

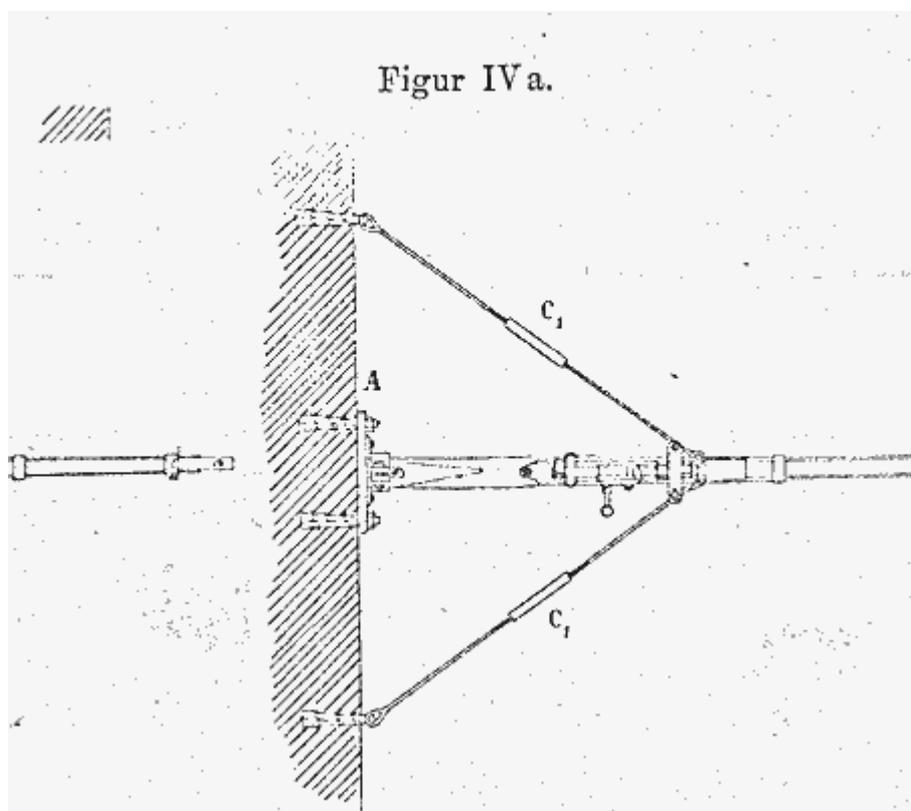
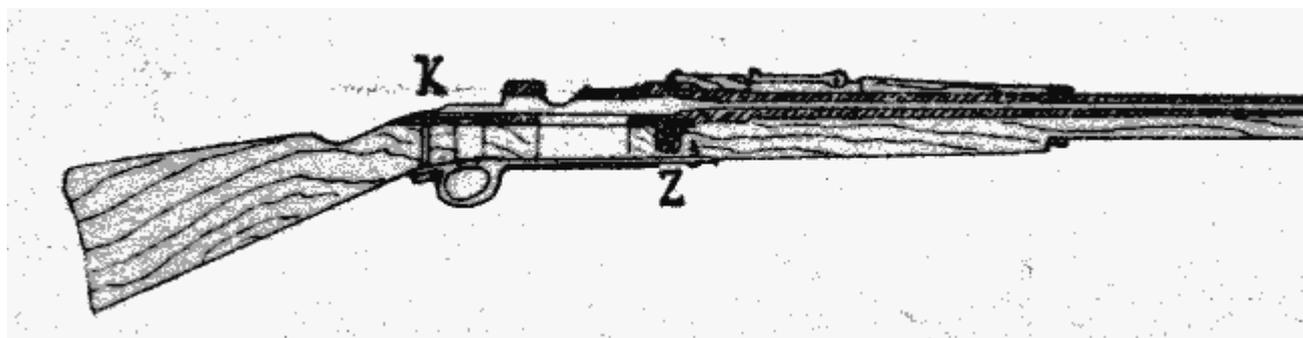
Untersuchungen über die Vibration des Gewehrlaufes

Carl Cranz

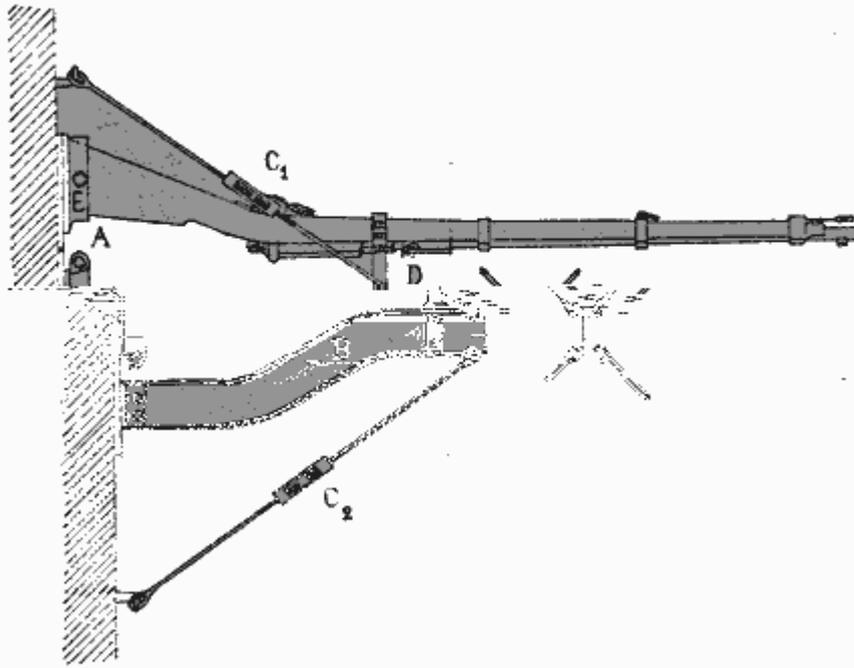
Load development

Ladder test

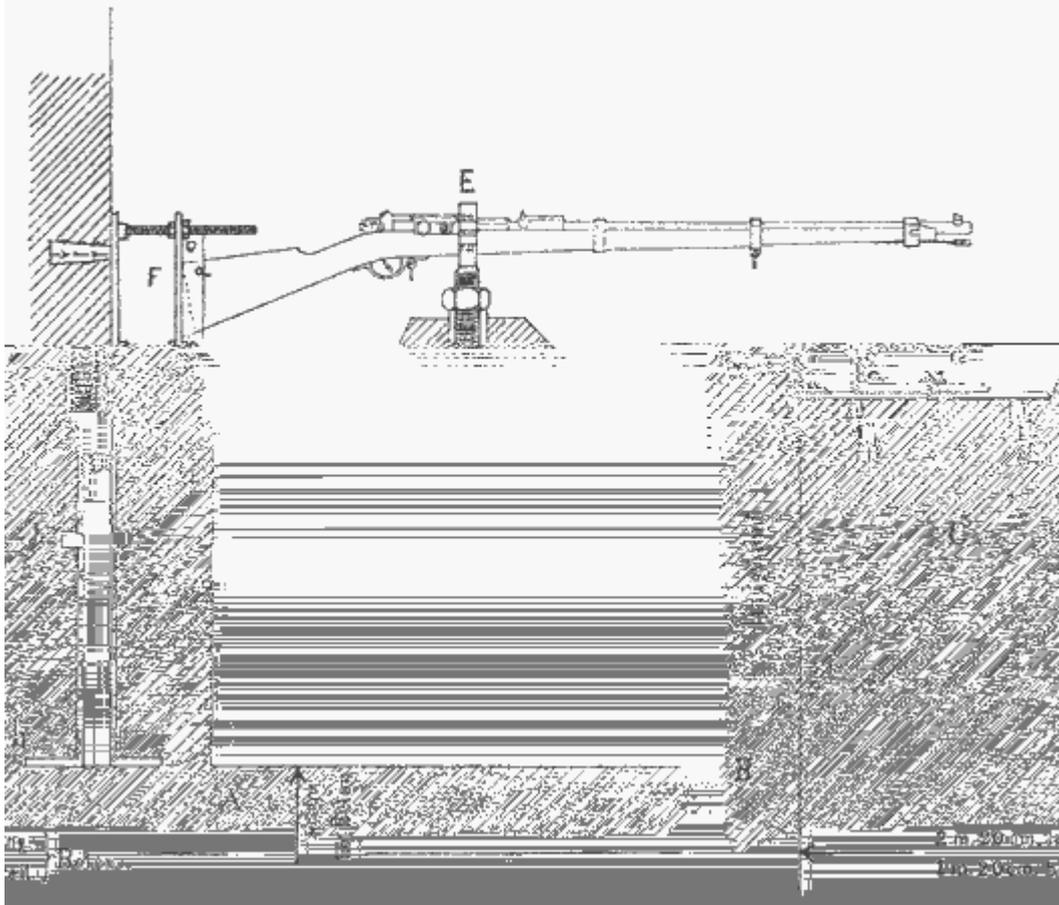
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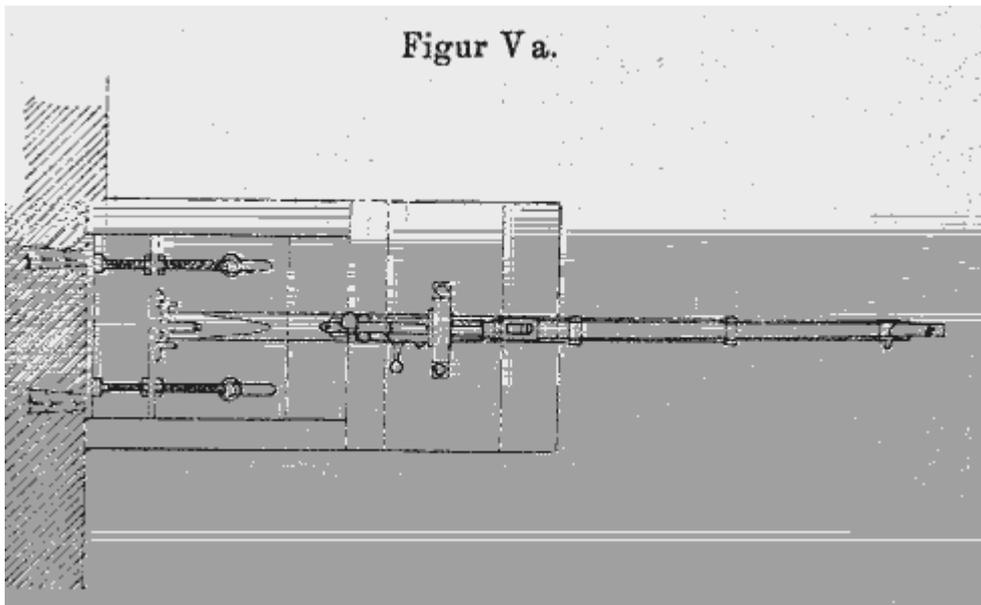


Figur IV b.



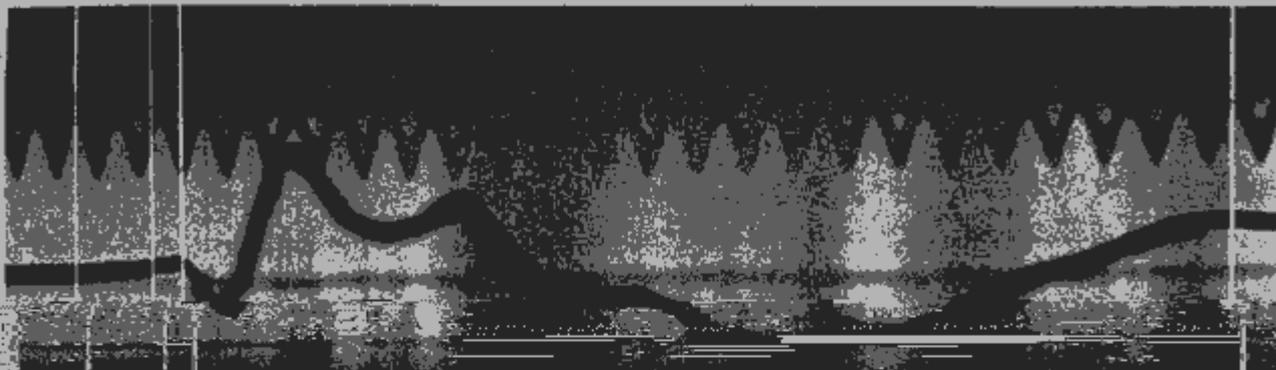
Figur V.





Zeitlicher Verlauf der Schwingungen an verschiedenen Ste

(Die Lichtpunktmarke, deren Ort durch den vertikalen Strich γ bezeichnet ist welchem das Geschoss aus dem Lauf austritt.)



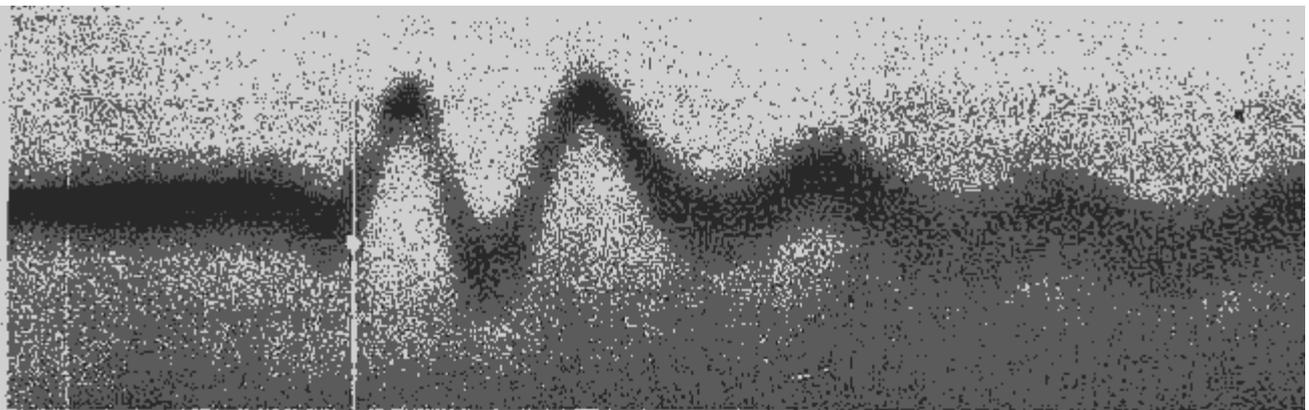
$\alpha \quad \beta \quad \gamma$ Schwingungcurve eines Punkts, der 1,5 cm von der Mündung



γ Schwingungcurve eines Punkts, der 9,7 cm von



... Schwingungcurve eines Punkts, der 11,6 cm von der M

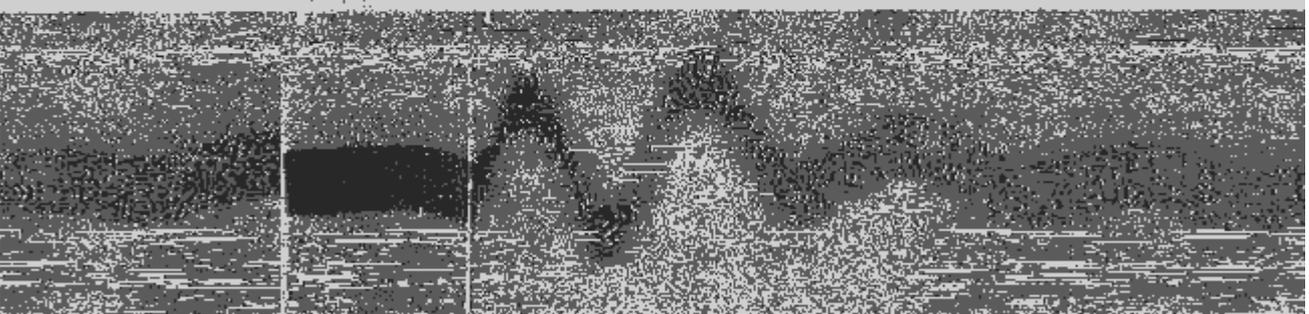


γ Schwingungcurve eines Punkts, der 45,5 cm von der



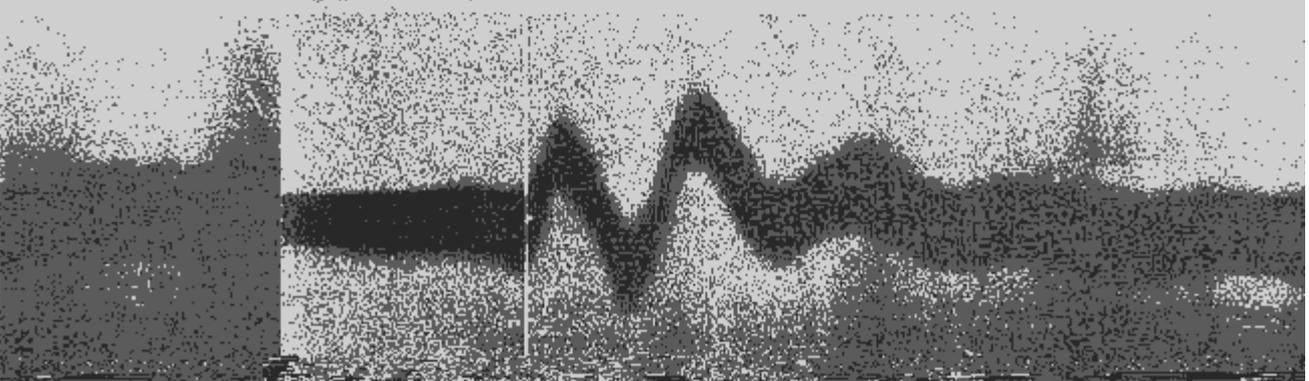
Punkts, der 50,0 cm

γ Schwing. e.



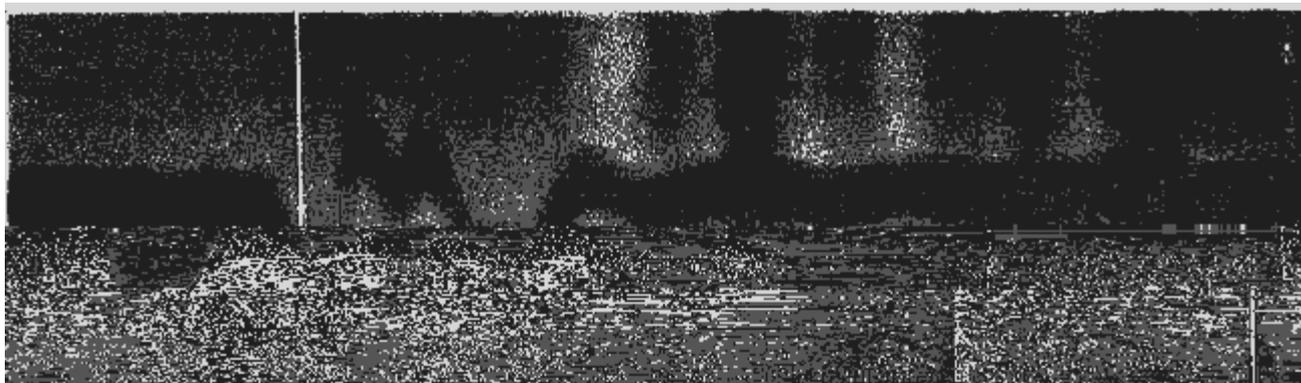
on der Mündung

γ Schwingungcurve eines Punkts, der 55,0 cm



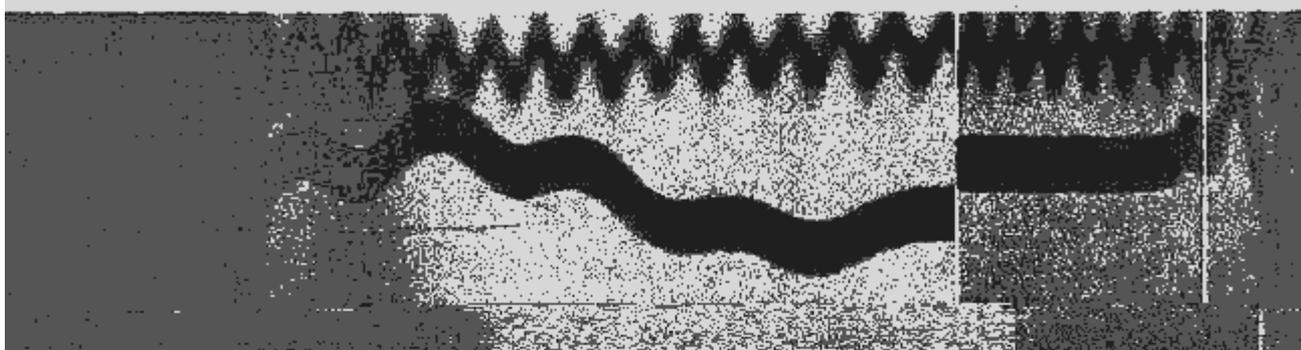
on der Mündung

γ Schwingungcurve eines Punkts, der 60,0 cm



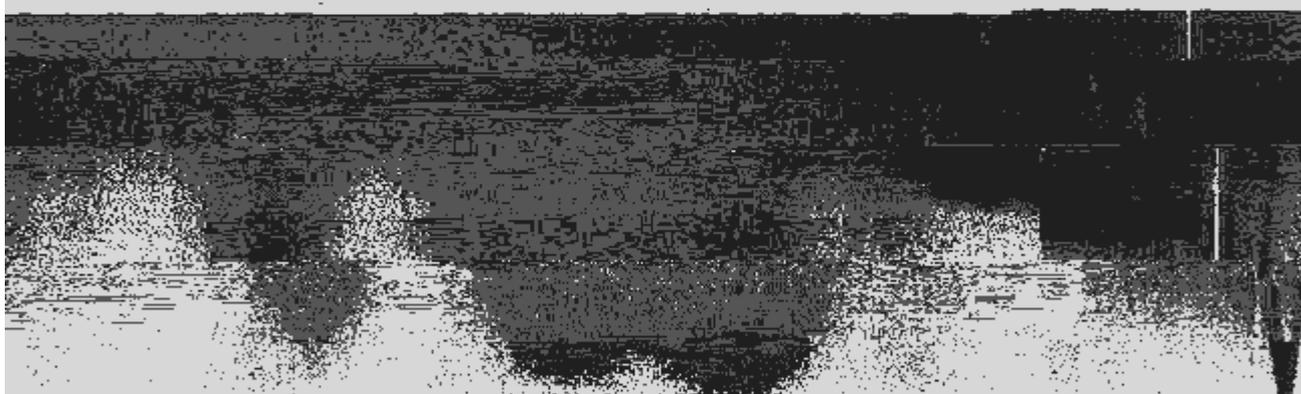
Schwingungcurve eines Punkts am Kolbenhals, 110,5 cm von δ

7

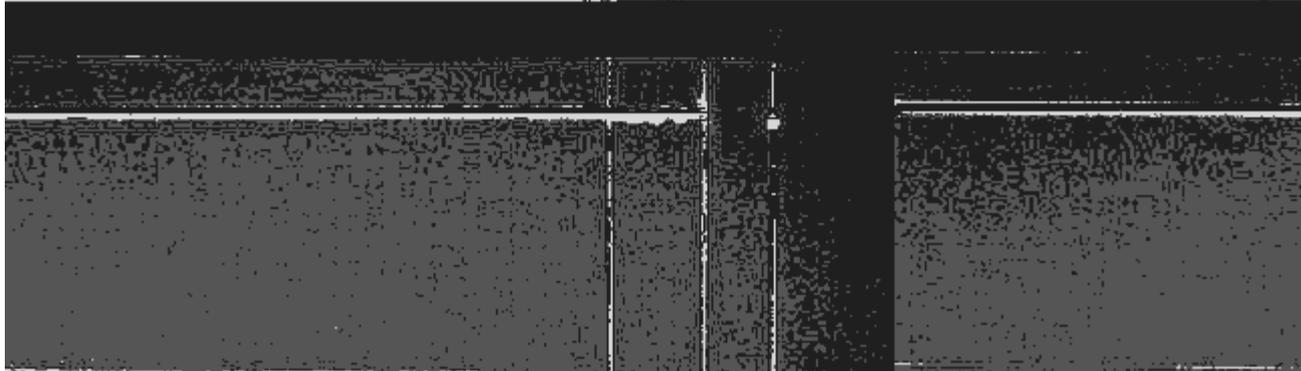


Schwingungcurve eines Punkts an der Mündung, falls das Gew

7



Schwingungcurve desselben Punkts wie bei Fig. 20 falls das Gew

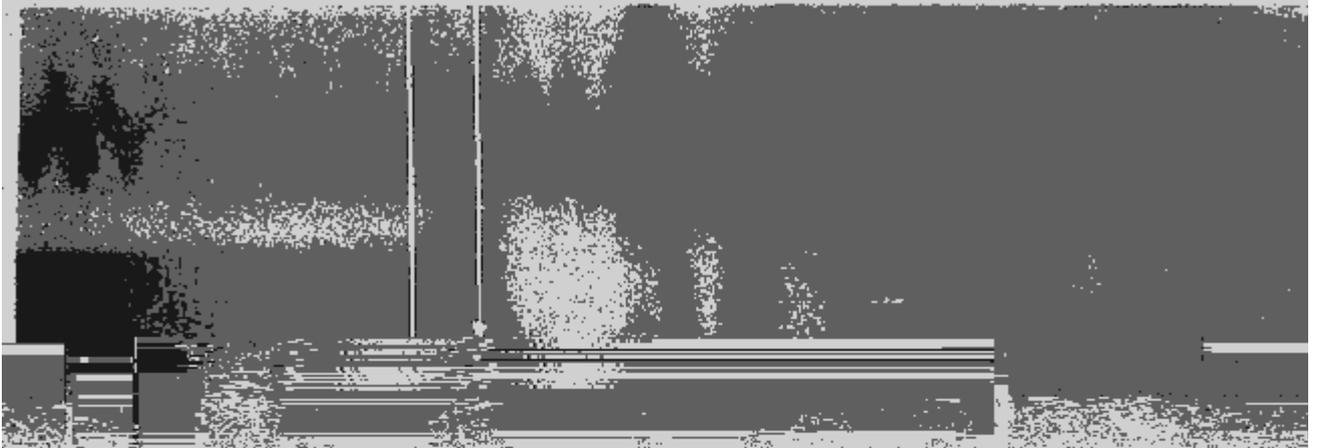


Punkts in der Nähe der Mündung mittelst Spiegelfühlhebel aufgenommen
die Bewegungen des Lichtpunkts bei den nach der Explosion
schweren Schwingungen des Gewehrs nach einer 1/10 Sek. nach dem Auslösen

Schwingungcurve eines I
starken Vergrößerung, si
Lichtstrahlenkomplex

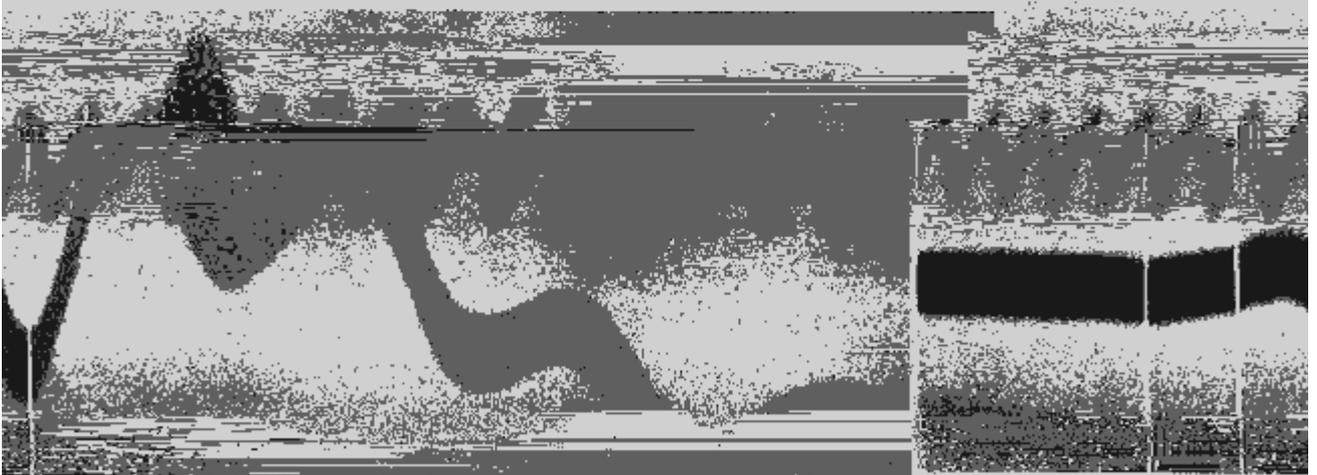


Schwingungen ohne Schuss, nur durch das Vorfahren des Schlag



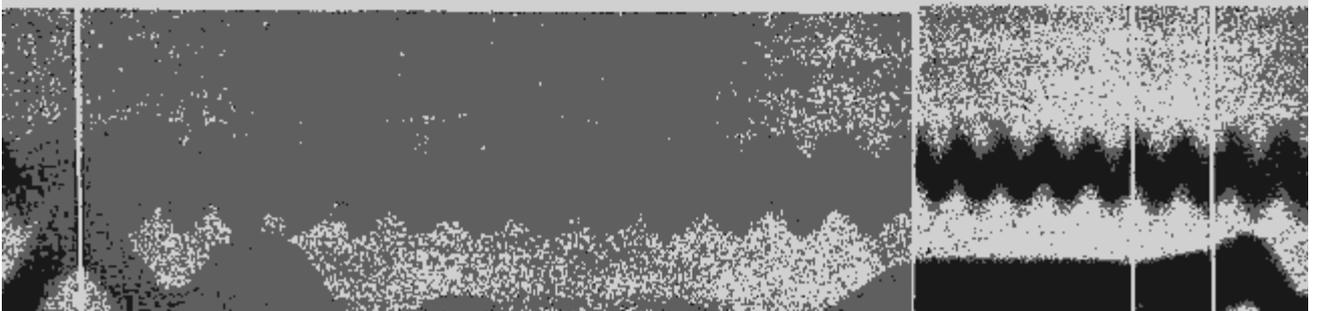
α γ
 β

Schwingungen bei elektrischer Zündung.



γ Schwingungcurve (eines Punkts 1,5 cm von der M

α β



Obige Bilder: C. Cranz und K. Koch, auf Wunsch sende [ich](#) Bilder in bessere Güte zu.

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Ladder test

Ergebnisse

für Gewehr M/71 nur für die Bewegungen des Laufes in der durch die Laufachse gehenden Verticalebene:

1. Das Gewehr führt in der Zeit vom Abdrücken bis zu dem Augenblick, in dem das Geschoss die Mündung passiert, abgesehen von der bekannten Rücklaufbewegung, Schwingungen aus, and zwar sowohl das eingeklemmte wie das freiliegende Gewehr.
2. Die Verbiegungcurve des Laufes, in jenem Augenblick and in jedem beliebigen späteren, lässt sich mit der geschilderten Methode elektrischer Momentphotographie mehrerer Laufstellen für jeden speciellen Fall auf circa einige Tausendstel Millimeter genau bestimmen.

Dr. phil., Dr. h.c. mult

Ordentlicher Professor an der Technischen Hochschule Berlin - Geheimer Regierungsrat Carl Cranz hat als Mathematiker, Physiker und Lehrer die moderne Ballistik in Deutschland begründet.

Noch als Lehrer am Friedrich-Eugen-Gymnasium in Stuttgart begann er mit seinen ballistischen Forschungsarbeiten, die ihn bald über die Grenzen seines Wirkungskreises hinaus bekannt machten. 1903 wurde er an die neu gegründete Militärakademie in Berlin berufen, um dort das erste theoretisch und experimentell arbeitende ballistische Forschungszentrum der Welt aufzubauen.

Die Arbeiten Carl Cranz' und seiner Mitarbeiter führten weit über den Stand der Kenntnisse und Erfahrungen hinaus, der bis dahin in der Ballistik erreicht worden war. Carl Cranz vertiefte und erweiterte die theoretischen Ansätze der Ballistik und entwickelte gleichzeitig zahlreiche neue Verfahren zur physikalischen Meßtechnik.

Schon vor 1914 erkannte er die Bedeutung von Überschall-Windkanälen, und in den 20er Jahren begann er bereits mit Arbeiten über Raketenantriebe.

Carl Cranz' Arbeiten waren für viele Gebiete der angewandten Physik richtungsweisend, so

- seine theoretischen Untersuchungen über den Kreisel- und Magnuseffekt;
- seine Arbeiten über den Luftwiderstand bei hohen Geschwindigkeiten;
- seine Entwicklungen in der Hochfrequenzkinematographie zur Registrierung schnellaufender Vorgänge mit Bildfrequenzen bis zu 107/s;
- seine Experimente zur Konstruktion zuverlässiger und genauer Zeitnormale.
- Mit besonderem Nachdruck hat sich Carl Cranz für die wissenschaftliche Aus- und Weiterbildung auf dem Gebiet der Ingenieurwissenschaften eingesetzt. Schon vor dem ersten Weltkrieg forderte er für alle Offiziere ein ingenieurwissenschaftliches Studium. Sein Weitblick als Forscher und Lehrer ist für die Carl-Cranz-Gesellschaft Vorbild.

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<http://www.ccg.dlr.de> <mailto:ccg@dlr.de>

Führende Persönlichkeiten aus Forschung, Industrie und Hochschule gründeten 1960 die Carl-Cranz-Gesellschaft. Sie benannten die Gesellschaft nach dem Schöpfer der modernen Ballistik, dem Professor für Technische Physik an der Technischen Hochschule Berlin, Carl Cranz. Ursprüngliches Ziel war es, eine wehrtechnische Aus- und Weiterbildung für Absolventen von Hochschulen und Fachkräften aus Industrie und Streitkräften zu organisieren. 1963 begann man mit der Durchführung von Lehrgängen. Inzwischen hat die CCG ihr Spektrum weit über den wehrtechnischen Rahmen hinaus ausgedehnt. Die CCG arbeitet eng mit Forschungsinstituten, insbesondere mit Einrichtungen der Großforschung, mit Hochschulen, mit der Industrie, mit Behörden und mit der Bundeswehr zusammen.

Untersuchungen über die Vibration des Gewehrlaufes

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Load Development

Fellow Riflemen,

A few notes on the side. Much has been written about accurate barrels, and a few comments have stuck in my mind over the years.

1. Chamber reaming. I recall an article written by a rifle barrel maker in the US somewhere, who mucked around with the 'ideal hunting rifle for XYZ purposes'. As I recall this was a .270 WIN patterned after the so-called 'mountain rifle' design. Point being this chap emphasised that by keeping the chamber tolerances tight, and specifically reducing the neck diameter a smidgin under SAAMI (something like max .0003-4 ?? inches) he got good to excellent results with just about any barrel/calibre combination.

2. In the mid 80's much was said about 'barrel tuning', and I suspect there is a lot to this. Some companies would 'tune' the barrel by removing chunks of it. How this was determined, I have no idea. What certainly makes sense is that at a certain point a barrel is less susceptible to erratic pattern "flex" at the muzzle. Maybe someone can enlighten us on how this works.

3. For many years SOMCHEM in South Africa provided a service where they would set up the most accurate load for you in any given projectile design // bullet weight combo. This was eventually called off as being an uneconomical service. Making enquiries about different powders the one day, the gentleman on the phone at SOMCHEM made it clear that he thought one should approach reloading "in a very disciplined fashion." (I think his name is Dr. Loubser - I hope he gets to see this e-mail).

"Oh really ?" I enquired sceptically, with my usual "I know it all anyway" attitude poorly concealed. Unfazed, the gentleman pointed out that in HIS (unstated and patently bloody considerable!!) experience, one needed to (a) determine optimum bullet seating depth, and (b) determine optimum velocity. "Hmmm", I said, my usual cynicism clearly identifying me as a "wannabe knowitall". This kind and wise gentleman continued to provide me with some sage advice. "Load 30 rounds", he said, "starting at MAX OAL and seating each deeper by about ten thou of an inch as you go along. That should do it". He further emphasised: "Once you've found the sweet spot, just do the same for velocity - 30 rounds - starting at MINIMUM charge this time, watching for pressure signs, and preferably with a chronograph; and you will find the optimum velocity for accuracy." I was already thinking of something else, when he piped up: "REMEMBER THIS: Optimum results are usually obtained in the middle somewhere, but not always", he sagely opined. "Yes, yes, yes, sure - whatever", was my stupid response (I hope he enjoys reading this). My brilliant intellect had already decided that I needed to convince this man that my powder was the problem, and that different burning rates would solve the problem of the shotgun-like patterns on the target. With much kindness and patience, this gentleman said the following to me.

"I know you Bisley types believe you have the most accurate rifles known to man. And I have

that no matter what he did, he just could not get the rifle to shoot accurately. "It doesn't make a difference - factory ammo, different brands, different weights, reloads, velocity, you name it - it refuses to group under about 4 or 5 inches" he said. Well, I gave the old Mauser a quick inspection, checking the screws and stock. Everything looked nice and tight, the bore was shiny - WHOA! LOOK AT THE THROAT EROSION ON THIS THING! I exclaimed. (It looked like someone had gone berserk with a Dremel tool and a sandblaster...). Disappointed by my response, the customer gave a deep sigh. "I'd wanted to hunt with that old rifle again..." he muttered wistfully to himself. I bit my tongue in an attempt not to point out that in my oh-so-considerable experience, the rifle was well and truly knackered. It had obviously seen its share of ammo, and with the old mild steels and the use of nitrocellulose propellant prior to smokeless, throat erosion was inevitable. So I said to him: "Look mate, let's give it a run on the bench." We had a sophisticated bench-rest system that really allowed you to remove the human factor from the firing process, and allowed for truly scientific accuracy testing. Like I said before, MOST optimum combinations of seating depth and velocity are in the middle somewhere. And it was clear that whoever had been doing the reloading had thought the same. Another misnomer being that you should seat the bullet close to the lands. This is mostly the case, but not always. To cut a long story short, I was about to tell this man his rifle was a relic that belonged in a museum, when the damn group started to tighten. And tighten And (You can ridicule this as much as you like, but this is what the man said to me). It turned out to that that old 8x57 Mauser was the single most accurate weapon I ever tested. When we were done, it basically put all the rounds into a single hole (I recall a group mentioned of something like 0.257" @ 100 meters - no doubt the BR people have bested this with a 6mmPPC-BRI. But from a large calibre rifle, and a basic hunting one?).

I've heard similar stories. And some are no doubt more fantasy than others. To date, I have not had time to implement the "scientific reloading" system on my .308 Bisley. But I can tell you systematic reloading procedures on my .30-06 produced consistent 3 shot 10 millimetre groups with match ammunition + match dies at 100 meters. From a hunting rifle ? Amazing. Not all rifles will do this, and having bigger scopes definitely helps. Point being, I couldn't get it under 1-1/2 inches with reloaded ammunition before that. Because I kept on mucking around in the middle somewhere, and that is just not good enough. You need to systematically determine the sweet spot. And, I suspect, that seating depth has something to do with the 'barrel harmonics'.

I know someone will find this helpful. With much thanks to the gentleman concerned,

Eben Mattheys (Perth, Western Australia).

Hallo Johan,

Eben Mattheys from Perth in Western Australia submitted below Story. We at Fullbore mailing list Fullbore@hawk.winshop.com.au regularly discuss such Accuracy related Stuff. I maintain a huntrelated Website in German and partly english at <http://home.snafu.de/l.moeller/>. In <http://home.snafu.de/l.moeller/Laufschwingungen/Gewehrlauf.htm> further below, eben's Story is printed.

Would you be so kind to read it and either authorize or criticize it, even better write an Article to the subject to be published, if you have the time and nerve to help us this way.

Sincerely Lutz

Cc: fullbore@hawk.winshop.com.au Sent: Wednesday, November 28, 2001 2:37 AM
Subject: Load development

Lutz,

Apologies for the late reply, but it's a bit hectic at the moment. It was certainly interesting to read the

A) Not limited absolutely by velocity: (or at least a narrow pre set requirement or specification or limit due to certain conditions)

I categorize this as Short range or "standard" shooting, such as Hunting: (usually up the 300meter/300yard range) when the highest possible velocity is **not** always that **important**.

(Exceptions is of course High velocity loads in heavy calibers which delivers high Kinetic Energy levels for specific short range hunting applications such as for dangerous game i.e. Cape Buffalo Elephant etc.)

B) Limited by velocity:

Where the application requires a **certain predetermined performance level**, which is **dictated by the distance/range wind**. This off course **Long range shooting** such as target shooting, sniping and certain specific hunting applications/conditions in excess of 300meters/yards, **which requires the flattest possible trajectory** and the **minimum time of flight**.

Example of application:

Target: -----i.e. PALMA shooting requires the maximum possible velocity from the .308win caliber.

Hunting: ----i.e. Prairie dog hunting, or long-range semi desert or desert hunting under adverse conditions high winds and temperatures.

The two **most convenient variable parameters**, with which to effect a change in the performance and accuracy/dispersion **with a given combination** of a particular weapon system (launch platform) and set of components are 1) The charge mass and 2) The round length.

Charge mass adjustment: --- I categorize this into the "Coarse" adjustment:

This effects large changes in performance. The reloader can adjust the performance over a wide performance range. This has the biggest effect because one can really change the "launch dynamics" and accuracy of the system.

This is the variable with which the reloader can **"ZOOM IN"** in on the **dynamic "sweet spot"** of the system.

The round length (COL/AOL) " = "Fine tuning" – adjustment:

With this variable, one can effect small/slight changes in performance. This provides one with the ability to "FINE TUNE", and **"FOCUS"** the performance and the launch dynamics, too suit the **"sweet point"** of the system. 36nse resri3(a-9.9(poi21 Tw[(3[(t cC)-5.6(, to-0.stem-0.)Tj- 43818.01 -1.1a)of t.

c) Alteration of the weapon.

For situation not limited absolutely by velocity I would recommend starting off by keeping the COL constant and vary the performance first. This initial COL should be based on practical parameters such as max magazine length, reliable feeding, or the limits determined by the available "leade or freebore" space, and preferably be as long as possible.

Once you have reached the best grouping, and you then feel there is room for improvement you should start to vary the (COL/AOL) round length. This adjustment, because it is so infinitely controllable, then serve as a "fine tuning tool" to suit the dynamics of the launch platform, hopefully for the better off course.

This situation is more flexible and "easier" to achieve because there is no strict limit on velocity, it facilitates one with a much wider range of adjustment regarding the charge mass = velocity (over 200 ft/p/sec for the typical rifle caliber).

For situation limited by velocity I would recommend start at the "start" charge, and go incrementally to the maximum performance level by observing for pressure signs and once at the desired level -- one can start "fine tuning" the system by altering the COL = projectile stand-off to the lands, This affects the initial combustion volume, which in turn increases or deceases the performance (velocity and pressure). This is especially true at the maximum performance levels.

Since, in this case, one is bound by a very narrow velocity range +/- 50ft/p/sec, the emphasis shifts more towards the "hardware" primer type, case type or condition projectile type and design and dimensions, which control the physical fit/interface of the different components.

I hope this will help you in developing the best possible loads for your conditions and system.

Regards
Johan Loubser
Ballistic specialist
Franklin, TN, USA

Lutz,

I must also apologize for not responding to your discussion of the terms used i.e. vibrations vs. flexing. I used the term "flexing" because I found it be much more descriptive of the actual behaviour of a tube/barrel when launching a projectile. I found that when I did seminars to shooters the term vibration generated a perception that the barrel is vibrating like a normal tuning fork when the bullet is launched. meaning that oscillations occured around a median with regular frequency. I my measurements the distortion or flexing measured did not at all represent that oscillatory behaviour during the high stress phase, when the bullet was moving inside the barrel. The typical vibration occured once the bullet left the barrel and the barrel were not axially stressed any more and it could oscillate "normally". This was clearly measured by us form small calibers medium to large caliber artillery, and although the term vibrations are a well entrenched scientific term we used the term "distortion of flexing" because we found that people immediately understood/grasped the mechanics of tube weapon launch dynamics. I often used the analogy in explaining the behaviour as a water hose which is suddenly opened with a high force, and the term vibration never really created the correct understanding. This is also the incorrect perceptions that exist, in the form of drawings of typical nodes depicting a typical balanced oscillatory profile which is just not true.

I hope this explains my persistence in explaining the dynamics as a "flexing" action during the launching (projectile in barrel) phase of the process.

Regards
Johan Loubser

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Carl Cranz

Load development

Ladder test

Ladder Test

From: "AW & JA Sainter" aw&j@sainter.freeseve.co.uk To: <fullbore@hawk.winshop.com.au>
Sent: Wednesday, December 19, 2001 10:12 PM Subject: Re: [Fullbore] Ladder test

To all Listers,
as far as i know, the late Creighton Audette devised *the Ladder test*. Randolph Constantine described it in the 1997 Precision Shooting Annual. It *works!*
Alan Sainter

Alan,
would you mind to delive a transtscript to us. If not possible, send me a high resolution scan by email and i shall convert it to Text.
Lutz

Lutz,
With my one finger typing ,it would take from now to Weihnacht to copy from the book. Send me your snail mail address & i will photocopy it. But this did i as instructed by the book. I needed a load for 5.56 using Sierra 77grn & H335 powder (which i wanted to use up). Audette says, guess at a very safe underload, and increase by .3 (point three) grain each time. So i started at 20.7 & made up 6 loads which took me up to 22.3. I fired them over a rest. The first few clang to the target bottom at 300 Yards. The final shots crept, but were still one and a half minutes below the waterline. Next time i started at 22.6 and went up to 24.1 in .3 increments. Again over a rest. This where the "Ladder" test proves its worth, all of a sudden shots 2, 3 & 4 arrived at the same elevation on the waterline, and shots 5&6 carried on up the ladder. Q.E.D.

Mfg Alan Sainter B.D.M.P. Hon Member. Frohe Weihnachten und ein Gutes Neues Jahr

Incremental Load Development Method

by Randolph Constantine

When you get a new Rifle or have an old one rebarrelled, or do anything else likely to change the Barrel vibration characteristics, such as hang a Bloop tube on it, or shorten it, usually to "develop" a Load for it becomes necessary. Another Thin that will require to develop new Loads to change over to moly-coated Bullets, like I did this past year to compete in Highpower. For this Magazines

readers, to develop a new Load usually means, to find something pretty close to the most accurate Load for the Rifle, unless considering some other really special Application.

Unless you need Bullets to fly supersonic at 1000 Yards. or enough Momentum to stop a charging Cape Buffalo, Muzzle velocity usually takes a Back seat to Accuracy. To find a load that will shoot Minute of Angle (MoA) of Buffalo at 20 yards is not too hard to do. But to find a Load for the .308 that will still be supersonic at 1000 yards and also shoot Subminute of Angle at that Distance the same Time can be a bit of a Problem. However, it is possible. The here described method can help.

Load development the old Way

For many Years the classic Method to develop Loads was to start with a particular Bullet, Powder, and Primer. Then load five Rounds with a supposedly safe Start load and to shoot a Group. If the Pressure signs (Primer appearance, Case head diameter, Bolt lift effort, etc.) seem to be normal, or at least not excessive, try another Five-round-group with 0.5 grains more Powder, of course, the same powder, McGee. I assume everybody knows, if 40.0 grains of 4895 are OK, you try not 40.5 grains Bullseye and live to tell about it.

In the old Days, you continued the Process until Groups tightened up significantly or until you had to pound the Bolt with a mallet open. In that Case you went to get a Can of a different Powder. Nowadays, the sophisticated among us stop when the Case head shows 0.0003" expansion, measured by a goad micrometer whith a vernier on it, that enables you to measure things to a tenthousandth Inch.

If you did not get the Accuracy kind you wanted or expected, you tried another Powder, or Primer, or Bullet and start all over. Sometimes this Process would have worked very fast. Sometimes it would not. When this Procedure found not the Accuracy sort, you looked for, you may have ended up burning up a large Components quantity and putting more Rounds than you wanted to through your Barrel, before you either found a Load that worked to your Satisfaction, or you decided, the new rifle or barrel is a Stinker

The Round number you might have to fire, before you find a good Load can be a significant Percentage of your Accurate barrel life, when you try to develop a Load for a Magnum intended to be used for 1000 Yard competition. There is a better way.

The incremental Load Development Method

There is a Load development I used more than 10 Years that can tell you quite a lot about a Rifle and that Kinds of components it likes and at that Velocity levels it will shoot best. I first read about this method in an article by the late Creighton Audette entitled, "It Ain't Necessarily So". This article appeared in the NRA's National Championship Training Clinics Manual Series in the volume, Highpower Rifle Shooting, Volume III. I never saw this Load development method mentioned anywhere else, although Creighton may have published something on it in PS back before I became familiar with the Magazine.

I once commented in these pages, some of these NRA manuals had been out of print, for indeed some of them had been. The NRA has informed the PS editor that all three of the Highpower manuals are now back in Print. These Manuals contain a Information wealth for Highpower shooters, not found anywhere else.

I picked Creighton's method on this up and tried it. It is simplicity itself and certainly seemed to work well enough to tell me those Loads to give me the best Accuracy in my Rifles at reasonable Velocities and Pressures with a particular Bullet.

Creighton Audette Incremental Load Development Method (or ILDM for short) essence is: Settle on Choice of Bullet, Primer and Powder and Case brand. Once you picked these things, there are two numbers you have to make up to use this Method: A Start load and a Load increment. That chosen, load 20 Rounds, start with the Start load and increase the Charge weight stepwise by the Increment for each subsequent Round. Load only one Round with each Charge weight. Then, using the same Aim point, fire all these Rounds on one Target and interpret the results. Here are the details.

Depending on each Bullet weight, base the Start load on both Increment and Maximum load for the Powder you picked, so we shall look first at increments first. Some examples are in order.

For Medium case capacity cartridges such as the .308 Win. or .30-06 Sprg. Audette's Standard increment was 0.3 grains. For small cases such as the .222 Rem, .223 Rem and the like, use 0.2 grains. For Medium-large Cases such as the .30-338, 0.3 shall also do. For really large Cases, so large that I don't know of anybody who is crazy enough to bench test them a lot, pick anything you like, 0.5 or even 1.0 for your **875 Nitrolautenboomer**. It's your Shoulder.

Your Start load (Charge weight) should be simply the Maximum charge weight for that Cartridge with that Bullet minus a Decrement, that is 20 times the Increment. Example: If your Increment were 0.3, the decrement would be 6.0 (= 20 times 0.3). In this Example the Decrement would be 6 grains. Your Start load must be safe with the used Components. If you fill a really slow Powder, such as 4350 or slower, fall not short below the recommended Minimum load for that Powder, to avoid the Risk for secondary Explosion. The Secondary Explosion Effect occasionally occurs with light loads of slow powders, or partly empty Cases with some slow Powder. It happens not every time, but is frequent enough and dangerous enough, that almost all Load manuals now list Minimum charge weights for slow Powders. If you fill such a slow Powder, look for such Warnings and heed them strictly.

To do next is to load up a Set test rounds by loading only one Round, that's right, only one Round, with each charge weight. Start with the Start load and load one round with it. Then load the next Round with 'Starting load + Increment' then the overnext Round with that Load plus the Increment and so on. You step up a Ladder. An example will make this clearer.

Example: If the Start load were 40.0 grains 4895 and you Increment 0.3 Grain, then load the 1st Round with 40.0 grs., the 2nd with 40.3, the 3rd with 40.6, the 4th 40.9, the 5th 41.2, the 6th 41.5, and so on Twenty incremental Loads will take you the Ladder up from 40.0 to 45.7 grains in 0.3 grain Steps. While loading keep the Cases in a Load block, to always know from its Location in the Block the Charge weight in each Case. The easy way to keep Things orderly is with a fine Paint mark pen to write the Charge weight on each Case just before filling the Powder into that case. And, yes, approximate Weights are not good enough; weigh each Charge to a tenth Grain (1/10 gr.).

Once 20 rounds are this Way loaded, store them all into a Box such as to remain in increasing Charge weight order and you know precisely each particular Load. Marked Cases are even safer against Confusion. Now start with the lightest Charge to shoot them in Charge weight order. To learn the most Information from your Efforts, you should at the range do some things:

1. Start with a clean Barrel and shoot about 5 Foulers rounds, loaded with the Start load before you begin the Ladder test. Shooting-the Foulers benefits several Goods: Fowlers allows you to get on target and opens you a Chance to move your Group on the target to a wanted Aim point. Fowlers enable a Chance to properly position and adjusted your Chronograph screens. Fowlers fowl the Barrel properly with powder fowl from the powder used for the incremental Ladder test. This last is important. After a load with one powder changed to another powder, even though both powders were from the same manufacturer, I all too often saw a Barrel to need as many as 4 or 5 Rounds to "settle down". I know not whether, while using the same Powder, to change Primers would have the same Effect, but it might. To start with a clean Bore and then

to foul it with a Group shot with the start Load results in a controlled Begin.

2. Starting with die lightest Charge to shoot the Ladder test rounds in increasing Charge weight order. Approaching the maximum load level watch for excessive pressure Signs. If they appear, stop!
3. If possible chronograph all Shots. Velocities should monotonically increase, but an occasional Oddball shot may yield an Off-order-velocity. To log Veleocities helps to interpret the Target. The chronograph has occasionally helped me to determine the powder charge, when I shot a round out of order.
4. This Step is the Key to the method: Shoot in a single Serie all Rounds on the same Target using the same Aim point. Number the Shots and Shot holes to identify best which Shot caused that Hole in the Target. Take good notes. Always be sure to write down any pertinent Data, such as the Fact that you saw the Crosshairs sights fade to the right, or down, or wherever for any particular Shot. This information is needed to interpret the Data.
5. Shoot the test at a goodly Distance, at least 200 Yards, but 300 Yards are better. Creighton advised in his article to use 300 Yards. A problem to shoot the Serie at 300 Yards is that it is very difficult to identify the Shots by Number on a Target that is that far away, unless you have a superior Spot scope, and it is a very calm day with no mirage, or use an electronic Target system. The Ladder test shall work at only 100 Yards, but sometimes, to discern what is happens on the Target, is tough. The first Time I ever tried this Method was at 100 yards with a new Obermeyer barrel that set 14 shots into a 1.25 Inch hole. That was kind of hard to interpret.

At 300 Yards, to shoot on a Range with Target pits and pit pulley pull the Target after each Shot and number each Shot hole with a Pencil on the Target face, or put numbered white Pastern over Holes that are in the Black, is better. At 200 yards, the Shot holes can usually be seen, but when a tight cluster occurs to identify which shot was such, is hard.

At any Distance on a pitless Range, you will have to resort to plot the Shots by Number on a Target diagram. When must note this, while you shoot, to have someone else to watch the Target through a Spot scope helps. Also to use the new Shoot NC targets from Birchwood-Casey, the Folks that make Tru-Oil, helps. These Targets feature a frangible Black paint layer over a fluorescent-green Underlayer. When a .30 caliber Bullet hits, the black Paint breaks off to leave a fluorescent green Bullet mark about 0.4 Inch Diameter. Even at 200 or 300 yards through heavy mirage such Marks are very visible. M. L. McPherson introduced these Targets to me. I believe, they are a great aid in the Ladder process. I had only one of these to use, for the Tests reported in this Article. I got some more for some later Tests I did with other Bullets in other Rifles.

Another important Guide to obey to successfully learn from a Ladder test, is to set the Rifle exactly the same Way up, as you intend to use it later on. This means, if you intend to use the Riffle with a Scope sight, then shoot the Test with a scope on the rifle. If you intend to shoot froma Rest, or other Support, use the same Rest on the same supporting Location under the Shaft, as later.

If you are going peep the Target through Iron sights (as in Highpower competition), then shoot the Test with the Iron sights you intend to use on the Rifle.

If you shoot a Ladder test with a Rifle differently set configuration to the intended Use, the Rifle's Recoil- and Vibration-characteristics differ enough, that the load you find, may not be optimum. Shoot any Ladder test with the Rifle set up the way you are going to use it! Exactly!

After you finished the Shots sequence, you have two Data collections, that, when looked at together,

can tell you a lot about your Rifle. They are: 1st the Data sheet listing the loads and their Velocities and the Target with the numbered shot holes, or the target together with a target diagram with shots numbered, self. 2nd the Target with the numbered Shot holes. That the importanter of the two.

To plot Shots on a Target diagram, to have the Target itself to compare to the Diagram is still useful. Usually this helps to correct the Diagram and enables to number most Holes in the Target. Now that, figuratively speaking, we have shot this Goat, we get to read the Entrails for Signs and Portents.

Interpreting the Data

I can hear the Wheels turning in your minds out there. You all ask, "How in Hamburger Helper can this Mess tell me anything. The answer is simple, but you need to know, what to look for. While ignoring the chronograph results look first at the Target. Are there any places on the target, where some Part of this Ladder seemed to like to produce a halfway decent group anyway?

As Velocity increases the Shot holes will usually pattern the Paper up. The lowest Velocity shot will usually hit the Target lowest. The highest velocity Shot will usually highest hit the Paper. In this upward Ladder will usually be Clumps. Those are of all most important. Sometimes Hits clump nice little round. Other times Hits clump only vertical. If in windless Environment the Hit holes scatter from right to left, as well as up and down, probably Time to try another Powder or another Primer or to check the Action bed in the Rifle arrived.

However, with any Powder- and Primer-combination usually happens, within the 20 Bullet impact pattern on a Target, five or six consecutive Shots clump someway, can be found. This happens not at random. The numbered Shot holes will march the Paper up, then stop for a few Shots and clump, before jumping out of the Clump and then resume their upward March.

The Key to interpret the Pattern, are all numbered Shot holes. You could shoot with all sorts mixed Loads with different Bullet weights. different Powders and Primers, different Cartridge cases brands, etc., 20 Shots at one Target and probably get a few nice Three- or Four-shot groups and maybe even a small Five or more shots group somewhere in the 20 hole pattern in the Target, but that wouldn't mean anything. Even all matched components everything else correctly arranged with the Ladder test, would a small Group not mean anything, unless that group was made by consecutive shots in increasing weight charge order.

We only look for small Groups formed by consecutive shots. Call such Groups "Sweet Spots", there the fired Rifle "cares not " about the Powder charge weight, as long as it remains in a certain Range. The Ladder test heart is simply to pick a Charge in the middle of the Sweet spot group charge weight range. One Benefit to find a load with this method is, a Load, tolerant to minor Powder charge weight variations. Even if your powder measure technique is not so accurate, the incremental Load development method (ILDm) with the Ladder test will show a load to be accurate with thrown charges.

The Ladder test works because ...

If you look at the Reason the right way, it is simple. As the Powder charge increases, the Muzzle velocity also increases, but the Time the bullet accelerates in the barrel (called barrel time) decreases. As Powder charge and Muzzle velocity increases, Recoil also increases, whipping the Barrel. I believe, the recoil induced Muzzle elevation interacts with Barrel-vibration- and Barrel-time-effects, work in the ILDM.

Several things work in the same time:

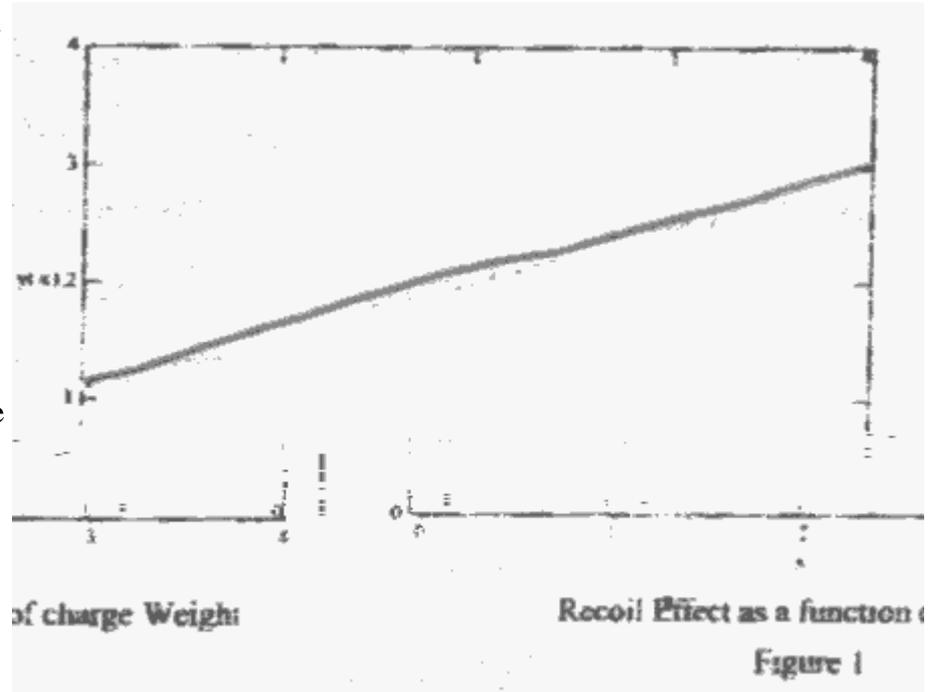
1. The Recoil forces the Barrel to move back and to rotate slightly around the Rifles Mass center, whipping the Barrel.
2. Responding to increased Powder charges the stepwise further accelerated bullet increases velocity + reduces Barrel time.
3. The Barrel vibrates in some regular Manner, changing the direction to point to.

The first two Forces combine to produce a Recoil effect. Force 2 combined with #3 also produces a Vibration effect. Recoil effect and the Vibration effect combine to the total Effect, to be seen as the Target pattern. We need to look at these effects individually.

The Recoil effect

A Path understand the Recoil effect is, to idealize the Situation. First assume the Rifle barrel was indefinitely stiff and rigid. At Shot fire two Things happen together to produce the Recoil effect:

- First muzzle rises because the recoil impulse is along the line of the bore, but the Rifle's Mass center is below the Bore line.
- Second under Gas pressure, the bullet accelerates to a certain muzzle velocity within a certain time, then travels with another



certain Time towards the Target. Each these Forces Magnitude is a function of the Load's powder mass. For a particular Rifle and Bullet, Muzzle elevation + Barrel time + Bullet flight time interaction determine the Bullet impact point elevation on the Target.

Strangely, as the Powder charge and Muzzle velocity increase, Muzzle rise due to Recoil at Bullet exit may, because of consequently decreased Barrel time, slightly decrease.

Trying different loads with heavy bullets in a short barreled Revolver such as a Smith and Wesson Chief or a Colts Detective Special at short distances, lower speed bullets may sometimes hit the Target higher. This effect is real. At close ranges slower Bullets will hit higher on Target than a faster same Mass Bullet. This happens, because the slower Bullet spends more Time in the Barrel, while the Gun rotates about its Mass center, thus leaving the muzzle at a higher Departure angle. However, since, for Rifles the Bore line change is usually small and faster Bullets fly in flatter Trajectory, there will be a Point at that Bullet trajectories will cross, thus giving the same Impact point on a Target. If the target was closer to the muzzle than that of the Trajectory cross, the slower Bullet would impact higher than the faster Bullet. At all distances beyond that Cross, faster Bullet would be higher than slower ones.

In short, if we shoot at a far enough Target, the two Effects: Recoil induced barrel up rotation + Flight time to the target, combine such, if the Rifle barrel was infinitely stiff, not to bend or vibrate, for bullets fired at the same Aim point, the Target impact elevation points would increasingly depend only on Muzzle velocity. Higher velocity bullets would strike the Target higher than Lower velocity

bullets.

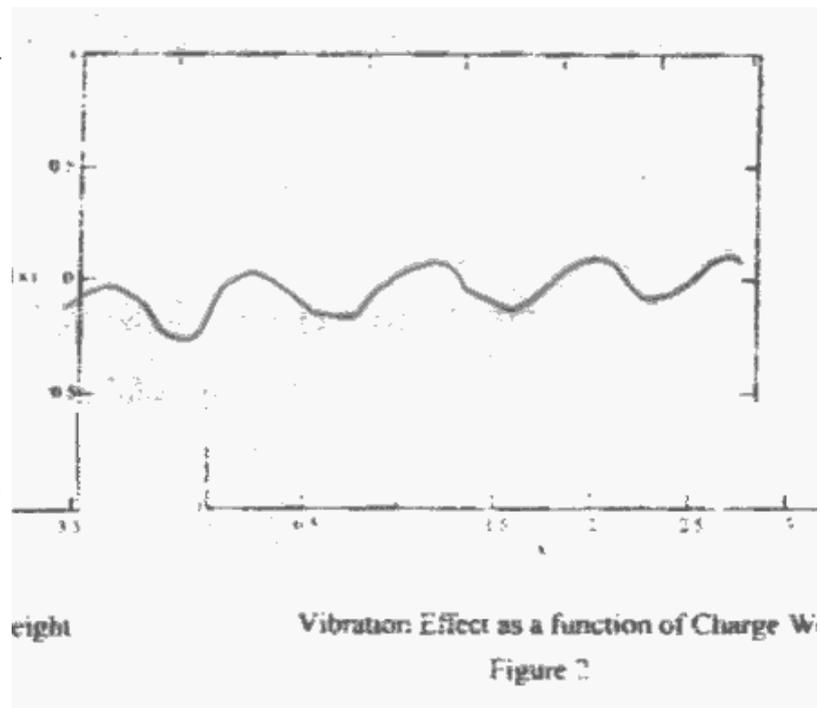
If the Powder charge weights are in the normal Range for that Cartridge and Bullet mass, then the Muzzle velocity will also increase with Powder mass. When we consider this Fact together with that in the previous paragraph, to see the Impact elevation point on the Target an increases with Charge mass becomes easy to see; i.e. more powder = higher velocity = higher Impact point on target.

If we draw a Target impact elevation point graph versus Powder mass, we get a graph like shown in Figure 1. The actual Target impact elevation point graph versus Powder charge matters not. Whether the graph bulges up or down matters not. The significant Figure 1 feature is, the Impact rises smoothly from left to right. For this reason, I choose a straight Line for the Purpose to illustrate the Facts.

The Vibration effect

OK, back to reality. We all know, there is no such Thing as an infinitely stiff Barrel. That was the physicist's idealisation. They all bend, wiggle and vibrate in all directions.

However, for the purpose of this Essay, i prefer to pretend all the Barrel vibrations are simple. To understand the Vibration effect, we also have to idealize to some extent. That Idealization is merely to assume, everything is so uniform that, whenever two Cartridges are loaded with the same Amount chosen Powder and fired at the same Aim point, the Barrel vibrates each Shot exactly the same Way and both Bullets will hit the target in the same Hole.



This assumption simplifies the Vibration effect. Powder charge weight changes modify two things upon Shot fire: Barrel time and the Barrel vibrations. These changes thus distort the Bore line direction at bullet's exit. But the Bore line at the Muzzle Bullet exit is the Bullets departure line and that, as we know, in a no-wind condition, together with the Bullet speed determines the Bullet destination. This Vibration effect happens simultaneously with the Recoil effect. Both distortions add up.

Being concerned with Harmonics and Vibrations in all Directions perpendicular to the Barrel axis only complicates Matters less adding anything to our understanding. Once we understand the simplest situation, the complicated one is easier to understand.

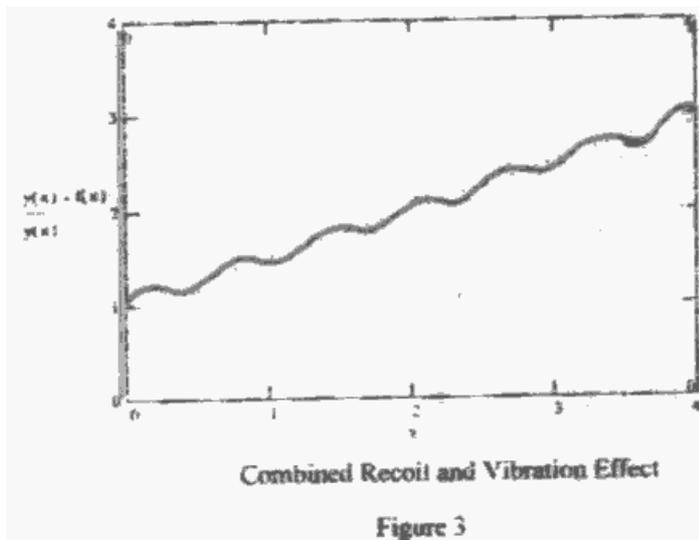
The Vibration effect will thus, for the purpose of discussion, be considered first as a simple sinusoidal vibration along a direction in which the Barrel points and will be assumed to occur all within the vertical Plane. A Graph of a typical Example is given in Figure 2. I know in real Life Things are complicateder than this, but we have to start somewhere.

Heads up! The vibration effect is not the same thing as a Vibration!

To persist to think of the Vibration effect as something that happens over time only clouds to

understand it. Truly Vibrations happen only in Time. The vibration effect here, is the effect in which Barrel vibration interacts with the Time the Bullet spends in the Barrel to cause the bullet's Target impact point to vary as a function of Powder mass. To increase the Powder charge increases the Muzzle velocity, while simultaneously decreasing the the Bullet time in the Barrel. Changing the powder charge also changes the Barrel's vibration pattern. Both work together to change the Bullet impact point on the Target regardless of, or in fact, in addition to, the vertical Displacement by the Recoil effect. The Vibration effect as plotted, is a function of powder mass, not of time. Now that we know why it works, we can combine both Effects together.

The combined Effect



The total effect of a changed Powder mass, the Bullets' impact point, is just that, a total. The Vibration effect adds to (by simple addition) the Recoil effect to yield a Graph like that shown in Figure 3. For clarity is the Recoil effect shown as a dashed line. Figure 4 is just a regional Curve blowup in Figure 3 with a little something added. Figure 4 shows 20 equally spaced points on the x-Axis and emphasizes those Points with these x-Coordinates and then projected these Points from the Graph over to the y-Axis. The Projected points heights look just like

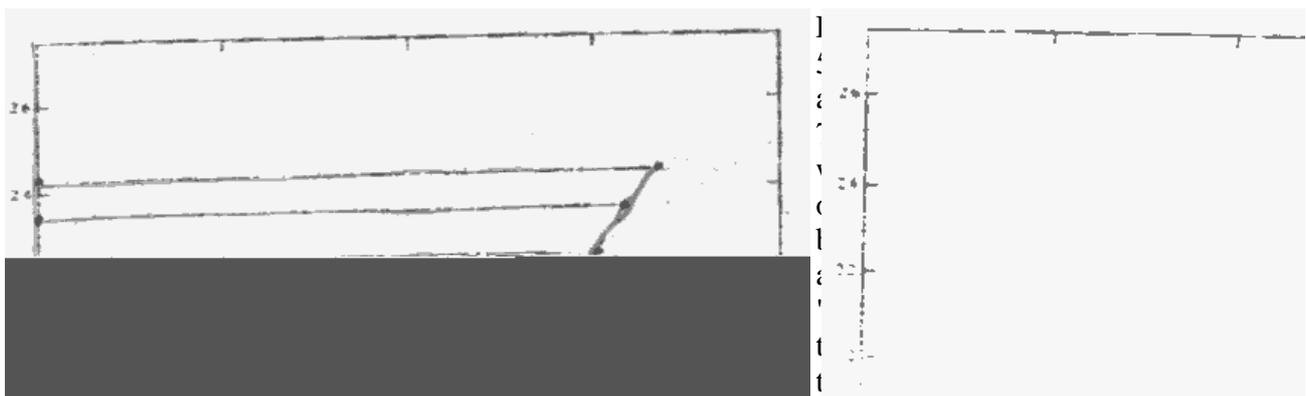
the Pattern you get on target, when you use this incremental Load development method. In this example two clumps appear. See in Figure 4 how the Vibration effect cause a Shot to end up lower on the Target even though the Powder charge and Velocity were for that Shot greater, than for a Lower charge and velocity shot, that crawled higher.

Where occur Sweet spots?

A close look at Figure 4 shows, when upon increasing Loads Recoil effect and Vibration effect move the Impact point in opposite directions, Sweet spots occur.

Around a Sweet spot, as a function of increased Powder charge, the Vibration effect downs the Barrel tip, thus descend the Impact point on the Target, while the Recoil oppositely ups the same Impact point.

Please note again, the x-Axis variable is not Time, but is powder mass.

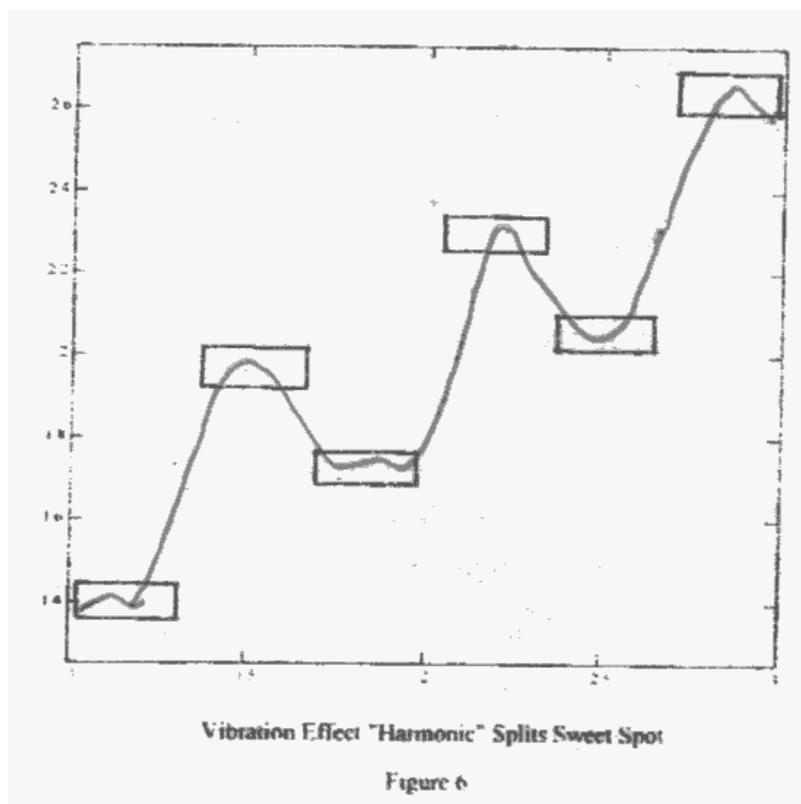


Vibration

effect function and then changing the "Harmonics" amplitudes and Phase angles. On each these Figures, a Box highlights the expected Sweet spot graph region. On Figure 5, the Sweet spots are small, almost nonexistent. In Figure 6, two potentially large Sweet spot split into two small ones on either side of the downward Cross point. Figure 7 illustrates a desirable situation, a large, flat Sweet spot.

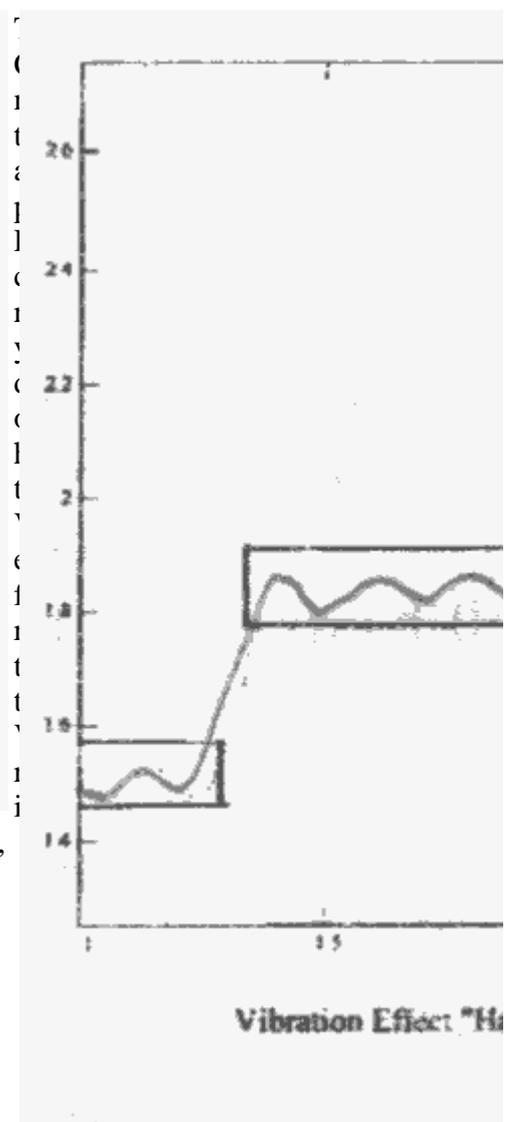
In the real World Things are obviously not always this nice, but they can come pretty close. The Barrel may usually laterally as well as vertically vibrate. The Muzzle will then wiggle in a Lissajou figure, to really complicate Predictions. However, almost every Time, the Vibration effect combines with the Recoil effect yielding at least one relatively nice Sweet spot.

The thing that enables the Method work in the real World is, the Vibration effect changes fast enough over Powder variation, that at least one whole Vibration effect cycle occurs within the '5.7 grain powder charge variation range'. "Vibrations" of this Frequency combine with the rising Slope of the Recoil effect, see Figure 1, to result in Combined effect regions that are almost flat, as to be seen in Figures 3 and 4. A flat Impact height - over - Powder mass Curve indicates vanishing dependency on Powder mass variation, hence a Sweet spot.



that Powder charge range. I know no way to predict that. Also, if the Barrel vibrates with any appreciable amplitude in the Barrel's first, second or higher harmonic Vibration mode, the Vibration effect - - Recoil effect - Interaction may allow only one "Sweet spot" or even none at all, much as in Figures 5,6, and 7.

But the whole Ladder Test idea is not to enable you to predict your Barrel vibrations but for a particular combination of bullet, primer and powder simply and practicable to enable you, to find at least one Sweet spot, if one at all exists.



For real stiff Barrels, the Recoil effect may overpower the Vibrations, as the Barrel vibrates at such low Amplitude, and thus no Higher velocity shots fall in a Clump low. Ideal would be to somehow be able to tune a Barrel, so the Vibration effect exactly balanced the Recoil effect and the Slope of the composite Curve (that actually sums Recoil effect and Vibration effect) at the downward Cross points would be Zero. I wish I knew how to do that.

To pick a load in the Clump middle tries to choose a Load near one of these downward Cross points of the Vibration effect. Even though we cannot separate the Recoil effect from the Vibration effect, the Sweet spots tell us, when one effect tries to cancel the other out.

The hard Way

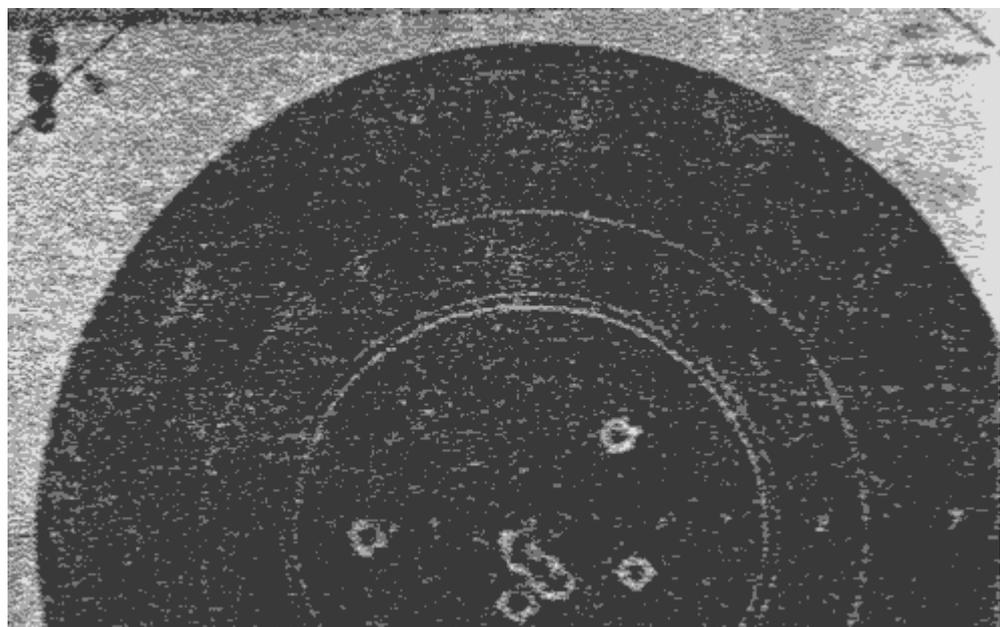
In a conversation with Roger Johnston of NECO I once raised this method to develop Load and he told me, how he once did something with one of his Schuetzen rifles, that had somewhat the same effect as the ILDM but had to be done very differently to generate enough Pressure to cause the bullet to upset and seal the Bore against Gas blow-by, but the Pressure cannot be allowed to be too high or bad things will happen: the Bullet may slump; unless p-wads are used, the Bullet base may be cut by the Powder gas; a lot Lead may be deposited in the Bore; even the Bullet may strip in the Rifles. So, depending on the Bullet hardness, Pressures have to be kept in a fairly narrow Range. This restricts the Charge range and available Velocities. How under these conditions to obtain best Accuracy?

Roger's answer was: If you can't tune the Load, tune the Barrel. He took the Rifle together with a few Tools to the Range: A Hacksaw, a Machinist's Square and a File and a large Amount Ammunition. Opposed to breach seating each bullet, Roger shoots fixed Ammunition. He shot a Group and then cut a half Inch off the Barrel and using the file and the square recrown it by hand. Then shoot another Group until the Rifle shot the Way he thought it ought to. He says he endured a lot of rude comments from the Peanut gallery, but took satisfaction in consistently beating most of them in matches.

This is definitely no easy way to gain Accuracy, but perhaps the only way to get to a Sweet spot for a Fixed load. However, it may not be the Method of choice for everybody. How good are you with a file? My Hat is off to Roger. May he bask in the reflected glow from my pate.

ILDM Results from real World

Back in early 1996 I decided I needed to see if I could develop some better Loads for the Rifle I used to shoot over the Course. After all, I rebarreled the Rifle and switched to using moly-coated Bullets, so some new Load development was in Order. I decided to try all three of the standard lower - weight Match bullets (150, 155 and 168 grains) available from



Sierra for the .308 and their then-new 175 grain Match bullet as well. I called up M. L. McPherson and arranged to move over to Cortez to test on his Club range with him. He too, had some Range work to do, so we settled on a Time and Day. The Cortez range is only 70 miles from my house instead of the 200 plus miles to the range down at Los Alamos, so moving over to shoot with Mic meant fewer Miles to drive. I ended up two trips to Cortez to get everything done, all because Murphy showed up to do his thing.

I started the test with the Sierra 150 grain Match King bullet with 41.0 grains VarGet Start load. The chronograph did not "see" the first shot, but it was nicely on target.

For this test I used something new to me, that Mic provided, one of the new Shoot N-CT" target centers made by Birchwood-Casey which I described earlier. Using this center eased to tell which shot hit where.

Things went along great in that first test until the 9th shot, that went way out of the group to the right; the 10th went way left: and the 11th went way out the top and right. A quick rifle inspection showed the bloop tube couple cracked, because I habitually over tightened the clamp screws. For me with that rifle on that day ended all shooting, but just those few shots gave me enough data, that I could pick a Load for the 150, that I could use with Confidence and Success.

The target for those 11 shots is shown in Photo I. That little group in the Target middle has six shots in it with powder charges varying from 41.6 to 43.1 grains VarGet and measures 1.04 inches on the

I6(c r)-6.9(i)1(owra)-9(sed t8(us4)-5.1 tra)-9-2(i)-3.9ins VGewets m8(yoad0(w)-7.2(o)-7(for the50.1 tra)-9-2(i)

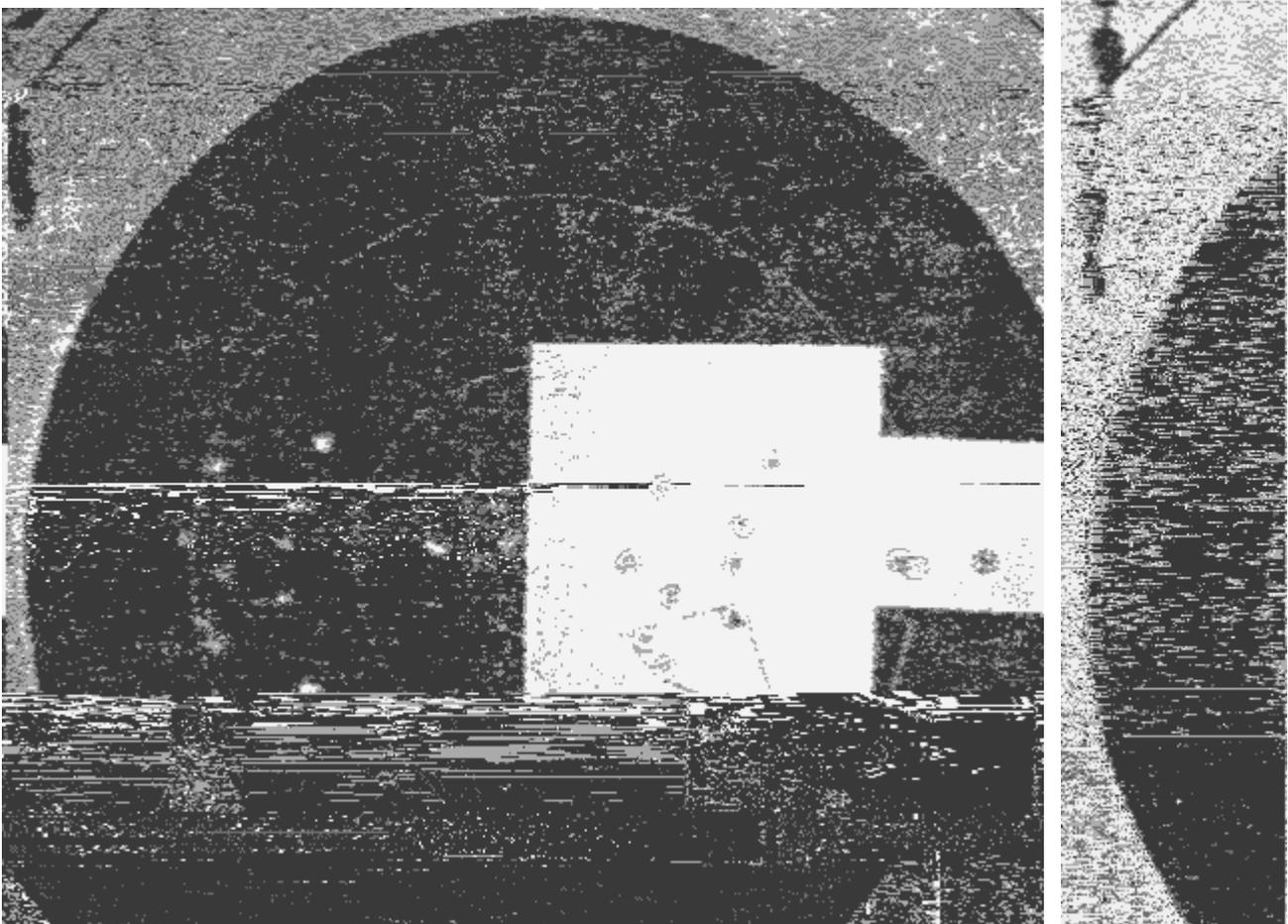
Matchking

and the new 175 grain Match King. The results were interesting. With the 155 grain Palma bullet and Varget, 16 shots went into a diamond shaped Cluster 1.837 inches wide by 2.072 inches tall (that's Center to Center), but in the middle of all that, shots number 5 through 9 were in a Cluster measuring 0.488 MoA Center to Center. With Shot #7 having a 41.8 grain charge and shot #8 at 42.1 grains, I just arbitrarily picked 42.0 grains as the Charge to use with the 155, if that was the Bullet I decided to use, as turned out to be. The Target for the 155 grain Bullet test is shown in Photo 2.

Things were not so good with the 168 grain Match King. Velocities were erratic. For each 0.3 grain Powder increment the Velocities seemed to increase about 15 to 20 feet per second on the average, but shots #5 and #10 jumped out of their Progressions and out of the forming groups. Also, there was way too much lateral Variation than could be attributed to the little Wind there was. If I had to pick a load for the 168 it would be 42.0 grains (shot #8 is 42.1 grains). Shots 6, 7, 8, and 9 formed a 0.778 MoA group. Not bad, but no where near as good as found with the 150s and the 155s. I prefer to find a Five or more consecutive shots group, if I can. Photo 3 shows the target shot with the 168's.

I also tested the then-new 175 grain Match Kings. I had shot them at 300 Yards in one Match and performed fairly well, but felt, I could do better than the load I used in that Match. As you can see in Photo 4, there are three distinct Clumps on the Target but no really close five or more consecutive Shots. There were some nice Three shot groups and one middling good Four shot clump. Shots 2, 3, and 4 edged a nice little 0.403 MoA Triangle and shots 5, 6, 7; and 8 went into 0.665 MoA. The best Five shot group comprised shots 11, 12, 13, 14, and 15 measuring 0.720 MoA.

I picked the 155 grain Bullet to use at 300 Yards. With that load, I shot my first ever clean Prone Rapid fire at Camp Perry to boot. I also use this same Load for Prone Slow fire when shooting reduced Distances. With this Load last Year I shot a 199-7X in the Prone Slow fire Stage of a 100 Yard match, and the one 9 was my fault.



While using the least Amount of Components in the Load development process, I believe Creighton's Incremental Load Development Method, the Ladder test, is the only Way to develop the most accurate Load with a particular Primer + Powder + Bullet - Combination. Of course the Objective is to develop an insensitive Load to minor in Charge weight variations, that occur when throwing all Charges with a Powder measure. With weighed Charges, that insensitivity should not matter, but can in Practice not hurt to have your Load sit in the Sweet spot middle, even if you weigh the Powder. Using the Incremental Load Development Method, I developed the most accurate loads I ever shot in competition. Using those loads, I shot the best Scores I ever shot. That is good enough for me.

Till next time, Keep'em in the Center.

Randolph Constantine
Lost Axe Ranch
47951 1 U. S. Hwy 160
Bayfield, CO 81122
U.S.A.

from 1997 Precision Shooting Annual

Untersuchungen über die Vibration des Gewehrlaufes

Carl Cranz

Gewehrlauf

Weiche Lauflagerung

Load development

Ladder test

Lutz Möller Main place