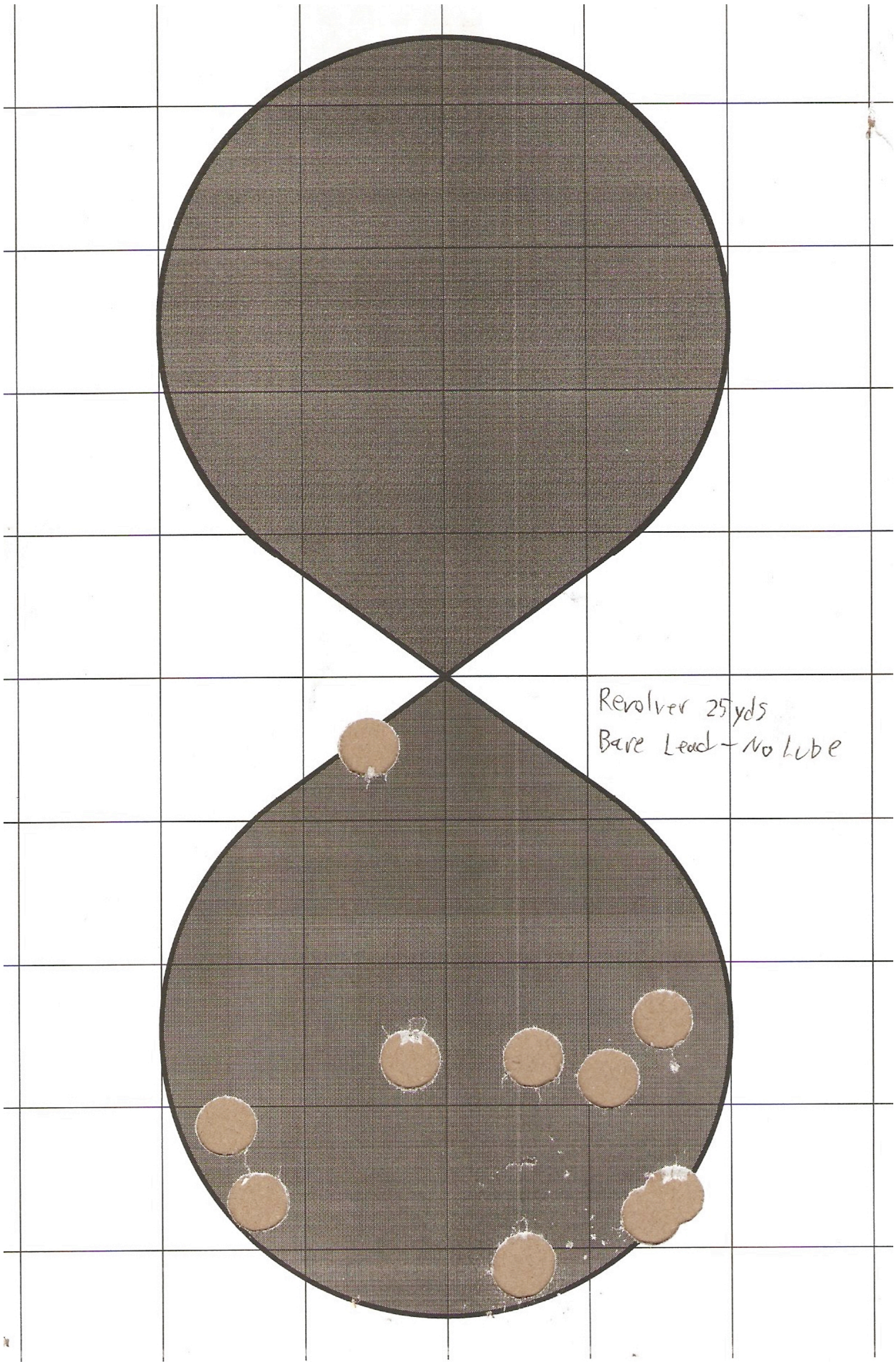


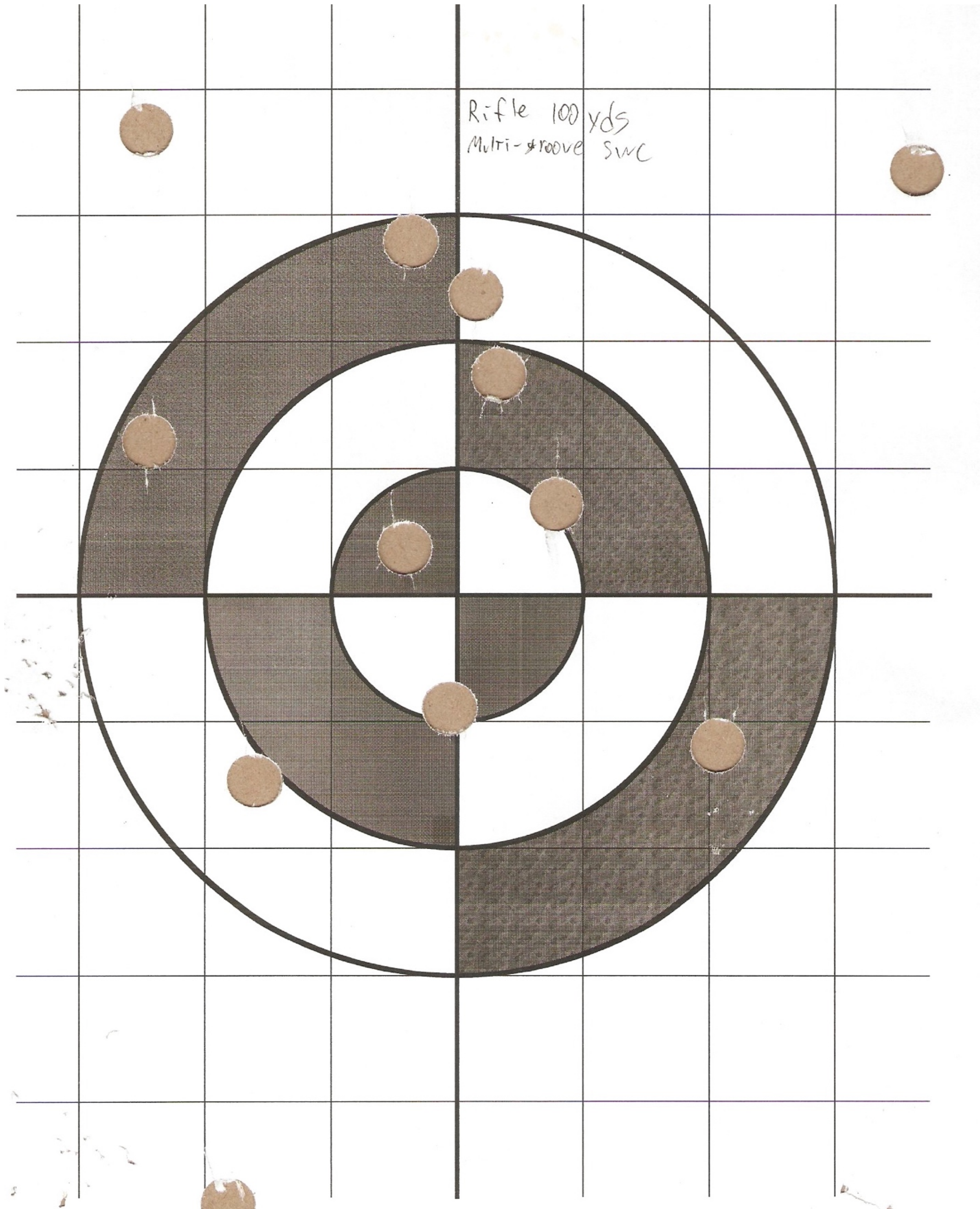
Revolver 25yds
Lyman "Super Moly"
bullet lube

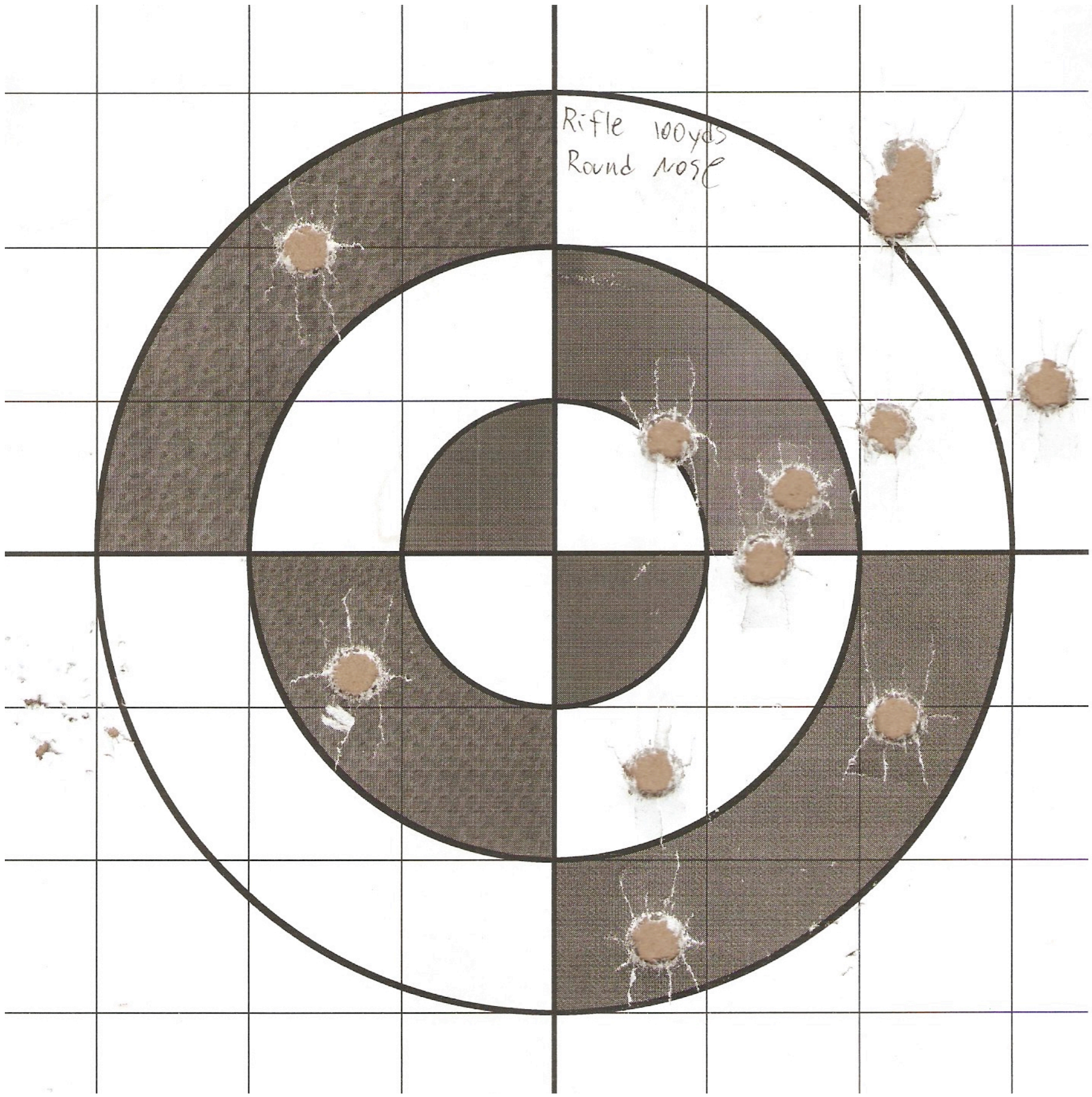

Revolver 25 yds
Alox Liquid
bullet Lube

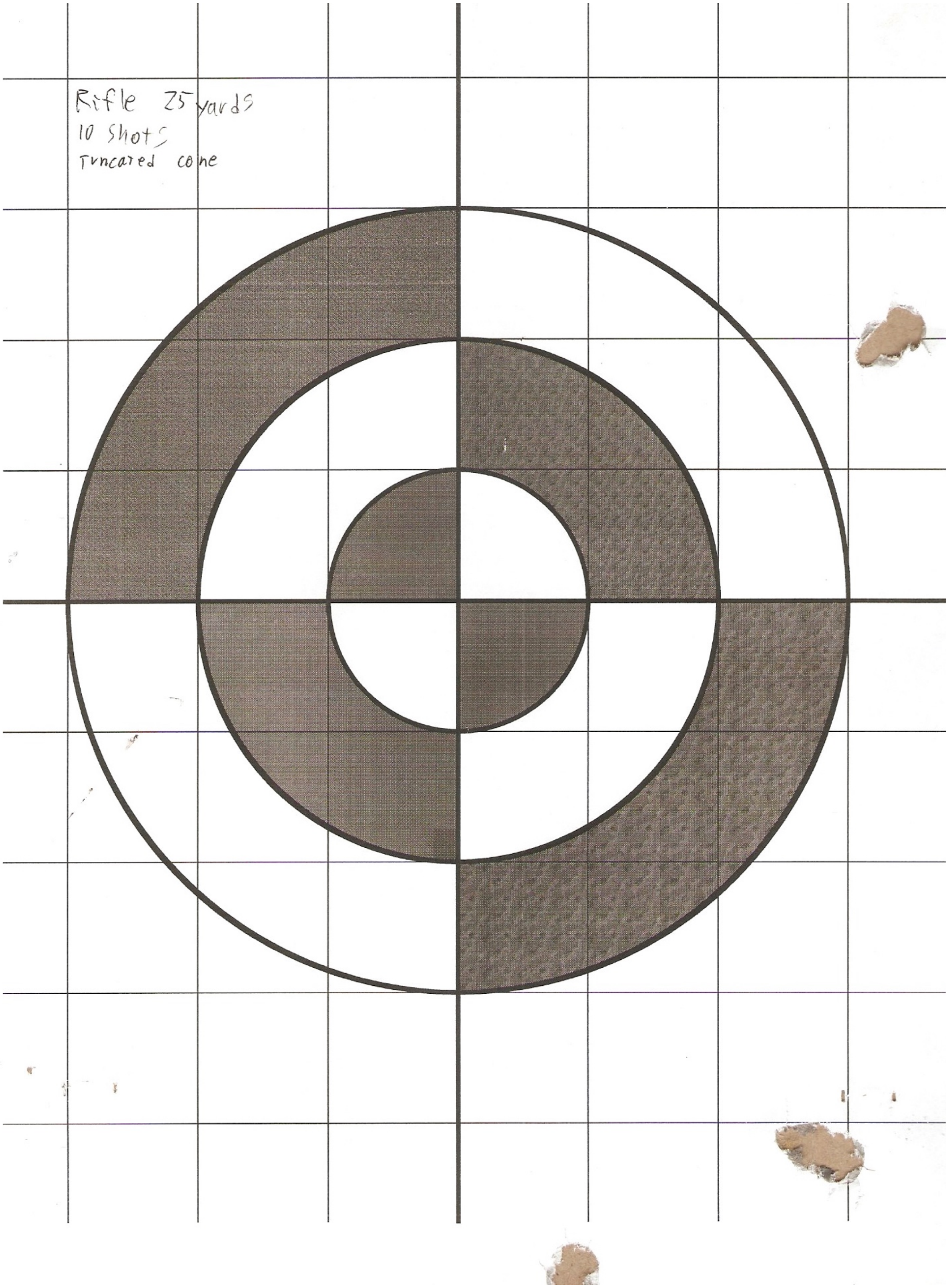


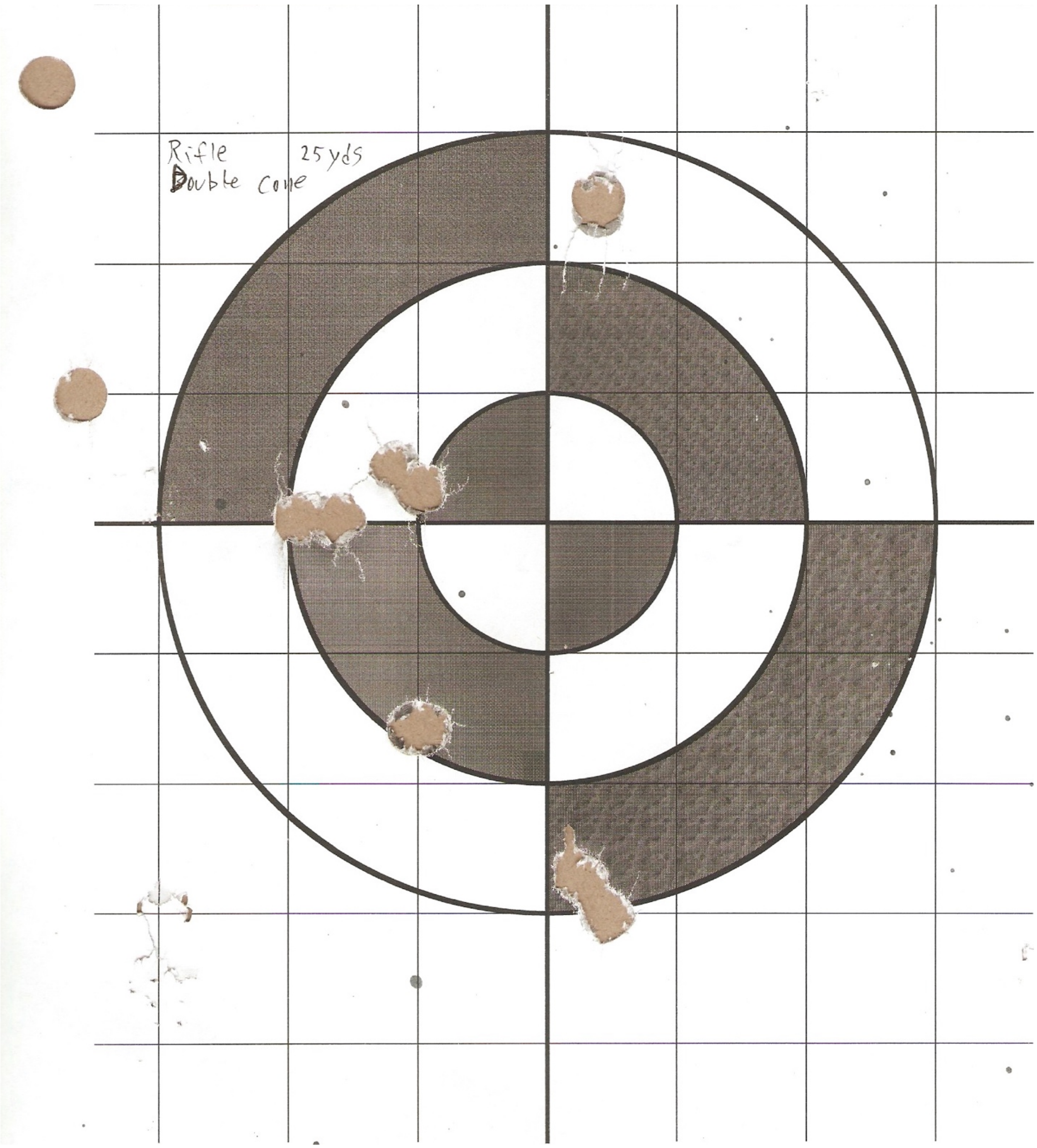
Revolver 25yds
CRC Dry Moly Spray Lube

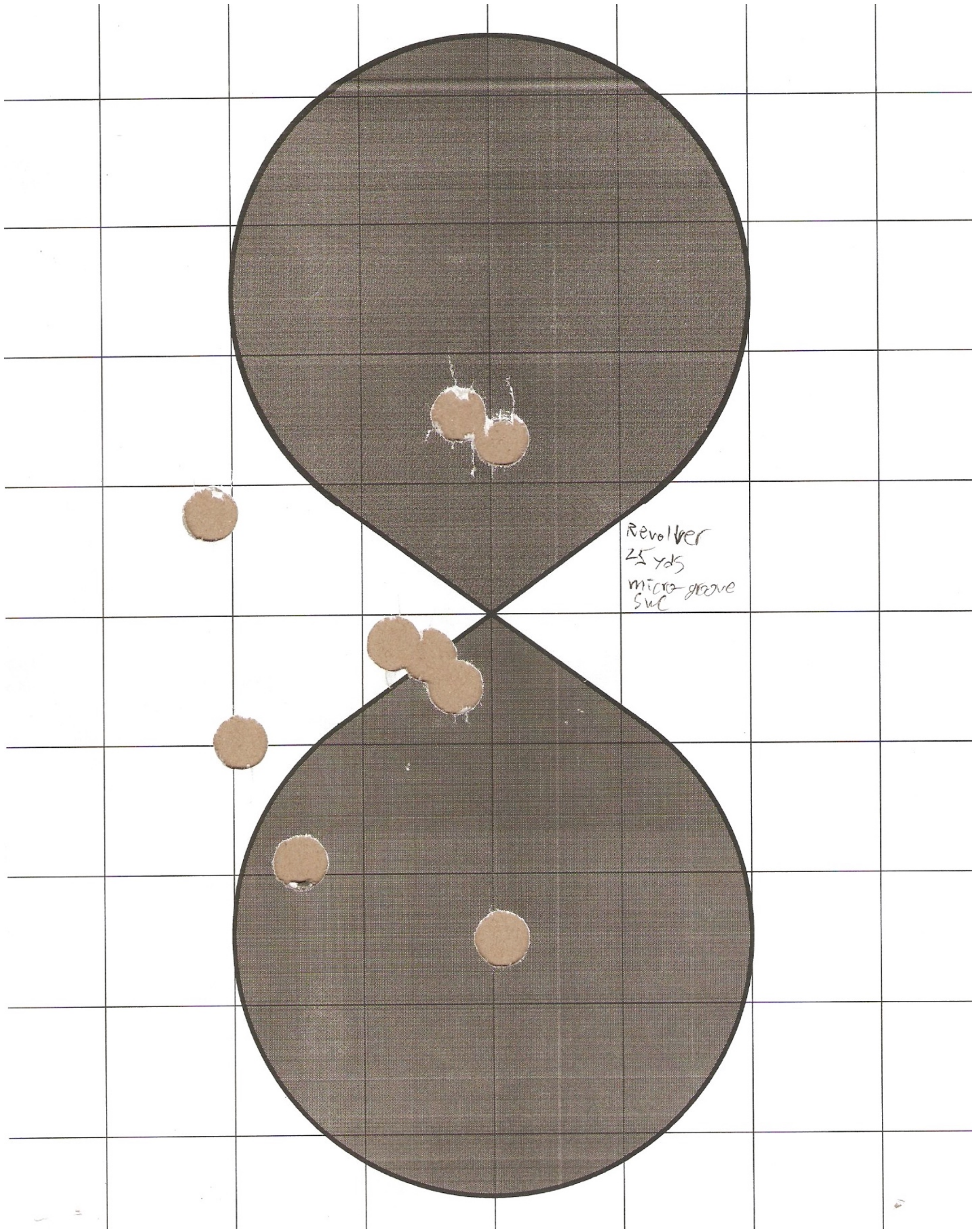

Revolver 25yds
Bare Lead - No Lube

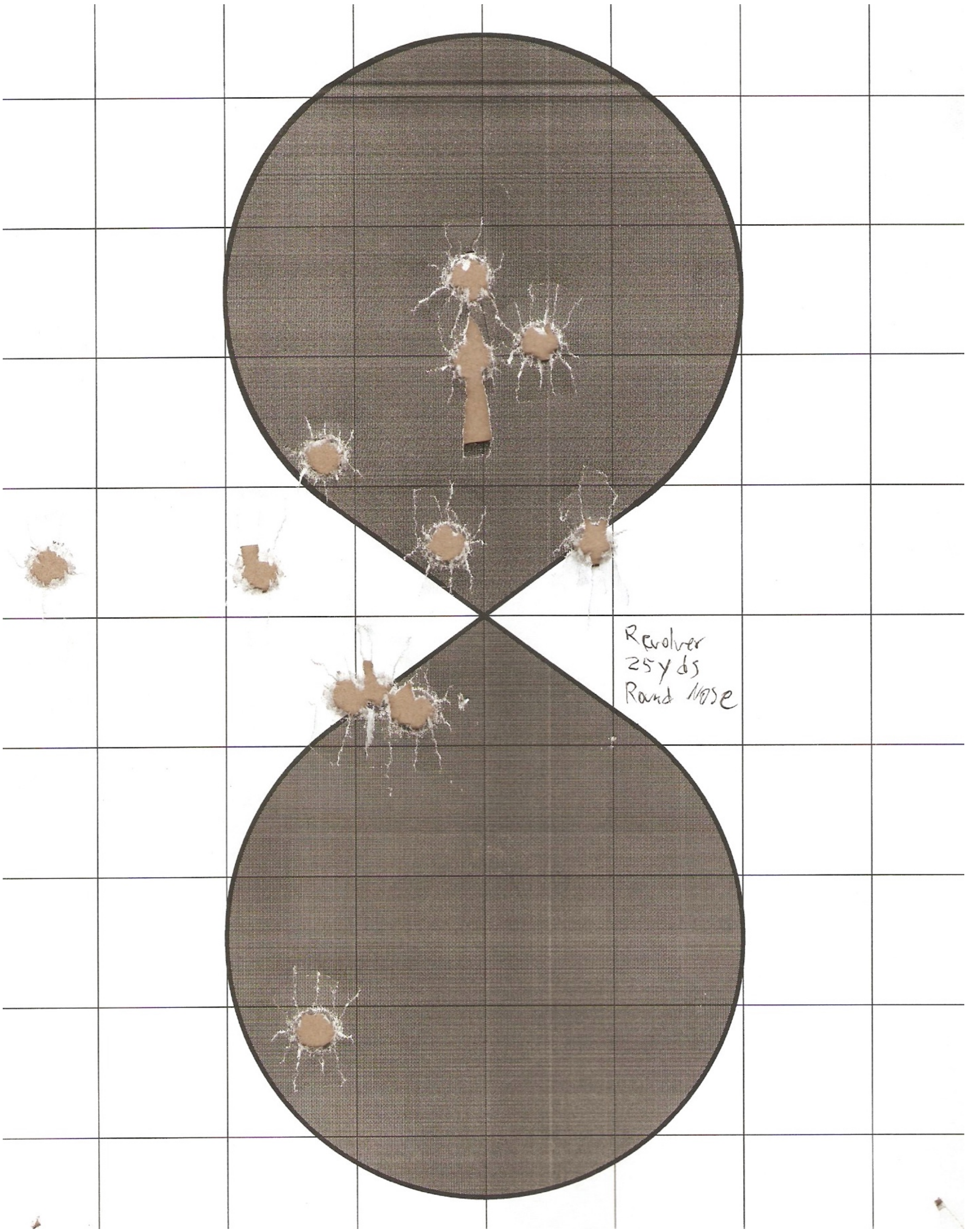

Rifle 100 yds
Multi-groove SWC

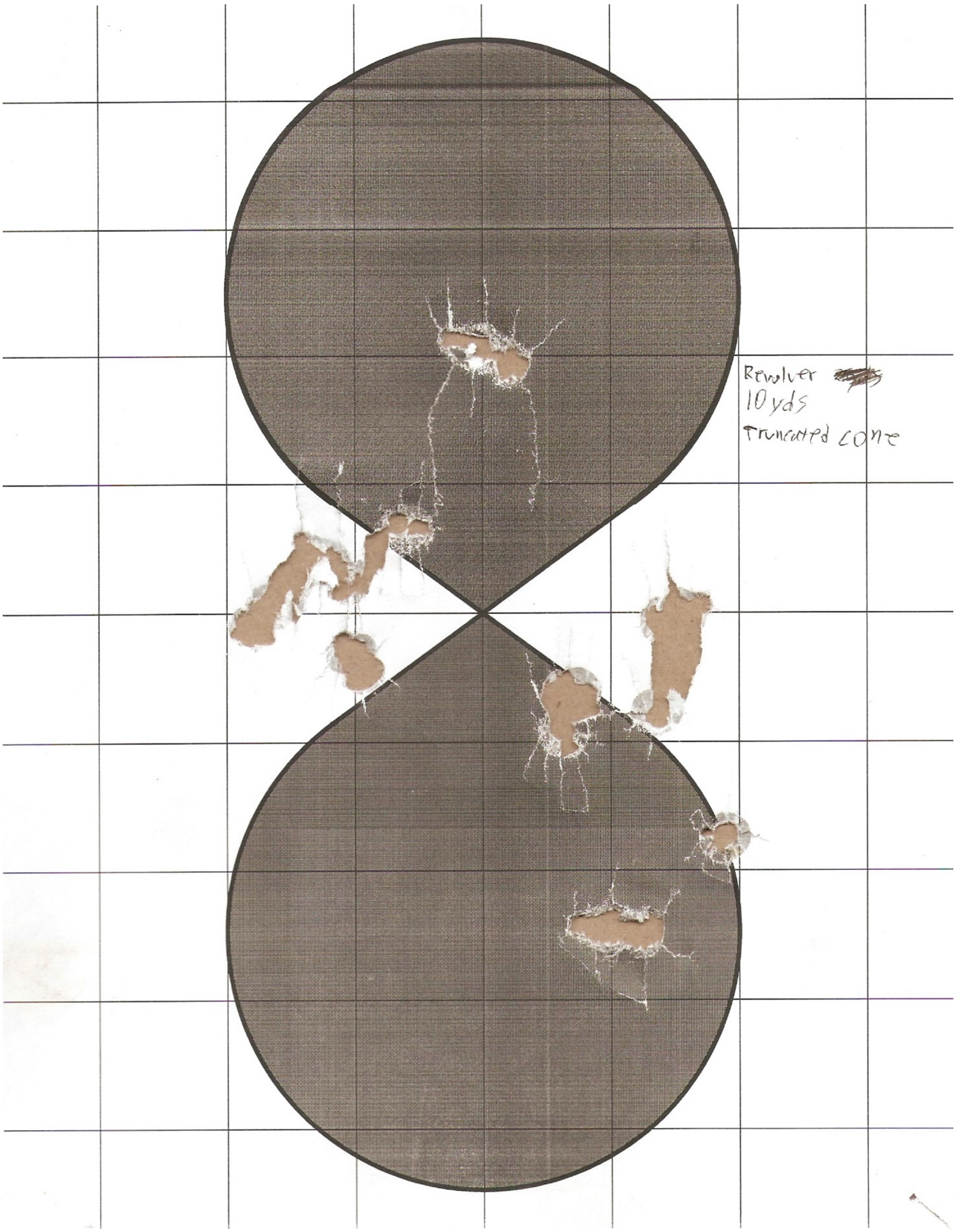

Rifle 100yds
Round nose


Rifle 25 yards
10 shots
Truncated cone

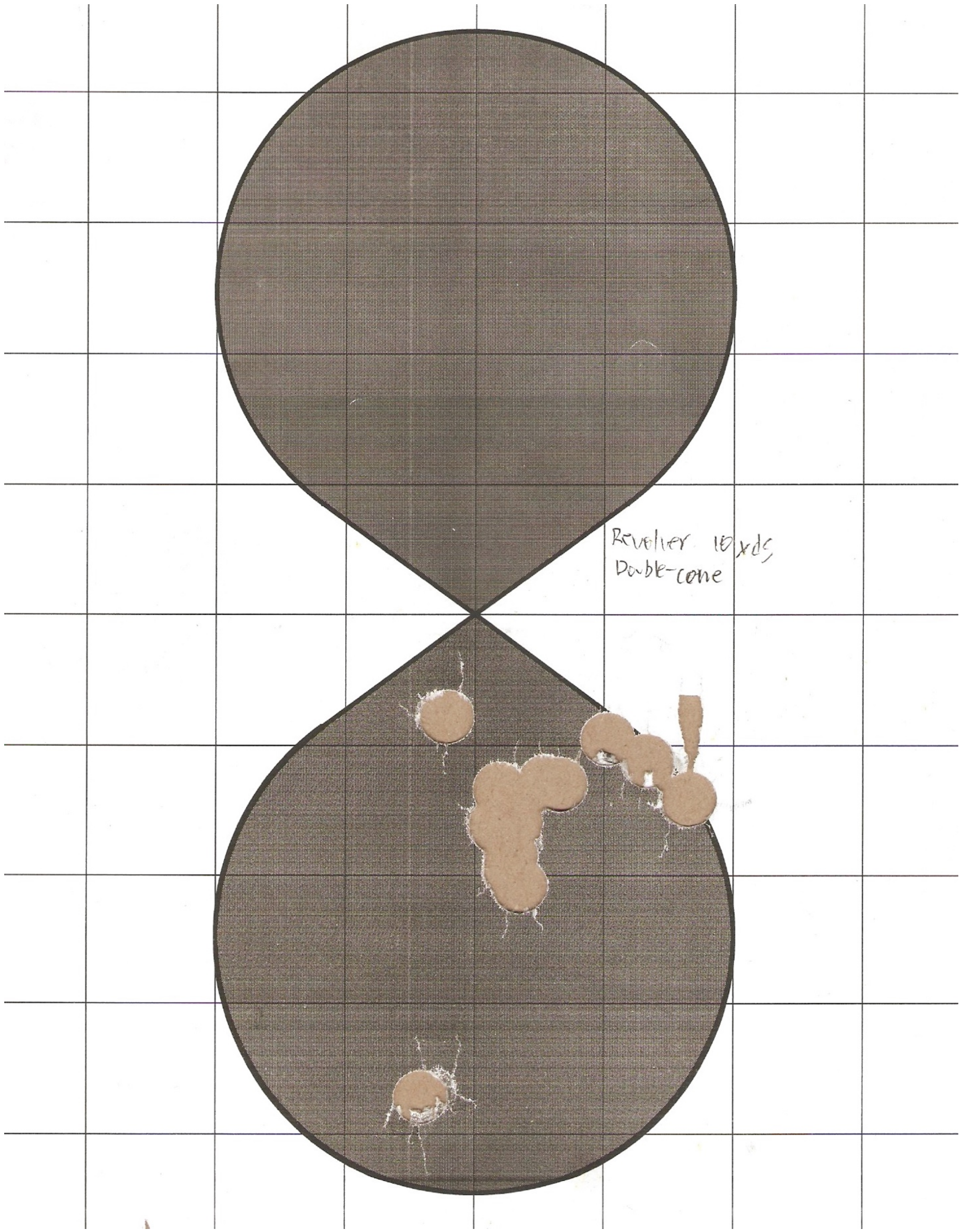

Rifle 25yds
Double Cone


Revolver
25 yds
micro-groove
SWC


Revolver
25yds
Round Nose



Revolver
10 yds
Truncated cone


Revolver 10 yds,
Double-cone