Alternative Firing Rifle Sighting Mechanism

by

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Submitted to the
MECHANICAL ENGINEERING TECHNOLOGY DEPARTMENT
In Partial Fulfillment of the
Requirements for the
Degree of

Bachelor of Science
In
MECHANICAL ENGINEERING TECHNOLOGY

at the

OMI College of Applied Science
University of Cincinnati
May 2002

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ABSTRACT

Due to the inaccuracies involved in the process of sighting in a scoped rifle, a prototype was developed. The Alternate Firing Rifle Sighting Mechanism holds and fires rifles while eliminating human error. To eliminate human error, this system uses a wire-assisted mechanism to pull the trigger and prevent unwanted movement. This mechanism is designed for easy mounting, easy adjustment, and accurate firing.

This prototype was designed to be adaptable with most bolt action sporting rifles. At the present stage, the prototype does not allow for the use of external clips. The prototype was developed using information gathered from potential customers. Initial surveys were given to members of the Coshocton Gun Club, Inc. to reach a target audience. These surveys helped establish a need for a product such as this, and supplied information on customer requirements used to develop a QFD (Quality Function Deployment). The analysis of the QFD establishes customer requirements. This information provided was converted into conceptual designs and eventually a prototype. Results from the proof of design shows that the prototype meets all the requirements developed by the QFD. Recommendations for further developed show the need for minor design changes and a need for alternate methods of manufacturing.

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INTRODUCTION

Many people who shoot scoped rifles find it hard to keep the sights on target while sighting in the rifle. There are many products of various types that are used to hold rifles in place. The objective of this project is to design and build a prototype system, which eliminates unwanted movement of a rifle while sighting in a scope. In order to function properly, a scope must be calibrated, or "zeroed" once it is mounted. All calibration firing is done from an artificially supported shooting position using a bench rest. A rifle bench rest is a device used in rifle shooting which is set on a shooting platform such as a workbench or table. A rifle is placed on this rest and the gun is held steady. A bench rest can also consist of a number of sand bags that can be manipulated to hold the gun. When the trigger is pulled the force required to pull the trigger will often move the rifle slightly off target. A force or weight in pounds is needed to engage the trigger. An average force must be applied to the trigger to cause the firearm to fire. Typically, non-target mode-firearms have a minimum trigger pull of 3 pounds. No matter what the weight of the trigger pull is, the force cannot be eliminated. These forces need to be equalized (6).

The process of sighting in a firearm is as follows. Once a facility is located to legally discharge firearms, a target needs to be set up (available at most sporting goods stores) at a distance of 25 to 100 yards from the shooting location. A comfortable gun rest should be used to eliminate as much human error as possible. Making certain the rifle is empty with no cartridge in the chamber and the breech open**,** follow the instructions that came with a commercial bore sighter and install the bore sighter in the muzzle of the rifle lining it up with the scope as close as possible by eye. Sight through the scope, two sets of cross hairs should be seen. One set is a plain cross hair (this is the one in the scope itself) and another set that is graduated or on a grid (this is the one in the bore sighter). These cross hairs should line up with each other vertically, horizontally and in complete alignment. If the vertical and horizontal cross hairs are not parallel with each other, adjust the bore sighter whatever direction it needs to turn in order to achieve this. The cross hairs need to cross or meet at precisely the same location. If they do not do that the scope will need adjusted so they do. There are two adjustments on any scope. One for elevation (usually on top) and another for windage (usually on the side). Follow the directions that came with the scope for how to access these adjustments and what tool to use (i.e.. screwdriver, etc.) to make this adjustment. Proceed to adjust your scope right, left, up, or down until the cross hairs match. Once this is complete, remove to bore sighter. Load one cartridge into the chamber and close the breech. Take aim at the target and squeeze off one round. Open the breech and be certain the rifle is not loaded, and then go check your target close up. Make sure the round is hitting the target. It does not need to be in the bull's eye. If the round is not hitting the paper target at all, move the target closer in 25 yard increments until the round consistently hits somewhere on the target. No scope adjustments can be made because it is not certain what adjustments need to be made. Once the round initially hits the target sheet, adjustments can be made to gradually move the target back out to the 100-yard mark(7).

Adjustments in the elevation and windage of the scope need to be made based upon the pattern the rifle is shooting. The elevation needs to be adjusted to provide the most accurate shot possible even though the distance from the rifle to the target in the field can range any where from 50 to 100 yards, give or take. To accomplish this, set the elevation so the pattern hits the target about three inches above the bull's eye. This will not alter closer shots significantly and will compensate for the longer shots. The windage adjustment should remain dead on center. Continue to fire no less than three shots to locate your pattern then make the necessary adjustments to the scope to achieve the three-inch high dead on center pattern.

PROBLEM STATEMENT

The object is to not assume that everyone knows how to sight in his or her rifle. There are many new hunters and shooters everyday. When shooters go to the rifle range, they all want to be able to at least hit the paper target. Human error is the biggest problem associated with sighting in firearms. No human being can hold or fire a rifle without moving. A rifle needs to be in a rigid position to obtain the best accuracy.

Getting a rifle sighted in on a target is often accomplished with the use of a rifle bench rest. This often consists of using special bags that will mold to fit the contour of the rifle. A problem with this method is that the rifle is never held perfectly on target. With the rifle being in actual human hands and being rested on a movable object, it takes much effort to accurately sight in a rifle. Many rounds must be fired through a gun before satisfactory results are obtained. In this case, holding the rifle on the sand bags is the problem. A sandbag allows a gun to have a contoured fit to the shooting surface, but the bags are too easily manipulated. A rigid gun mount is needed to keep a rifle perfectly still.

Another problem due to human error when sighting in a rifle is the trigger pull. "Trigger pull" is defined in the Association of Firearm & Toolmark Examiners (AFTE) Glossary as: "the amount of force which must be applied to the trigger of a firearm to cause sear release." No matter how steady a gun is held, the position will change with the trigger pull. This will pull the gun off target slightly causing it not to fire completely accurately.

RESEARCH

Research was conducted in order to find the best way of achieving the project objective. The research done was primarily Internet patent research and catalog research of similar products on the market. Survey research was also gathered by two surveys distributed to members of the Coshocton Gun Club, Inc. These two surveys gathered information pertaining to need for such and product and customer wants and needs.

The majority of the Internet research was done on patents pertaining to bench rest devices for firearms, such as US patent: "US3827172: Bench Rest Device for Firearms and "US3827172: Portable Shooter's bench rest." The product most similar to the one developed and is listed under US Patent number US3827172 and entitled "Bench Rest Device for Firearms." This patent was issued to an individual by the name of Everett Howe in August of 1974. This technology would work, but it does not totally solve the problem being addressed. This product provides an adjustable support device for firearms, but does not eliminate necessary forces.

Product research found bench rests designed especially for sighting-in and bench rest shooting. Many products are of cast metal construction that provides stability to stay put but is light enough to carry in the field. The rifle bed on this model measures 5" across, 3 1/4" deep. Height extends to 8 1/4" retracts to 5 3/4" Screw type pointed anchor pins (may be fully retracted) in each tripod foot (8). This rifle rest provides a good base for a rifle but does not eliminate the problem of unwanted movement. These types of rests are often used with rifle rest bags. These bags are usually made of leather and are shaped and stitched to form total supports for stock and barrel. These rests provide a good platform, but since they are filled with sand they do not eliminate movement. Another similar product is a rest that is made for target practice, sighting-in, and long-range varmint hunting. This portable bench rest give stable support yet is adjustable. This product eliminates the need for heavy, bulky sandbags. This rifle rest is manufactured of square tubular steel. This rifle rest provides a better platform to shoot from than the previous ones mentioned. This rest still relies heavily on user input to fire the weapon. This will cause movement while firing a weapon (7).

PROJECT OBJECTIVES

The objective of the project was to design and build a prototype, which will allow the user to accurately aim and fire a rifle in order to increase the efficiency of calibrating the scope and firearm. The prototype will consist of five main components: a means of holding the mechanism to a sturdy shooting surface, a means of rotating the firearm to the left and right in order to aim at the target, a means of raising the forearm stock of the firearm in order to aim at the target, a means of pivoting the stock of the firearm in order to aim the firearm and a means of firing the firearm in order to eliminate human error which occurs during trigger pull.

The prototype is designed to be adaptable to most sporting and hunting rifles. The prototype is designed to be applied to these rifles with minimal effort, and in a way that is easy to use for the average rifle shooter. The user must install the rifle on the rest and make sure it is secure. A wire guide must then be installed to the trigger guard and the wire fire system can then be adjusted.

The proof of design statement (see Appendix A) lists the specifications of the prototype. This involves specifications of the accuracy of the prototype, adjustability of the prototype, and easy of use of the prototype.

PROJECT ELEMENTS	**SOLUTION ELEMENTS**
Weight	Weighs under 25lb Material (Aluminum)
Elevation Adjustment	Elevate +/- 2 inches
Rotational Adjustment	Rotate +/- 2 inches
Trigger Pull (Firing)	Operate 10 lb trigger (Firing Mechanism)
Recoil Force	Withstand 20lb recoil (Structural Design)

Table 1 – Problem/Solution Elements

SCOPE OF REPORT

The remaining sections of the report will cover the design procedure from initial concepts through final design, building and testing. This will include a discussion of the Quality Function Deployment development, mechanical design of all necessary components, project schedule and prototype budget, building and assembly and test results. Recommendations for further improvements of the prototype are also included.

DESIGN PROCEDURES

Due to the nature of the project, the design procedure was on the mechanical basis. The overall design procedure was determining the customer's needs via survey, a QFD, and analyzing conceptual ideas to find the one that fit closest to what the customer wants. Project management included calculating and estimating a prototype budget along with developing a schedule for design, building and testing.

QUALITY FUNCTION DEPLOYMENT (QFD)

The design principles for the prototype were based upon the House of Quality (see Appendix C). This house of quality was constructed as results of the surveys presented in the first and second phase of the design process. Most of the information used in the House of Quality was taken from the second survey, which was what it was designed for. The QFD showed that the most important features that the prototype should possess are an adjustable gun mount and an adjustable firing mechanism. Weight was also an important factor. That is why aluminum was chosen as the material mainly used throughout the prototype (1).

From the QFD, four conceptual ideas were developed. The first concept was to use a wire that would mount to the trigger guard and push the trigger to fire the gun. The second concept was to use a wire mounted behind the trigger and attached to a servo. The servo would be activated by radio control to pull the trigger. The third concept was to use a wire mounted behind the trigger guard and attached to a hand lever. The hand lever would be pulled to fire the trigger. The fourth method was to use a linkage mounted to the rifle rest to pull the trigger. A second survey (see Appendix B) was developed and presented to fifteen members of the Coshocton Gun Club, Inc. These surveys were returned and the information analyzed. From these surveys it was possible to determine the customer wants as they relate to the design project. This information was widely used in the development of the QFD.

In order to select the best concept, the Pugh's Selection Method (see Appendix D) was used. For the first trial run, the third concept was used at the Datum. From this run, the design concept number two was eliminated. For the next run of the matrix, the fourth concept was used as the datum. From the Pugh's Selection Method, design concept number three was selected as the best design concept.

MECHANICAL DESIGN

The idea behind building the prototype was to find a way to make all the objective work together to develop a working prototype. Five firearms were selected and analyzed for use with the prototype. It was very important to find firearms that would be adaptable with the rifle rest and that they were a variety of calibers. The calibers range from .22 to .22-250.

The prototype was broken down into several subassemblies (see Appendix G) that could be designed independently. The first subassembly design was the firing mechanism. The firing mechanism consisted of four main parts. The first part was a wire guide that mounted under the trigger guard. This created a way for the wire to securely wrap around the trigger. The second part was the wire tower. This part mounted to the rifle rest and is positioned directly behind the trigger. The wire runs through this tower and it has the ability to adjust the tension of the wire on the trigger. The last two parts are the hand and lever. This design was taken from a standard bicycle hand brake. The wire connects to the hand brake and when pulled, the rifle will fire.

The second subassembly of the prototype is the base of the rifle rest. This is a flat structure that gives the system stability. The base will be mounted securely to a shooting surface when in use. The design concept for the base was to create a platform for which the rifle can rotate to the left and right. For strength and weight concerns, the materials used were mainly aluminum square tubing. This will give the rest a lightweight and good strength. There is a plate at the butt stock end of the base, which has a pivot hole. This feature is in place to allow the cradle mechanism to rotate about. Toward the forearm stock of the rest there is a thumbscrew in place. This allows the cradle to be tightened to the base once it is in the desired position.

The third part of the subassembly is the cradle. This part serves as a platform for a few of the subassemblies to attach. The pivot pin is in place to be inserted into the base to allow the cradle to pivot to the left and right. At the opposite end, there is a slotted grove with a fifteen-inch radius in place. This is in place to allow the thumbscrew to tighten once the cradle is in the desired position.

The fourth subassembly is the elevation device. The elevation device mounts to the cradle assembly. The elevation device is mounted just forward of the slotted groove to make adjustability more convenient. This device consists of a number of parts. The main body of the device is a three-inch by four inch by one-inch bar of aluminum. This is mounted to the cradle by brackets attached to the sides. Five holes are drilled into the top of the device. Four of these holes are designed for guide rods, which will be in place at the four corners. The final hole will be drilled and tapped in the center. In this hole, a five inch threaded stub will be put into place as the elevation tool. A fine threaded bar was selected to make adjustment very precise. The thread selected will require eight turns to move up or down one quarter of an inch. This will allow for enough precision at longer ranges. The elevation devise is designed in such a way that the screw mechanism is not directly attached to the elevation device. The screw merely just pushes it. The elevation device is held into place by the four guide rods. Mounted on top of the elevation platform is the gun rest, which pivots. The pivot is designed to hold the forearm of the gun, but allow it to rotate during elevation.

The fifth assembly is the butt stock bracket. This assembly mounts to the cradle at the pivot point. The assembly is designed to hold the butt of the gun and be strong enough to withstand the recoil once the rifle is fired. The mount is made of one inch aluminum tubing. A pivot point is also designed into this subassembly to allow the rifle to rotate and elevate while remaining secure.

In order to determine whether or not the prototype would withstand the forces of recoil that would be delivered from the firearms, a series of stress calculations needed to be performed. For the impact forces used on the prototype a force of 20lbs was selected from the NRA website (9). The forces acting on the rifle rest were under dynamic conditions. As a rule of thumb the forces are to be double in these conditions before the factor of safety are applied. This was preformed, and with a factor of safety of 3, the impact force used was 120lbs(4).

Shear and bending stress analysis was preformed (see Appendix I) on all the pins and bars of the prototype. The main pivot pin was in a state of single shear and netted a maximum shear stress of 620.48 psi. The pivot pins used in the elevation devices were under a double shear condition. They netted a maximum shear stress of 1222.35 psi. The worst case of stress was found in the threaded bar. Under the provided conditions, the threaded bar must withstand 9803.92 psi (2).

PROJECT SCHEDULE AND BUDGET

An estimated budget was developed from the prototype design. The estimates were made using the information of materials selected and the material costs. Budget did not include any information that would be needed to calculated wages paid for manufacturing. All manufacturing time was preformed free of charge. No cost for machinery was figured in due to the fact that all components were manufactured using the machinery at the North Lab. The estimated budget for the prototype was calculated to be $105.00.

The actual budget required to build the prototype was $100.00. This was very close to the original estimation. The budget could have been reduced slightly but extra materials were required due to machining mistakes made in the North Lab. The price of the prototype also stayed under the estimate because separate individuals donated a considerable about of materials. A spreadsheet of the entire budget is available in Appendix F.

PLAN FOR TEST AND BUILD

Building and testing of the prototype was preformed during the spring quarter of 2002. This stage of the project included the fabrication, assembly, and performance testing and troubleshooting. The majority of the materials needed for fabrication were purchased from McMaster-Carr (see Appendix J). The fabrication of the project took place in two different locations. The first location is in Coshocton, Ohio. This location has been selected because there are some necessary tools there that will be needed to build the project. The second location selected will be the North Lab at the University of Cincinnati, College of Applied Science. This location was selected because of its welding and machining capabilities. Once the fabrication of all the necessary parts was completed the assembly of the project took place at the College of Applied Science. Performance testing of the project took place in Coshocton, Ohio at the Coshocton Gun Club, Inc. This location has been selected because of its familiarity and availability.

The plan for testing was to mount the prototype to a shooting table and fire a 10 round group at 25 yard and a 10 round group at 50 yards. The targets were analyzed to determine whether or not they meet the requirements. The system was tested using all five of the guns selection. This includes the Ruger 10/22, the Remington Model 700, the Ruger 10/22 Standard, the Marlin 882S, and the Anshultz Target Model. Five additional individuals at the Coshocton Gun Club, Inc preformed the test.

BUILDING AND ASSEMBLY

Project schedule was used to provide a structured method for building and assembly. The first step involved in building and assembly was to purchase all the require parts need for construction of the prototype. Once all the materials required were purchase, construction began in the North Lab machine shop. Once every piece was manufactured the assembly process began.

All materials with the exception of purchased machine screws were manufactured using a lathe, milling machine and band saw. Each component of the base assembly was cut to length using the band saw. Once the entire base components were sized and fit into the fixture, they were brought to the welding lab were they were mig welded. Since aluminum is such a difficult material to weld, welding was assisted by Darrel Peacock, the evening welding instructor.

The remaining materials were machined from solid aluminum blocks with the use of an end mill. All these parts were machined within the two months allowed time schedule. Once all the remaining parts were constructed the assembly of the prototype took place in the North Lab. Testing began once the assembly was completed. Enough testing was done to ensure that all tasks could be completed before the proof of design agreement was verified.

TEST RESULTS

For the prototype design, five items were selected for tested. These items tested included accuracy testing, the total weight of the prototype, the elevation and rotational range of the prototype, the method of firing, compatibility with selected rifles and customer satisfaction. All of these tests were conducted at the Coshocton Gun Club, Inc.

Accuracy Testing

The proof of design states each rifle selected will be tested for accuracy at 25 yards and 50 yards. The accuracy was specified to be +/-1.0 inch at 25 yards and +/-1.5 inches at 50 yards. It was also specified that at 25 yards, 90% of all rounds fired by each rifle would be within the desired group and at 50 yards, 80% of all rounds would be within the desired group.

The test method consisted of setting up each rifle and firing a ten round group at 25 yards and 50 yards. Each target was measured to determine whether the desired goal was reached. This ten round process was performed five times with each of the five rifles selected. Figure 1 shows the accuracy results at the ranges tested for each rifle. Accuracy test results are listed in Appendix K.

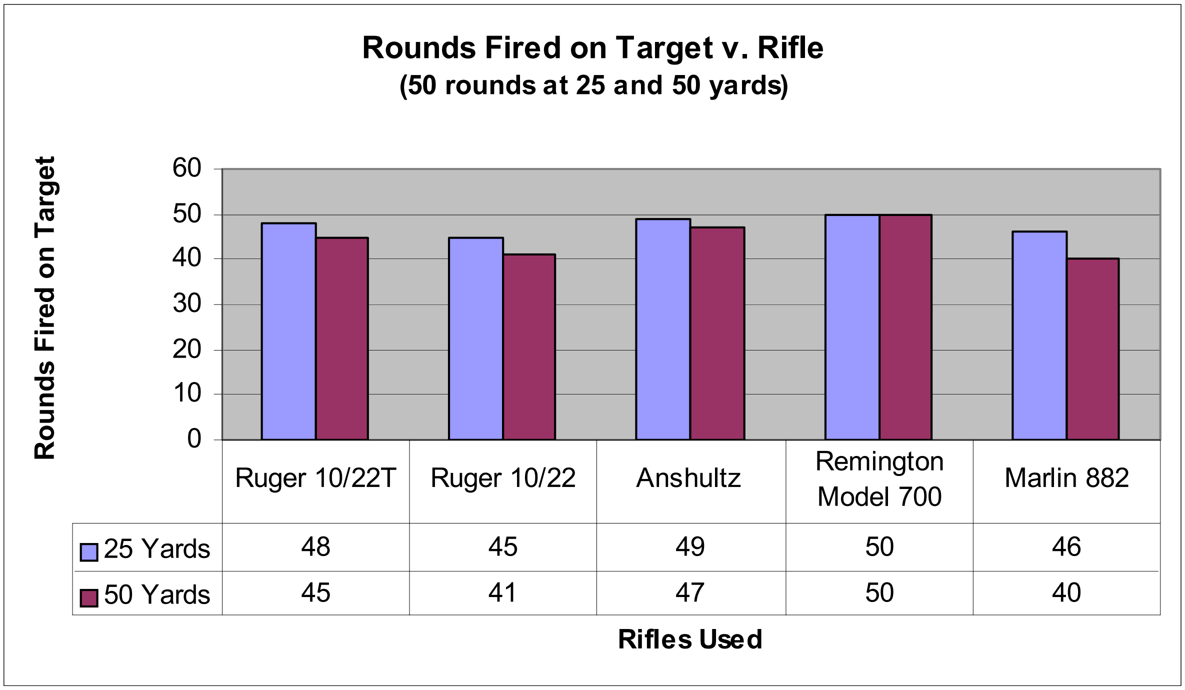

Figure 1 – Accuracy Test Results

WEIGHT TESTING

The target value specified in the proof of design for the weight of the prototype was determined to be less than 25 pounds. This value dictated the use of aluminum as the main material used in manufacturing. After the completed prototype was assembled, a standard weight scale was used and the final weight of the prototype was determined to be 14 pounds. This was well within the desired range for the prototype.

ADJUSTMENT TESTING

The proof of design states that the prototype will be adjustable for elevation and rotation of the rifle. The target value states that the prototype will elevate +/- 2.0° so that the entire target will be in the field of view at 25 yards. The target value for rotation states that the prototype will rotate +/- 2.0° so that the entire target will be in the field of view at 25 yards. This was tested and proved at the Coshocton Gun Club, Inc. All rifles selected cover the target in all directions at 25 yards.

FIRING METHOD TESTING

The proof of design states that the prototype will have an alternated firing mechanism so that all human error is eliminated. The alternate firing mechanism was in the form of a wire firing mechanism similar to a wire braking system used on a commercial bicycle. All standard adjusting screws were used to eliminate slack in the wire. The wire mechanism was mounted behind the trigger to equalize the forces due to the trigger pull and prevents movement of the rifle.

COMPATIBILITY TESTING

The proof of design states that the prototype will be compatible and operates with the five rifles chosen for testing. These five rifles were a Ruger 10/22 Target model, a Ruger 10/22 standard model, a Remington Model 700, an Anshultz Target and a Marlin 882S. All five of these rifles were compatible with the prototype and met all the requirements of the proof of design agreement.

CUSTOMER SATISFACTION

The proof of design states that five additional individuals at the Coshocton Gun Club, Inc. will perform all of the proof of design tasks. Each of these five individuals assembled to prototype, mounted and set up each rifle, made all the proper adjustments and fired each series of ten rounds. This was all completed within the proof of design agreement parameters.

RECOMMENDATIONS AND CONCLUSIONS

RECOMMENDATIONS

As the prototype was being developed, many possible design changes to the prototype became clear. The first recommendation is a need for a different method to fabrication. Before any plans can be made for further investigation of bringing the product to market, cheaper methods of construction need to be developed. Machining every individual part was very time consuming and not practical for mass production. Machining could be made possible with the use of CNC technology. More cost effective methods such as sand casting or injection molding could be used to eliminate the need to mass amounts of machine work.

As far as the design is concerned, changes need to be made so that the prototype could be used with more than the five rifles selected. These design change would include the need for more adjustment of the wire mechanism. A taller elevation devices needs to be design to cover more targets at longer ranges and the wire mechanism also needs more adjustment to accommodate this change. The base needs to be extended greater than the 23 inches designed so that rifles which use and external clip can be fitted.

CONCLUSION

The prototype designed for this senior project was tested with the five rifles selected. The prototype is a fixture for these rifles to mount to. Once the firearms were mounted, the design proved that the prototype would have the ability to rotate to the left and right at 2 degrees. The prototype also proved the ability to elevate +/- 2 degrees. This was calculated so that a paper target would be in view at 25 yards. The prototype had an alternative firing mechanism, which mounted the trigger housing, which was fired away from the rifle. This eliminated human error. The trigger pull in the design was less than 10 lbs. There was no additional friction to the system so the trigger pull for each rifle remained the same. The prototype was to weigh less than 25lbs and weight 14lbs. This weight reflects the materials selected for fabrications. The design engineer and five members of the Coshocton Gun Club, Inc completed all the testing on the prototype. All proof of design requirements were met.

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7) http://www.gunstands.com/bench.htm
8) http://www.hoppes.com/BenchRests.htm
9) http://www.nra.org

APPENDIX A

Proof of Design

Proof of Design Agreement

1) The system will be accurate within +/- 1.0 inch at 25 yards and +/- 1.5 inches at 50 yards.
   a). The will be tested at the Coshocton Gun Club, Inc.
   b). The bench rest will be mounted to a shooting table
   c). The test method will be to shoot a 10 round group at 25 yards and a 10 round group at 50 yards.
   d). At 25 yards, 90% of the fired rounds will fall within 1.0 inches of the target and at 50 yards, 80% of the rounds will fall within 1.5 inches of the target.

2) The system will be adjustable for elevation and rotation of the rifle.
   a). This will be tested at the Coshocton Gun Club, Inc.
   b). The system will elevate +/- 2.0˚ so that an entire standard target will be in the field of view at 25 yards.
   c). The system will rotate +/- 2.0˚ so that an entire standard target will be in the field of view at 25 yards.

3) The system will have an alternate firing mechanism so that all human error is eliminated in the firing process.
   a). This will be tested at the Coshocton Gun Club, Inc.
   b). The system will operate on a cable/wire system.
   c). The system will be adjustable to reduce slack in the wire.
   d). The system will be hand operated.
   e). The force of the trigger pull will be no more than 10 lbs. This will be proven with a test scale.

4). The system will be compatible and operable with the five guns chosen for testing.
   a). This will be tested at the Coshocton Gun Club, Inc.
   b). This system will work and be tested with a Ruger 10/22 Target chambered in .22 cal., a Remington Model 700 chambered in .222 cal., a Marlin 882S chambered in .22 magnum, an Anshultz Target .22 cal., and a Ruger 10/22 Standard.

5). The system will weigh less than 25lbs. This will be tested using a scale

6). The system will take less than 10 minutes to mount and set-up. This will be tested using a stopwatch.

Five additional individuals at the Coshocton Gun Club, Inc. will perform the above tasks.

______________________________ ______________________________

Dr. Thomas Boronkay Date Eric Underwood Date

APPENDIX B

Survey Instrument

Senior Design Survey

Personal Information

Name: ____

E-Mail:____

Demographic Information

Are you Male or Female (circle one)

Are you in a gun club? YES or NO

What type of shooting sports do you participate in? (If so, check all that apply)

□High-power Rifle □Pistol Shooting □Trap Shooting □Skeet Shooting

□Sporting Clays □Bowling Pin Shooting

How regularly do you participate in the shooting sports listed above? _________

Are you a hunter? ___________________ (If so, check all that apply)

□Deer Hunting □ Waterfowl Hunting □Small Game Hunting □Turkey Hunting

□Varmint Hunting

How often do you participate in the hunting types listed above? _____________

Do you reload ammunition? YES or NO

General Questions

Do you use a rifle rest of some sort to sight in a firearm? YES or NO

1-not important 10-very important (circle one)

How important is using a rifle rest for sighting in a firearm?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

____

How important is it for the rifle rest to be lightweight?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

____

How important is it for the rifle rest to be adjustable?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

____

How important is if for the rifle rest to be universal?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

____

How important is it for the rifle rest to be easy to use?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

____

What are the biggest problems you face while sighting in a firearm?

____

____

Does the weight of the trigger pull cause your firearm to move off target?

____

____

Survey

General Questions

Do you use a rifle rest of some sort to sight in a firearm? YES or NO

1-not important 10-very important (circle one)

How important is using a rifle rest for sighting in a firearm?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:____

How important is it for the rifle rest to be lightweight?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be adjustable?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is if for the rifle rest to be universal?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be easy to use?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be Reliable?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be inexpensive?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be safe?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be Portable?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be Durable?

1 2 3 4 5 6 7 8 9 10 N/A

Comments:

How important is it for the rifle rest to be of Minimal size?
1 2 3 4 5 6 7 8 9 10 N/A
Comments:____
____

What are the biggest problems you face while sighting in a firearm?
____
____

Does the weight of the trigger pull cause your firearm to move off target?
____
____

If so, does this cause you trouble when sighting in a scope?
____
____

Please list bolt action firearms used at your range.
Make: ____________________ Model: ____________________
Make: ____________________ Model: ____________________
Make: ____________________ Model: ____________________

APPENDIX C

QFD

House of Quality

	Material Property	Endurance Strength	Yield Strength	Mass Density	Cost of Materials	**Manufacturing**	Part Tolerances	Quality Control	Cost of Manufacture	**Design**	Minimal Parts	Adjustable Gun Mount	Adjustable Firing Mechanism	Importance to End User	Satisfaction to Hoppes's	Satisfaction to Outers	Future Satisfaction	Improvement Ratio	Sales Point	Improvement Ratio	Relative Weight
Cost		1	1	3	9		3	9	9		9	3	3	4	2	3	5	1.3	1.5	7.8	0.15
Reliability		3	3	1	1		9	9	1		3			3	3	3	3	1.0	1.0	3.0	0.06
Ease of Use											3	9	9	3	4	2	4	1.7	1.0	5.1	0.10
Minimal Weight				9							9			4	3	1	5	1.7	1.0	6.8	0.13

APPENDIX D

Pugh's Selection Method

Criterion	Concept 1	Concept 2	Concept 3	Concept 4
Manufacturing Cost	S	-	S	
Easy to Adjust	-	-	+	D
Does not come apart	S	S	S	
Easy to Install	-	-	-	A
Easy to Remove	S	S	S	
Easy to Produce	+	-	-	T
Reliable	S	-	S	
Minimal Parts	S	-	+	U
Universal	-	-	S	
Safe	S	-	S	M
Easy to Use	S	S	S	
Does not damage	-	-	-	
Fires rifle	S	S	S	
Sum +	1	0	2	
Sum -	4	9	3	
Sum S	8	4	8	

Criterion	Concept 1	Concept 4	Concept 3
Manufacturing Cost	S	+	
Easy to Adjust	-	-	D
Does not come apart	S	S	
Easy to Install	S	+	A
Easy to Remove	S	+	
Easy to Produce	S	+	T
Reliable	S	+	
Minimal Parts	-	-	U
Universal	S	+	
Safe	S	S	M
Easy to Use	S	S	
Does not damage	S	+	
Fires rifle	S	S	
Sum +	0	7	
Sum -	2	2	
Sum S	11	4	

APPENDIX E

Time Schedule

April	*March*	*Week 1*	*Week 2*	*Week 3*	*Week 4*

Day

APPENDIX F

Budget

Budget

Source	What	Donated	Loaned	Cost	Services
North Lab	Aluminum/Steel	X		N/A	
North Lab	Machine Tools			N/A	X
Robert Hunt	Welding			N/A	X
Robert Hunt	Painting			N/A	X
Robert Kohler	Belzona	X		$25.00	
Robert Kohler	Jigs/Fixtures		X	$15.00	
Ric Underwood	Misc. Parts	X		$50.00	
MET Design Lab	Design Software		X	N/A	X
Wal-Mart	Ammunition			$10.00	
Wal-Mart	Targets			$5.00	
Kimberly Elliott	TV/VCR Combo		X	N/A	
Kimberly Elliott	Video Recorder		X	N/A	

***Total Budget Cost: $105.00**

Source	What	Donated	Loaned	Cost	Services
McMaster Carr	Aluminum/Steel			$74.95	
North Lab	Machine Tools	X		N/A	X
North Lab	Welding	X		N/A	X
Robert Hunt	Painting	X		N/A	X
Robert Kohler	Belzona	X		N/A	
Robert Kohler	Jigs/Fixtures	X		N/A	
Auer Hardware	Misc. Parts	X		$25.00	
MET Design Lab	Design Software		X	N/A	X
Wal-Mart	Ammunition	X		N/A	
Wal-Mart	Targets	X		N/A	
OCAS	TV/VCR Combo		X	N/A	
Kimberly Elliott	Video Recorder		X	N/A	

***Total Actual Cost: $99.95**

APPENDIX G

Mechanical Drawings

* See Drawing Files for part drawings

APPENDIX H

Bill of Materials

	RIFLE PROGRAM PARTS LIST				
	DOCUMENTING THE DESIGN				
Qty/ Rest	Part Description	Part Number	Source	Design	Engineer
1	Tekro Adjustable Lever	N/A	Harris Cyclery	ELU	Underwood
1	QBP Stainless brake cable	N/A	Harris Cyclery	ELU	Underwood
1	In-Line Cable Adjuster	N/A	Harris Cyclery	ELU	Underwood
1	Fully Threaded Stud	91565A732	McMaster -Carr	ELU	Underwood
3FT	Aluminum Rectangular Bar	8975K217	McMaster -Carr	ELU	Underwood
1FT	Aluminum Rods	6750K16	McMaster -Carr	ELU	Underwood
6FT	Aluminum Square Tubing	6546K11	McMaster -Carr	ELU	Underwood
8	Braces	17715A55	McMaster -Carr	ELU	Underwood
100	Machine Screws	91771A825	McMaster -Carr	ELU	Underwood
2	Thumb Screws	90200A110	McMaster -Carr	ELU	Underwood

APPENDIX I

Calculations

Sample Calculations

Stock Beam:
Force = 20lb
Dynamic Conditions = 40lb
Factor of Safety = 3
Impact Force = 40lb x 3 = 120lb

Moment of inertia
$I = 1/12\ (1.0)(1.0)^3 – 1/12(.87)(.87)^3$
$= .0833 - .04774$
$= .03556\ in^4$

$c = ½\ (1.0) = 0.5”$

$\sigma = Mc/I$
$= (120)(4)(.5)/(.03556)$
$= 6749.16$ psi

Forearm Pivot Point
“double shear”

$F = ½\ P= 60lb$

$A = ¼\ \pi\ d^2$
$= (.25)(3.1415)(.25^2)$
$= .04908\ in^2$

$\tau = F/A$
$= 60/.\ 04908$
$= 1222.35$ psi

Pivot Point
“single shear”

Diameter = 0.5”
Force = 120lb
$A = ¼\ \pi\ d^2$
$= (.25)(3.1415)(.5^2)$
$= 0.19634$

$\tau = F/A$
$= (60)/(0.19634)$
$= 620.48$ psi

Bearing Stress
P = 120 lb
t = 0.5”
d = 0.5”
$\tau = (120)/(.5)(.5)$
$= 480$ psi

Butt stock Pivot Point
“double shear”
F = ½ P= 60lb

$A = \frac{1}{4} \pi d^2$
$= (.25)(3.1415)(.25^2)$
$= .04908 \text{ in}^2$

$\tau = F/A$
$= 60/.04908$
$= 1222.35$ psi

Forearm Stock Mount
Force = 20lb
Dynamic Conditions = 40lb
Factor of Safety = 3
Impact Force = 40lb x 3 = 120lb

$I = 1/12\, bh^3$
$I = 1/12\, (1.0)(1.0)^3$
$= 0.0833$

$\sigma = Mc/I$
$= (120)(6)(.5)/(.0833)$
$= 4321.72$ psi

Threaded Elevation Bar

τ = 4(shearing force)/3(cross sectional area)
$= 4(120)/3(.25)(3.1415)(.5^2)$
$= 814.94$ psi

$\sigma = My/I$
$= (120)(1)(.25)/\ \frac{1}{4}\ (3.1415)(.25^4)$
$= 9803.92$ psi

Clamping Force

$M = F \times d$
$= 120 \times 6$
$= 720$ in-lb

$Ff = M/r$
$= 720/(0.5)$
$= 1440$ lb

$N = Ff/\mu$
$= 1440 / 0.61$ Marks Standards
$= 2360.65$ lb

$Fc = N/4$
$= 2360.65 / 4$
$= 591.16$ lb

$A_{contact} = p \times L \times \pi\,(r_1^2 - r_2^2)/\cos 30$
$= 28(0.938)(3.1415)(.12125^2 - 0.11^2)/\cos 30$
$= 0.24786\ \text{in}^2$

$\sigma = Fc / A_{contact}$
$= 590.46 / .24786$
$= 2381.03$ psi

Stresses in Threads

$d = r_1 - r_2$
$= .12125 - .110$
$= .01125$ in

$f = .125/p$
$= .125/28$
$= .004464$ in

$h = 2(d \times \tan 30) + f$
$= 2(.01125 \times \tan 30) + .004464$
$= 0.017455$ in

$A = \pi \times d \times h$
$= (3.1415)(.2425)(.017455)$
$= .0133\ \text{in}^2$

$A = A \times p \times L$
$= (.0133)(28)(.938)$
$= .34925\ \text{in}^2$

$\tau = (1/0.577) \times F/A$
$= (1/0.577) \times (590.16)/(.34925) = 2928.41$ psi

APPENDIX J

Manufacturers Specifications

Cable Hardware

NEW! Barrel Adjuster Conversion Kit $3.95 Each

This unit is intended to fit into a top-tube cable stop and provides a fingertip adjustment for your rear brake. This is very desirable on drop-bar conversions of bicycles originally built for upright bars (upright-bar brake levers usually incorporate a barrel adjuster, while drop-bar levers do not.)

In-Line Cable Adjusters $9.95/pair

Cut your cable housing anywhere and install a barrel adjuster wherever you find it convenient.

Cables

QBP Stainless Slick ® premium inner cables $3.95 each

These are very high-quality rust-proof cables. The cables are die-drawn to smooth out their surface for reduced friction. Double-ended, for road or mountain levers.

QBP Stainless Slick ® premium inner tandem cables $4.95 each

As above, but in tandem length.

QBP Stainless Slick ® premium brake cable sets $17.95

Everything you need including: Front & rear stainless, die-drawn cables; 4 ferrules; cable donuts; Teflon ® lined housing (black.)

Shimano or Quality Lined Brake Housing $.75/foot

None better! We stock Black, Blue, Red, Yellow, & White

Brake Levers for Upright Bars

Levers shown here include cable adjusting barrels and reach adjusters that allow the rest position to be adjusted so that even riders with short fingers will be able to reach them.

They require "barrel" type cable ends.

Ritchey WCS $29.95

These are top-of-the-line forged units, made by DiaCompe. Black with gold levers, 180 grams.

They match the Ritchey Cantilevers , but work with any center-pull cantilevers or any caliper brakes.

Tektro Adjustable Levers $19.95

These have an adjustment for mechanical advantage, so they work with _all_ types of brakes, including direct-pull ("V-type"), center-pull cantilevers, all types of calipers and drum brakes.

APPENDIX K

Accuracy Results

APPENDIX L

Conceptual Designs

APPENDIX M

Free Body Diagrams