

The AutoSpot

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Thank you, Mr. Benton

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## Project Management

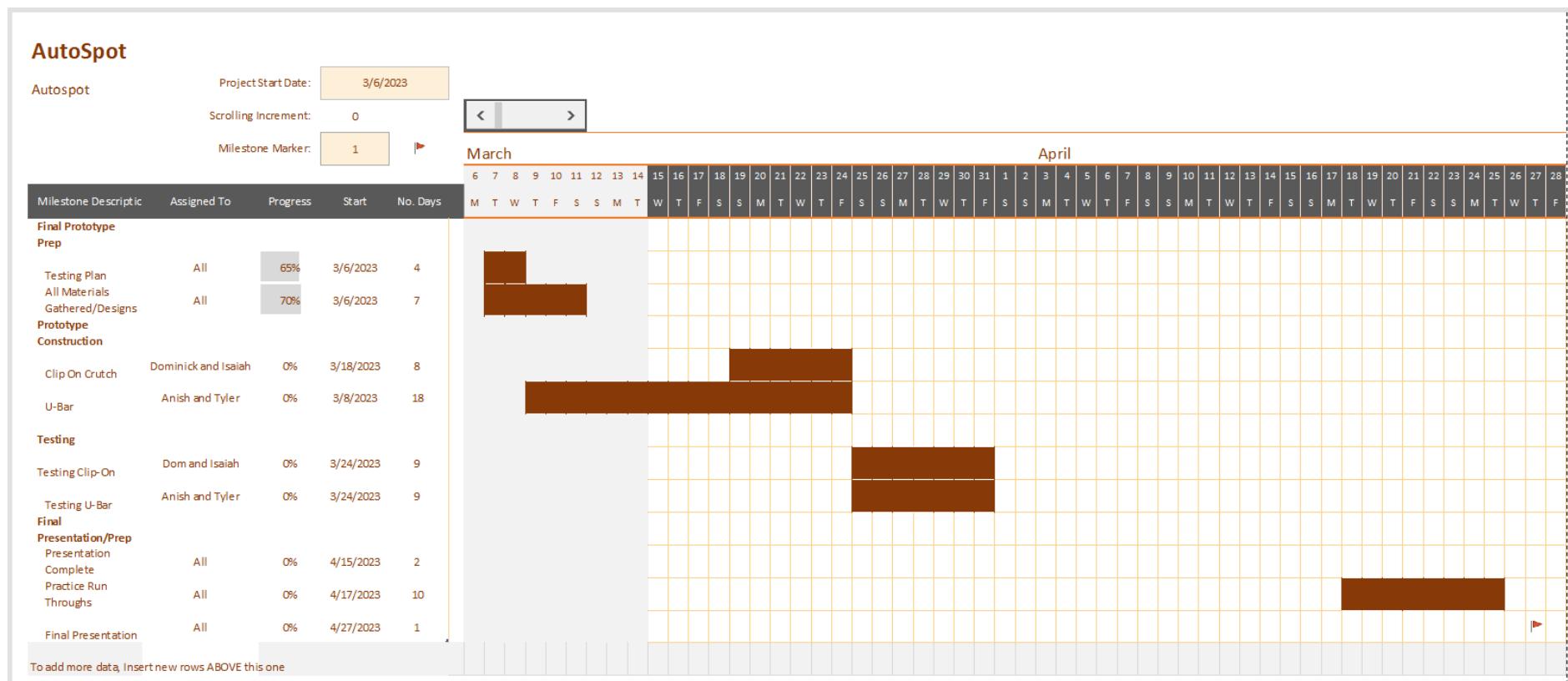


Figure 1: Gantt Chart that was used for Phase 3

### **Problem Statement & Statement of Purpose**

Since COVID broke out in 2020, the fitness industry has seen an increase people who workout at home gyms. According to Greg Carson, Store Manager for Lynx Barbell, over 75% of his customers in 2021 have their own home gym compared to only 35% in 2018. However, People who workout at home can't spot themselves when they barbell bench press ("to spot" someone is having someone or something assist the lift when the lifter fails a rep or needs help racking and unracking the weight). This is a problem in home gyms across America, according to various studies from BMJ Journal, The National Library of Medicine, and Legal Match, over 6000 people get injured by being crushed by bench press yearly. According to Dale Sapecky, Store Manager for Premier Fitness Source and former Bodybuilding Champion, this problem affects home gym goers and even commercial gym goers of all experience levels. We hope that our solution will enhance the gym experience for Americans and further encourage physical activity.

To solve our problem we brainstormed dozens of different possible solutions. Our initial ideas ranges being reasonable like a pulley system to outlandish like a cage that releases a gorilla who lift up the barbell. We then narrowed it down to 4 potential designs to prototype.

## PHASE 1: Problem Justification

### Research

#### Artifact 1

Kyle Thomson, 22, died Monday after a barbell he was lifting slipped from his hands and fell on his neck at Elite Edge Transformation Center.

He was bench pressing 315 pounds at the time.

Norvell, K., & Langman, M. (2016, December 6). Man bench pressing 315 pounds dies after barbell slips. Des Moines Register; USA Today.

<https://www.usatoday.com/story/news/nation-now/2016/12/30/student-dies-weightlifting-accident/95992420/>

#### Artifact 2

The literature search identified 20 case reports, 7 case series, prospective cohort, and meta-analysis. Most case reports/series reported pectoralis major ruptures caused by bench pressing (table 2). The meta-analysis showed that the 57-bench press is the most common activity leading to pectoralis major ruptures. Furthermore, four cases of triceps tendon ruptures were identified, of which three had been using oral anabolic steroids and had reported preceding chronic elbow pain before the rupture. Therefore, two of them had received local steroid injections as treatment for triceps tendinopathy some weeks before the 47 ruptures. One case of weightlifter's shoulder Cia, osteolysis of the distal clavicle)— and five cases of 48 bench presser's shoulder Cia, insertional tendinopathy of the pectoralis minor muscle), — as well as posterior— and anterior shoulder dislocations— have been described. In addition, various fractures have been reported because of the bench press: one case report described a 31 patient who had suffered a clavicle fracture while performing the bench press ballistically— and another described a lifter who had suffered a scaphoid fracture when the barbell slipped out of his 45 43 hands. — Also, a second rib fracture— and a Salter-Harris type I fracture of the distal radius have been reported.

Bengtsson, V., Berglund, L., & Aasa, U. (2018). Narrative review of injuries in powerlifting with special reference to their association to the squat, bench press and deadlift. *BMJ Open Sport & Exercise Medicine*, 4(1), e000382. <https://doi.org/10.1136/bmjsem-2018-000382>

### **Artifact 3**

During a four month span in that deployment, Drs. Salazar and Choate treated nine male patients (four Army, five Air Force) for pectoralis major tears. All were injured while doing bench press weight training. At the time of injury, the weight on the bench press bar ranged from 135 pounds to 415 pounds, with an average of 258 pounds. The servicemen ranged in age from 23 to 52, with an average age of 32. Three were officers and six were enlisted

Loyola University Health System. (2018, March 22). Military surgeons report “alarming frequency” of bench press injuries. *ScienceDaily*.

<https://www.sciencedaily.com/releases/2018/03/180322124948.htm>

### **Artifact 4**

Summary/conclusions The risk of injury in both sports were similar to other non-contact sports also requiring strength/power, but low compared to contact sports. The severity of injuries differed in the included studies. Since little has been studied regarding possible risk factors to injuries, further research is therefore warranted to explain why athletes get injured and how to prevent injuries

Aasa, U., Svartholm, I., Andersson, F., & Berglund, L. (2016). Injuries among weightlifters and powerlifters: a systematic review. *British Journal of Sports Medicine*, 51(4), 211–219. <https://doi.org/10.1136/bjsports-2016-096037>

### **Artifact 5**

ProSpot Fitness@, Inc. is changing the way men and women lift weights. Based on patented and patent-pending technology, ProSpot Fitness has developed 'spot' less weight training systems that allow users to lift weights without using spotters. Called Grab & Go technology,

it utilizes computerized touch sensors and a quadruple cabling system that allows a lifter to release a barbell or dumbbells from any position and lock them instantly at the point of release.

Pro Spot Fitness – Health & Diet News. (n.d.). Retrieved September 12, 2022, from <https://www.prospotfitness.com/>

#### **Artifact 6**

lawsuits against fitness centers and personal trainers have resulted from these injuries. For instance, in 1993, a lawsuit of the case Cabay vs. Leontini in Ohio where the plaintiff was involved in a power-lifting competition. While lifting 275 pounds during the warmup routine for the contest, the weightlifter was injured when the bar struck him in the head due to insufficient stability of the weight bench. As a result, the plaintiff suffered severe and devastating head injuries [6]. Though the plaintiff signed a participation release form before entering the competition, there should have been a spotter there to assist him while he performed his warm-up routine. A spotter would have helped if the bench were unstable. If the weightlifter would have had an appropriate spotter, whether it was human or mechanical, this incident could have been avoided.

Cole, J., Hutchins, A., Byrd, T., & Dobbs, J. (2022). ABPS: Automatic Bench Press Spotter. Google.com.

[https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi326SHh476AhWQMEQIHei2CNsQFnoECA4QAw&url=https%3A%2F%2Fciteseerx.ist.psu.edu%2Fviewdoc%2Fdownload%3Fdoi%3D10.1.1.621.6945%26rep%3Drep1%26type%3Dpdf&usg=AOvVaw2zKgGaqN7TP0a-6x6WoM\\_6](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi326SHh476AhWQMEQIHei2CNsQFnoECA4QAw&url=https%3A%2F%2Fciteseerx.ist.psu.edu%2Fviewdoc%2Fdownload%3Fdoi%3D10.1.1.621.6945%26rep%3Drep1%26type%3Dpdf&usg=AOvVaw2zKgGaqN7TP0a-6x6WoM_6)

#### **Artifact 7**

Because the bench press can potentially kill you, it's highly recommended that you perform the bench press with a spotter. (Here's how to spot someone on the bench press). If you fail a lift, they can quickly assist in getting the barbell off your body.

Brett & Kate McKay. (2020, August 20). The 4 Rules of Bench Pressing Without a Spotter. The Art of Manliness.

<https://www.artofmanliness.com/health-fitness/fitness/the-4-rules-of-bench-pressing-without-a-spotter/>

### **Artifact 8**

#### THE DO'S OF SPOTTING THE BENCH PRESS

- Do use an over/under grip when spotting. This ensures that the bar won't slip out of your hands should you need to pull it off
- Do guide the bar out of the rack if the lifter requests a lift-off
- Do keep a strong flat back and assume a ready stance. You don't want to strain your lower back should you suddenly need to offer a large amount of assistance.
- Do keep your hands close to the bar if that makes the lifter feel more comfortable.
- Do offer assistance if the bar comes to a complete stop and starts going back down
- When offering assistance, do guide them past the sticking point while allowing them to do the majority of the work.
- Do use up to three spotters if the person is lifting more weight than one person can spot

Persons two and three should be at either end of the bar.

#### THE DON'TS OF SPOTTING THE BENCH PRESS

- Don't put your crotch right in the face of someone bench pressing. You're there to help, not to T-bag them. Nobody wants a whiff of rotten crotch as they're trying to press heavy weight either.

- Don't yank the bar off the rack on the lift-off then let go suddenly. This is jarring and causes the lifter to lose tightness in the back.
- Don't offer assistance before the bar comes to a complete stop and starts traveling back down.

Nobody likes a spotter who gets overzealous at the first sign of difficulty

- Don't yell 'You got this'" if the bar has come to a dead-stop on the person's chest and they start flailing their legs.
- Don't stand so far away from the lifter that you can't actually assist if you're needed

Kuster, T. J., & Nation, T. K., T. (2018, October 2). Tip: How to REALLY Spot the Bench Press. T NATION. <https://www.t-nation.com/training/tip-how-to-really-spot-the-bench-press/>

### **Artifact 9**

Having a spotter on the Bench Press is critical. You balance weight over your chest, neck and head. A failed rep with no spot can result in hundreds of pounds crashing down on the most sensitive parts of your body with catastrophic consequences. Luckily, having a spotter allows you to lift heavy weight and push yourself with the assurance that you can do so with minimal risk of injury.

Haley, A. (2015, February 23). How to Provide a Spot for the Bench Press. Stack. <https://www.stack.com/a/bench-press-spot/>

### **Artifact 10**

Lifters who push themselves in the gym know better. To them, knowing when to ask for a spot—and knowing how to spot someone when they ask—is like wearing a seat belt. It doesn't seem like that big of a deal until you really need it. And if you keep training long enough, you'll have a few stories about someone who needed it.

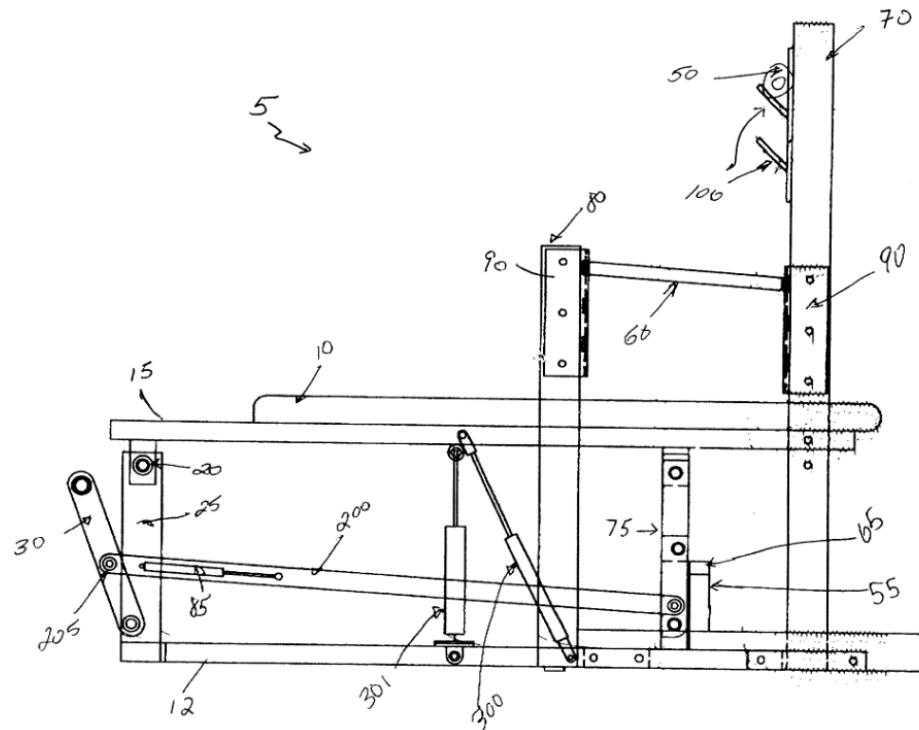
Eastman, H. (2021, April 15). Spotting 101: How to Spot the Bench, Squat, and Dumbbell Press. Bodybuilding.com.

<https://www.bodybuilding.com/fun/spotting-101-how-to-spot-the-bench-squat-and-dumbbell-press.html>



## Previous Solutions

### US6689027B1

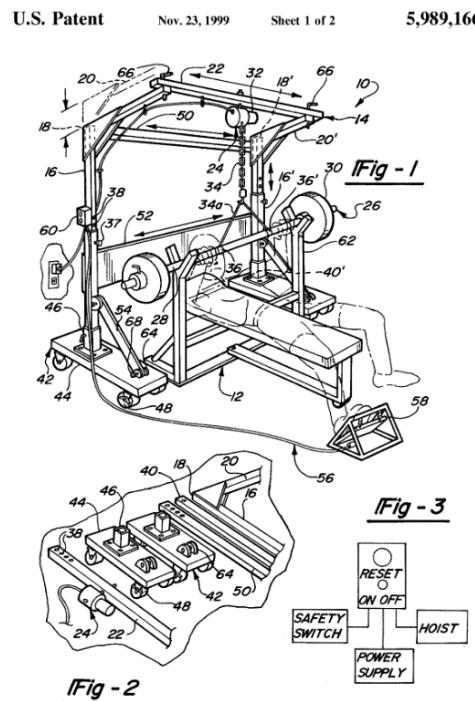


1. Uses a pedal and mechanical knuckle to shoot up support pads to hold the weight and leave a gap between the user and the barbell.
2. Heavily reliant on user's reaction time to press the pedal, if failed the support pads do not engage and the user is still crushed
3. If incorrectly timed, the support pads can rip out arms out with their immense amount of force from their tension if engaged when the barbell is down.

Gardikis, D. (2004). US6689027B1 - automatic spotting weight bench.

Google Patents. Retrieved September 8, 2022, from

<https://patents.google.com/patent/US6689027B1/en>

**US5989166A**

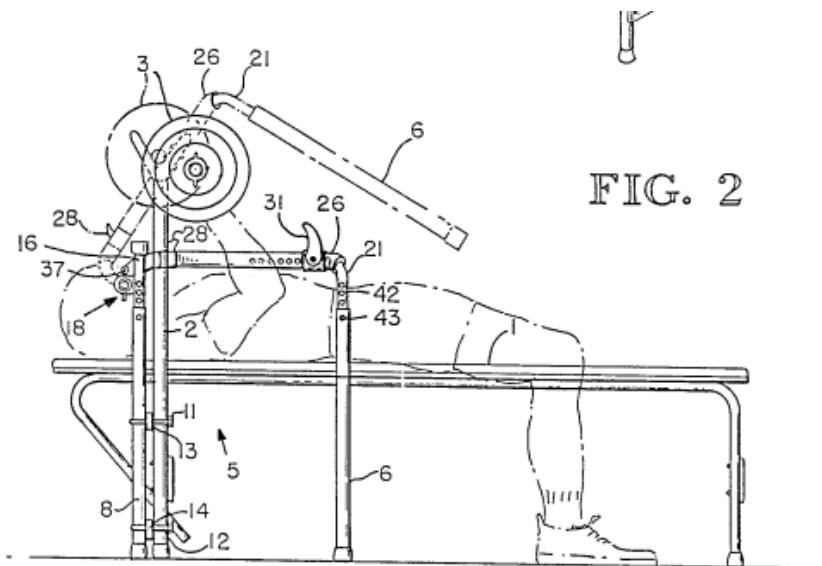
1. Requires that the bar be perfectly balanced with the chain in the center in order to function properly. If not, the barbell could swing around and cause other injuries.
2. The mechanism uses a pedal to engage. This takes away the lifter's ability to use leg drive, an important form technique when bench pressing.
3. It is reliant on the user's reaction time. If the barbell is dropped, the lifter has less than a second to react before the barbell falls on them.

Capizzo, K., & Capizzo, F. (1997). US5989166A - adjustable barbell

press apparatus. Google Patents. Retrieved September 8, 2022,

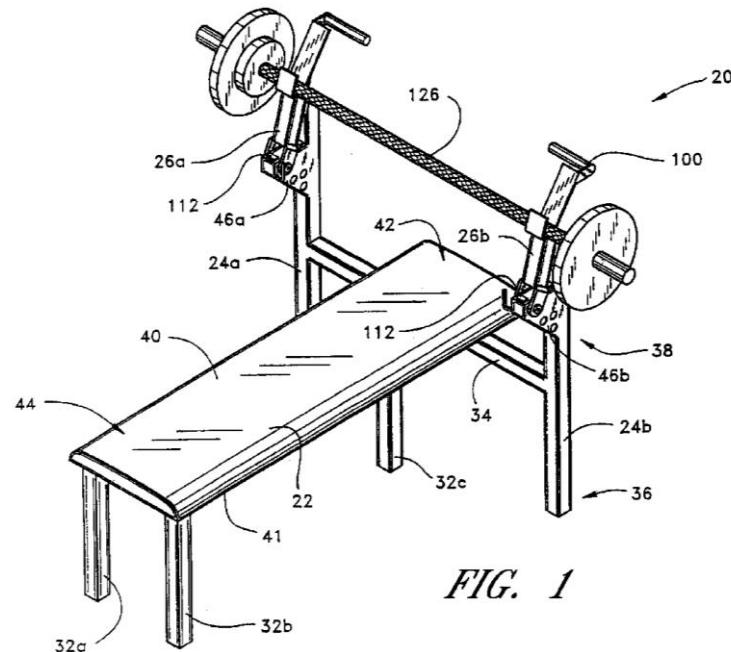
from

<https://patents.google.com/patent/US5989166A/en?oq=US5989166A>

**US4757998A****FIG. 2**

1. This device does not allow for the full range of motion. Part of creating an auto-spotter is allowing for full range of motion because things like safety bars already exist, but those things limit movement.
2. Along with making it so the barbell cannot come all the way down to the chest, it makes it so it must be moved in a specific curved motion.

Landin, M. G. (1987). US4757998A - safety device for a weight-training bench. Google Patents. Retrieved September 8, 2022, from  
<https://patents.google.com/patent/US4757998A/en?oq=US4757998A>

**US6447433B1***FIG. 1*

1. This design does not play the whole role of a spotter, protecting against both drops and failed reps as injuries are possible both ways.
2. This design only fixes the problem of an awkward liftoff from the rack. Normally the rack would be placed behind the lifters head which would cause problems with an imperfect liftoff.

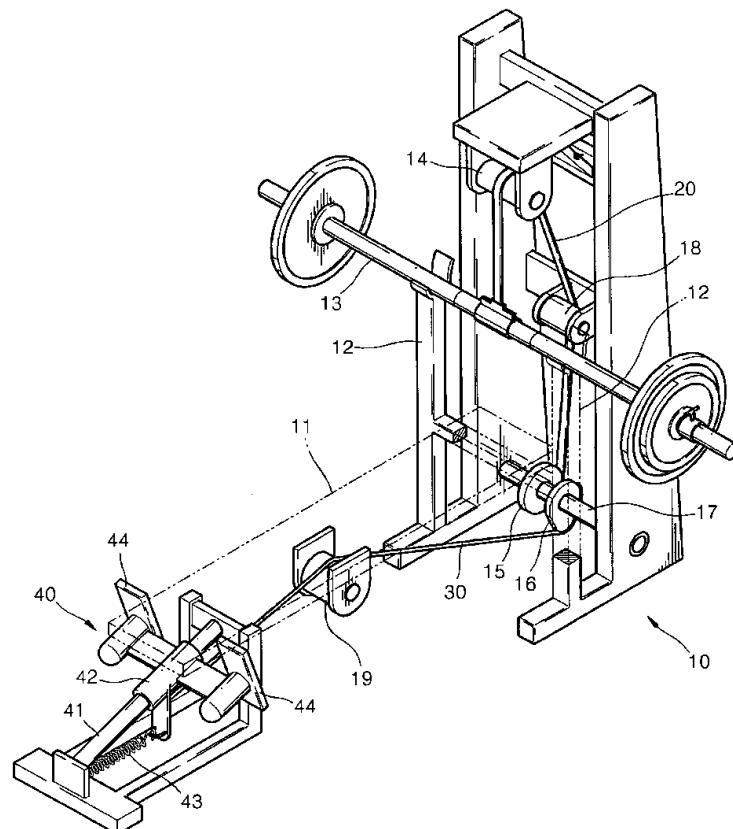
Reyes, G. (n.d.). Weight-bar support structure with retractable arms.

Retrieved September 11, 2022, from

<https://patents.google.com/patent/US6447433>

**US20060148624A1**

Fig. 01

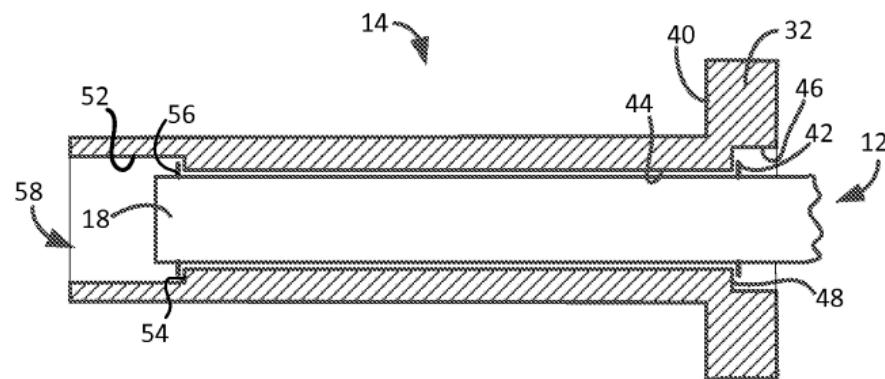


1. This design requires the use of the feet while bench pressing.

The positioning removes the use of leg drive, an important form technique for bench pressing. Also it could pose a potential distraction and draw away focus during the exercise.

Bae, S.-W. (n.d.). Bench press. Retrieved September 11, 2022, from

<https://patents.google.com/patent/US20060148624A1/en>

**CN202951170U**

1. Merely a way to split the barbell for storage. It is held together by pins and holes which could pose a strength issue if placed incorrectly.
2. It doesn't actually come apart during the exercise so it doesn't solve the problem.

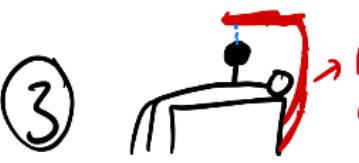
Google. (n.d.). CN202951170U - split type Barbell Rod. Google Patents. Retrieved November 1, 2022, from

<https://patents.google.com/patent/CN202951170U/en>

## PHASE 2: Developing Solution

## Brainstorming and Preliminary Sketches

# Brainstorming Sketches

- ① Have a running calculator that calculates required weight that is required to pull bar up
- ②  support bars right above chest to hold
- ③  rope system attached to bench
- ④  button on bar that when individual clicks all weight on bar falls off and bar is easily lifted
- ⑤  button on bar that when pressed, the bar splits in half and the lifter lets it fall to floor
- ⑥  out of bench stand, bars shoot out and catch bar on ends then raise them to appropriate back height
- ⑦  gyroscopic balancer that moves with bar until failure
- ⑧  light mesh that hardens/tightens when lifter starts to fail lift
- ⑨  two blocks with bar shaped holes shoot in & hold bar. works by tracking bar then locking in new re-tracking
- ⑩  electro magnet rail pulls bar into two allowing for user to get out easily
- ⑪  bench pushes itself upright & bar can be dropped on floor safely

... will have indicate with

Figure 2: This is 11 of our initial brainstorming ideas, each with a little image to the right to visualize what each possible solution could look like. These ideas are very simple to allow us to add on to them.

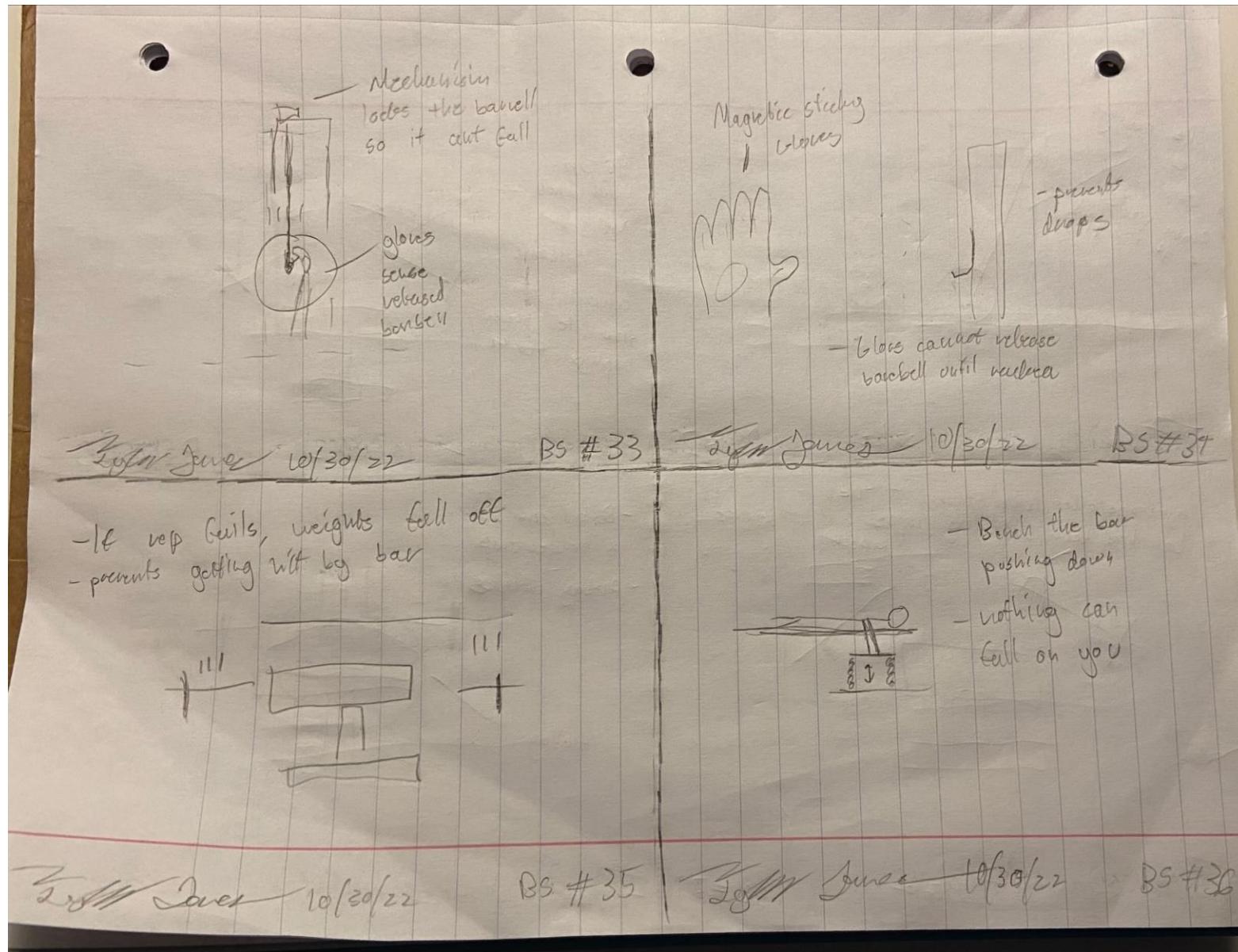


Figure 3: Above are 4 brainstorming sketches from our second round of brainstorming. They involve both solutions that involve modifying the equipment, and having add-ons to solve the problem.

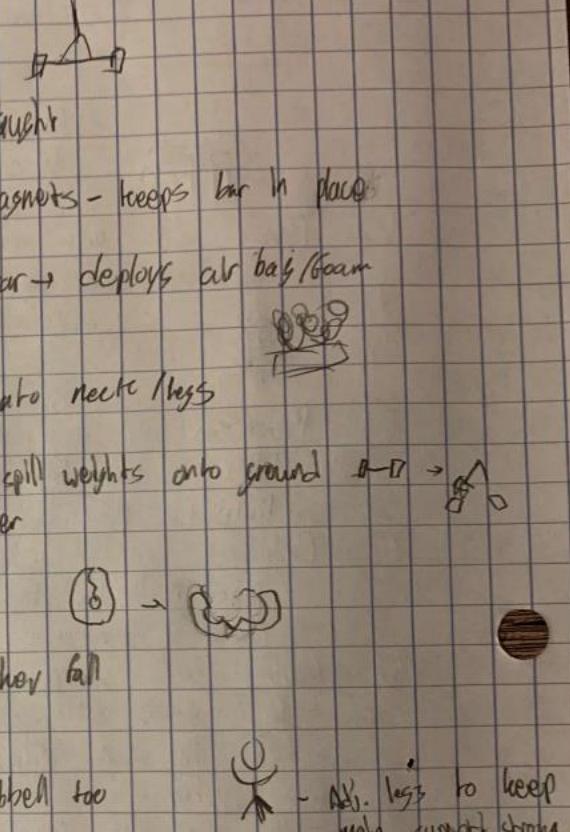
- (11) Panic button  
 - Pressing button on bar will make it stop  
 - Could be applied to any current method  
 - Faster instead of foot press
- (12) Panic Button - bench drop  
 - Pressing button lowers bench
- (13) Panic Button - wrench system  
 - Pressing button makes wrench go taught
- (14) Panic button - Magnet  
 - Pressing panic button activates magnets - keeps bar in place
- (15) Panic button - air bag - bar  
 - Pressing button sends signal to bar → deploys air bag/boom
- (16) Panic button - air bag - vest  
 - Pressing button will deploy vest -  
 - U shaped to prevent bar rolling onto neck/legs
- (17) Collapsible rod  
 - Triggering rod to unfold in middle + spill weights onto ground →   
 = Sensor, button, etc. could trigger
- (18) Detachable weights  
 - Button triggers weights to uncollapse  
 - Falls off → let bar itself retrack  
 - Basket to catch weights when they fall
- (19) Weight catchers  
 - U shaped supports cut sider bar  
 - Could be set up to help w/ climbber too
- (20) Weight catchers - detachable  
 - If weights hit catch w/ enough force → sensor will cause weights to split like in 18  
 - Re-track bar + doesn't require bar add ons - design new weight sys.
- 

Figure 4: These are 10 ideas from the first round of brainstorming. They are all simple ideas, some with little sketches to help visualize the possible solution.

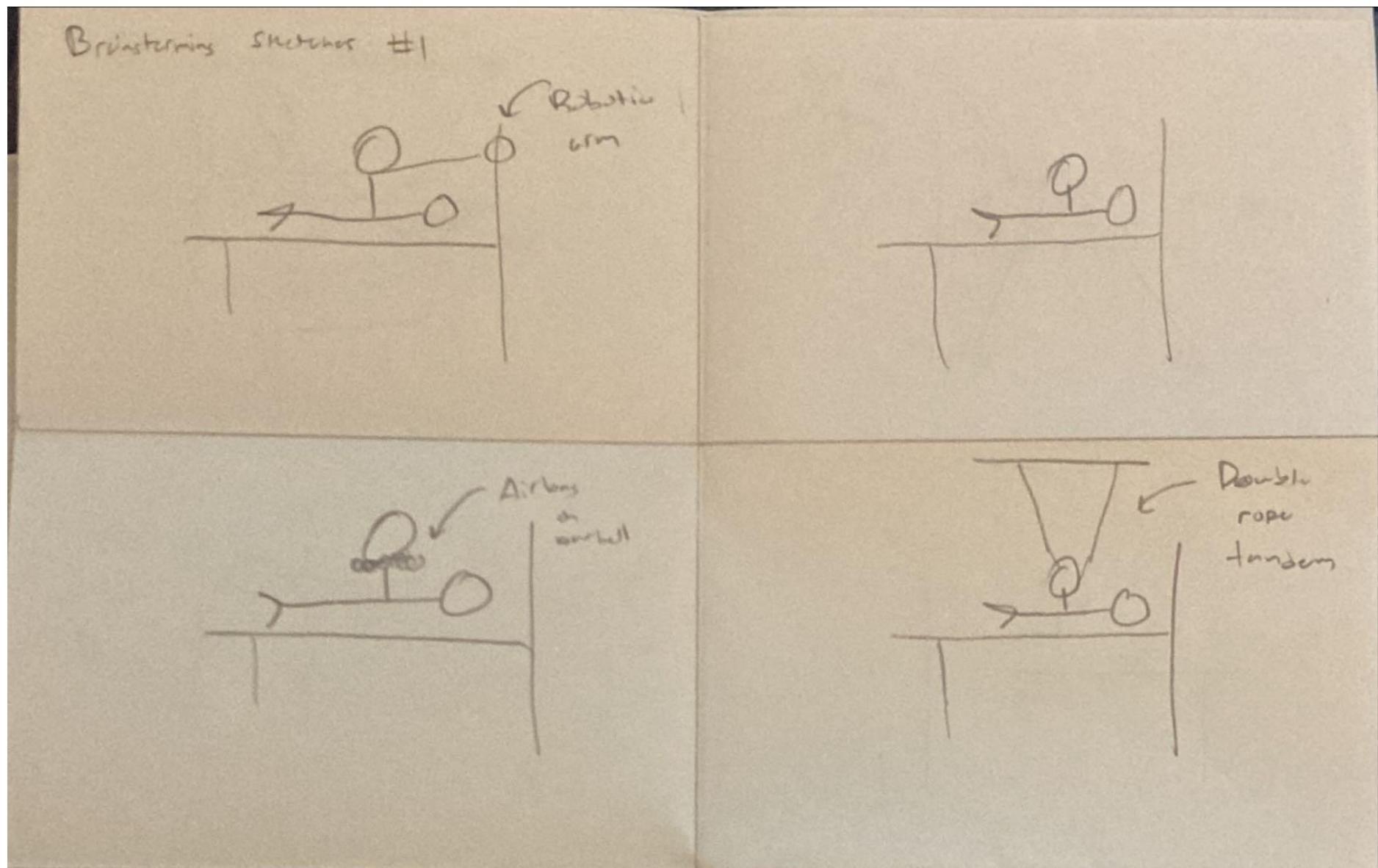
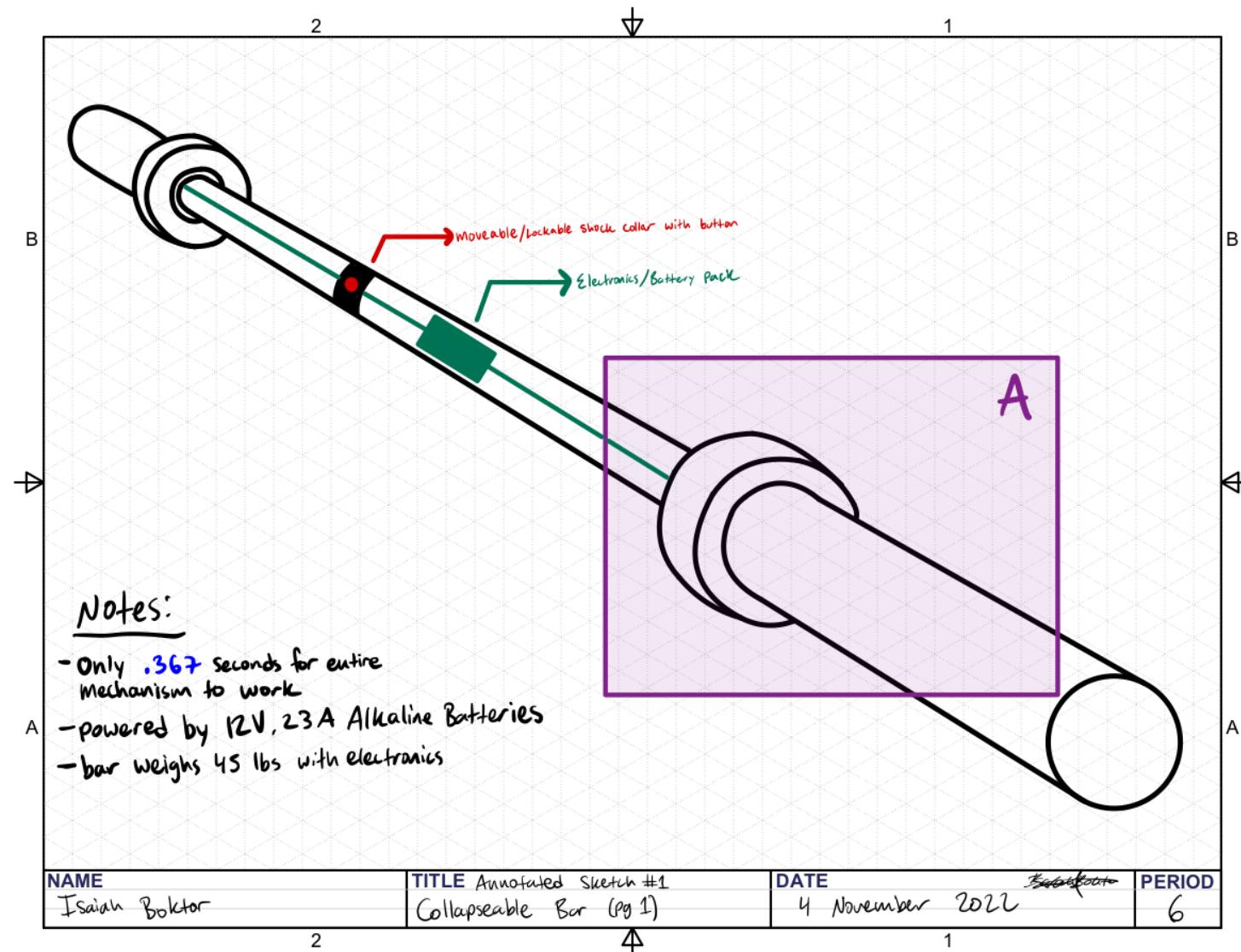
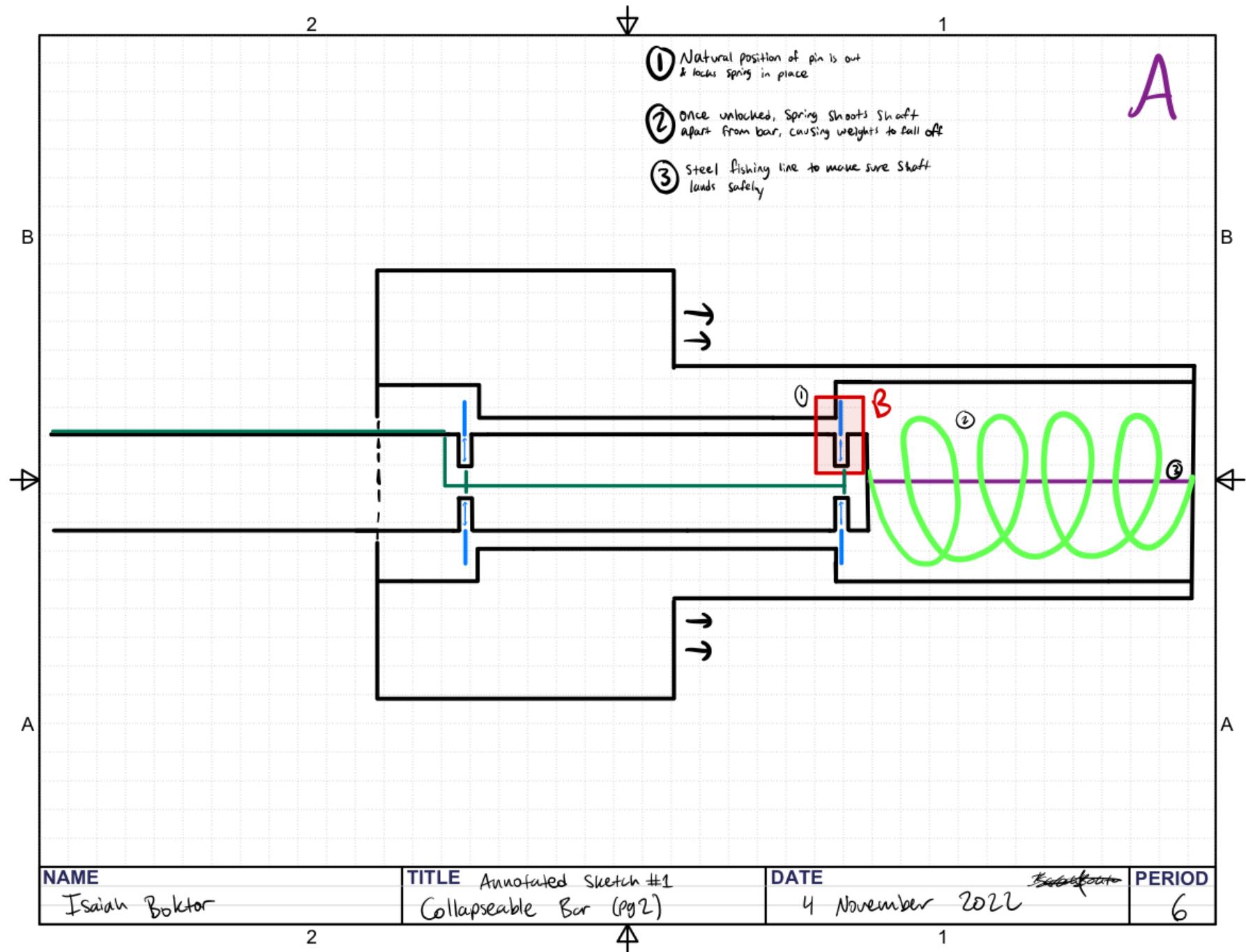


Figure 5: This is an image of another 4 brainstorming sketches. Each of these involves modifying the bench press rack or bar.

## Annotated Sketches

## Collapsible Bar





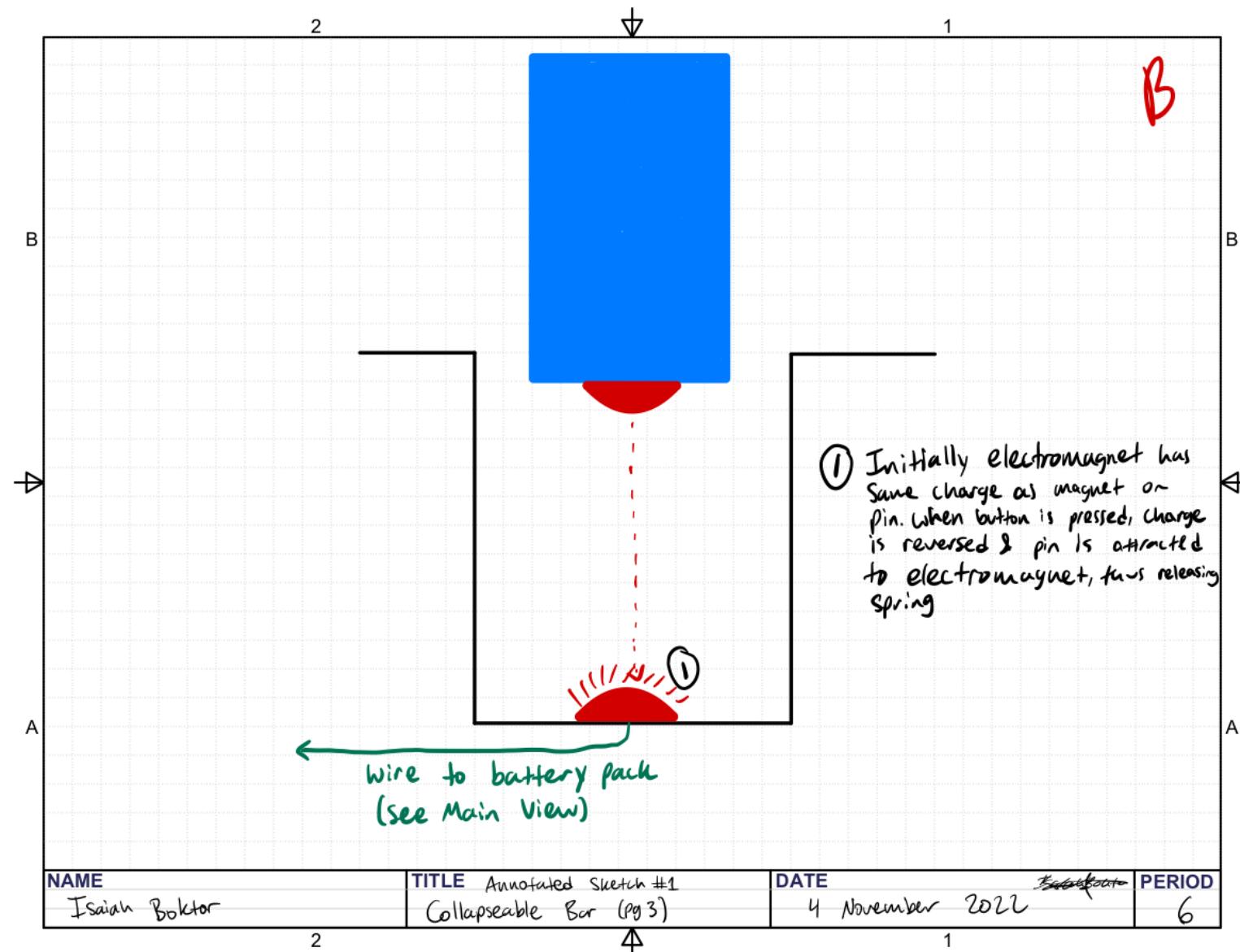
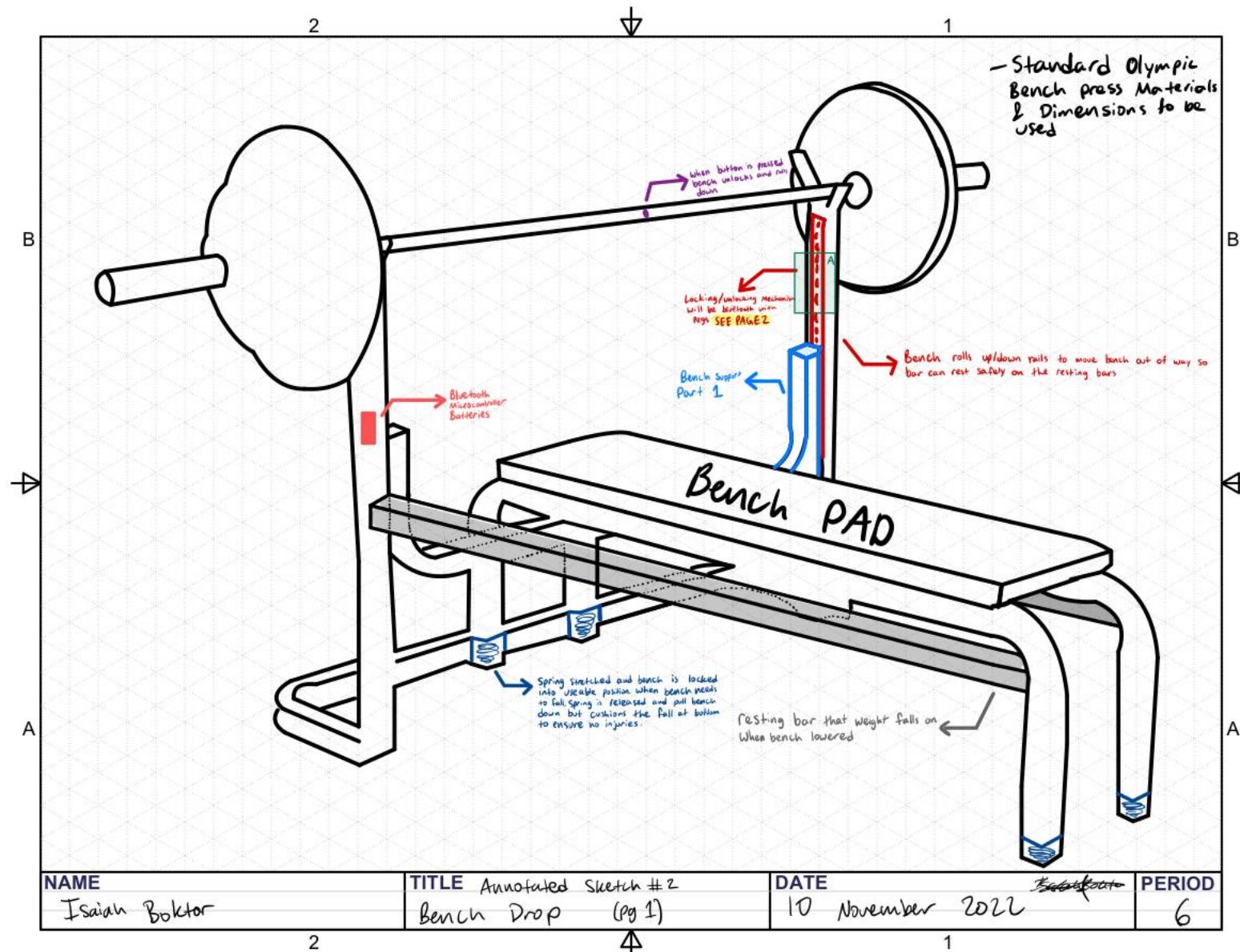


Figure 6: These sketches detail out collapsible bar design. The Idea is based around having the sides of the bar with the weights fall off to remove the danger of heavy weights. I includes 2 addition views for detail.

## Bench Drop



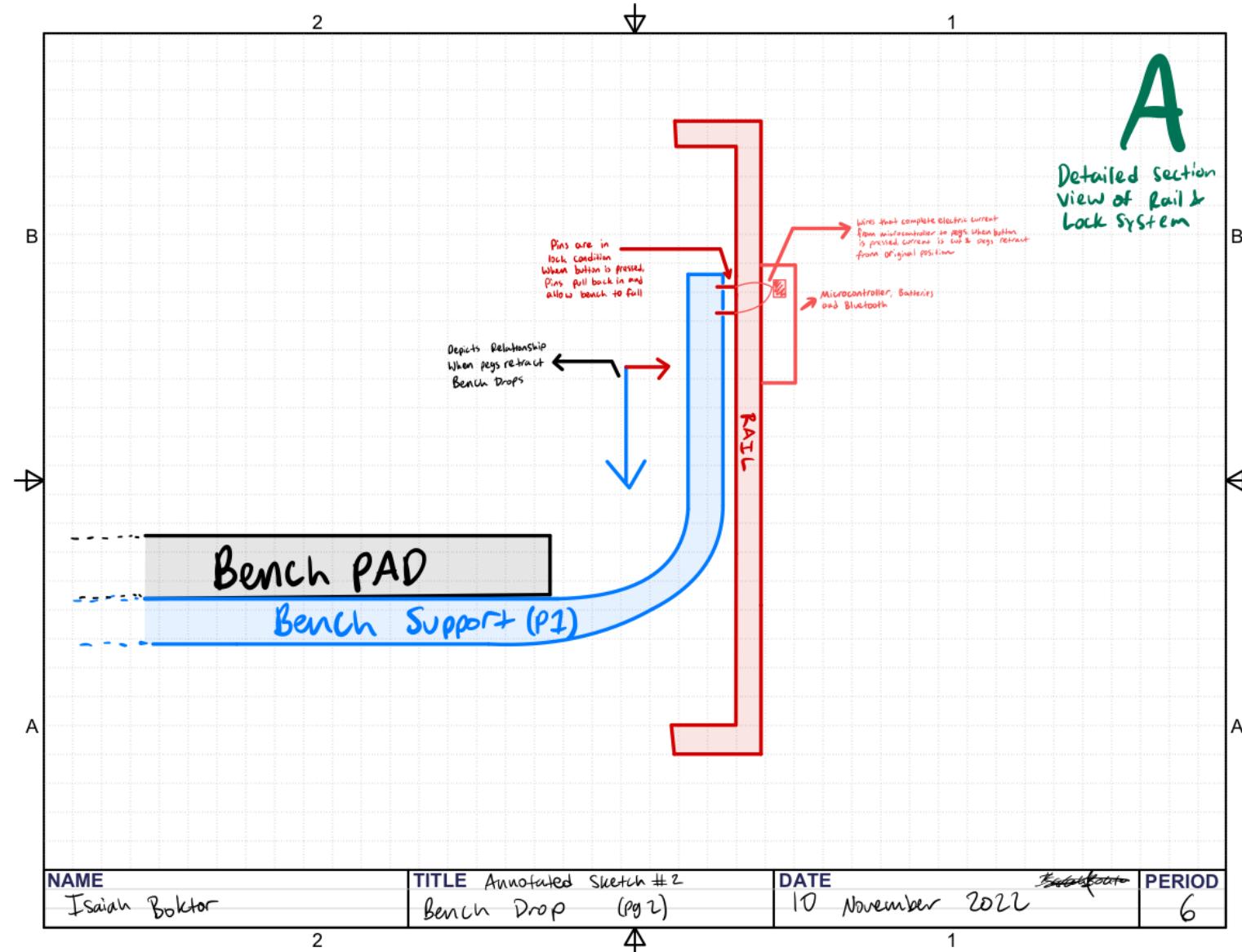
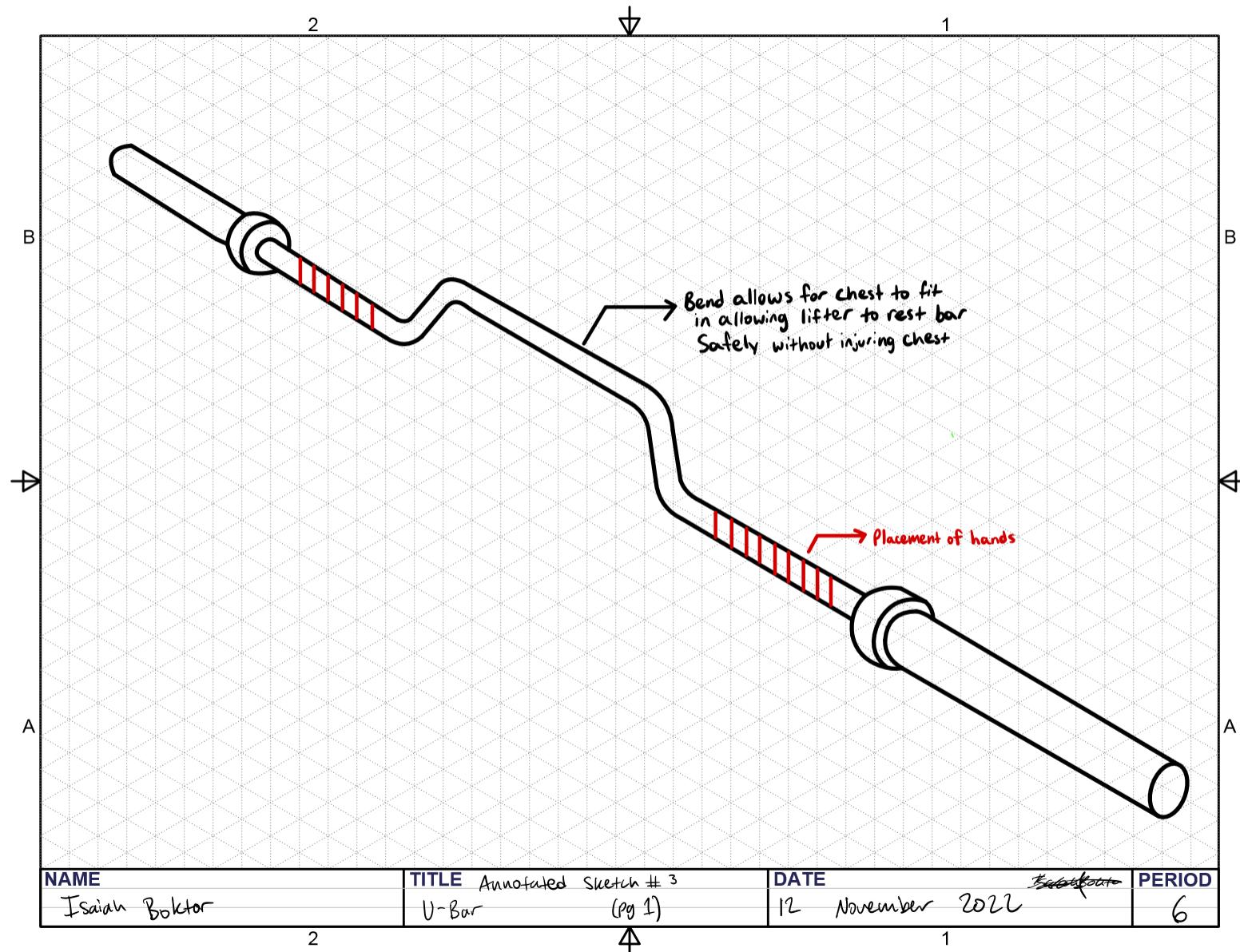


Figure 7: These are the annotated sketches for the Bench drop Idea. It is intended for the bench to fall below safety bars which the bar falls on to protect the lifter. A close up view is included

**U-Bar**

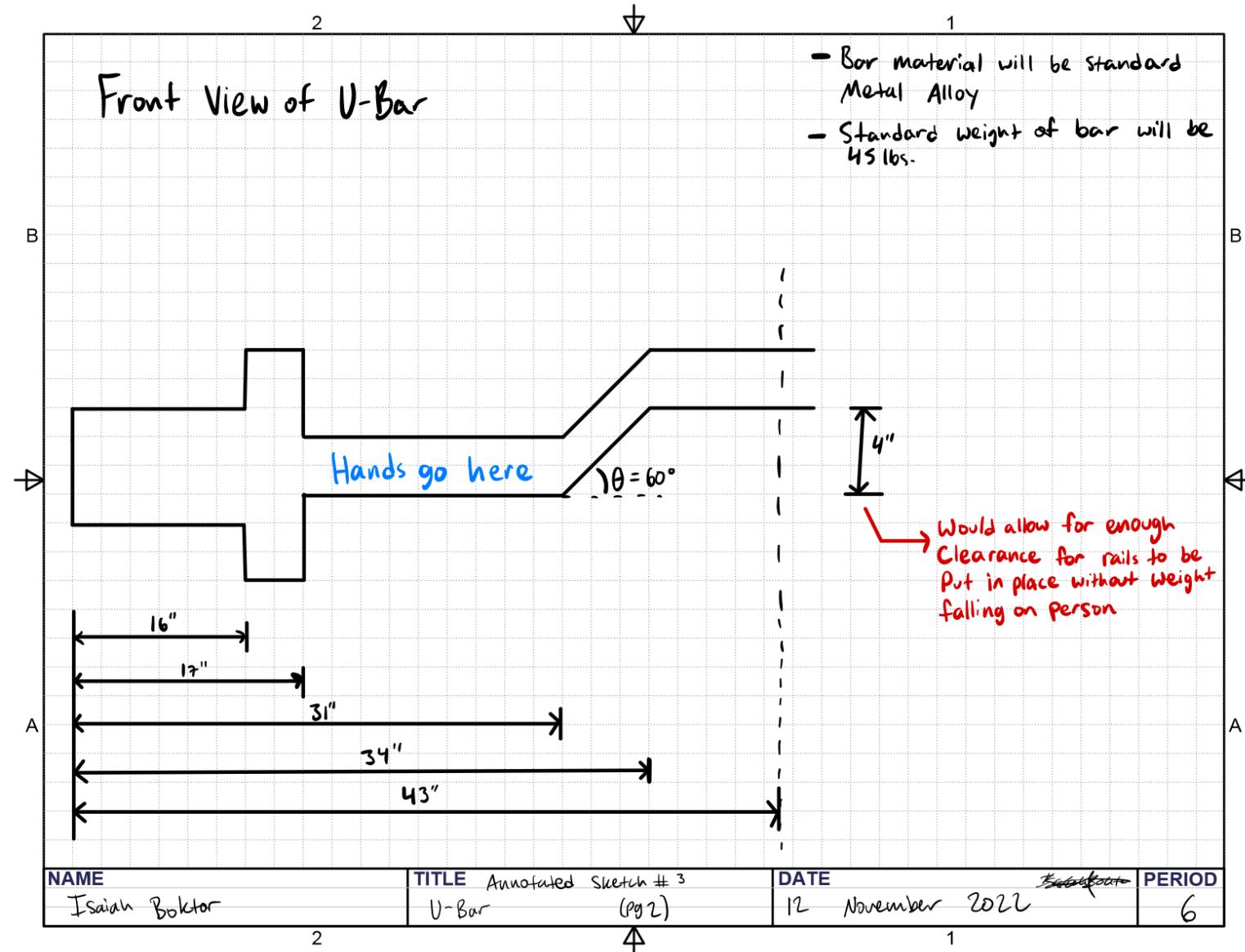
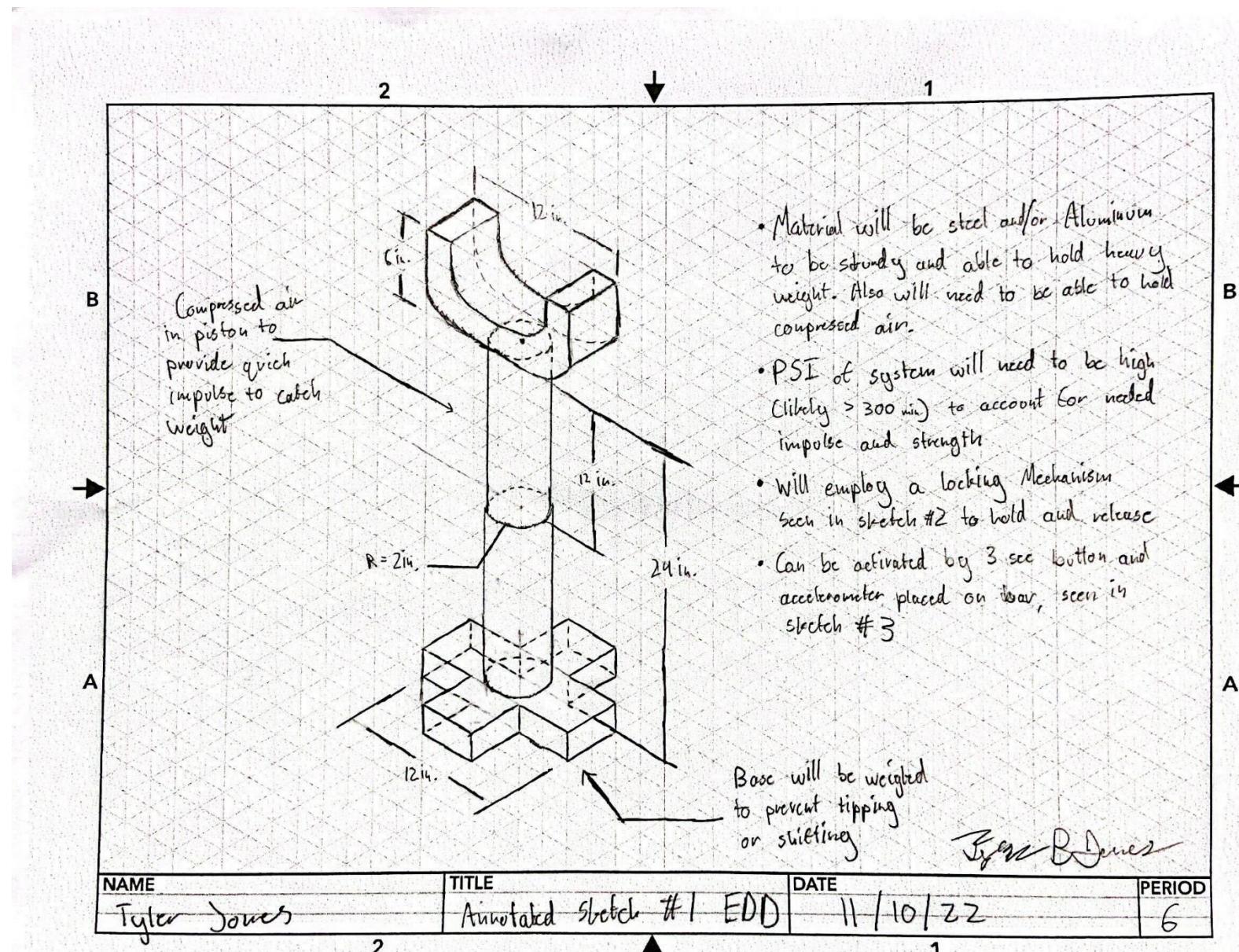
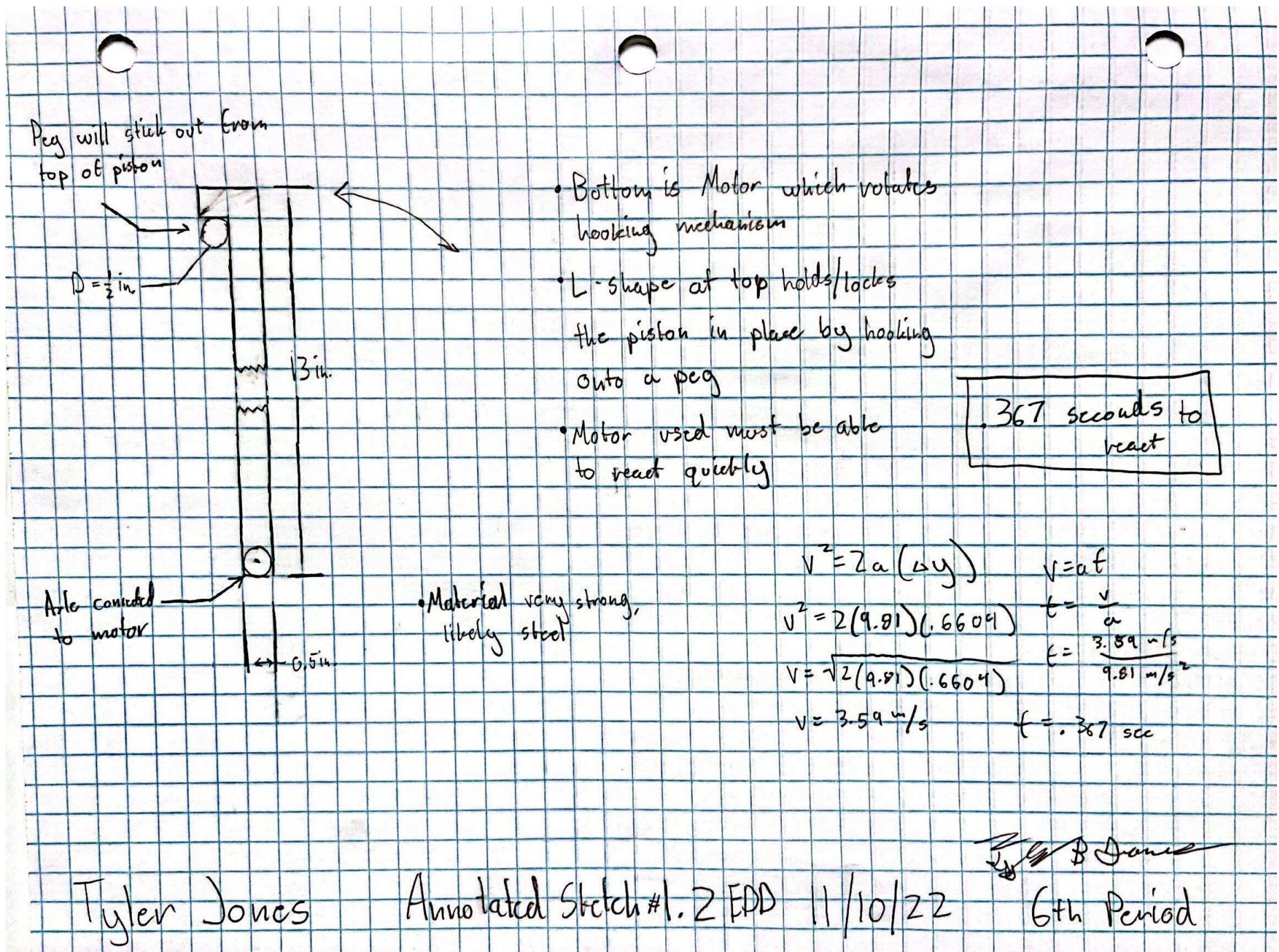


Figure 8: The Ubar design is depicted Above. The bend in the bar is supposed to allow for a full range of motion without touching the lifter if rep is failed. A side view is included in the second page.

## Pneumatic Spring Spotter





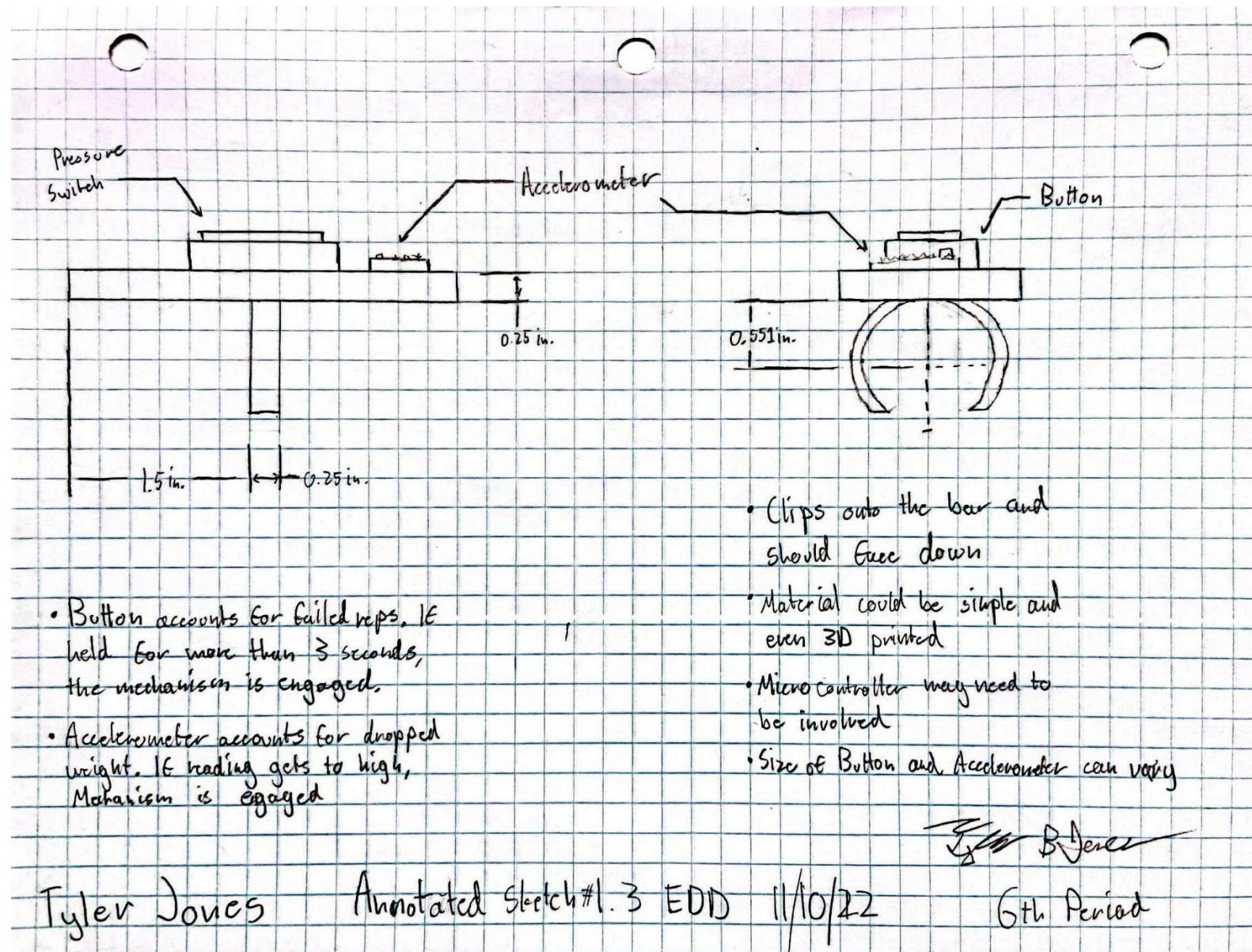
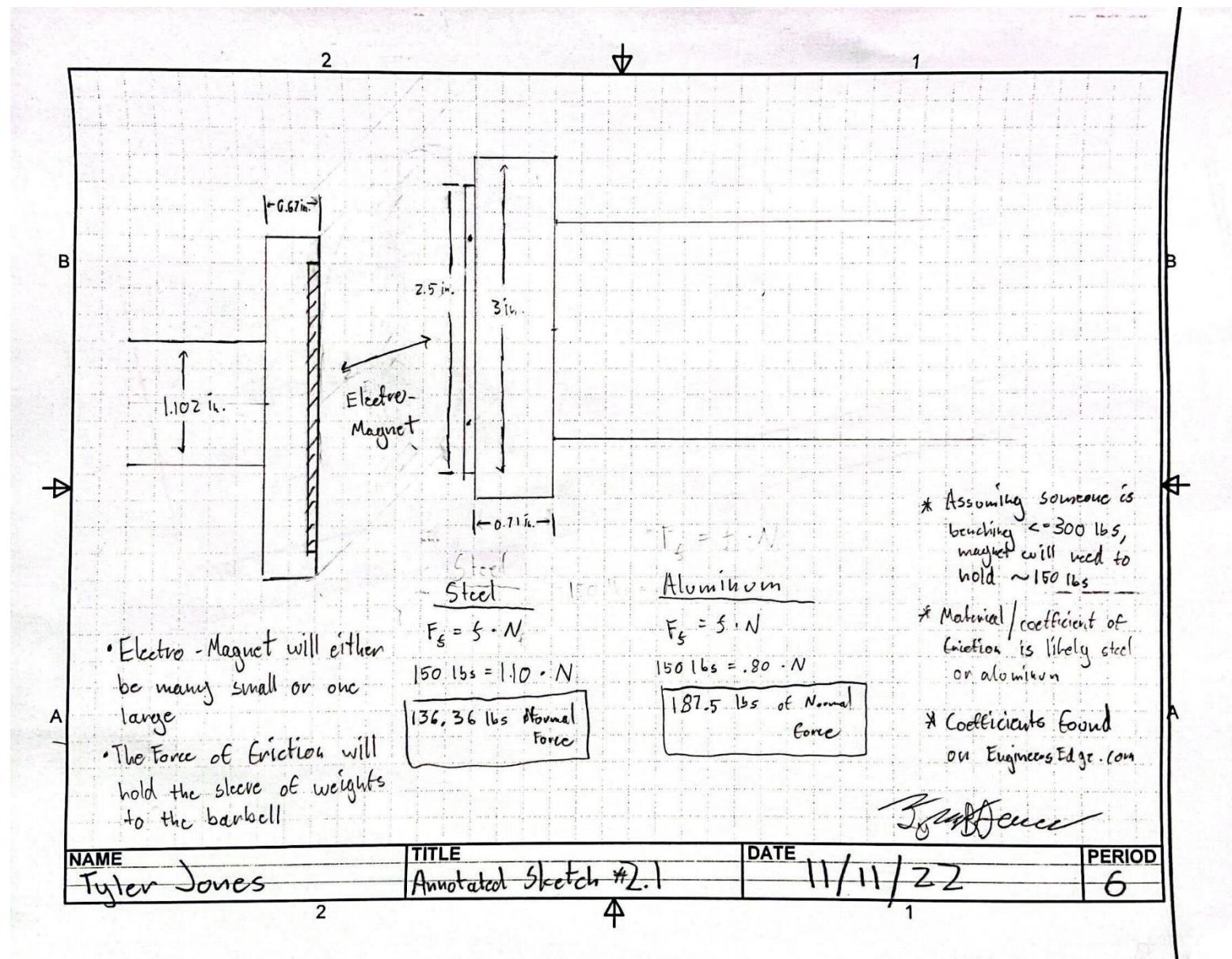


Figure 9: This is the Pneumatic Spring Spotter. The idea revolves around compressed air being used to shoot the rack up and catch the bar. The second page details a potential locking mechanism. The third outlines a potential controller.

## E-Mag Drop Spotter



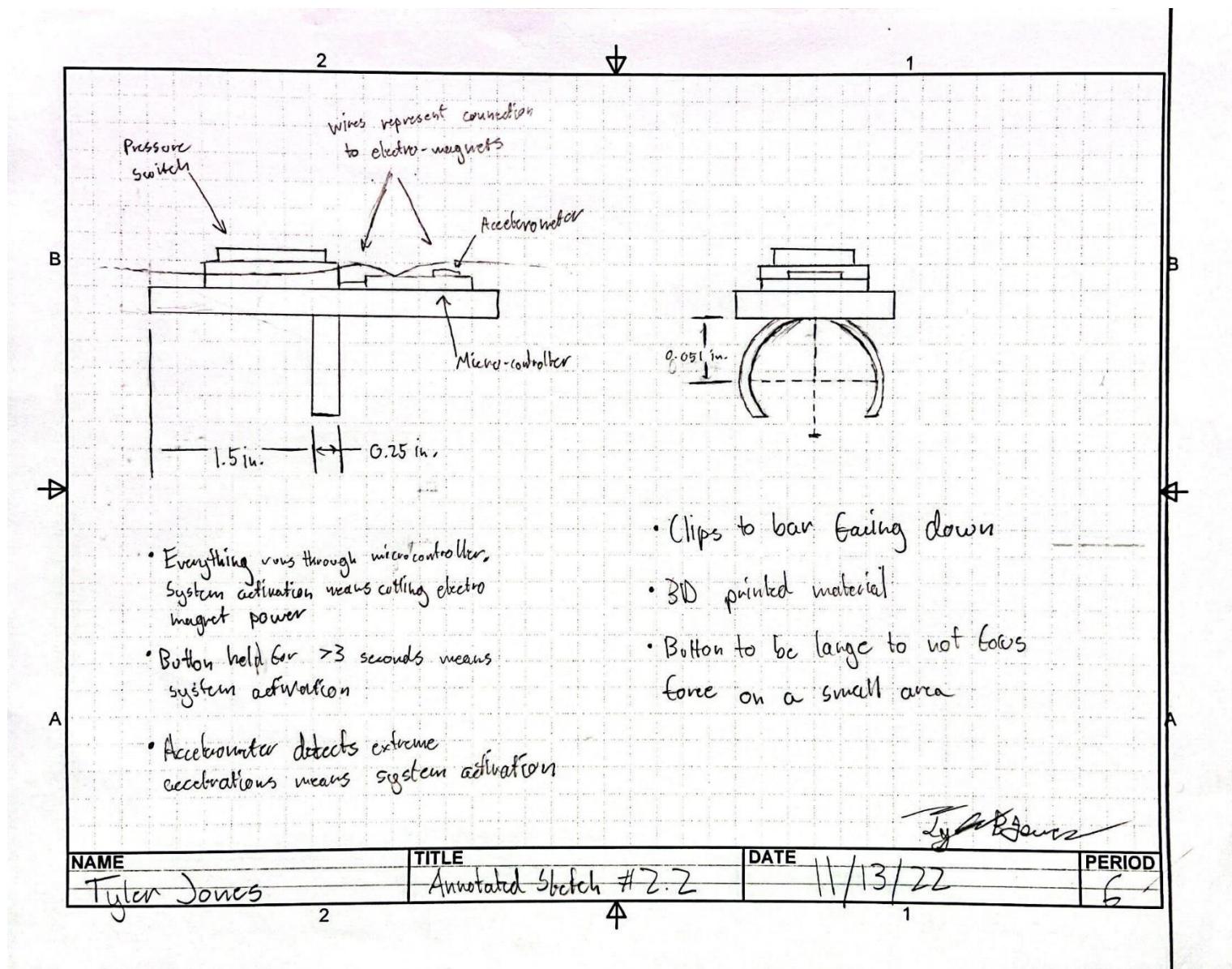
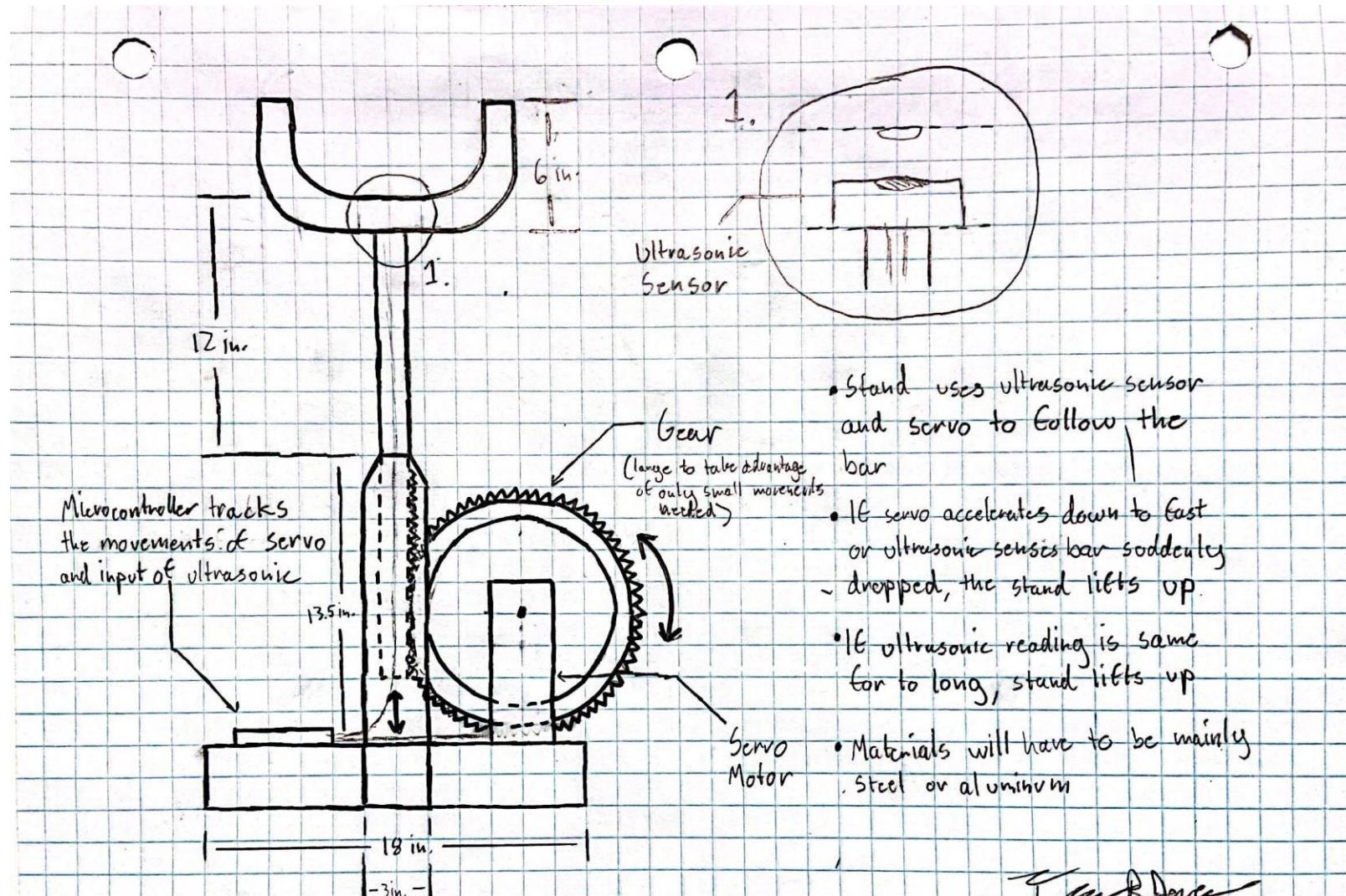


Figure 10: This is the E-Mag Drop Spotter. Similar to the collapsible bar the weight fall when an electromagnet is turned off. The second image shows a potential controller for the mechanism.

## Follow Spotter



Tyler Jones

Follow Spotter AS #3.1

11/4/22

6

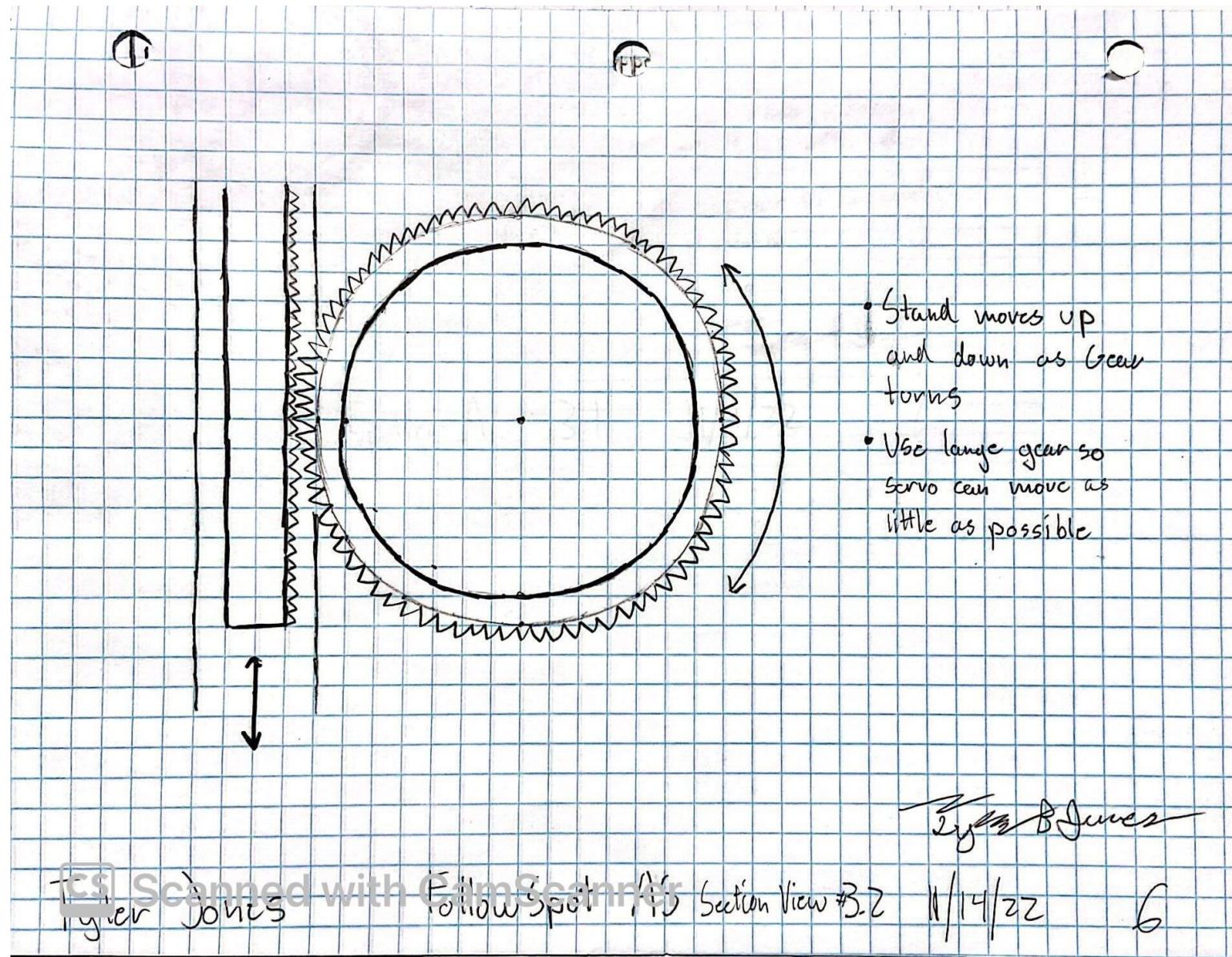
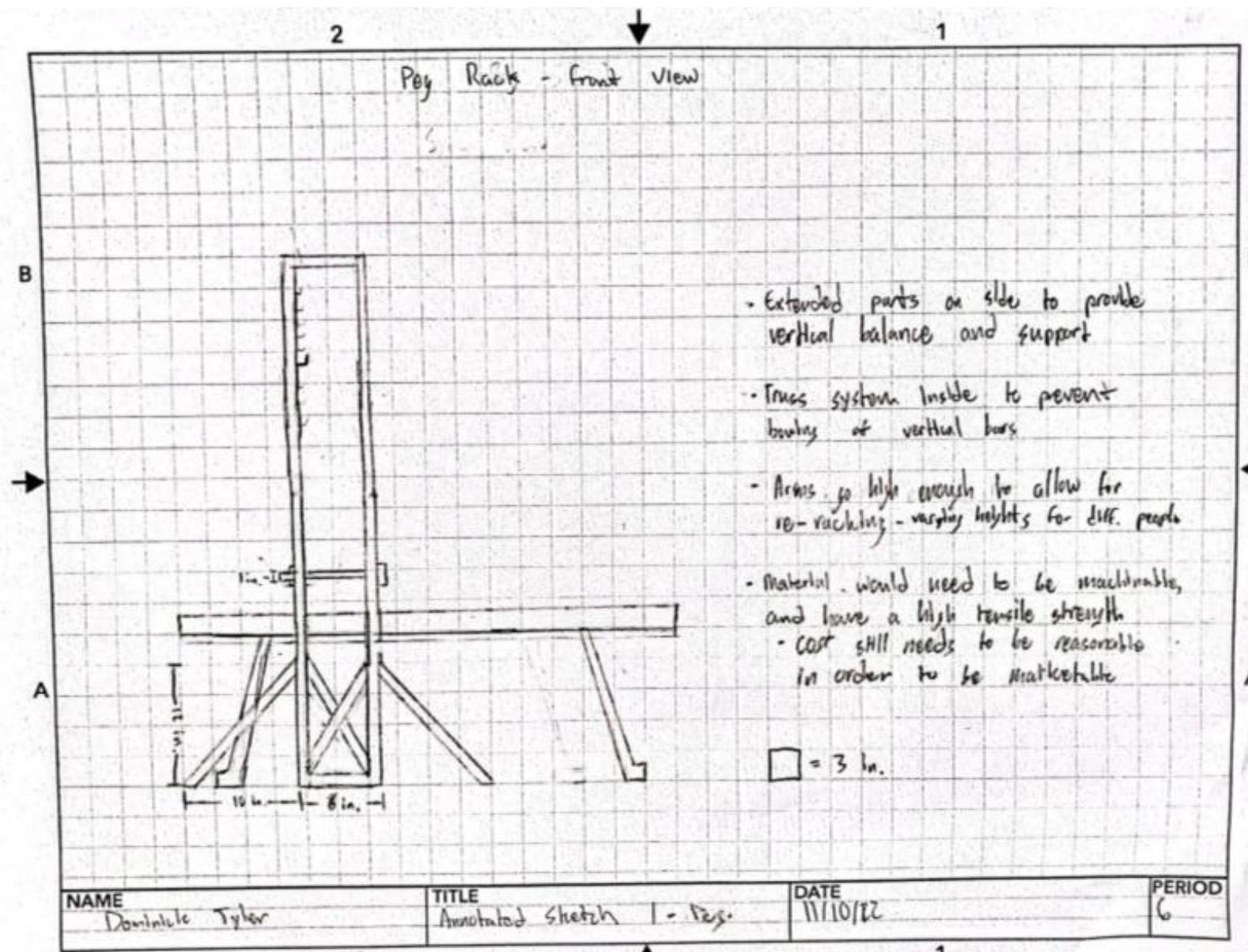
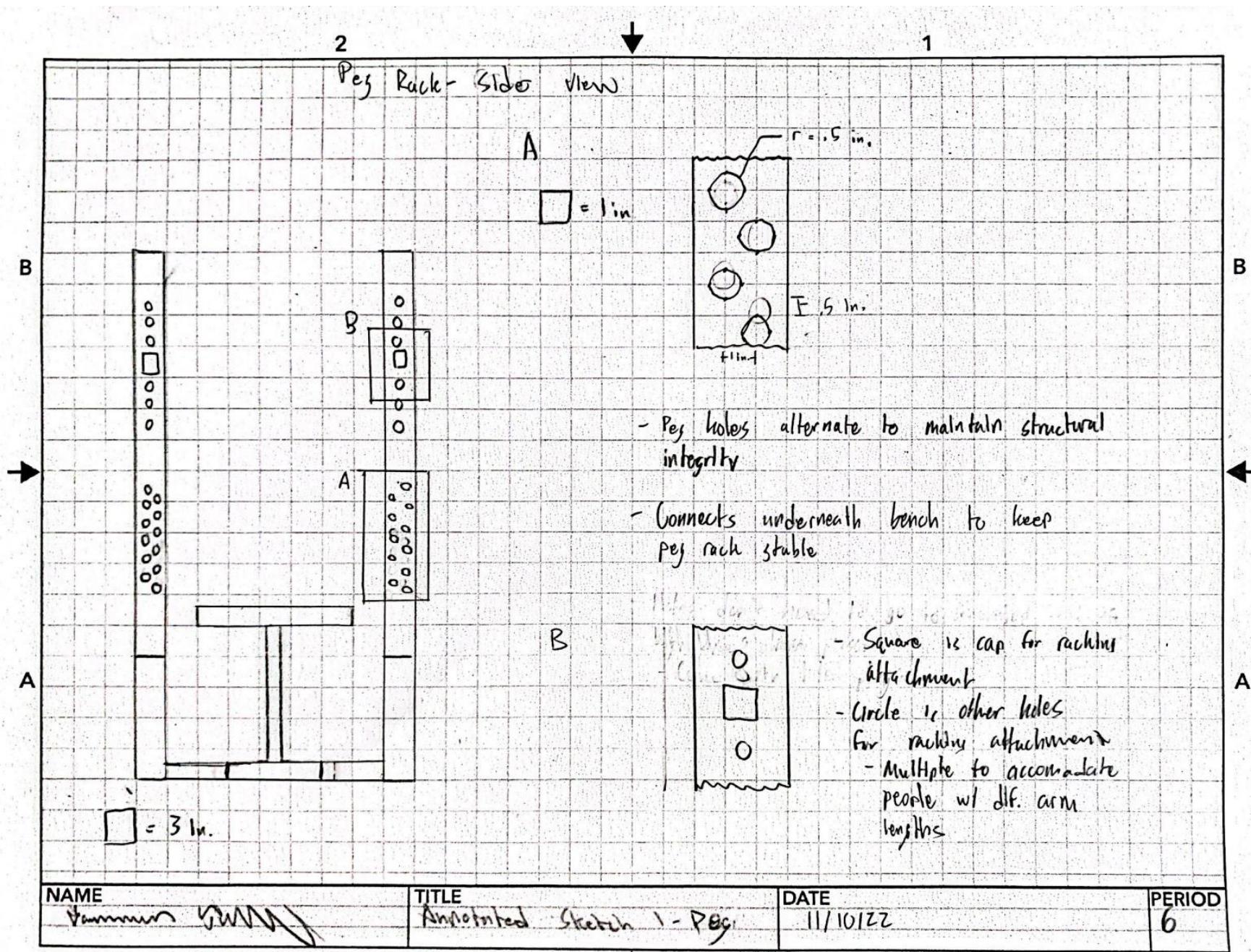


Figure 11: Above is the Follow Spotter design. It is intended to work like an actual spotter, following the bar using a gear. We had the idea potential use a screw as well. The second page has a close up of the gear. The third image shows a potential controller

## Peg Rack





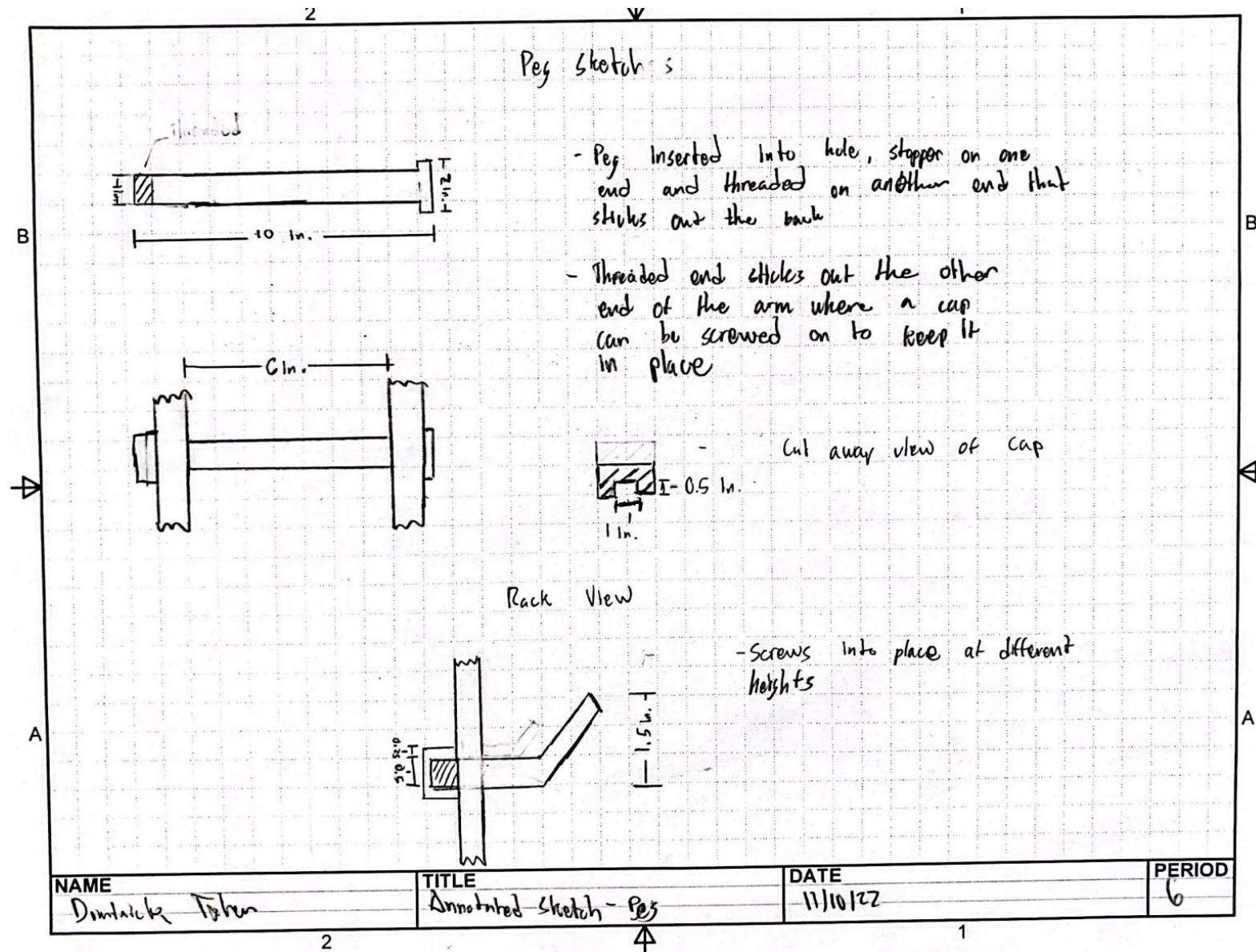
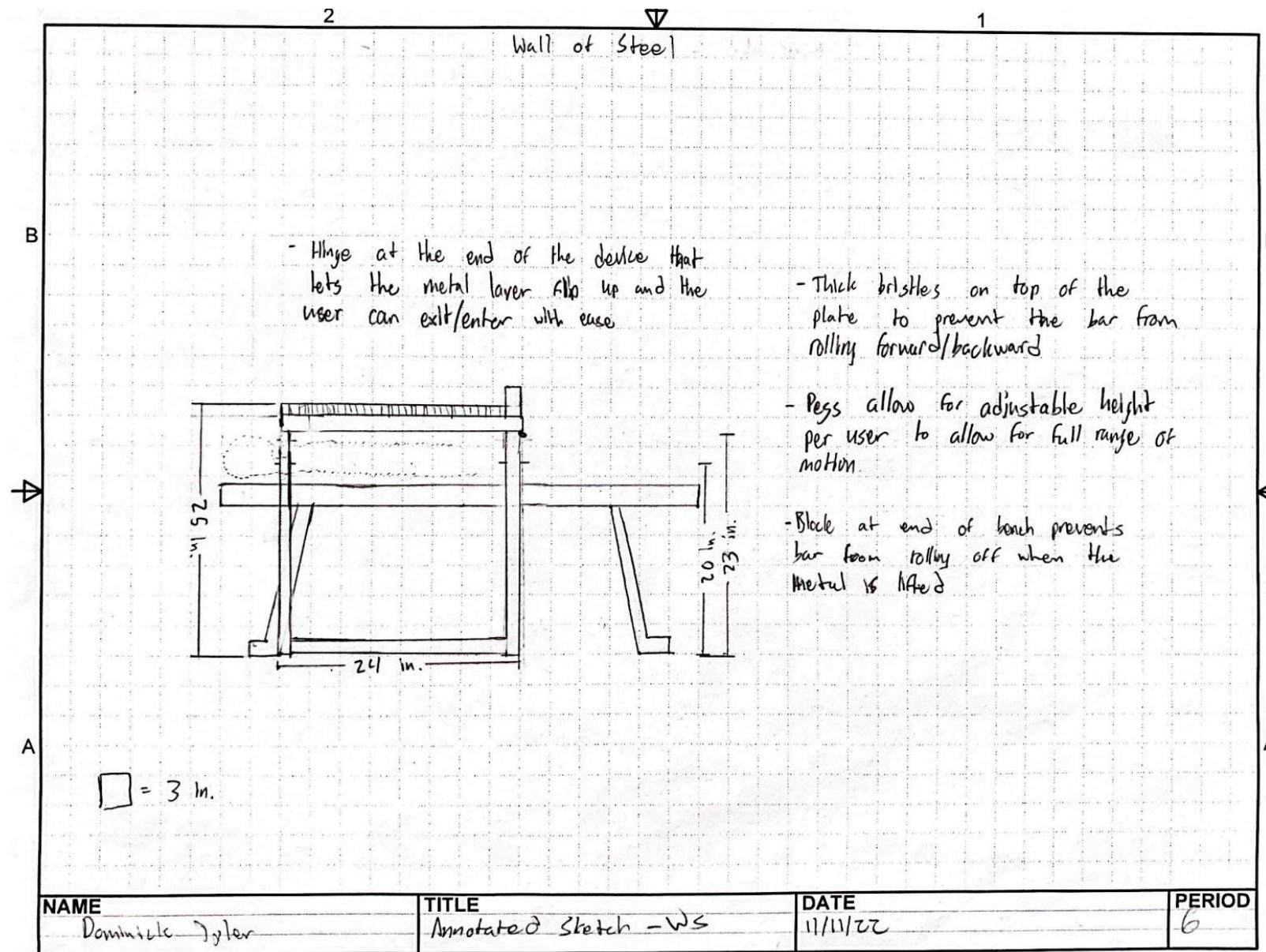


Figure 12: These images depict the peg rack. This design is meant to modify a bench press stand/cage by adding more holes to put the pegs in. The second page depicts a side view. The third page shows a close up of a peg.

# Wall of Steel



<p><b>Wall or Steel</b></p> <ul style="list-style-type: none"> <li>- Top part will have legs extending downward into the base.</li> <li>- Holes will be drilled into the metal to allow pegs to be inserted</li> </ul>	<p>A. <math>\square = 1</math></p>	<p><math>R = 0.375 \text{ in.}</math></p>	<p>B. <math>\square = 1 \text{ in.}</math></p> <p><math>30^\circ</math></p> <p><math>1/2 \text{ in.}</math></p> <p><math>R = 1/2 \text{ in.}</math></p> <p>- Angle of incline from one end of the device to the other will not exceed <math>30^\circ</math></p>
<p><math>\square = 2 \text{ in.}</math></p>	<p>2</p>	<p>4</p>	<p>1</p>
<p>NAME Dominique Tyler</p>	<p>TITLE Annotated Sketch - WS</p>	<p>DATE 11/12/22</p>	<p>PERIOD 6</p>

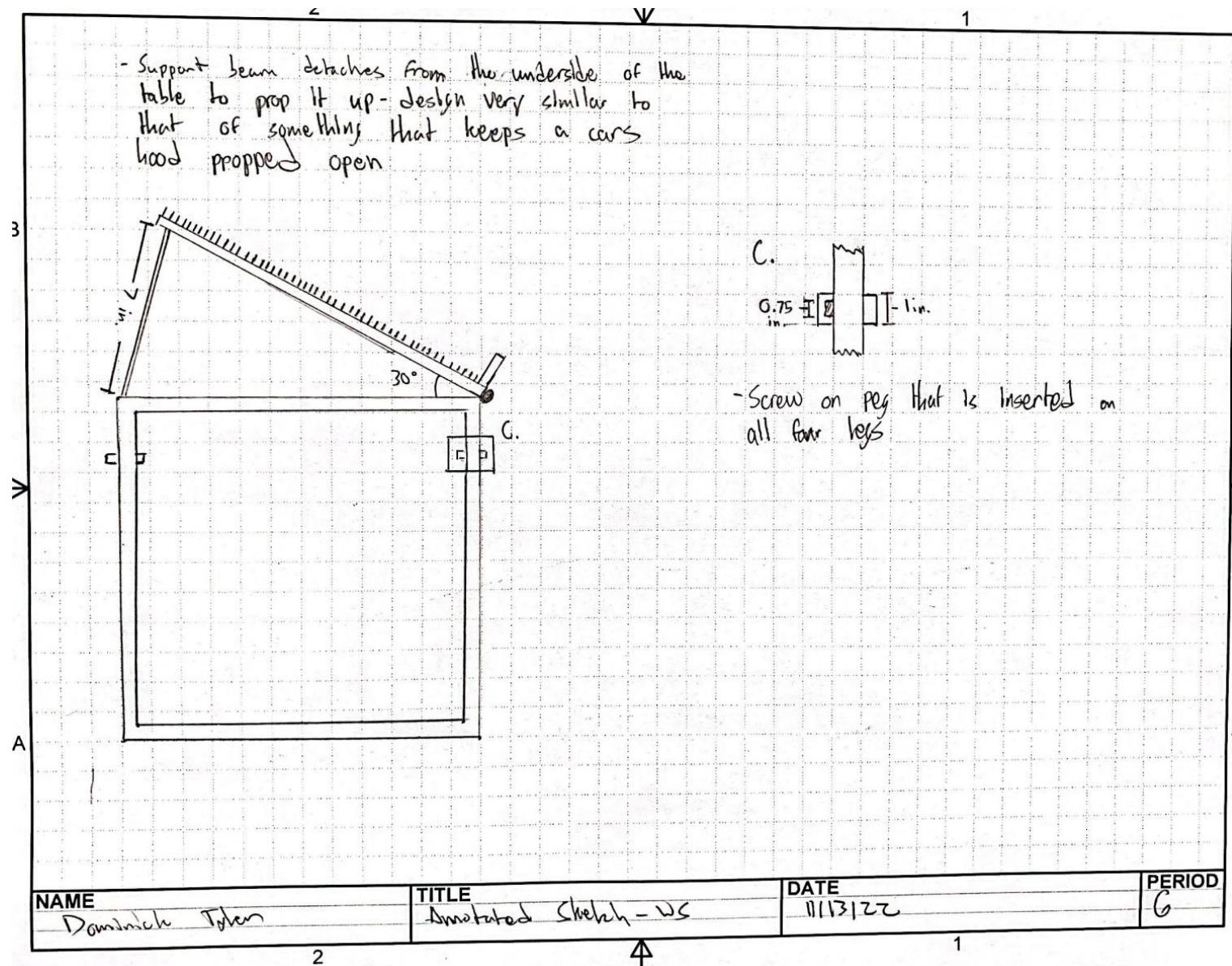
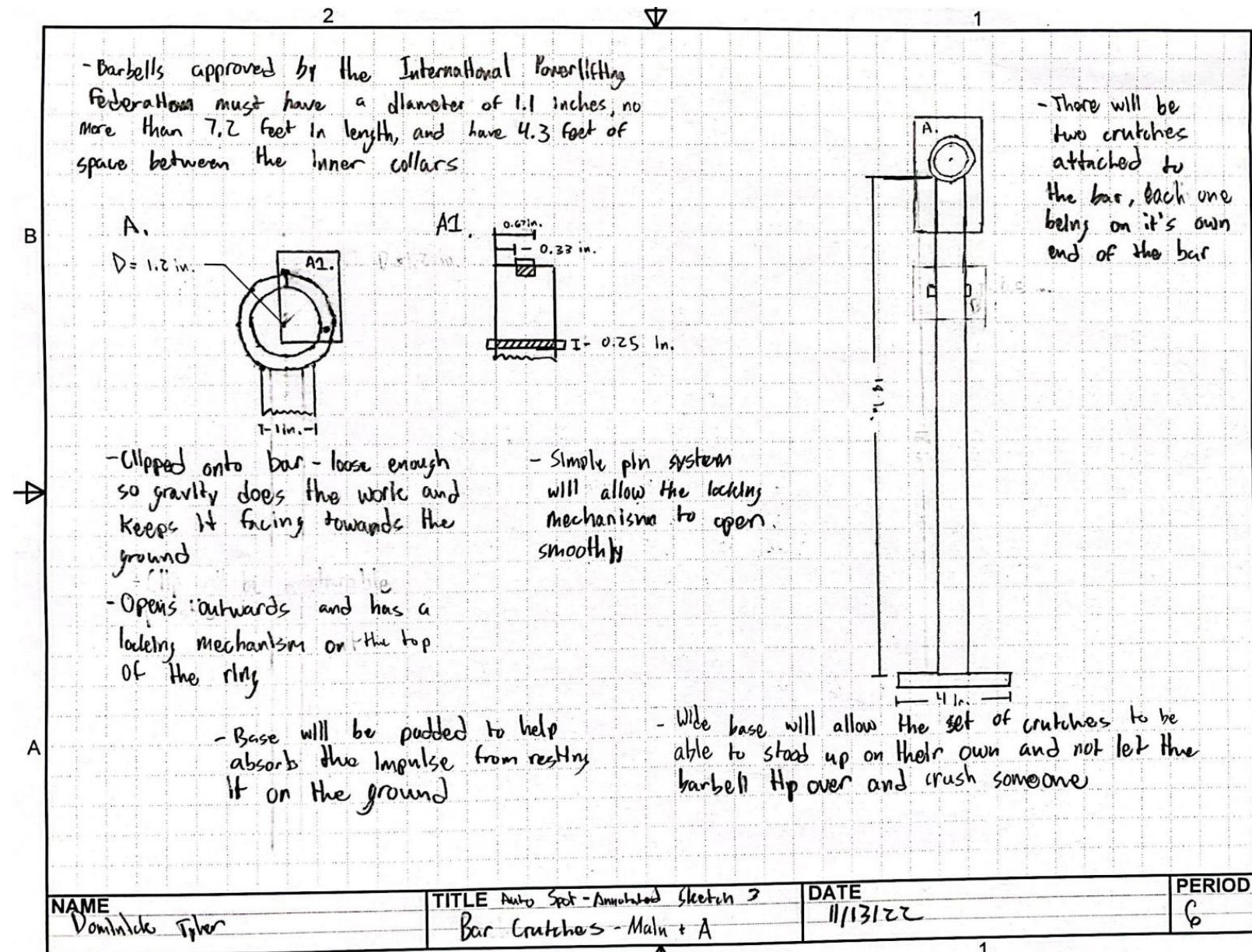


Figure 13: The above sketches show the wall of steel design. It uses a light but sturdy plate on a hinge that protects the lifter. Sketches 2 and 3 show close ups of the mechanism.

## Clip-On-Crutch



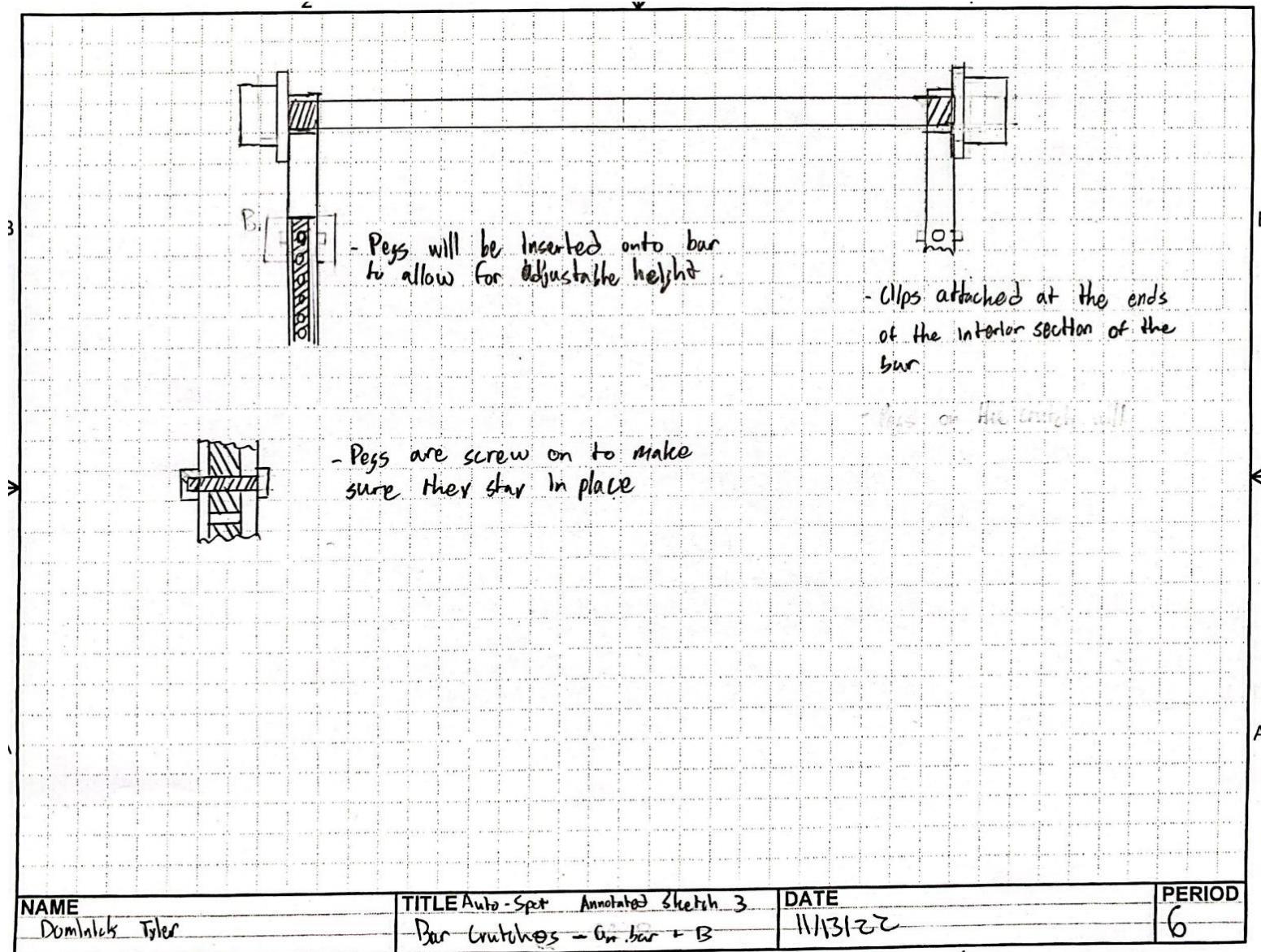
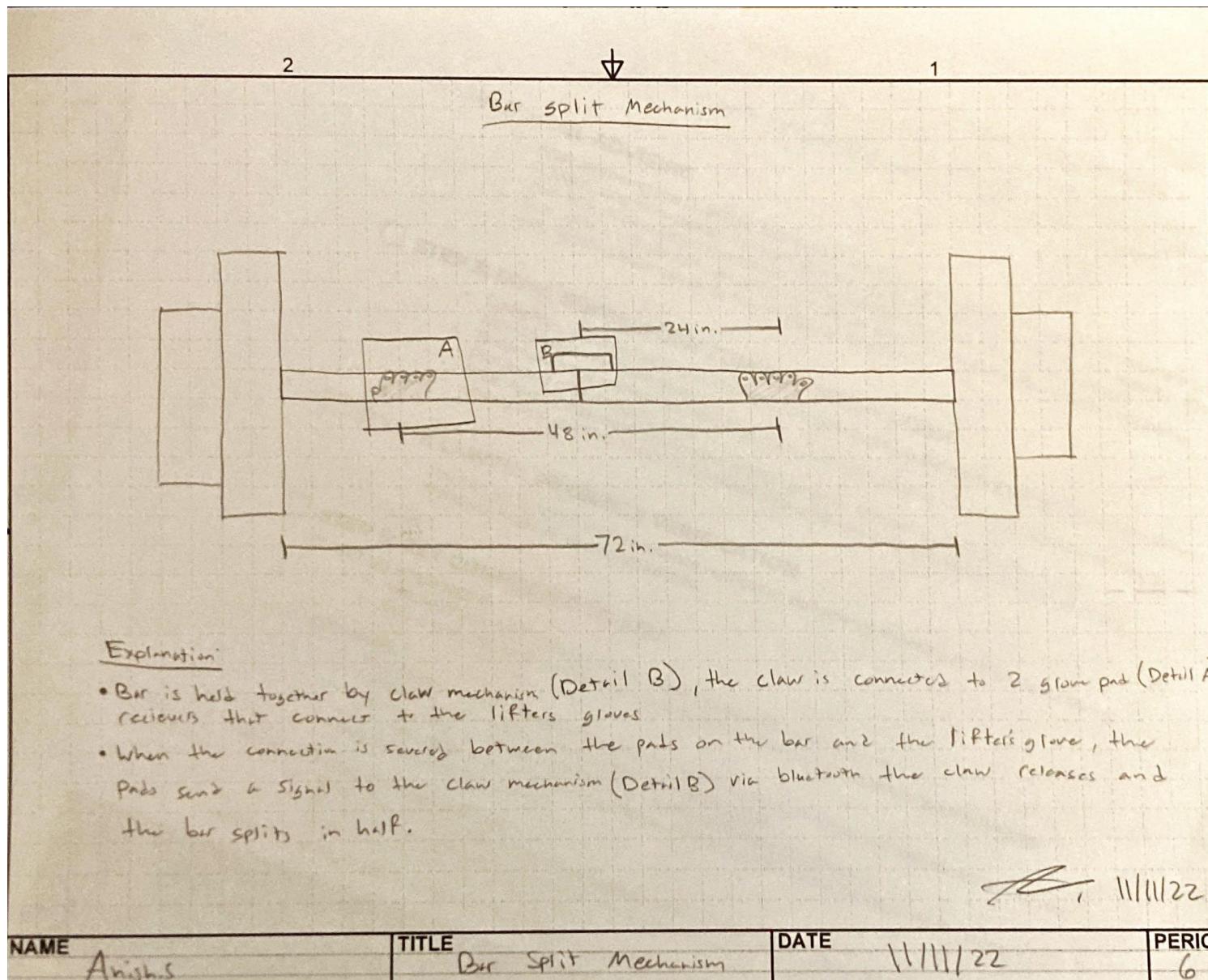
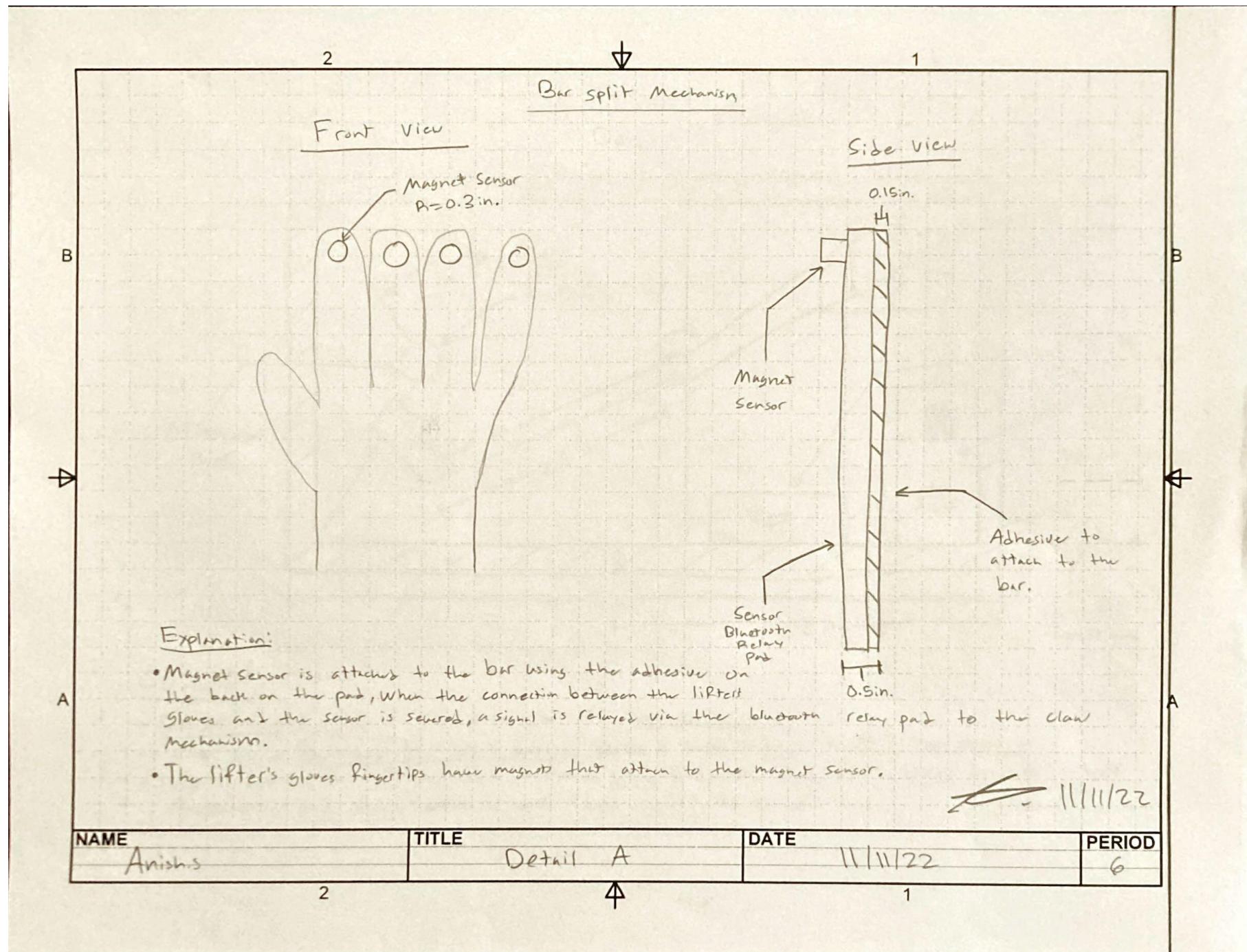


Figure 14: Seen above are the Clip on crutch Sketches. These are modified clips that hang down from the bar to prop it up if needed. The second sketch shows a side view and a close up.

**Selfie Stick**



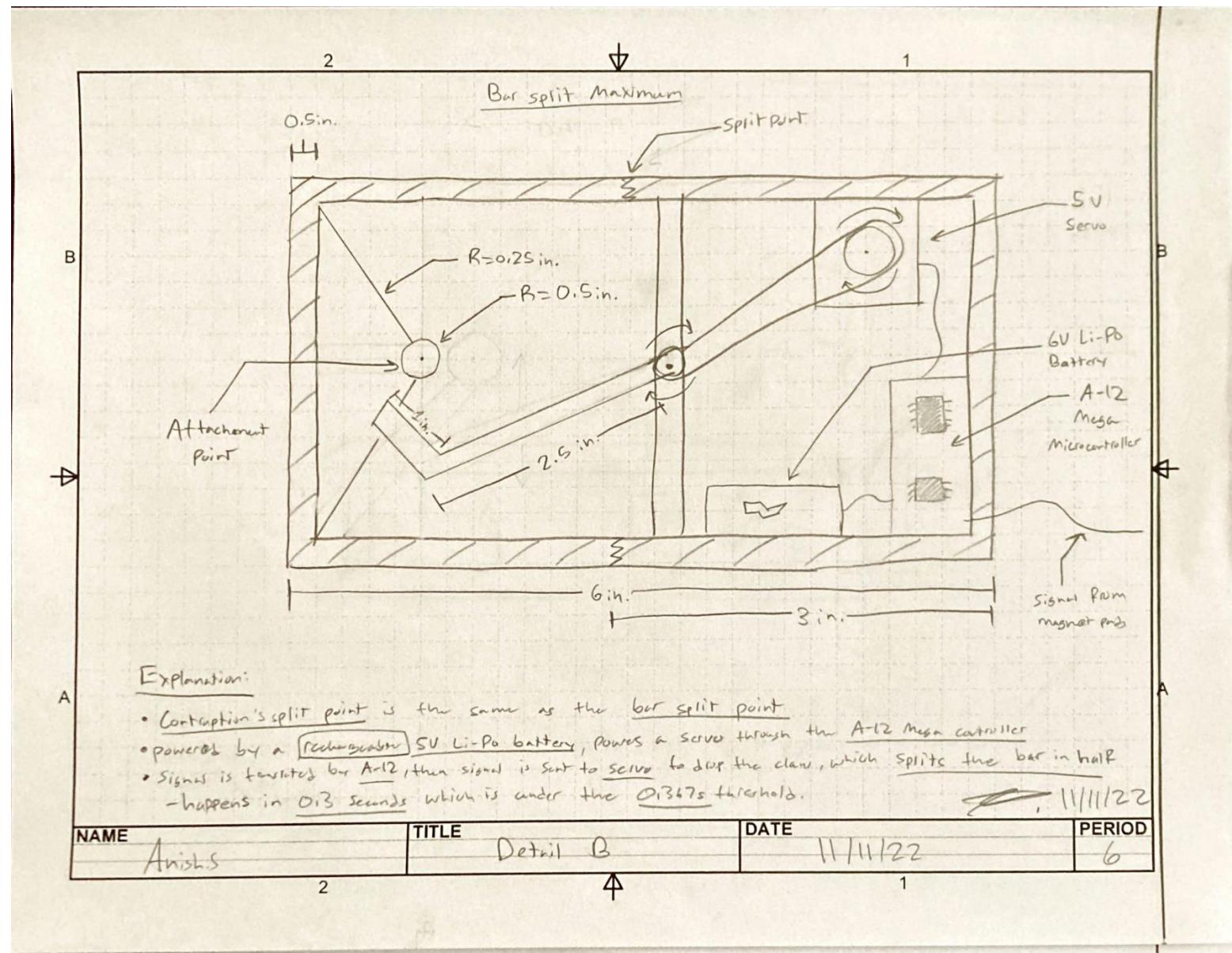
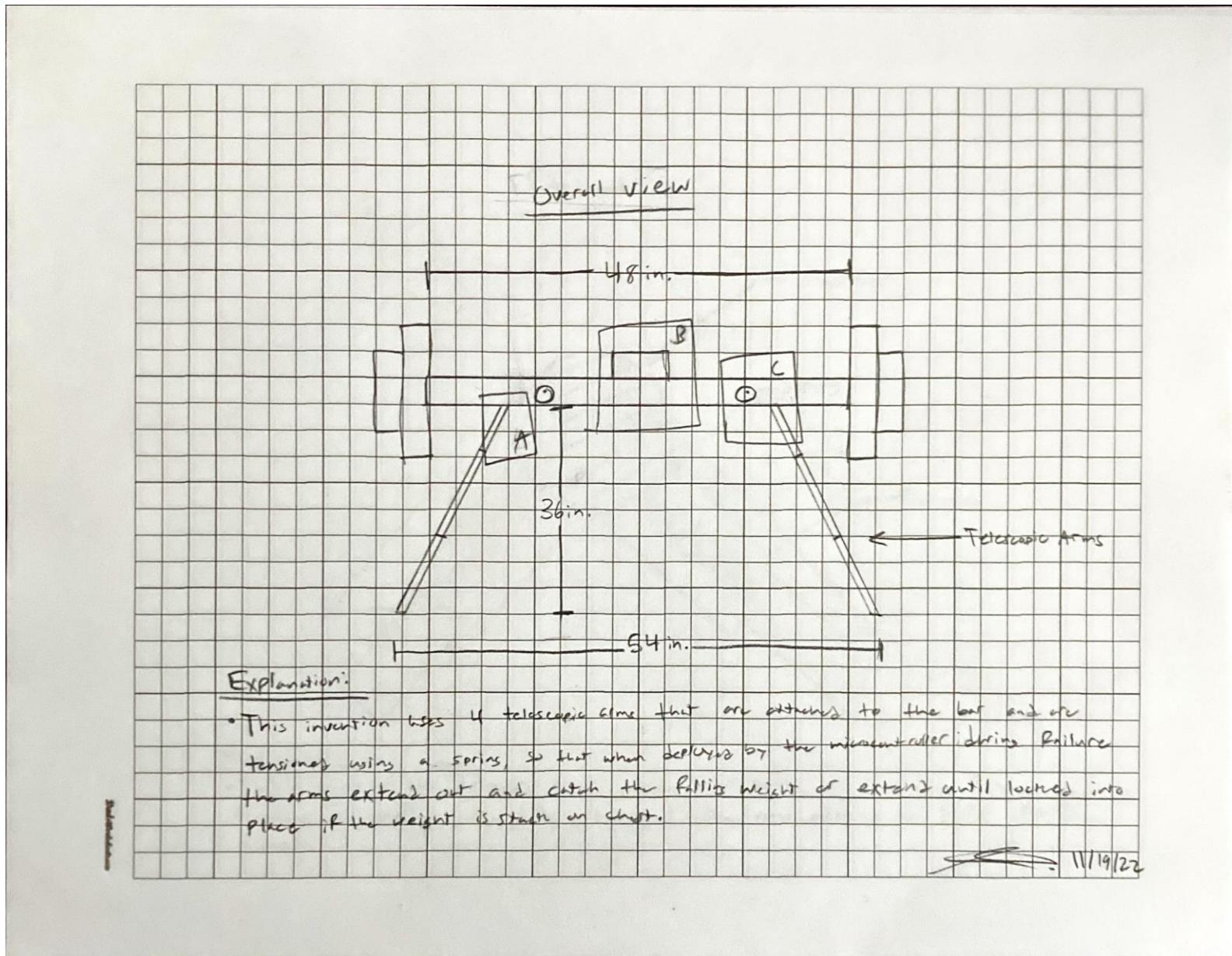
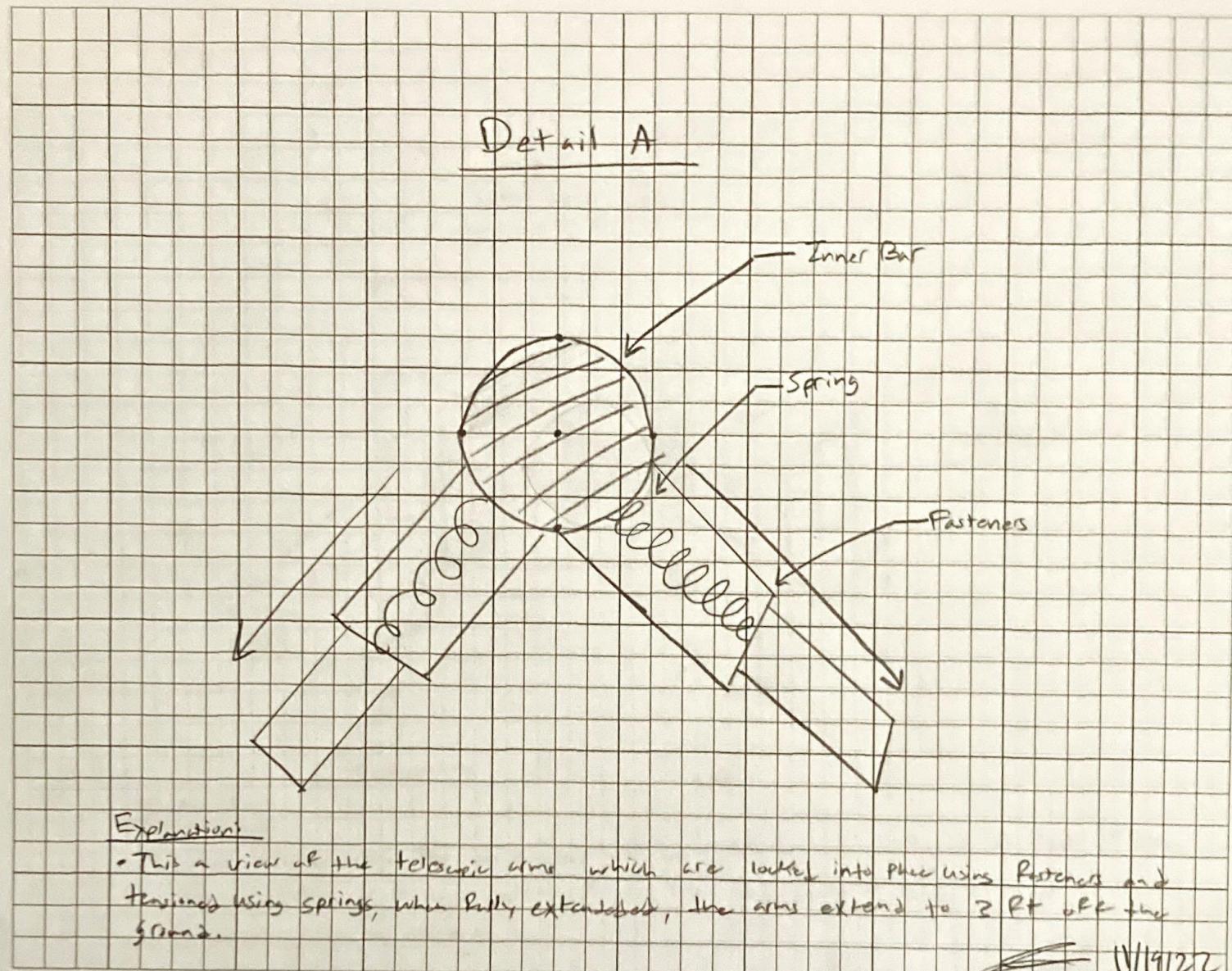
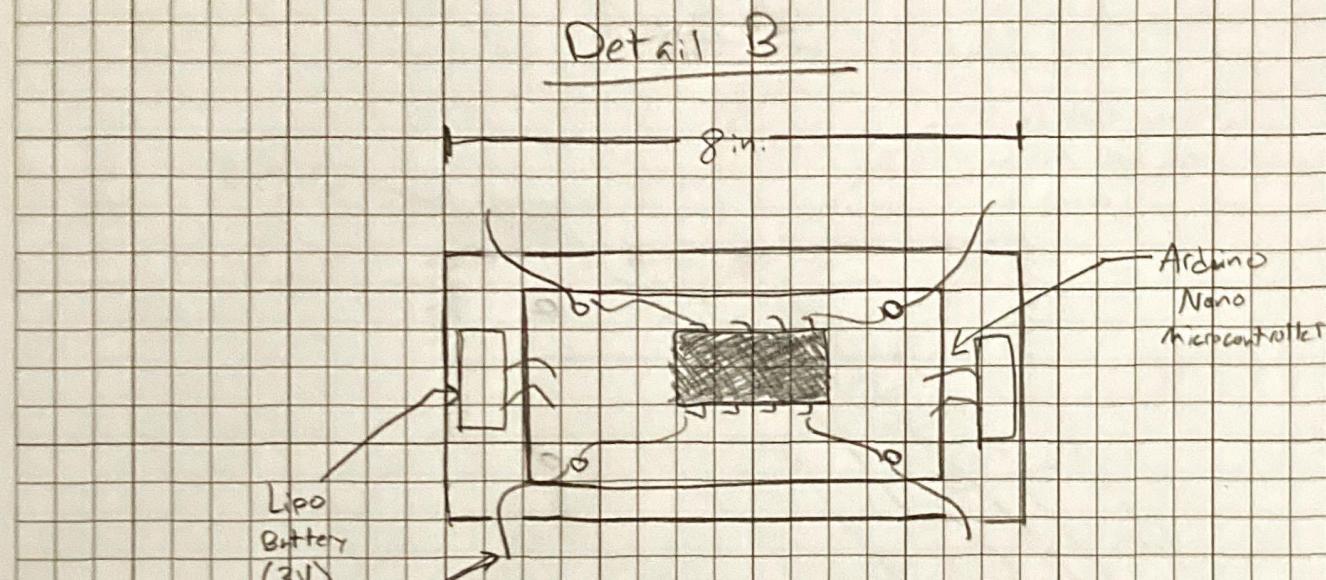


Figure 15: This is an initial sketch of the bar slit mechanism. It uses a controller to signal the mechanism to split the bar in half if the lifter fails the rep. The second sketch details the idea for sensor gloves. The third sketch is a close up of the release

**Hold-It-Together**



Explanation:

- This microcontroller has an accelerometer built into it and a timer, so that if the bar is pulling or in one position for too long, the controller sends a signal to the telescopic arms to extend.

~~11/19/22~~

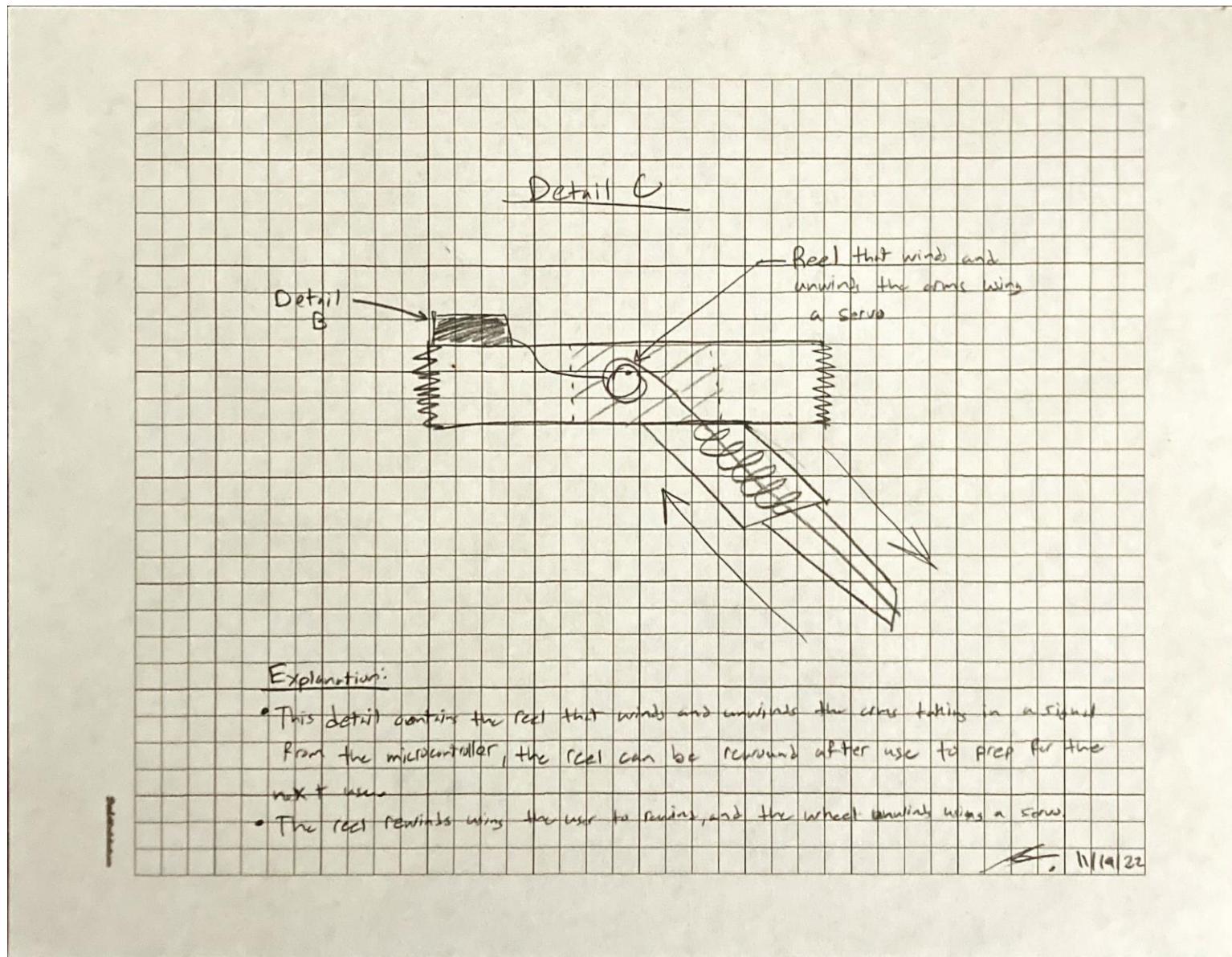
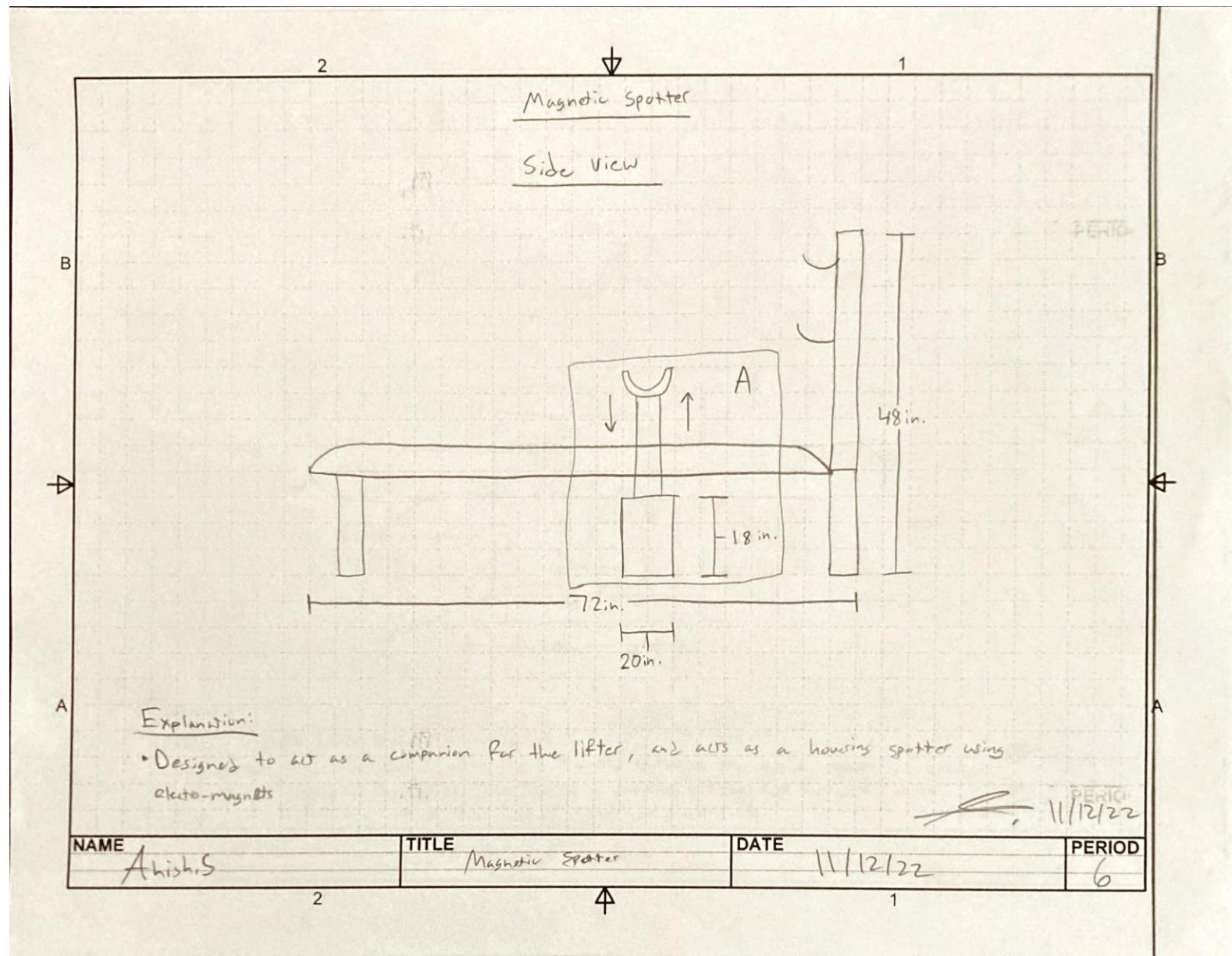


Figure 16: These three depict the Hold-it-Together design. It is intended to extend legs which prop up the bar. The second sketch shows a possible mechanism for the telescopic arms. The third sketch shows a possible controller. The Fourth sketch shows a mechanism

**Force of Attraction**

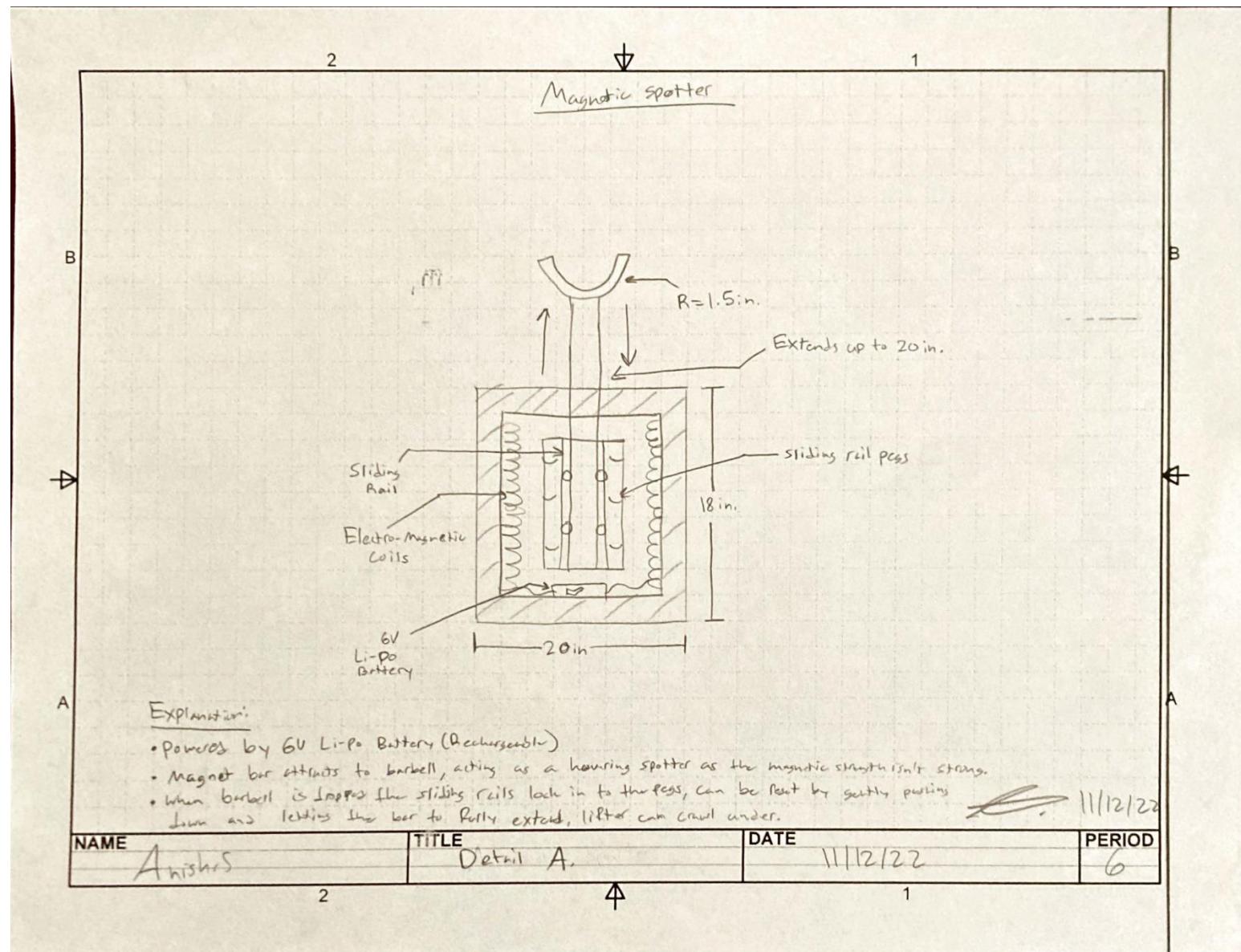


Figure 17: The Sketches above illustrate the magnetic spotter. It is similar to the pneumatic spring spotter except it uses magnets for deployment. The second sketch shows a detail view.

## Design Specifications

- Target Consumer: Commercial or Home gym goers who cannot spot themselves bench
- Performance: Invention that doesn't hinder bench press motion, provides fail safe for failed and dropped reps.
- Target Cost: Under \$500
- Size and Weight
  - o Bar: 45 lbs., <86.6" L, 50 mm D
  - o Chest Protection (Peg Rack & Wall of Steel): <150 lbs of total material. 3-8 ft in length, 2-4 ft in width
  - o Clip on Crutch: 1.5 ft – 3 ft in length. 5 lbs per crutch
  - o Hold-it-together: ~50 pounds of total material. Standard barbell length and width
  - o Follow Spotter: Min height of 3 ft. -- 18 in. Length and Width of Base, ~40 lbs. of material with majority in base
- Aesthetics
  - o Chest Protection: Strong colors and sharp angles.
  - o Clip on Crutch: Sleek and secure looking.
  - o Hold-it-together: Must blend in with the bar to avoid confusion, same color as bar.
  - o Follow Spotter: Covers for sensor, gear, and servo to prevent damage and create sleeker look.
- Materials
  - o Bar: Steel
  - o Chest Protection: Steel, Aluminum, Rubber, Plastics.

- Clip on Crutch: Steel, Foam Padding.
- Hold it together: Carbon Steel alloy, Steel, Aluminum, Rubber.
- Follow spotter: Steel, Iron or other heavy material for the base.
- Safety and Legal Issues
  - Bar: Weights can shoot off too hard and hit something/someone, Still get crushed if the mechanism fails.
  - Chest Protection: Plate could bend under load and deform hurting the user, Peg could fail and injure the user.
  - Clip on crutch: Arm deformation could cause injury, Peg holding each leg at designated length deforming could result in injury.
  - Hold it together: Bar snapping could hit someone nearby, Bar may not snap in time and still injure the weightlifter.
  - Follow Spotter: Specs and identification on max weight it should hold, Strong gears and safety system in event of failed catch
- Ergonomics: Allow for safer lifting without the use of other people, Keeps bench motion safe
- Operating Environment: Home or Commercial Gym, not specific
- Global Environment: No toxins, safe to environment
- Service Life
  - Bar: 15 years
  - Chest Protection: 10 Years
  - Clip on Crutch: 6 Years
  - Hold it together: 5 years
  - Follow Spotter: 5 years

- Product Life
  - o Bar: 10 years
  - o Chest Protection: 5 Years
  - o Clip on Crutch: 4 Years
  - o Hold it together: 2.5 years
  - o Follow spotter: 3 years
- Durability & Maintenance
  - o Specific Part
    - Bar: Springs, Pins, Shaft
    - Chest Protection: Hinges, Bristles
    - Clip on Crutch: Clamp
    - Hold it together: Claw, Servo motor
    - Follow Spotter: Gears, Servo motor
  - o Maintenance
    - Bar: Battery must be replaced every month, Bar to be lubricated every year, Spring to be replaced every 10 years
    - Chest Protection: Peg swapped every 2 years
    - Clip on Crutch: Peg swapped every year

- Hold it together: Claw must be swapped after every 5 uses, Servo must be changed every 4 months, Battery must be charged every night, Microcontroller must pass a test every month
- Follow Spotter: Gears and servo motor will need replacing every few months to 1-2 years depending on number of heavy drops
  - Special Tools: Hold it together: Lathe, 3D printer
  - Replacement Parts
    - Bar: Only replacement part is spring: will be acquired via internet
    - Chest Protection: Spare pegs for rack will come with initial shipping, can be purchased online as well, Spare holder on wall for propping up the plate of metal
    - Clip on Crutch: Comes with spare crutch & pegs
    - Hold it together: Spare Servo, Spare claw, Spare batteries, Spare system if broken
    - Follow Spotter: Spare Gears, Common gears so they're easy to find, Servo motor if too much force is put on it
- Design Constraints: Must not injure the weightlifter during activation, Must not hinder the bench press process, Must not add no more than 10 lbs to the barbell, Must be portable, Cannot add anything that acts as a cage or needs a wall outlet, Must be able to activate in 0.367 seconds, Must be able to be repaired by someone with no knowledge of the system

Validation:

- Prof Brian Jensen: I'm impressed by several of your ideas! I'm afraid I wasn't able to take the time to go in-depth and understand each idea, but I want to give you as much feedback as I can. Some of your ideas are more complex, involving sensors and actuators, and

others are very simple (like using pegs or other stops to prevent weights from falling on a person. I think both approaches are valuable, and you may want to consider a combined concept that uses the simple/inexpensive approach as a backup just in case something goes wrong with the more complicated solution. As I said, I also like the idea of using one of the simpler (no electronics) ideas as a back-up.

Good luck! I hope your project turns out well. Brian Jensen

- Prof Howard Chen: Looking through your designs, quite honestly, I think Mr. Benton knows about this stuff as good, if not better than I do. I am offering my advice as a second pair of eyes and nothing more. This is an area that I do not consider to be my specific area of expertise. I will defer to his judgement if what I say is in conflict with his opinions.
- Prof Book: I received your request on my phone and will look more closely at your design when I'm at my computer. I just wanted you to know that I'll try to assist you.
- Prof Jacob: Normally I try to help. (2) material selection part is not that difficult, I think the deign part is more involved. For materials, it is a question of the required strength/modulus and function required for a specific component vs weight condition. Polymers are useful if significant forces are not involved (where you need complex shape or low friction – like with Teflon surface, etc.) (3) if you can use more or less similar materials if it is possible, that would be best, otherwise, unequal thermal expansion coefficients etc. could cause issues unless it is designed properly. (4) gear mechanism to support 150 lbs will be a challenge, if size and weight are constraints (5) if you go to Mechanical Engineering department website and look for research groups, you will find a design group. You may want to contact them to see whether they are willing to help. It will take some time from them to go through this, so I am not sure whether anyone will be willing to help. You can also contact someone at the “Invention Studio” in Mechanical Engineering, this is exactly the

kind of projects they do all the time; thus it is much easier for them to help. I wish I could offer more help; but someone has to spend a lot more time to give you some meaningful help. All the best

## Decision Matrix and Justification

### Decision Matrix

**PLTW | Engineering**

Specifications	WEIGHT	Collapseable Bar		Bench Drop		U-Bar		Pneumatic Spring Spotter		E-Mag Drop Spotter		Follow Spotter		Clip-on-Crutch		Adjustable Peg Rack		Wall of Steel		Hold-it-Together		Force of Attraction		Selfie Stick	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Safety	9	5	45	5	45	5	45	7	63	5	45	7	63	7	63	7	63	3	27	3	27	5	45	3	27
Cost	5	3	15	5	25	7	35	3	15	1	5	3	15	7	35	3	15	5	25	7	35	1	5	3	15
Feasibility	8	5	40	3	24	7	56	3	24	1	8	5	40	7	56	1	8	5	40	5	40	1	8	1	8
Product Life	3	5	15	5	15	7	21	1	3	3	9	5	15	5	15	7	21	3	9	3	9	3	9	1	3
Durability	7	5	35	5	35	7	49	3	21	5	35	3	21	5	35	7	49	5	35	3	21	5	35	1	7
Meets Costumer Needs	6	7	42	7	42	5	30	5	30	3	18	7	42	5	30	3	18	1	6	5	30	3	18	5	30
Size & Weight	2	7	14	3	6	7	14	7	14	7	14	5	10	3	6	1	2	1	2	7	14	7	14	7	14
Performance	4	3	12	5	20	3	12	5	20	3	12	7	28	1	4	5	20	3	12	5	20	3	12	1	4
Aesthetics	1	3	3	3	3	1	1	7	7	7	7	3	3	1	1	1	1	5	5	3	3	7	7	7	7
<b>TOTAL</b>		<b>221</b>	<b>215</b>		<b>263</b>		<b>197</b>		<b>153</b>		<b>237</b>		<b>245</b>		<b>197</b>		<b>161</b>		<b>199</b>		<b>153</b>		<b>115</b>		

**Mockups****U-Bar**

### Collapsible Bar



**Follow Spotter**



### Clip-On-Crutch





## PHASE 3: Prototyping and Testing

### Prototype Procedure

#### **U-Bar**

- Materials/Equipment:
  - 10 Galvanized Steel Pipe
  - Welding equipment.
  - Protective Paint (gray)
- Bought a 10ft pipe for raw material.
- cut the pipe into weldable sections with different angles based on the design drawings.
- got the sections welded together for the final prototype.
- ended construction with a coat of protective paint to ensure no damage is done before testing.

#### **Clip-On-Crutch**

- Materials needed
  - Square Wire lock pin
  - Aluminum bars
  - Wood
  - L-Joints
  - Clip

- Mark up aluminum for location of drilling holes
- Rivet L-Joints into Aluminum
- Screw L-joints into wood
- CAD Part
  - Designed with a new bottom part that extends into aluminum
  - Used 100% Nylon infil as a means to make it strongest possible
- Inserted CAD Part into aluminum, drilled into place with a screw

**Prototype Images****Clip-on-Crutch**

*Figure 18: Measuring out where we would drill holes into the Aluminum bar.*



*Figure 19: Use of the drill press, used a drill bit with the same radius as the square wire lock pins we acquired.*



Figure 20: Using a rivet gun to connect the L-Joints to the aluminum bar.



*Figure 21: Screwing the Aluminum arms into the wooden base.*

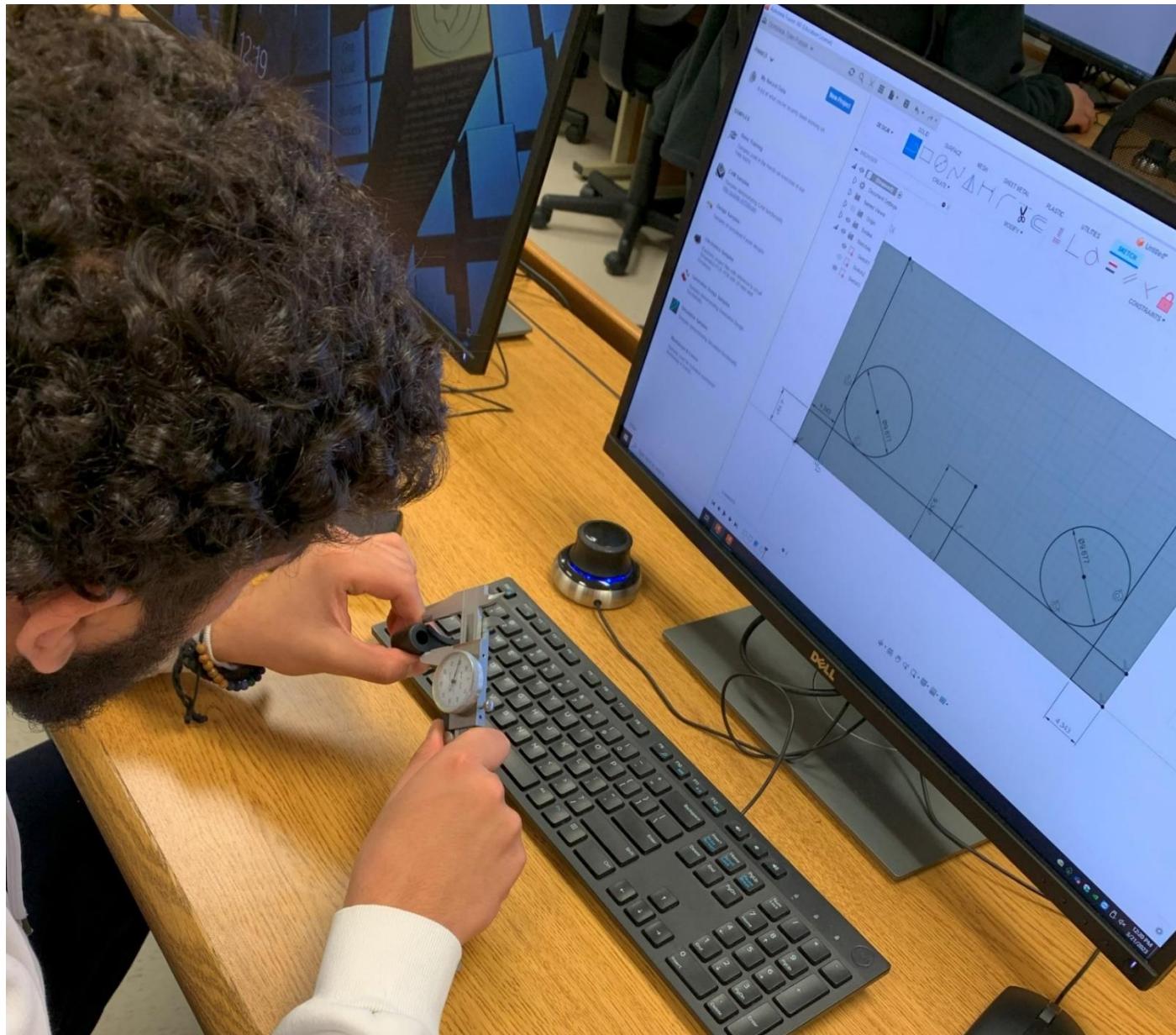


Figure 22: Creating a CAD model part of the bottom part of the clip to attach it to the arm of the Clip-on-Crutch



*Figure 23: First iteration of the CAD part, the final design used 100% Nylon infill.*

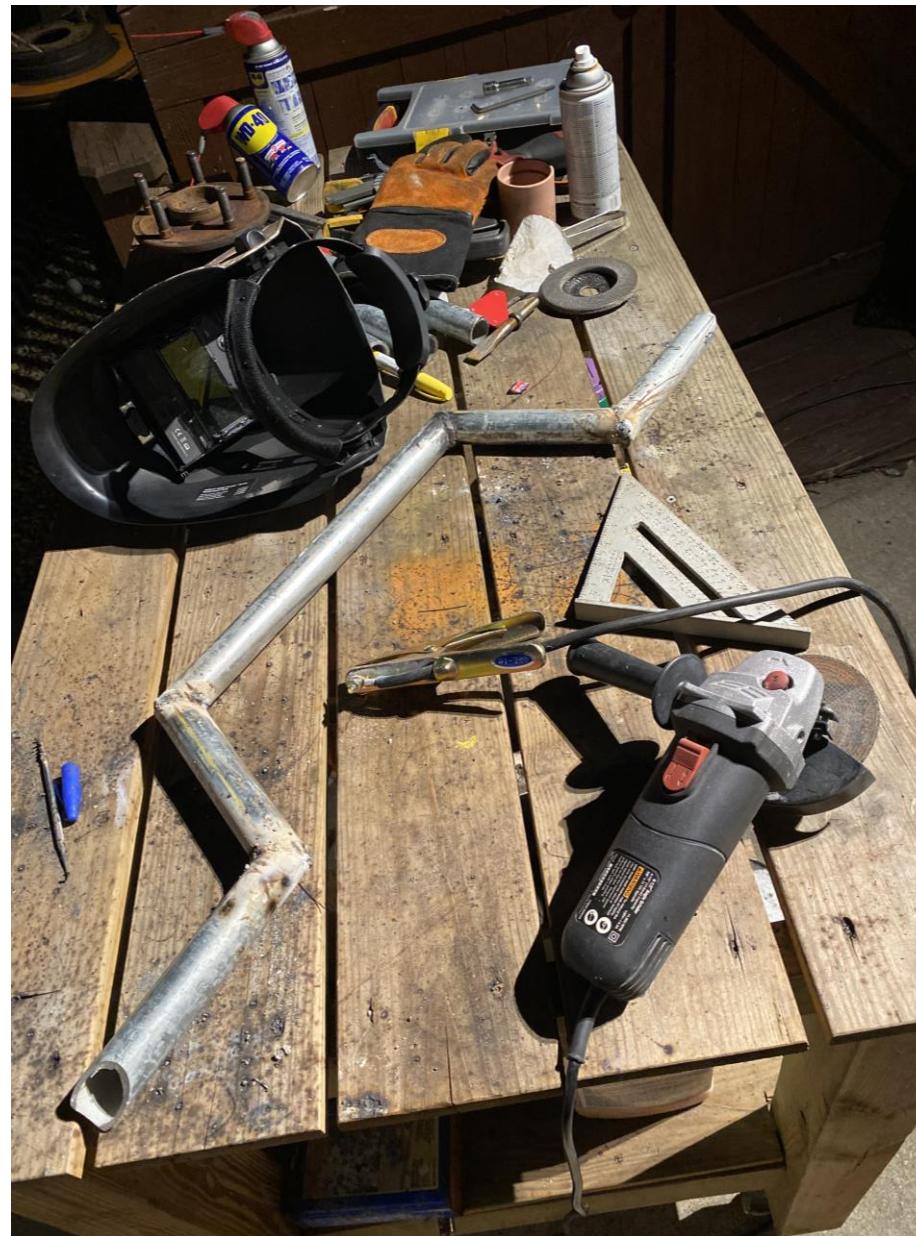




*Figure 24: Finished prototype of the Clip-on-Crutch, with the clip fully assembled to the arm.*

**U-Bar**

*Figure 25: Marking up where cuts will be made on the steel.*



*Figure 26: Halfway done with welding, can see cuts made to the bar.*

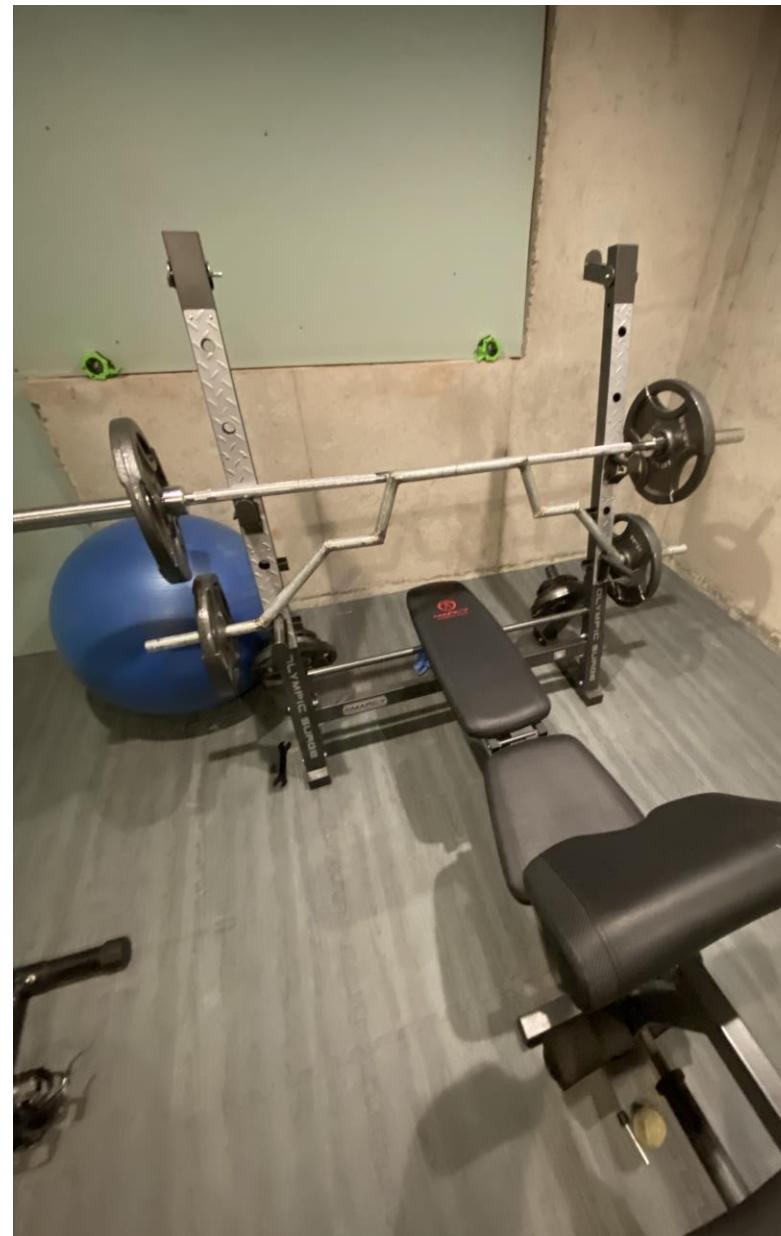


Figure 27: Finished product of U-Bar prototype, with normal barbell for reference.

**Testing Procedure**

- Reps Test
  - 45 lbs, 90 lbs, 135 lbs, 185 lbs, and 225 lbs
  - Have the user rep the specified weight amount
  - Have a spotter with the user for
- Drop Test (Clip-on-crutch only)
  - 45 lbs, 90 lbs, 135 lbs, 185 lbs, and 225 lbs
  - Drop the bar from a full extension height

**U-Bar**

- i. Place weights on U-Bar
- ii. Commence Rep test for the U-Bar
- iii. For failed reps, just let go and the bar should just be above the lifter's chest.

**Clip-On-Crutch**

- i. Attach properly to both ends of the bar
- ii. Put weights onto the bar at incremental weights
  - a. The crutch must be able to support each weight amount standing up before commencing the rep test
  - b. Examine for damage before each test
- iii. Have a user complete the rep test, make sure full range of motion is achieved

iv. Commence Drop Test

- Safety Considerations
  - Human Spotters
  - Coach Brunner and other strength coaches will be supervising

## Testing Results

### U-Bar

Rep Test:

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Pass	N/A	Hard to rack, wobbly b/c of height
95	Pass	N/A	Next design would need to be longer to improve racking capability
135	Pass	Scratches on racking portion	
185	Pass	N/A	
225	Pass	N/A	

### Clip-On-Crutch

Rep Test:

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Pass	N/A	Suggested to have looser clip - let it spin
95	Pass	N/A	Liked it - mentioned it could be used as a potential training device as well
135	Pass	N/A	
185	Pass	Screws loosened - retightened	
225	Pass	Solid Overall Structural Integrity	

Drop Test:

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Fail	3D Print part broke - supports bent	Need to have stronger parts - machined steel parts would be wanted
95	N/A	N/A	Learned how it would most likely break - would have spare parts with package
135	N/A	N/A	Material difference - weight would change
185	N/A	N/A	
225	N/A	N/A	

## PHASE 4: Next Steps

### Recommendations

Looking into the future for this project, we have a few changes that would help our designs in the manufacturing process.

1. Manufacturing
  - a. Clip-On-Crutch
    - i. Stronger raw materials are needed with less reliance on joints.
    - ii. More modular and ergonomic design to allow for final production.
  - b. U-Bar
    - i. Make the bar longer, and use solid material to make it standard barbell weight.
    - ii. Extend the bends and edges to lower the rotational inertia to allow for a smoother user-experience.
2. Final Notes:
  - a. Both solutions are both viable and functional solutions, and we are proud that they came out the way we designed them
  - b. And we are looking to improve using feedback for our final product

## Reflections

Isaiah Boktor: Looking back on these last 8 months has been crazy. It is hard to remember the start of this project and to remember what it felt like to begin on this journey of EDD. However, I can confidently say that I enjoyed it very much. Throughout EDD I have learned a lot about myself, engineering, and dealing with others. This project is not just a year's work, but a culmination of the last four years of our lives put into project form. We all worked extremely hard this year and I'm proud to say that we came up with viable solutions. This project went well for me and I put in a lot of work to make it happen. It was well defined and we worked good as a team to push this project forward and stay in the timeline. I'm glad that I picked this problem and that we worked through some solutions to come where we are today and hopefully we can take what we learned throughout this year and apply it in our lives for the future so we can all make a positive change in this world. The AutoSpot has been my favorite project of Engineering at Walton.

Tyler Jones: As I reflect on the last Year, I'm able to say confidently I enjoyed our project. It had its ups and downs from beginning to end but I'm proud of what we've accomplished. Starting at the beginning of the year, I'm glad of my choice of the problem over the other 3 we brainstormed during class. However, though I liked my topic and lifting is a big hobby of mine, I was never truly passionate about the problem. I think my initial brainstorming was where I wish I would've put more effort. Looking back, I know if I had put more time in I could have come up with a problem that I was 100% invested in. However, this doesn't mean I didn't like the problem, I just feel I could've done better. To repeat myself I am very proud of what we accomplished. I love that we were able to have a lot of fun with it as we began to brainstorm solutions. After all, our group had good chemistry as we have been friends for a while. As we selected 4 designs to prototype, I was happy with the one we chose, I was really excited to begin construction of the Follow Spotter. However, I became very disappointed as I searched but couldn't find cheap parts that would fit the needs of the construction and I had to abandon the prototype. Our testing was really cool to do and I

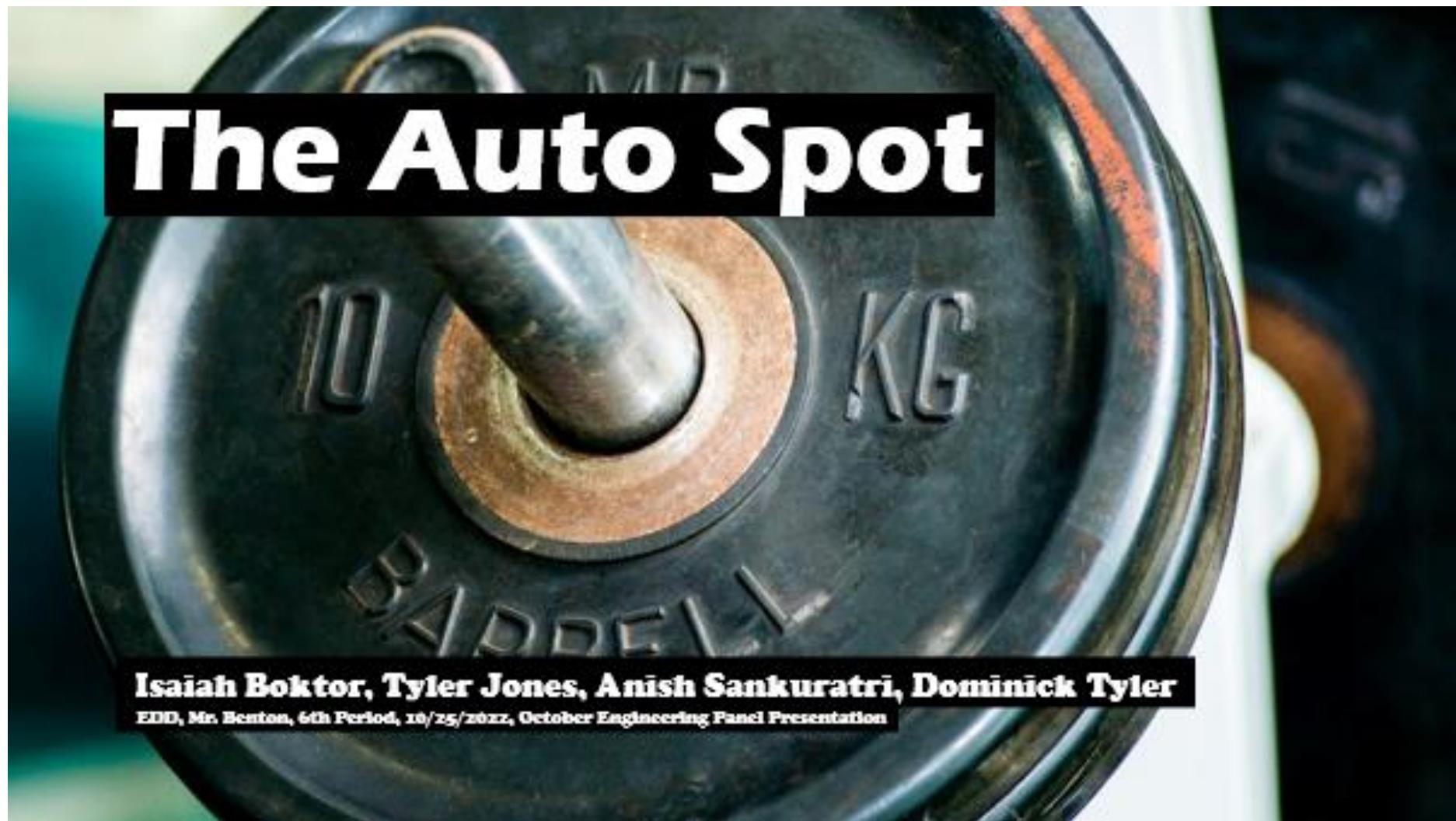
was much more impressed with the results than I had expected, especially that of the Ubar. I remember being very nervous for the final presentation, but we all did great on it. It probably helped that we would distract each other while practicing and I would listen to music while practicing by myself. To recap, I'm very happy of what we accomplished and truly enjoyed my first opportunity to

Anish Sankuratri: Wow! What a year! This project was truly something special. Just to recap, a brief description of the project is the auto spot, an invention aimed to create a way to where home users of a bench press machine or bench press style variation using a barbell would not have to worry about injuring themselves doing that exercise, we started off with an autonomous design and then we transitioned into passive designs and then we transitioned into static designs. But enough of that information stuff. My true feelings on the project were that of progress and teamwork. I had a great team working with me on this project, while we were all good friends, and wanted to goof around, we also kept each other in line when tasks needed to get done. Also, we made sure that we all practiced our presentations together to ensure success during the live presentation. All in all, this project experience was great, and I couldn't have done it with a better team.

Dominick Tyler: Reflecting on this year, the project was an overall massive success. We were able to create two strong and viable solutions to our problem, and while they do need improvement, we knew that they wouldn't be perfect off the rip. Maintaining a more consistent work ethic throughout the year would be something we could have done better. There were weeks where we were working non-stop, and others to be put bluntly were not very productive. Our lessons from our first year class were reinforced with our final designs, and personified the acronym KISS: Keep It Simple Stupid. Our final solutions were static ones, that were made with a combined total of \$150 dollars between the two of them. Creating a relatively cheap and effective solution was a major part of our goals for our designs. All in all we became much stronger presenters, and how to work as a group better. I made some life-long memories with my friends, and grew a lot as a person. This experience will be very important for my senior design project that I would have to make as a senior in college.

## Presentation Materials

## Problem Justification Presentation



**People who workout at home  
cannot spot themselves, which is  
dangerous and can lead to trauma  
and overexertion injuries.**



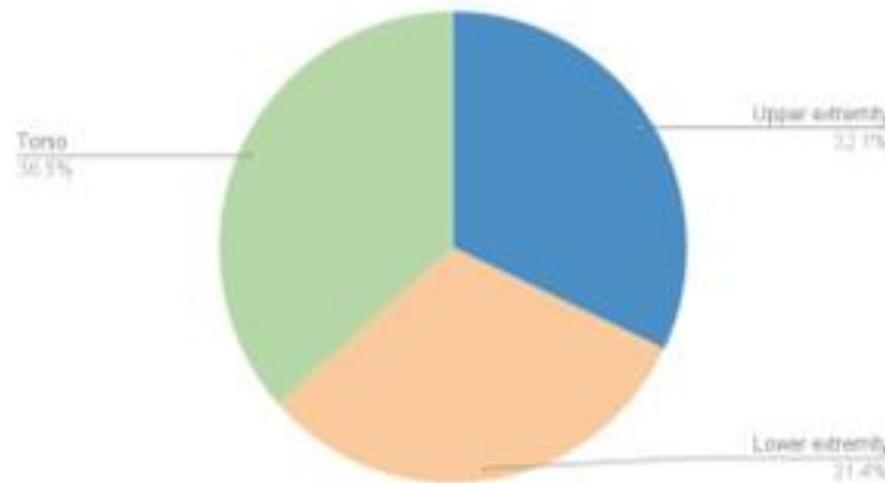
Why?

# Research

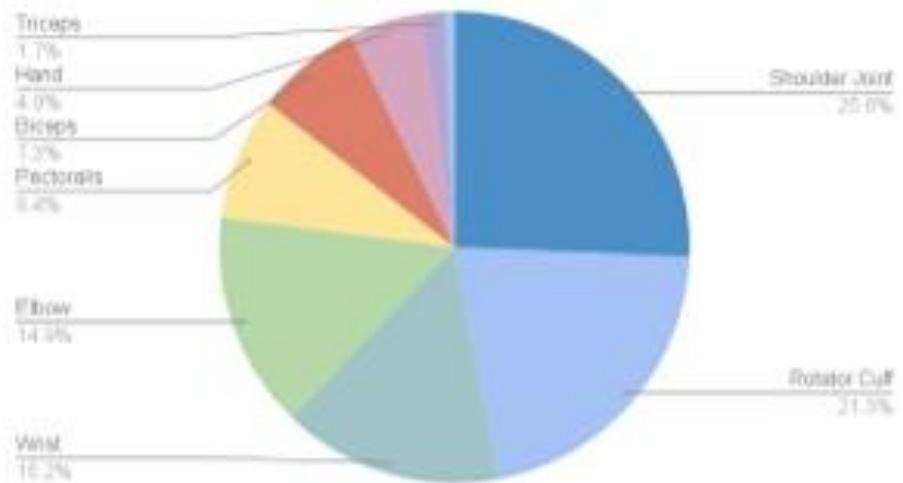


# Injury Statistics

Reported Injury Frequency by Region of the Body



Relative Frequency of Upper Extremity Injuries



# Injuries per Year

Gym Injuries: 57,058

Upper Extremity: 18,316

Bench Press  
10,440

Crushed  
6,055



## Smith Machine



Dale Sapecky, Store Manager &  
Former Bodybuilding Champion



Coach Kay, Football & T&F Coach  
Coach Spotz, Lacrosse Coach



Greg Carson, Store Manager

# Experts

# Researched Patents

1

US6689027B1

David Gardikis, Jr.

2

US5989166A

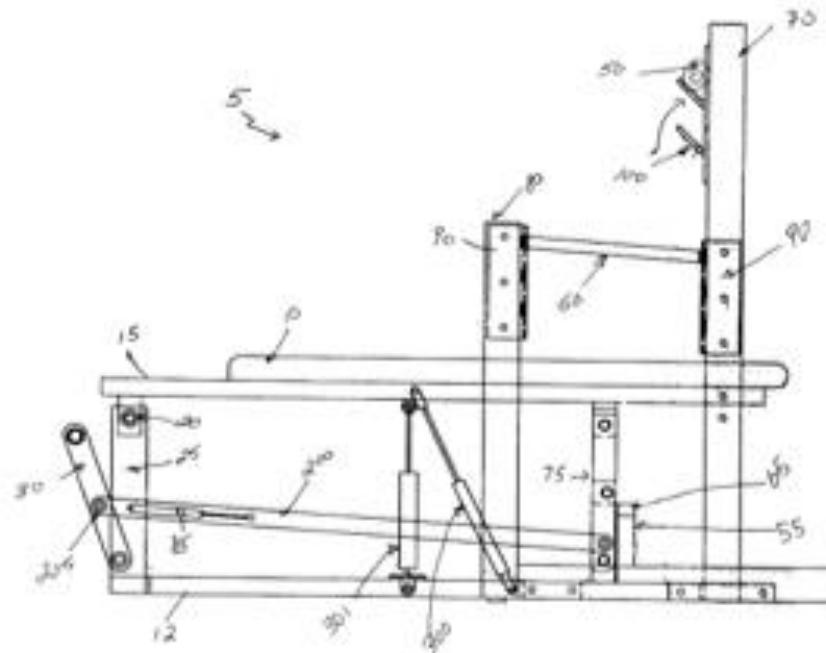
Kevin Capizzo  
Frank Capizzo

3

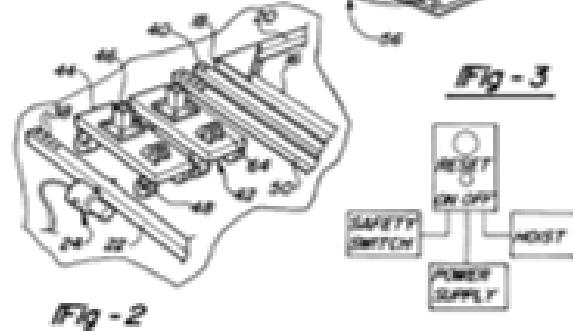
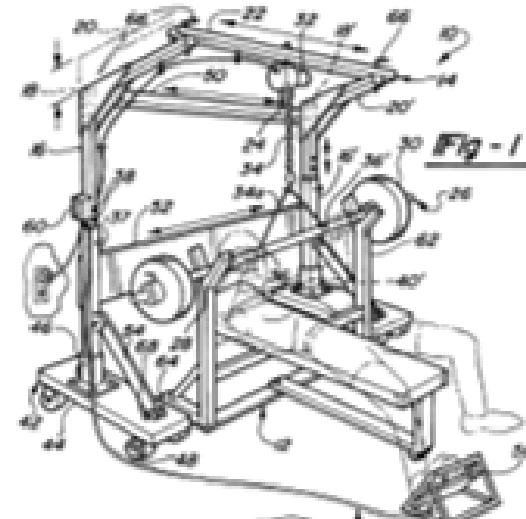
US20060148624A1

Sang-Wook Bae

# US6689027B1:Automatic Spotting Weight Bench



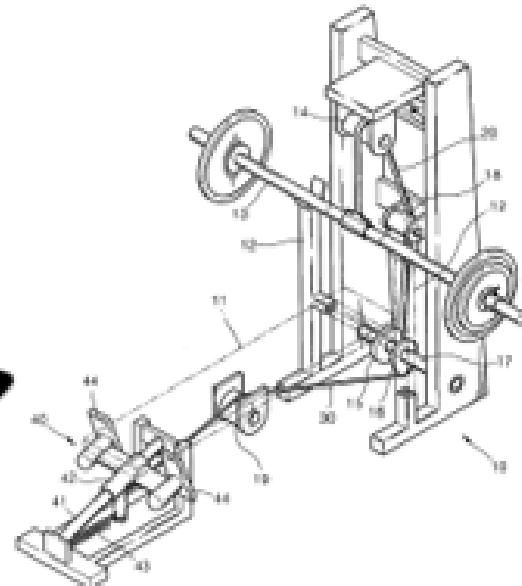
U.S. Patent Nov. 13, 1999 Sheet 1 of 2 5,989,166



# US5989166A: Adjustable Barbell Press Apparatus



Fig. 01



# US20060148624A1: Bench Press

# Conclusion

"Hey there! I think an  
autospotter sounds like a  
really cool idea! Stay  
Relentless!"

- Jesse James West



"Hi I think this is a great  
idea."

-Larry "Wheels" Williams

Since COVID broke out in 2020, people have been working out in home gyms more. People can't spot themselves when they barbell bench ("to spot" someone is having someone or something assist the lift when the user is getting tired or unable to lift the weight in order to maintain safety of the lifter). This is a problem in home gyms across America, according to various studies from BMJ Journal, The National Library of Medicine, and Legal Match, over 6000 people get injured by being crushed by bench press yearly. According to Greg Carson, a Store Manager for Lynx Barbell over 75% of his customers in 2021 have their own home gym compared to only 35% in 2018. According to Dale Sapecky, Store Manager for Premier Fitness Source and former Bodybuilding Champion, this problem affects home gym goers and even commercial gym goers of all experience levels. This solution could enhance the gym experience for many Americans.

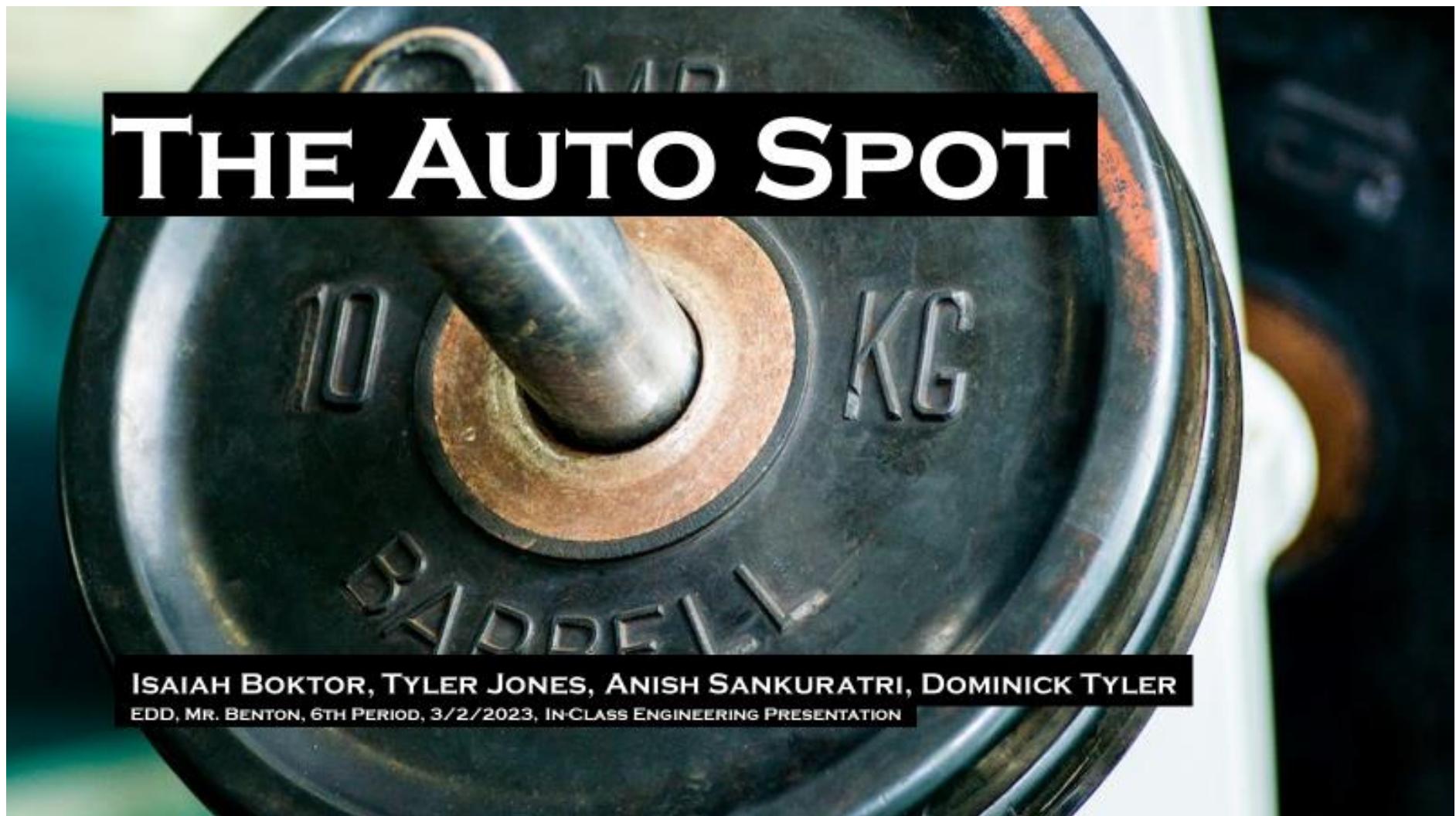
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Solution Development Presentation

# THE AUTO SPOT

ISAIAH BOKTOR, TYLER JONES, ANISH SANKURATRI, DOMINICK TYLER  
EDD, MR. BENTON, 6TH PERIOD, 3/2/2023, IN-CLASS ENGINEERING PRESENTATION



PEOPLE WHO WORKOUT AT  
HOME CANNOT SPOT  
THEMSELVES, WHICH IS  
**DANGEROUS AND CAN LEAD**  
TO TRAUMA AND  
**OVEREXERTION INJURIES.**

# PHASE 1

Defining the Problem



# Injuries per Year

Gym Injuries: 57,058

Upper Extremity:  
18,316

Bench Press  
10,440

Crushed  
6,055

# PHASE 2

Developing a Solution

## Design Specs

Safety

Feasibility

Durability

Consumer  
Needs

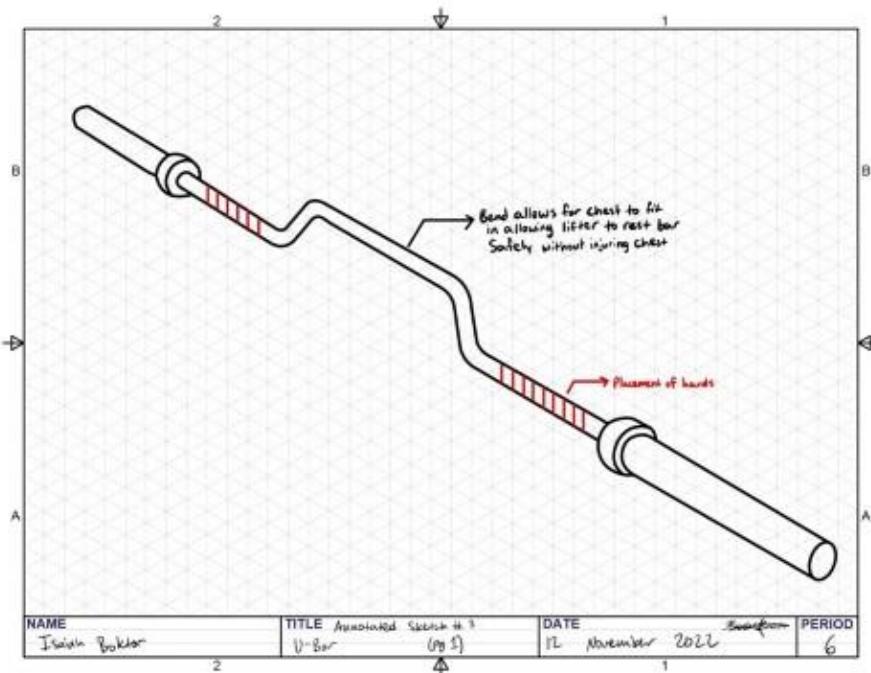
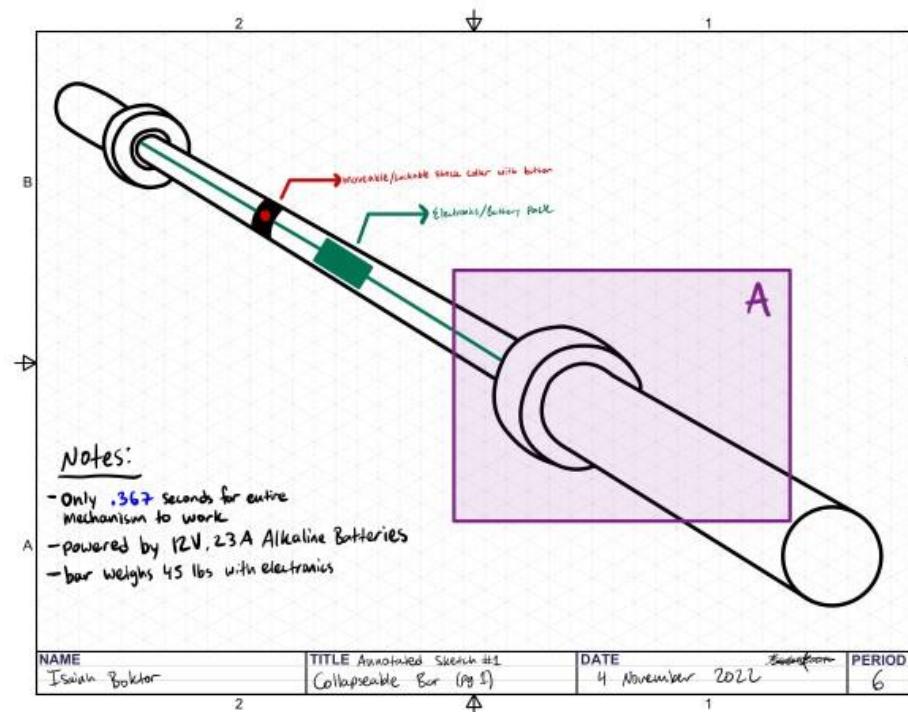
Cost

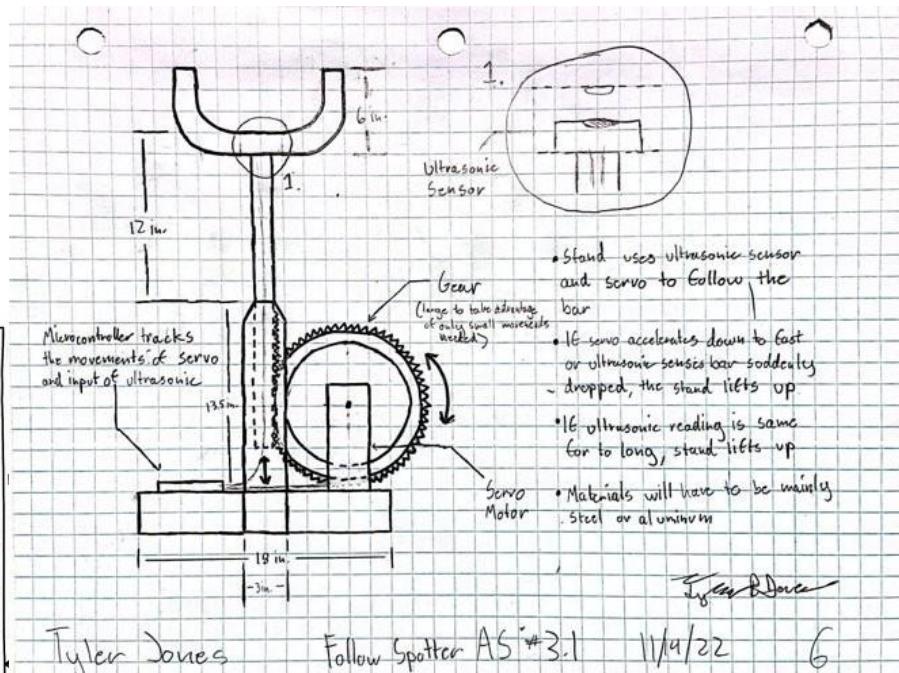
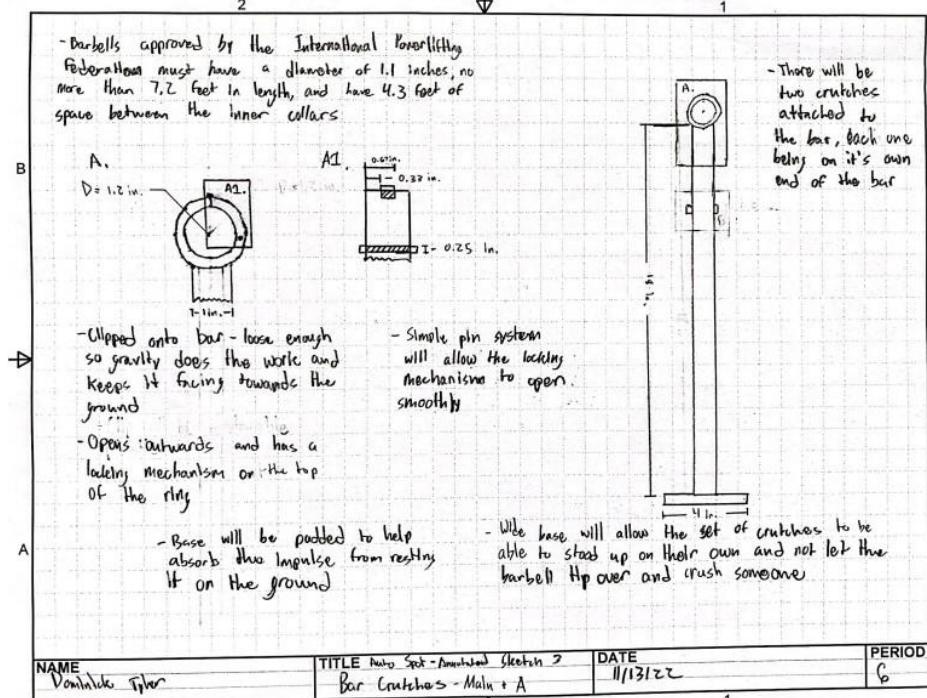
Performance

Product Life

Size/Weight

Aesthetics







Dr. Howard Chen



Dr. Brian Jones



Dr. Wayne Book

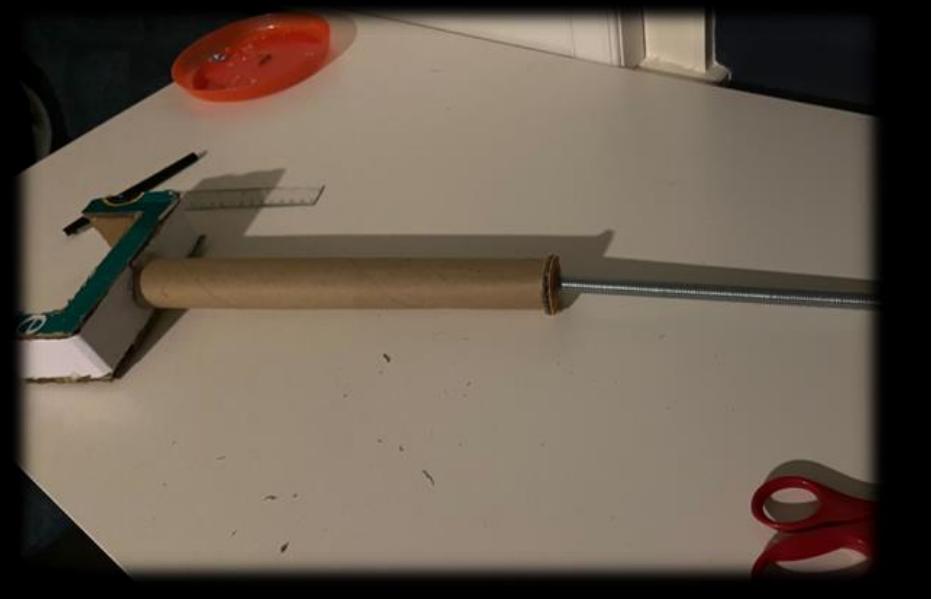
## Project Experts

# PHASE 3

Mockups



# The Follow Spotter

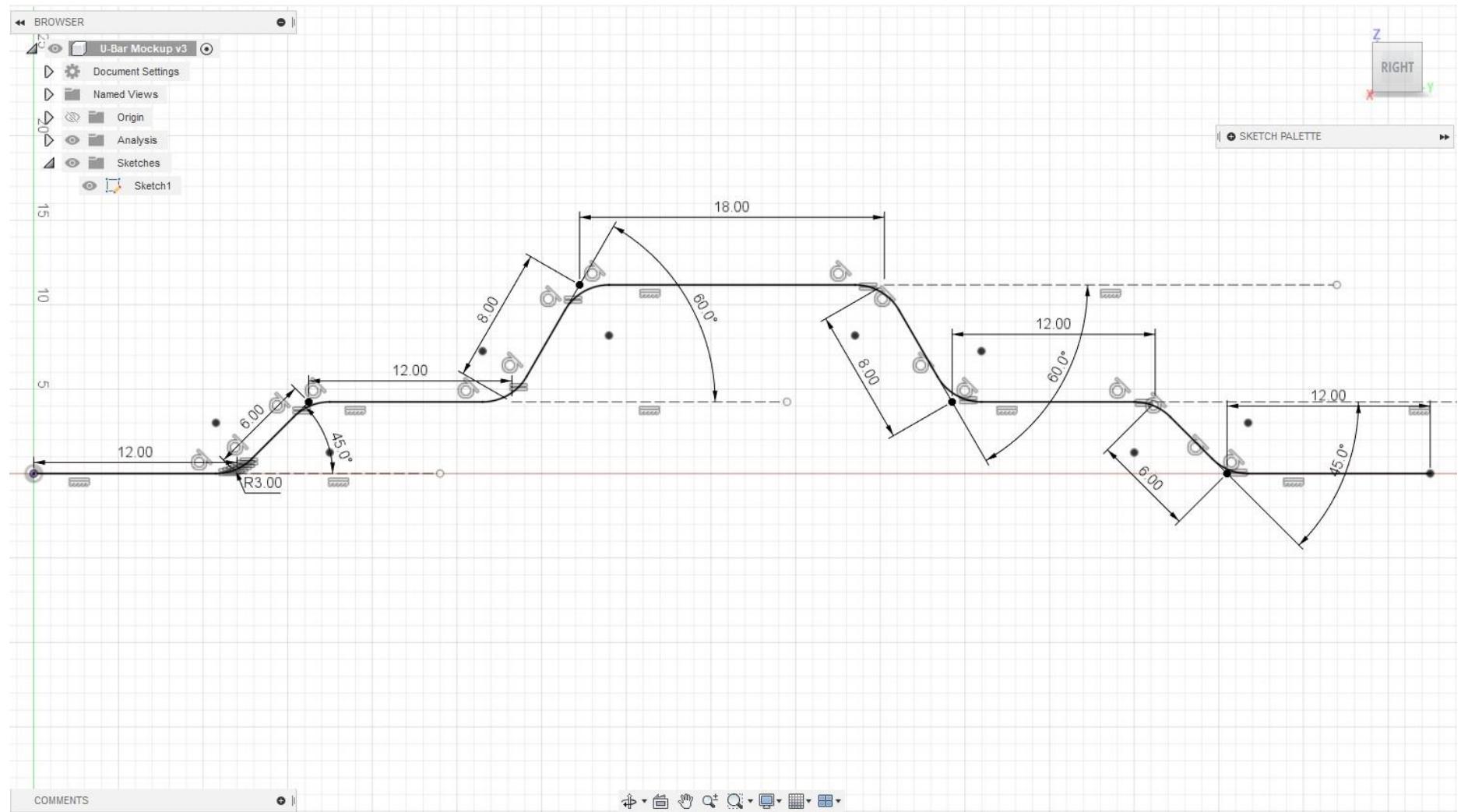


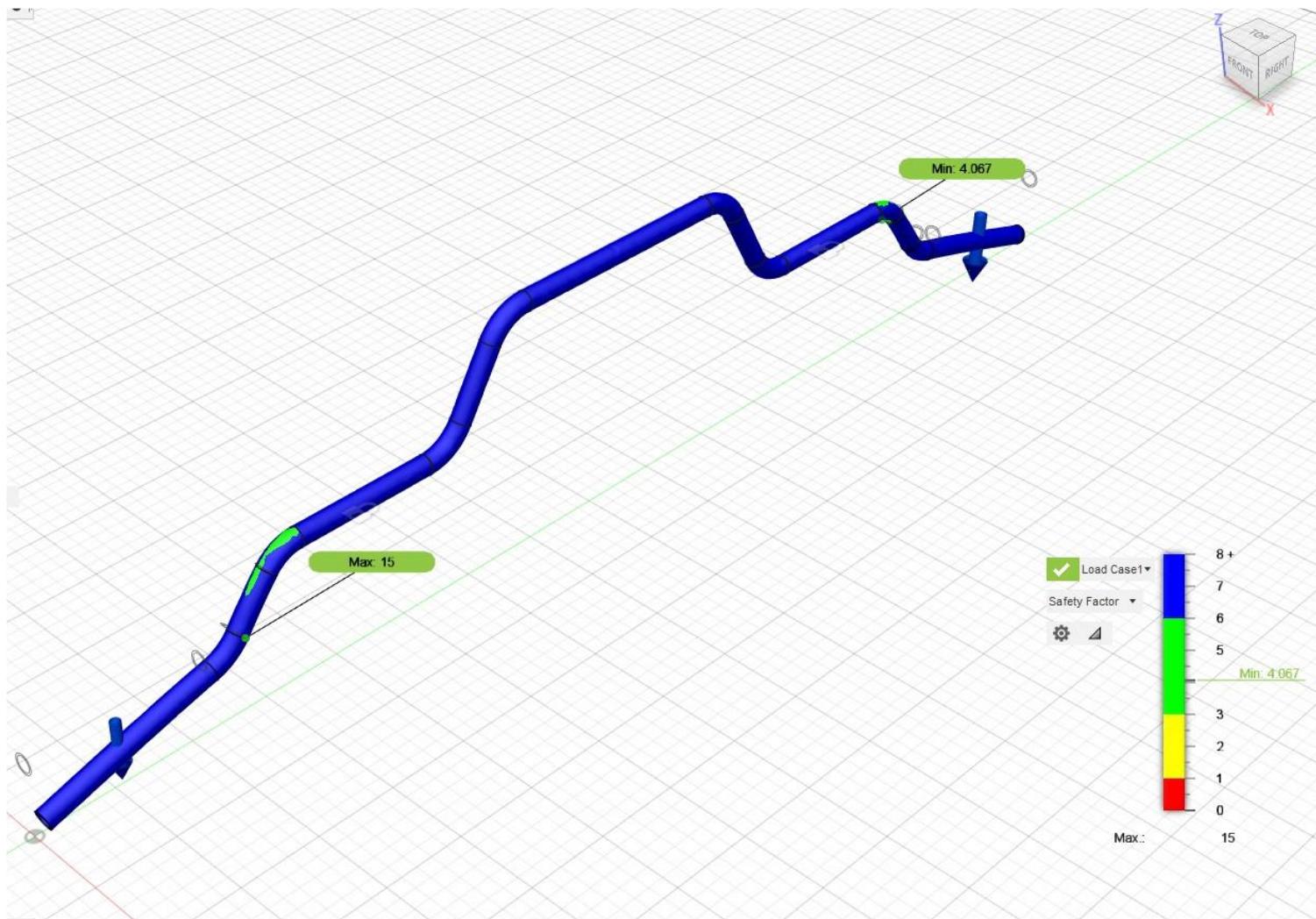


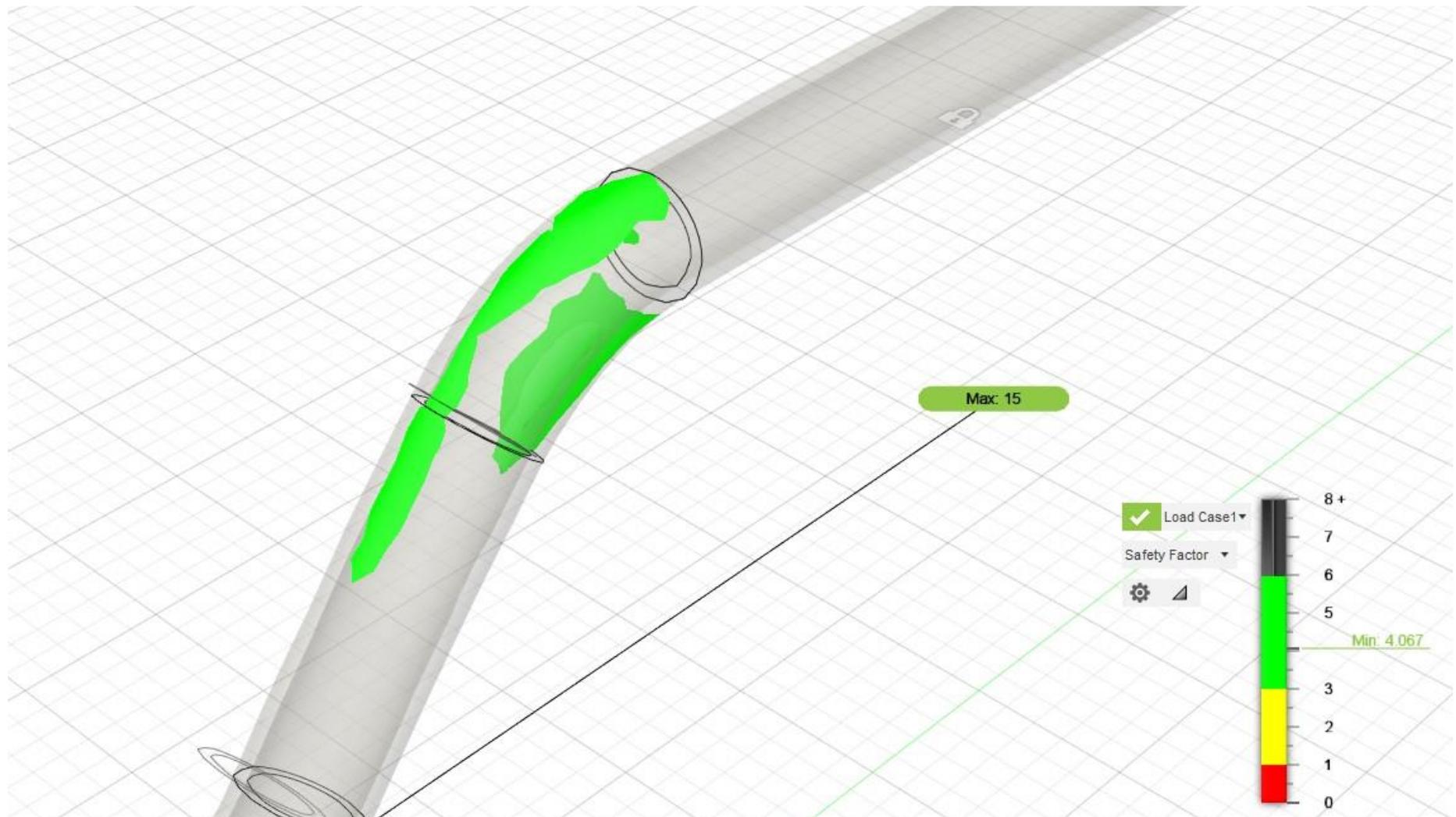


# PHASE 4

Prototyping & Testing











# Conclusion

"Hey there! I think an  
autospotter sounds like a  
really cool idea! Stay  
Relentless!"

- Jesse James West



"Hi I think this is a great  
idea."

-Larry "Wheels" Williams



Since COVID broke out in 2020, people have been working out in home gyms more. People can't spot themselves when they barbell bench ("to spot" someone is having someone or something assist the lift when the user is getting tired or unable to lift the weight in order to maintain safety of the lifter). This is a problem in home gyms across America, according to various studies from BMJ Journal, The National Library of Medicine, and Legal Match, over 6000 people get injured by being crushed by bench press yearly. According to Greg Carson, a Store Manager for Lynx Barbell over 75% of his customers in 2021 have their own home gym compared to only 35% in 2018. According to Dale Sapecky, Store Manager for Premier Fitness Source and former Bodybuilding Champion, this problem affects home gym goers and even commercial gym goers of all experience levels. This solution could enhance the gym experience for many Americans.

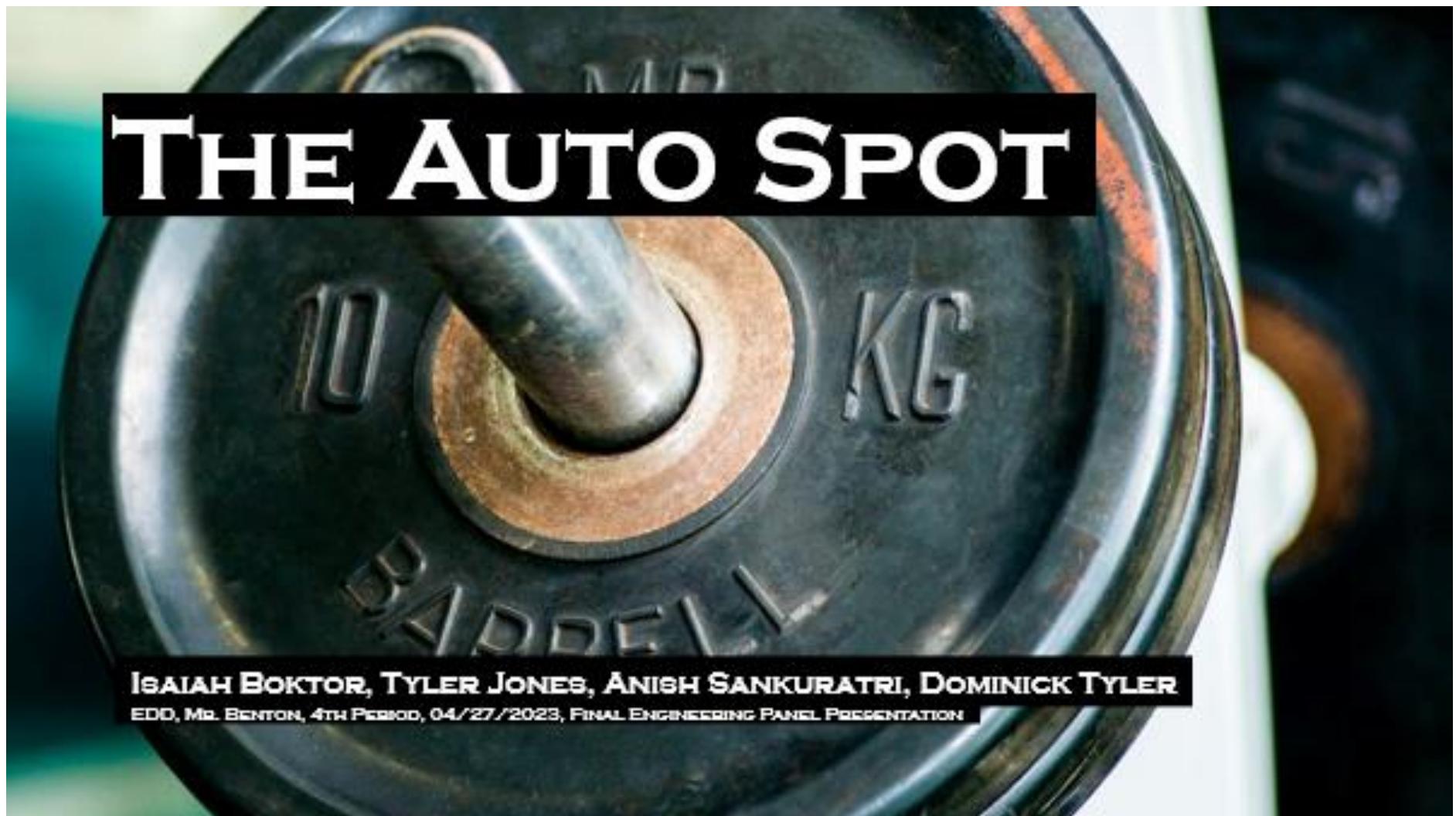
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Final Presentation

# THE AUTO SPOT

**ISAIAH BOKTOR, TYLER JONES, ANISH SANKURATRI, DOMINICK TYLER**  
EDD, Mr. BENTON, 4TH PERIOD, 04/27/2023, FINAL ENGINEERING PANEL PRESENTATION



# PHASE 1

*Defining the Problem*

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THEMSELVES, WHICH IS  
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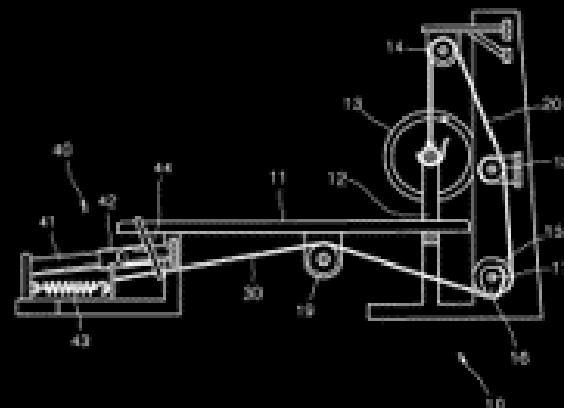
Coach Kay, Football & T&F Coach  
Coach Spots, Lacrosse Coach



Greg Carson, Store Manager

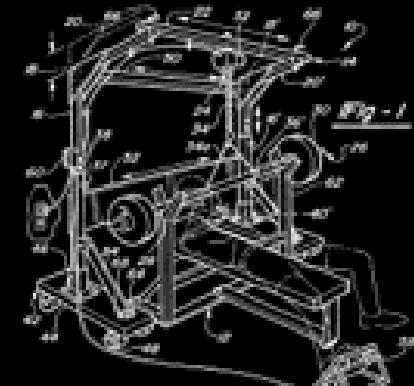
## PROBLEM EXPERTS

Fig. 02

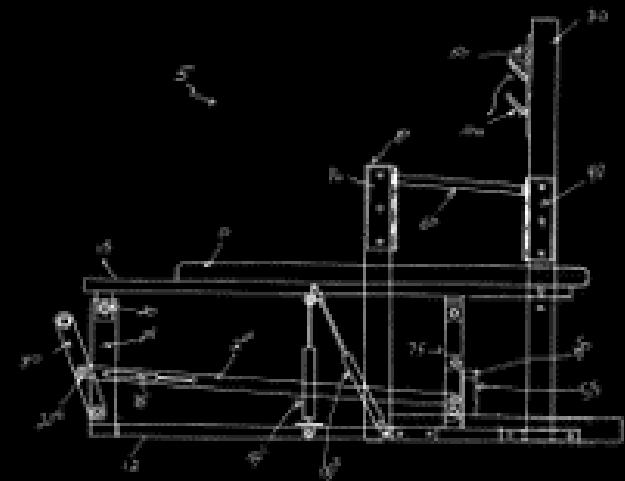


US6689027B1  
David Gardikis, Jr.

U.S. Patent No. 6,689,027 Date of Pat. 11/10/2003 Inventor(s) Kevin Capizzo & Frank Capizzo



US5989166A  
Kevin Capizzo & Frank Capizzo



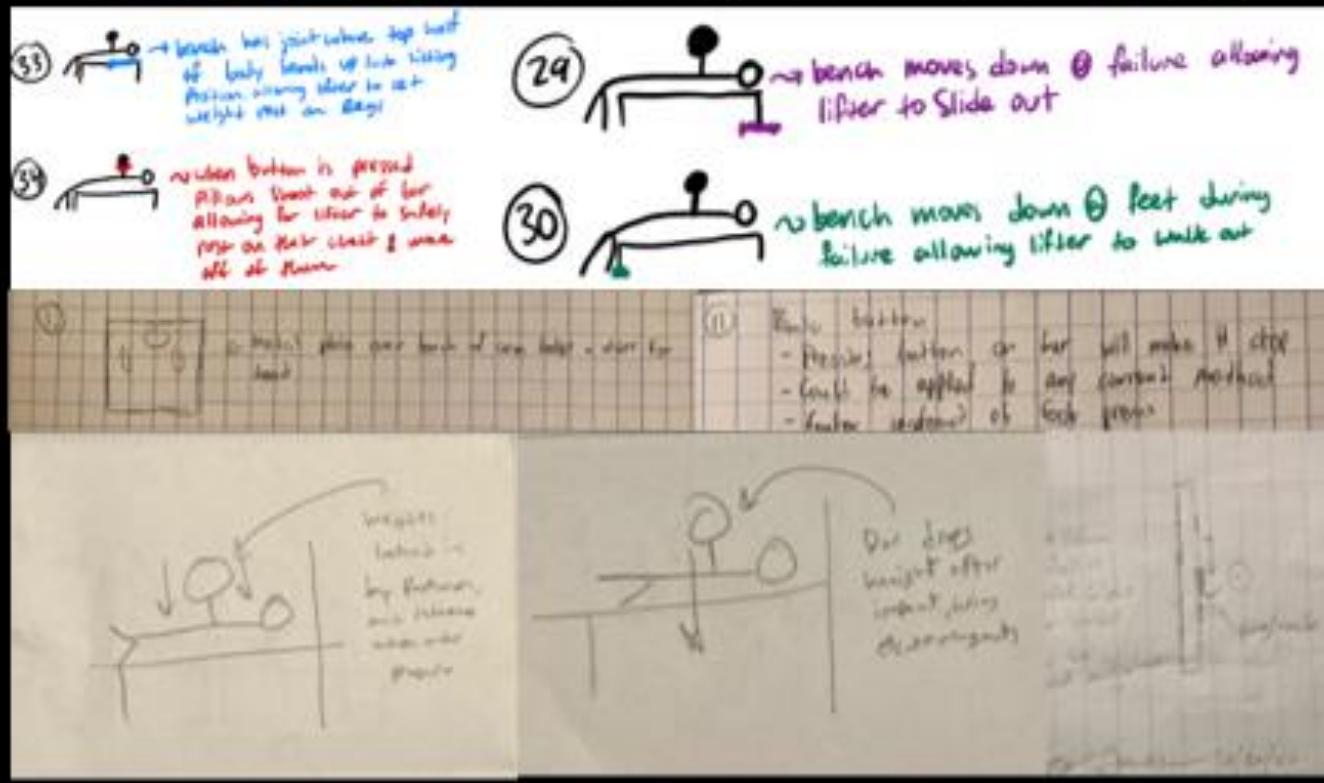
US20060143624A1  
Sang-Wook Bae

## PREVIOUS SOLUTIONS

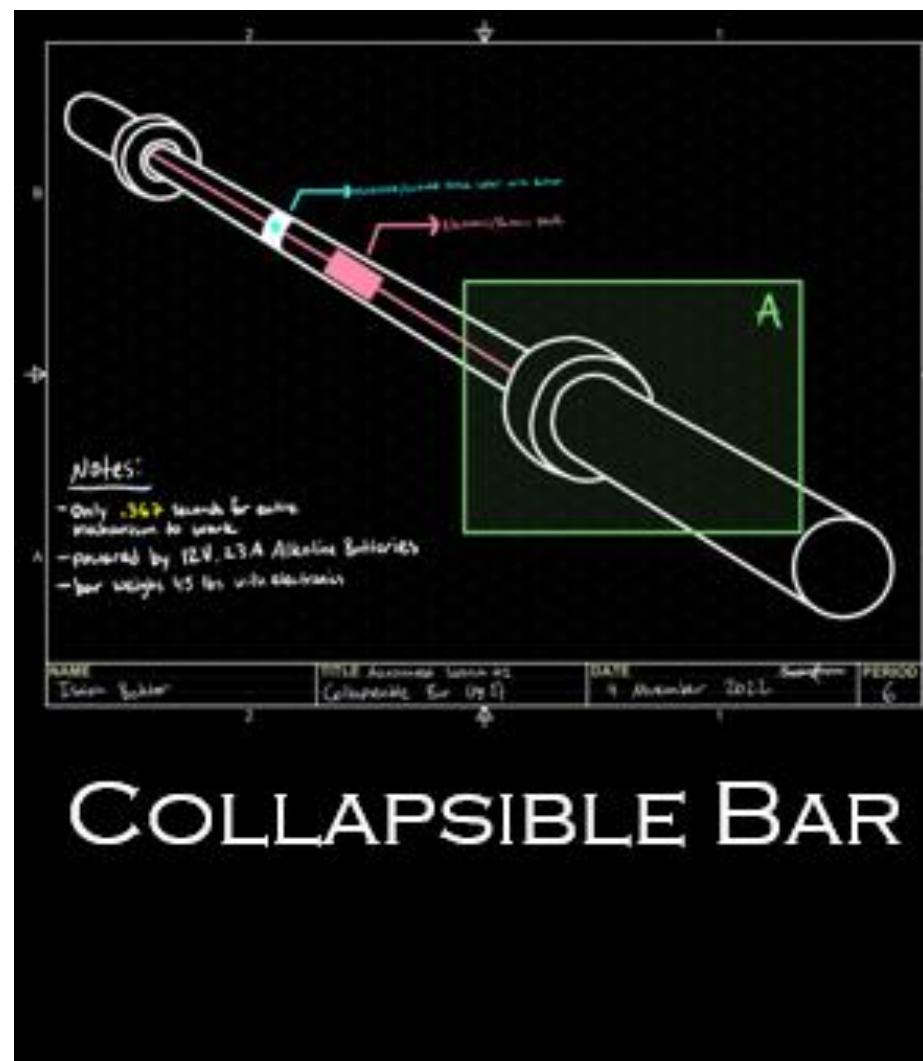
# PHASE 2

Developing a Solution

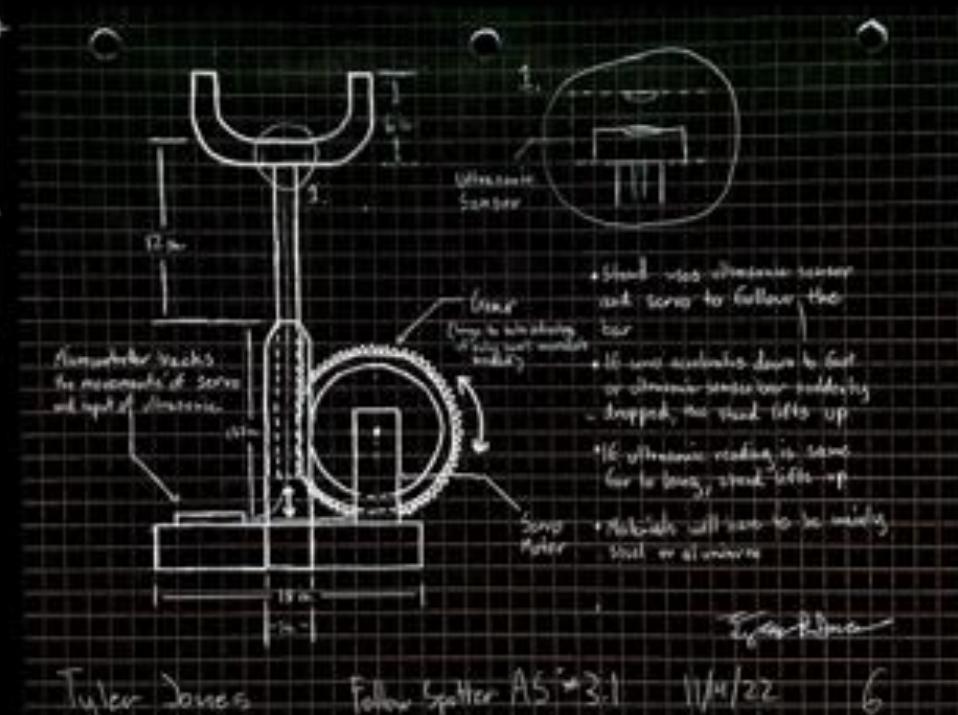
# BRAINSTORMING SKETCHES

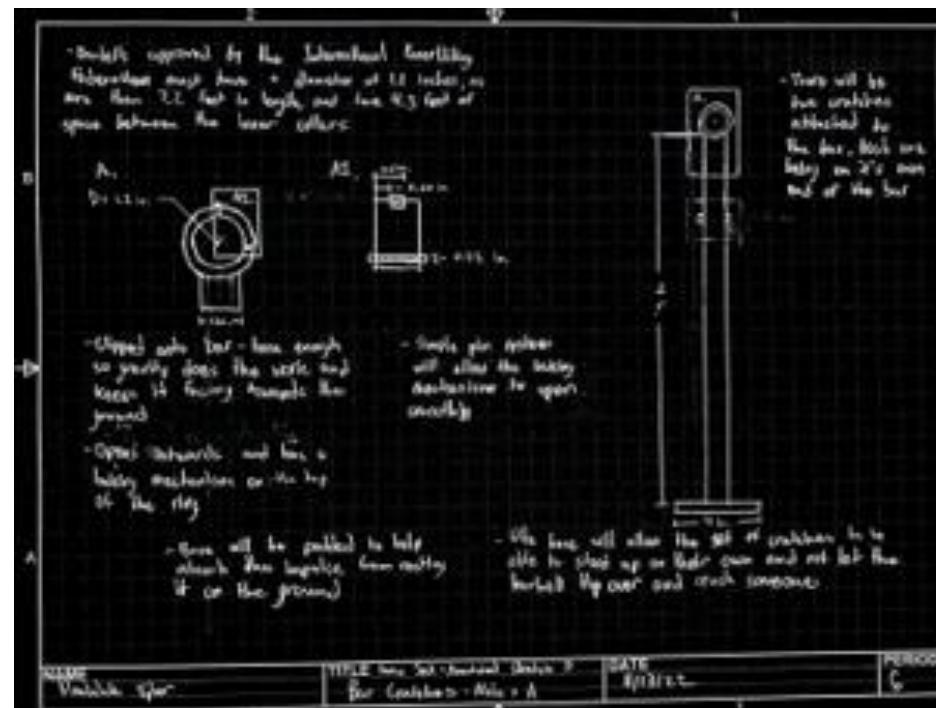


# DECISION MATRIX

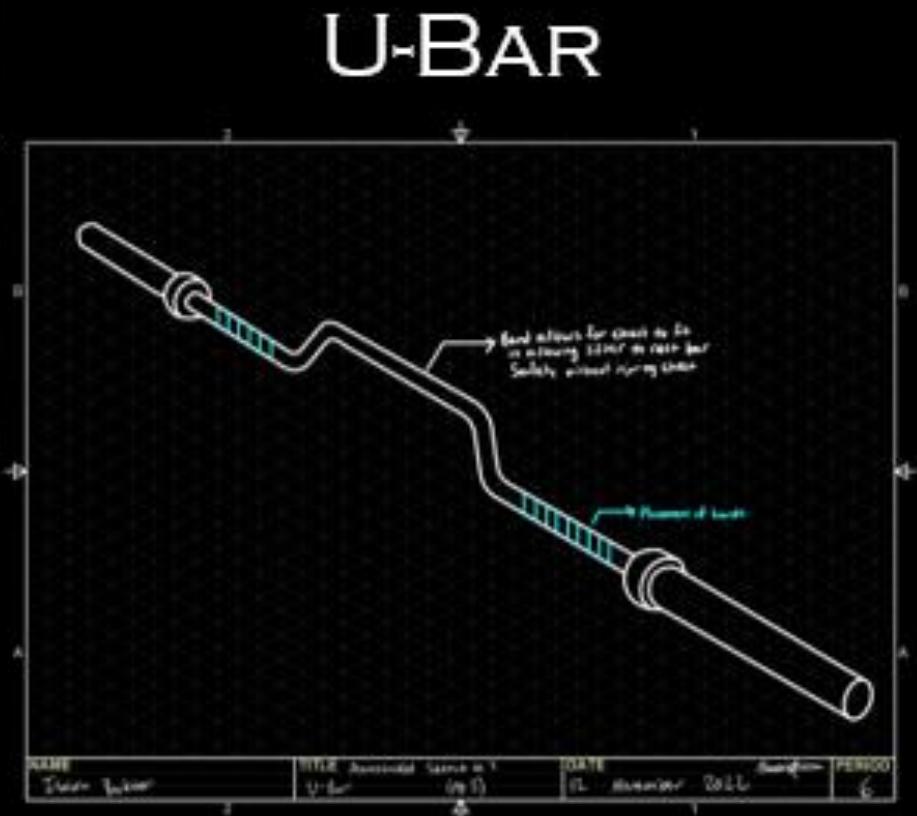


## FOLLOW SPOTTER





## CLIP-ON-CRUTCH





Dr. Howard Chen  
Professor of Mechanical  
Engineering & Admin of Senior  
Design Project @ UAH



Dr. Brian Jones  
Professor of Electrical Engineering



Dr. Wayne Book  
Professor of Mechanical  
Engineering

SOLUTION EXPERTS



FOLLOW SPOTTER

COLLAPSIBLE BAR





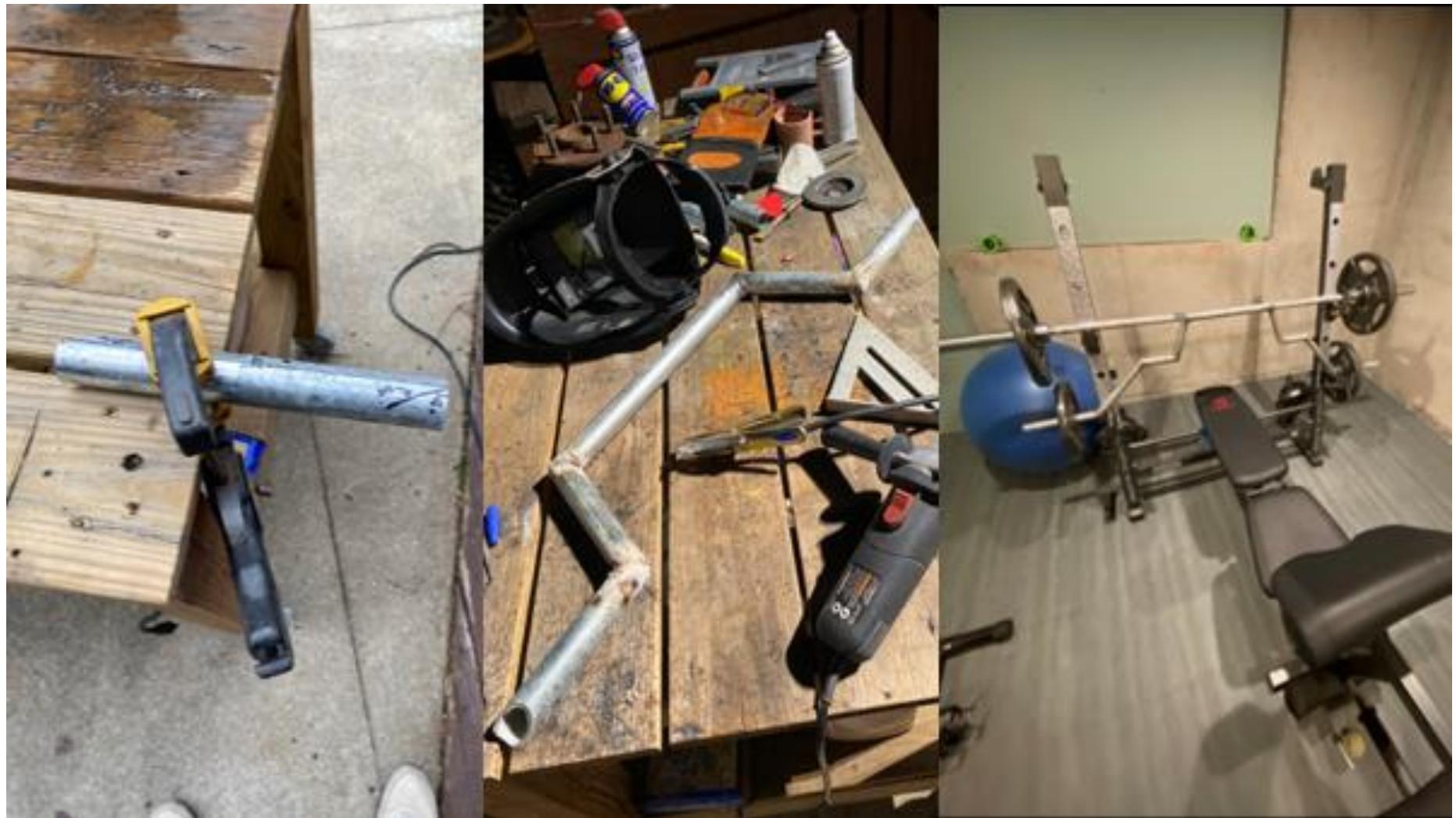
CLIP-ON-CRUTCH



U-BAR

# PHASE 3

Prototyping & Testing





## TESTING PLAN

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45			
95			
135			
185			
225			







## CLIP-ON-CRUTCH FALL TEST

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Fail	3D Print part broke - supports bent	Need to have stronger parts - machined steel parts would be wanted
95	N/A	N/A	Learned how it would most likely break - would have spare parts with package
135	N/A	N/A	Material difference - weight would change
185	N/A	N/A	
225	N/A	N/A	

Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Pass	N/A	Suggested to have looser clip - let it spin
95	Pass	N/A	Liked it - mentioned it could be used as a potential training device as well
135	Pass	N/A	
185	Pass	Screws loosened - retightened	
225	Pass	Solid Overall Structural Integrity	

## CLIP-ON-CRUTCH LIFT TEST



Weight on User (lbs)	Pass/Fail	Damage	Feedback & Notes
45	Pass	N/A	Hard to rack, wobbly b/c of height
95	Pass	N/A	Next design would need to be longer to improve racking capability
135	Pass	Scratches on racking portion	
185	Pass	N/A	
225	Pass	N/A	

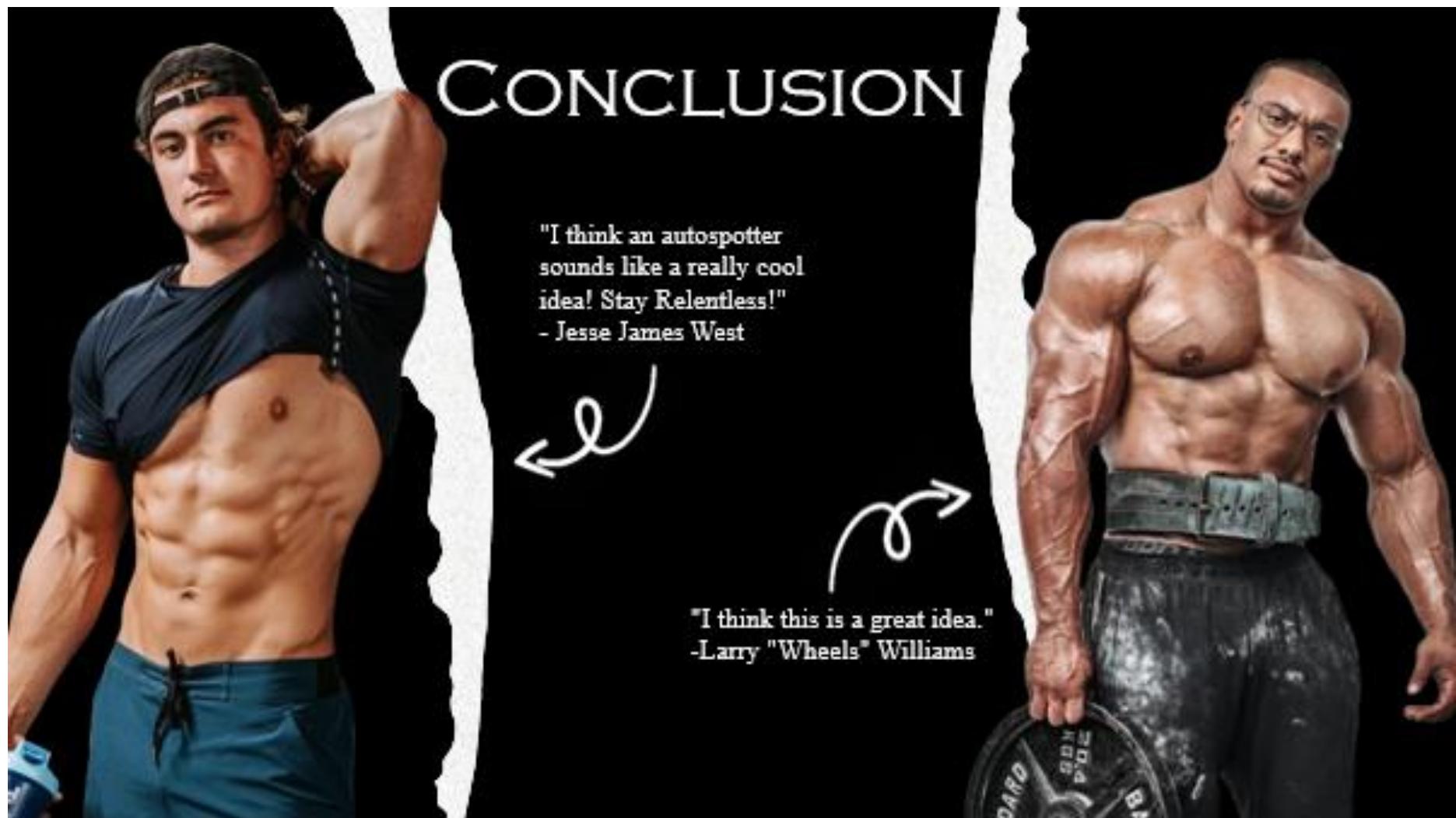
## U-BAR LIFT TEST





# PHASE 4

Moving Forward



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## References

## Appendix

- Spotting: having someone or something assist the lift when the lifter fails a rep or needs help racking and unracking the weight.

