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JME 4110: Plant Tissue Sampler

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Joint Engineering Program

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This document contains the design for a device to take plant tissue samples from a plants leaves. Within the report are design ideas, final design, rationale behind design choices based off of customer interviews, relevant codes and standards, bill of materials, and part drawings. The final drawings of the device and its parts are included along with pictures with descriptions of the parts and video links of a demonstration and presentation.

JME 4110
Mechanical Engineering Design Project

Plant Tissue Sampler

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1 INTRODUCTION

1.1 VALUE PROPOSITION / PROJECT SUGGESTION

Our device will be used to take plant samples and make it easier to place into test tubes. The current process being used by our customer is a paper hole punch. They have had trouble with the samples getting stuck in the hole where the hole punch is located. They also have to fumble about to get it into test tubes or testing trays. Our design should alleviate some of these difficulties and make a more streamlined process to take plant samples and transport them to the tubes or trays. The device should also not contaminate the plant samples and should be resistant to ethanol for cleaning purposes.

1.2 LIST OF TEAM MEMBERS

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2 BACKGROUND INFORMATION STUDY

2.1 DESGIN BRIEF

Proposed design for a plant tissue sampler and place them in a container. The materials used will be ethanol resistant. Another requirement for our design will be to ensure that the plant specimen is not contaminated. The design will be used by the Danforth plant science center. A simple, easy to use device is the focus for our design. We must accommodate our design based on OSHA regulations for plants sampling. First, the device will take individual samples out of plants. Then the device will dispense the samples into a container for lab testing. Throughout the process, the sample cannot be contaminated according to the OSHA regulations.

2.2 BACKGROUND SUMMARY

A search for existing patents pertinent to our device led us to two different patents that are shown in the figures below.

Manually operated hole punch
US 20090064509 A1
ABSTRACT

https://www.google.com/patents/US20090064509

A manually operated single hole punch employs a pair of pivoted members having squeezable handles. A pair of opposed jaws have canopies formed from transparent or semi-transparent material to facilitate alignment of the punch with the material to be punched and to observe a reservoir which receives punched remnants.

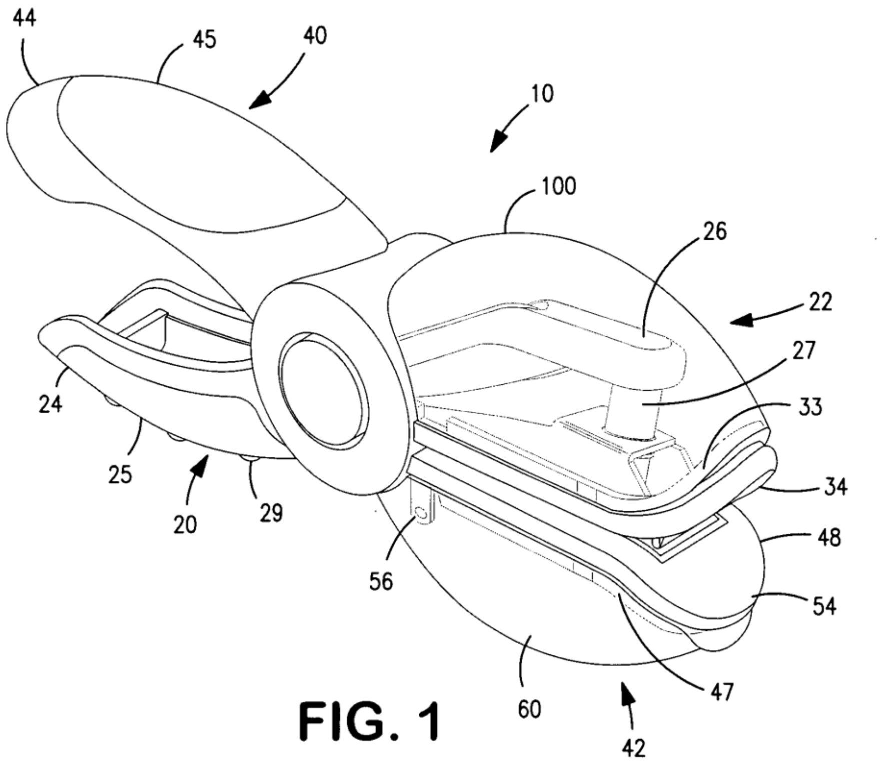


FIG. 1

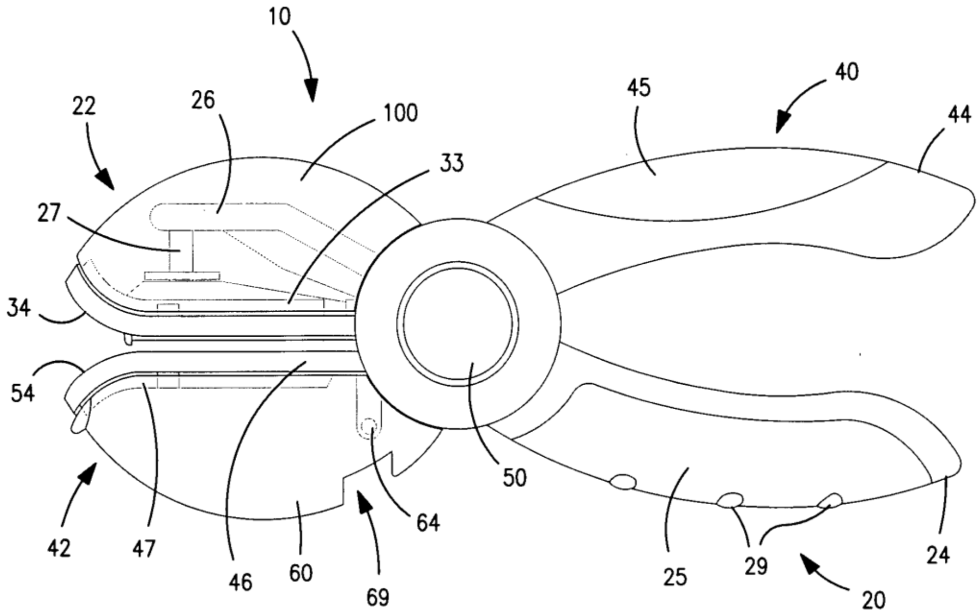


FIG. 2

Figure 1: Hole Punch Side and Orthoganal Views

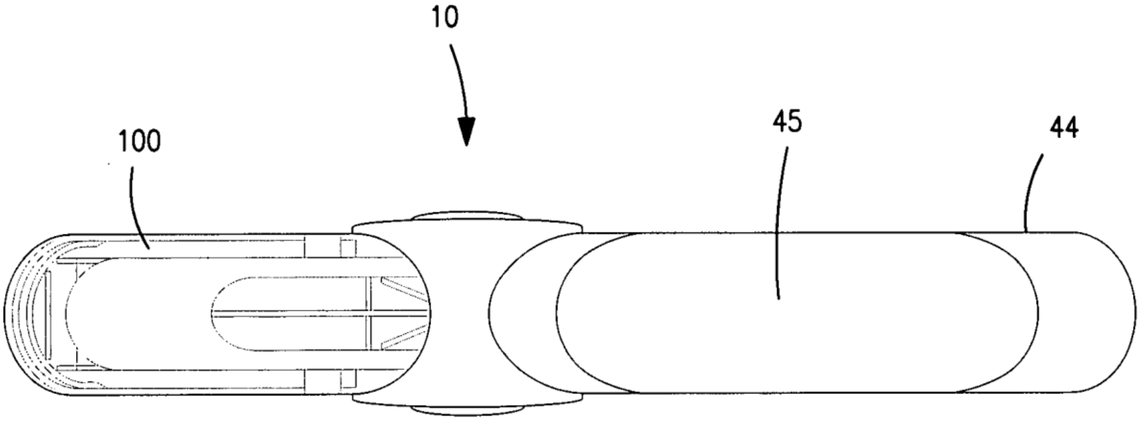


FIG. 3

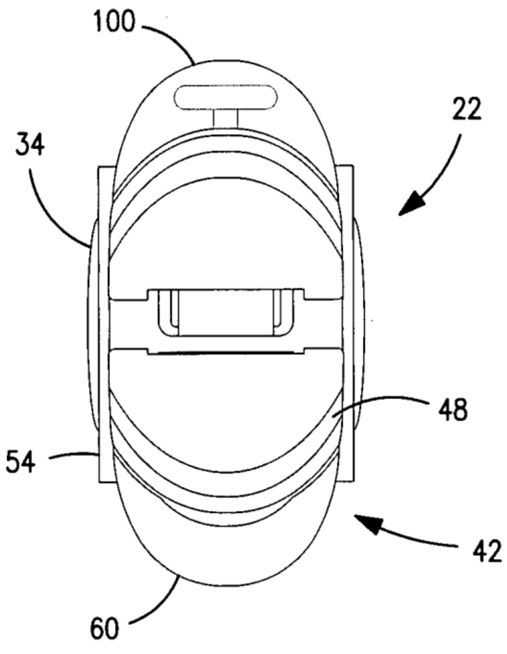


FIG. 4

Figure 2: Hole Punch Top and Front Views

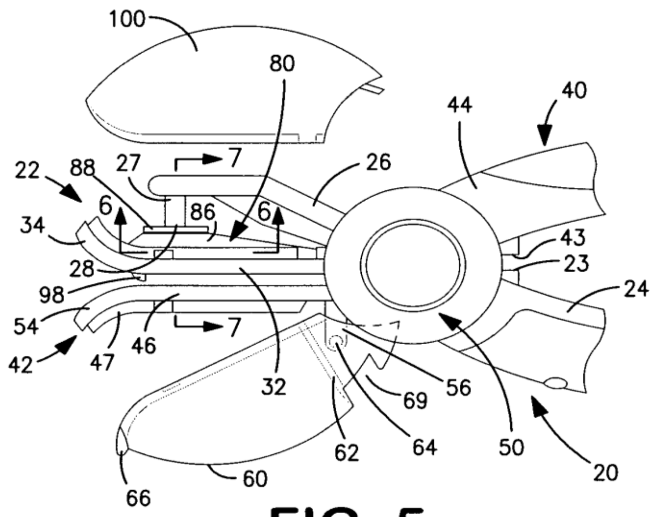


FIG. 5

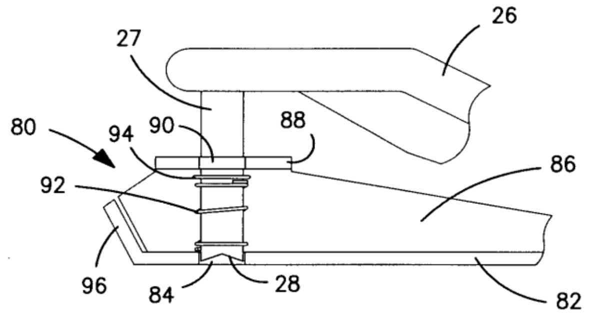


FIG. 6

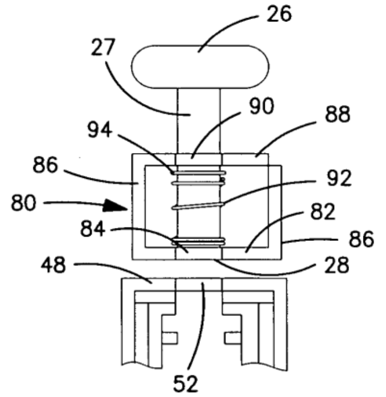


FIG. 7

Figure 3: Hole Punch Apparatus Views

DESCRIPTION

TECHNOLOGICAL BACKGROUND

This application relates to manually operated punches adapted for punching a hole in paper or similar materials. More particularly, this application relates to a single hole punch which is operated by squeezing a pair of handles.

In one embodiment a manually operated punch is adapted for punching a single hole. The punch employs a first member comprising a first handle and a first lever hammer which has a punch. A second member comprises a second handle. Opposed first and second jaws are disposed in fixed relationship to the second handle. The second jaw has an anvil aperture. The first and second members are pivotally mounted wherein the handles oppose each other and the jaws oppose each other so that the punch aligns with the aperture. The handles are normally biased apart, and the punch is displaceable into the aperture upon forcing the handles toward each other to thereby punch a hole. The second jaw has a canopy which forms a reservoir at the interior which is exteriorly visible for retaining the remnants of the punched hole.

In one embodiment the jaws each have canopies which are formed from transparent or semi-transparent material. The first and second jaws form a mouth which converges inwardly and is spaced from the punch. The mouth is configured as a narrow restriction to prevent a finger from being exposed to the punch. The handles preferably have a soft overmold portion to facilitate manual grasping and squeezing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side perspective view of a hole punch;

FIG. 2 is a side elevational view of the hole punch of FIG. 1 taken from a generally

FIG. 3 is a top plan view of the hole punch for the view of FIG. 2;

FIG. 4 is a front elevational view of the hole punch of FIG. 1.

FIG. 5 is an enlarged fragmentary side view, partly exploded, partly in phantom, and partly in an open position, of the hole punch for the view of FIG. 2;

FIG. 6 is an enlarged fragmentary sectional view of the hole punch taken along the lines of **6-6** of FIG. 5; and

FIG. 7 is an enlarged fragmentary frontal sectional view of the hole punch taken along the lines of **7-7** of FIG. 5.

DETAILED DESCRIPTION

With reference to the drawings wherein like numerals represent like parts throughout the several views, a manually operated hole punch is generally designated by the numeral **10**. The hole punch has a contoured, soft touch configuration which facilitates usage thereof and is further adapted to be operated in a safe and effective manner. The hole punch **10** preferably functions to receive a sheet of paper or similar material (neither illustrated) and to, upon manually squeezing a pair of handles, punch a single generally circular hole in the paper or material.

The hole punch **10** is relatively compact and in one embodiment has dimensions of approximately 141 mm in length, a maximum height of 57 mm and a maximum width of 25 mm.

The hole punch comprises a pair of cooperative lever arms **20** and **40** which are connected by a pivot assembly **50**. A pair of rotatably fixed jaws **22** and **42** extend forwardly from the pivot assembly **50**. The hole punch **10** is configured and operable in a plier-like fashion. Lever arm **20** comprises a handle **24** and a hammer **26**. The hammer **26** orthogonally mounts a shaft **27** terminating in a punch **28**. The punch **28** reciprocates relative to jaw **22**. The punch **28** in one preferred form has an inverted V-shaped configuration.

Lever arm **40** comprises a handle **44** with the handles **24** and **44** being generally similar in shape and disposed in opposing relationship. The handles are dimensioned and contoured for manual grasping.

With additional reference to FIGS. 5-7, jaw **42** includes a plate member **46** which receives a metal anvil platform **48** having at an interior location, an anvil aperture **52**. The plate **46** tapers outwardly at a forward end **54**.

A pair of parallel brackets **56** (FIG. 5) extends orthogonally from the plate. The brackets have a pair of aligned openings which receive inward pivot pins **64** of a canopy **60**. The canopy **60** is formed of transparent or semi-transparent material and includes a partition **62** adjacent the pair of inward pins **64** which snap into the openings of the brackets. The canopy includes forward lip **66** so that the canopy may be easily moved from a closed position and pivoted (downwardly in the drawings) to an open position. The canopy **60** also has a rear opening **69**. The canopy **60** functions as a reservoir for the punched material. The canopy **60** can accordingly be pivoted to an open position to remove the punched remnants.

Jaw **22** has a plate **32** which is similar in peripheral shape to plate **46** and is disposed in generally opposing relationship to form a mouth. The plate **32** outwardly tapers at forward end **34**. It will be appreciated that the tapered portions **54** and **34** of the plates inwardly converge to form a very restricted entry-way to the generally parallel spacing between the plates **32** and **46** of the jaws.

With additional reference to FIGS. 6-7, the plate **32** receives a bent metal frame **80** which has a lower platform **82** with a central opening **84**. A pair of side-members **86** support an upper platform **88** which has an opening **90** through which the punch shaft **27** is received. The punch shaft thus reciprocates through the openings **90** and **84**. A coil spring **92** is disposed between platform **82** and a retaining ring **94** radially projecting from the punch shaft **27** to bias the punch **28** and the hammer **26** away from the anvil aperture **52**. The frame **80** includes an oblique tab **96** (FIG. 6) which engages an underside at the interior front of the tapered portion to help retain the frame **80** to the jaw **22**. The frame may also be secured by a rear stud (not illustrated). A pair of projections **98** (FIG. 5) at the forward portion of the plate **32** prevent the plates **32** and **46** from flexibly collapsing into each other under an intense punching force even though the opposed plates are essentially fixed in parallel relationship. A canopy **100** of transparent or semi-transparent material encloses the hammer/punch/frame assembly and has a shape to very similar that of canopy **60**.

The jaws **22** and **42** are contoured bulbous members which cooperate to form a bull-nose-type shape. The canopies **60** and **100** are preferably molded from transparent or semi-transparent plastic materials. The plates **32** and **46** respectively have lips **33** and **47** which closely receive the canopies in a snap-fit fashion. Canopy **60** interiorly forms a reservoir for the hole remnants. The reservoir can be easily observed due to the transparent wall material and can be pivoted open about pins **64** by a finger engagement against lip **66** for emptying purposes.

The handles **24** and **44** for the hole punch are preferably formed from contoured plastic materials and include soft overmolds **25** and **45** to provide a comfortable gripping action. Overmold **25** includes ribs **29** to facilitate squeezing the punch for manual operation thereof. The handles each have a pair of opposed stops **23** and **43** (FIG. 5) which engage to limit the pivot travel between the handles and the displacement of the punch **28**.

It will be appreciated that the hole punch **10** functions in an efficient manner wherein the paper to be punched is slid into the mouth rearwardly and properly aligned by observing the punch **28** location through the transparent canopy **100**. The handles **24** and **44** are then squeezed together to punch the hole from the paper at the desired location. The hole remnant is deposited in the reservoir **60**.

The pivot assembly **50** comprises an internal pivot connection **54** which pivotally retains the lever arm **20** to the rest of the assembly. The pivot connection is spring loaded via spring **92** so that normally the handles are disposed in the illustrated relationship of FIG. 2. Squeezing of the handles forces the hammer **26** and punch **28** to move toward the anvil aperture **52** for punching a hole in the received paper. The engagement of the retaining ring **94** against the platform **88** underside limits the maximum (upward) pivoting of the hammer/punch.

Electric paper punch
US 6269721 B1

https://www.google.com/patents/US6269721

The present invention provides an electric paper punch (hole puncher) with a reinforcement mechanism. The paper punch comprises a module with a paper slot and punch pin, an axle, a connecting module connected to the punch pin, and a motor. The connecting module has a rear wall that is arc-shaped and works in conjunction with an eccentrically shaped wheel to drive the punch pin forward and backward as the eccentrically shaped wheel rotates within the wheel groove. The arc-shaped wall of the connecting module is reinforced to prevent distortion from repeated pressure exerted during movement of the punch pin.

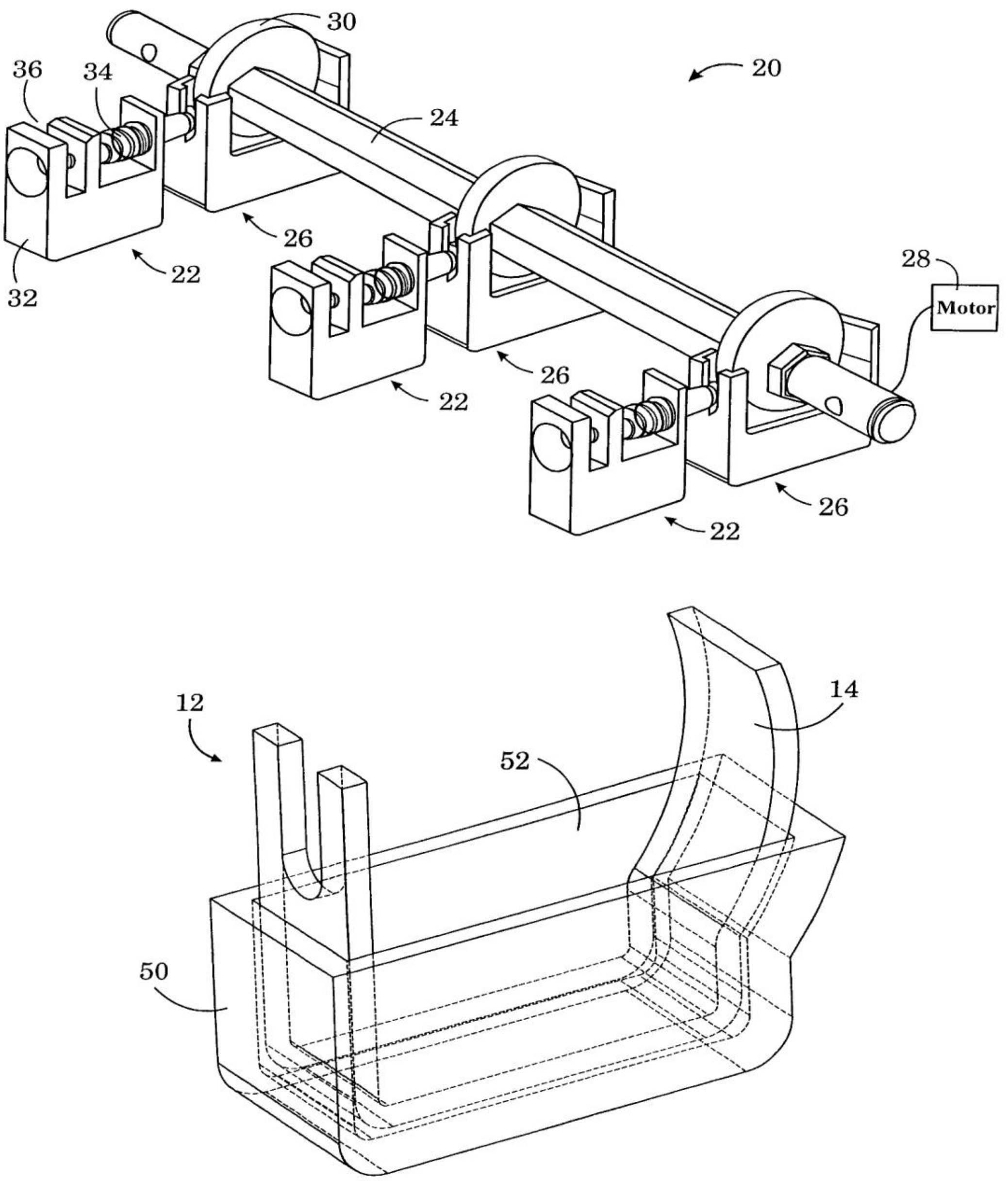


Figure 4: Electric Paper Punch Views 1

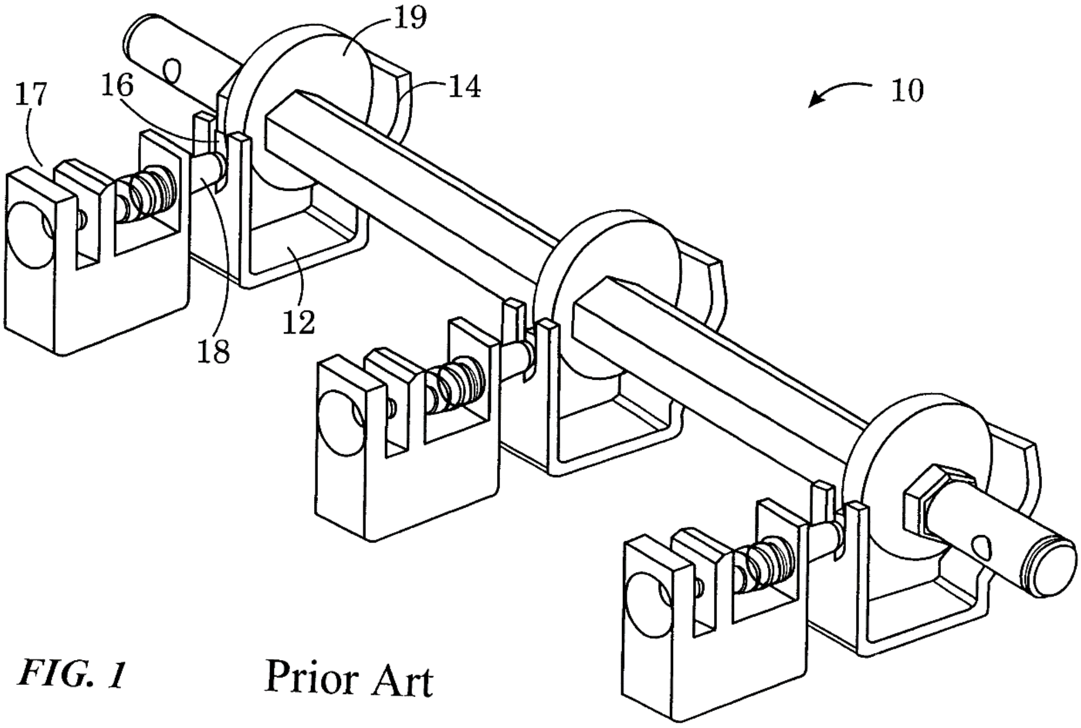


FIG. 1 Prior Art

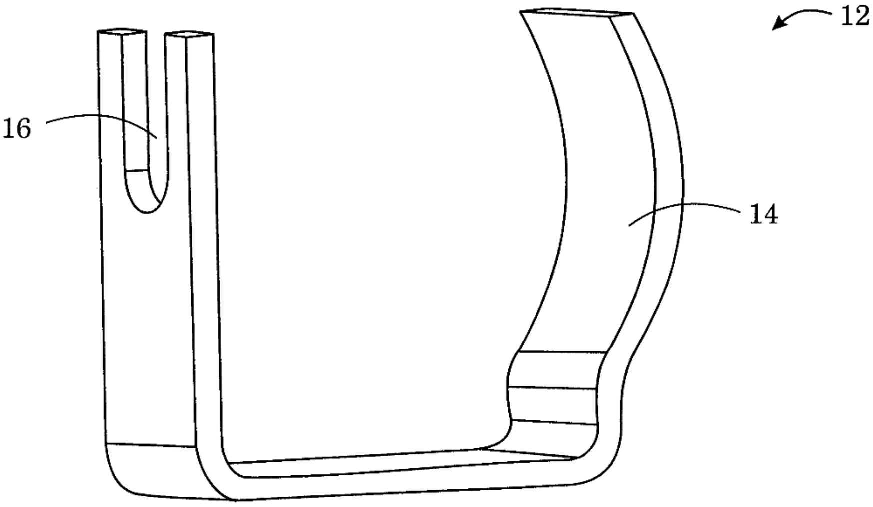


FIG. 2 Prior Art

Figure 5: Electric Paper Punch Views 2

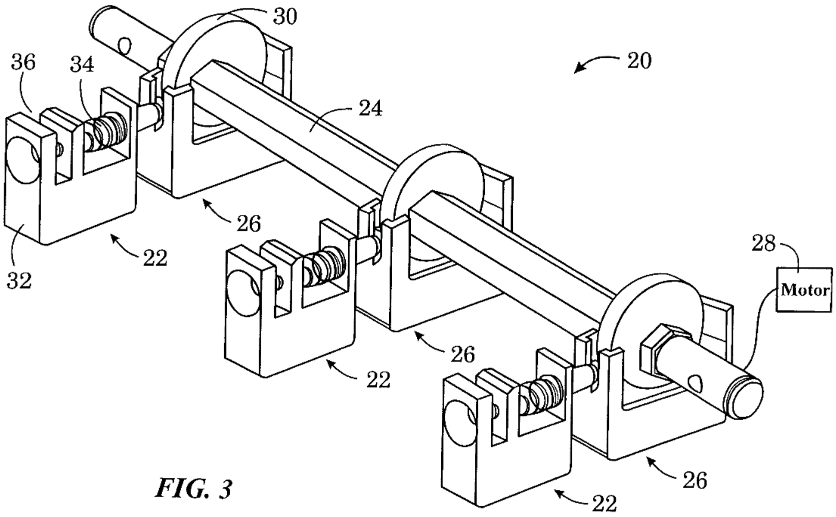


FIG. 3

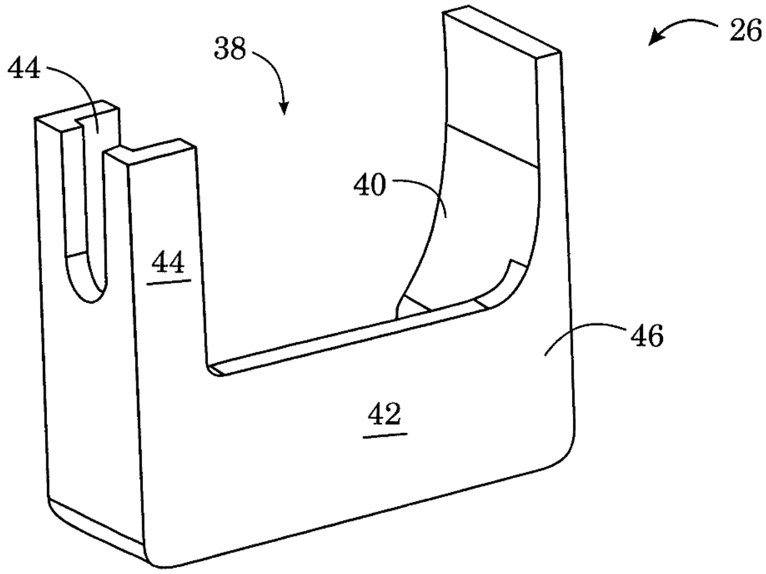


FIG. 4

Figure 6: Electric Paper Punch Views 3

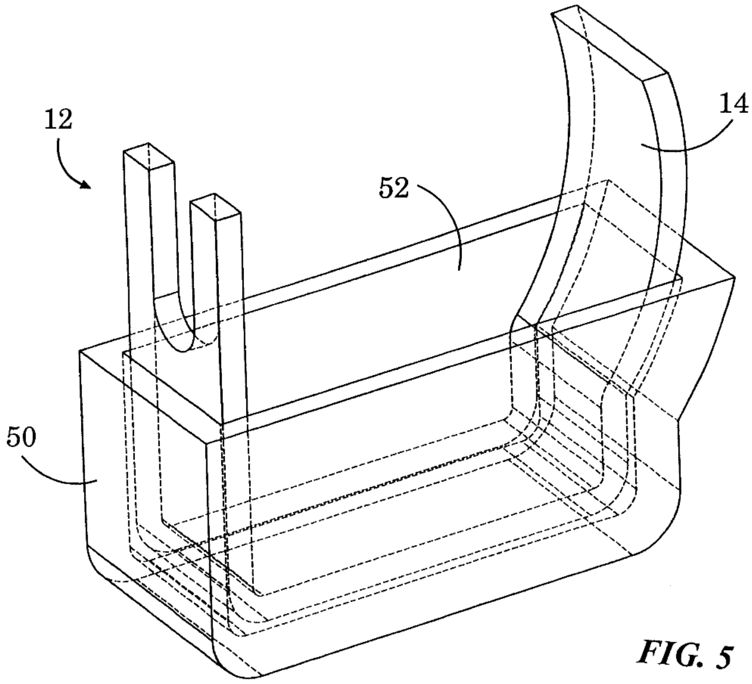


FIG. 5

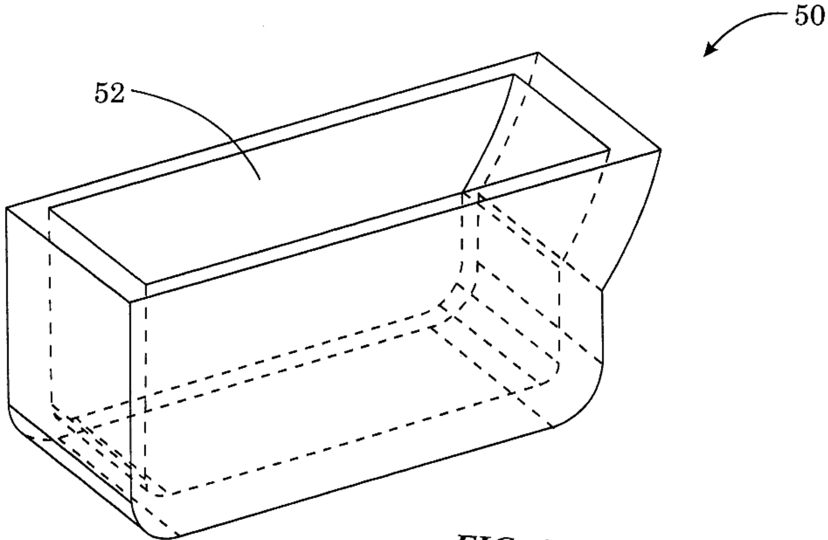


FIG. 6

Figure 7: Electric Paper Punch Views 4

DESCRIPTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an electric paper punch, and more particularly, to an electric paper punch comprising a reinforcement mechanism.

2. Description of the Prior Art

A standard paper punch uses a punch pin to punch holes through paper loaded in it paper slot. There are two kinds of paper punches: manual and electric. With the manual paper punch, a lever arm is depressed to punch holes through paper with the punch pin and the punch pin is rebounded by a spring attached to the punch pin when the lever arm is released. The amount of paper the manual paper punch can handle at once is directly related to the length of the lever arm. The longer the lever arm, the more paper can be accommodated. However, the spring must have great elasticity in order to allow the punch pin to return to its original resting position.

In a typical electric paper punch, the punch pin is advanced with an electric motor. Please refer to FIG. **1** and FIG. **2**. FIG. 1 is a perspective diagram of a prior art electric paper punch **10**. FIG. 2 is a perspective diagram of a connecting module **12** of the electric paper punch **10** in FIG. **1**. The electric paper punch **10** comprises three connecting modules **12**. Each connecting module **12** comprises an opening **16** at its front end for supporting a punch pin **18**, an eccentric wheel **19** installed above a bottom side of the connecting module **12**, and an arc-shaped wall **14** at a rear end of the connecting module **12**.

During operation, the eccentric wheel **19** pushes the connecting module **12** and punch pin **18** forward to punch holes in paper placed in the paper slot **17**. Then, the eccentric wheel **19** will push the arc-shaped wall **14** of the connecting module **12** back. Because the rear end of the punch pin **18** is connected with two sides of the opening **16** of the connecting module **12**, the connecting module **12** will pull the punch pin **18** back at the same time. However, this backward force may cause distortion of the arc-shaped wall **14** of the connecting module **12**.

SUMMARY OF THE INVENTION

It is therefore a primary objective of the present invention to provide an electric paper punch comprising a reinforcement mechanism to solve the mentioned problem.

Briefly, in a preferred embodiment, the present invention provides an electric paper punch comprising:

a housing;

a punch module for punching a hole in papers comprising a punch base fixed in the housing with a paper slot for loading papers to be punched, and a punch pin slidably installed in the punch base for punching a hole through the papers loaded in the paper slot;

an axle rotatably installed in the housing comprising an eccentric wheel for driving the punch pin forward and backward;

a connecting module installed in the housing under the eccentric wheel in a forward-and-backward slidable manner, the connecting module comprising a front end connected to a rear end of the punch pin, a wheel groove positioned under the eccentric wheel for allowing the eccentric wheel to rotate in it, and an arc-shaped wall forming a rear end of the wheel groove wherein the punch pin and the connecting module will be driven forward to punch the papers in the paper slot when the eccentric wheel is rotated forward within the wheel groove, and the arc-shaped wall will be pushed backward by the eccentric wheel to move the connecting module and the punch pin away from the paper slot when the eccentric wheel is rotated backward; and

a motor installed in the housing for rotating the axle so as to rotate the eccentric wheel forward and backward;

wherein the connecting module further comprises a reinforcement mechanism for strengthening the arc-shaped wall of the connecting module so as to avoid distortion of the arc-shaped wall caused by pulling the punch pin backward away from the paper slot.

It is an advantage of the present invention that the electric paper punch according to the present invention has a reinforcement mechanism that prevents distortion of the connecting module and can punch holes through more paper at once.

These and other objects and the advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective diagram of a prior art electric paper punch.

FIG. 2 is a perspective diagram of a connecting module of the electric paper punch in FIG. **1**.

FIG. 3 is a perspective diagram of an electric paper punch according to the present invention.

FIG. 4 is a perspective diagram of a connecting module shown in FIG. **3**.

FIG. 5 is another reinforcement mechanism for strengthening the connecting module shown in FIG. **2**.

FIG. 6 is a perspective diagram of a holder shown in FIG. **5**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Please refer to FIG. **3** and FIG. **4**. FIG. 3 is a perspective diagram of an electric paper punch **20** according to the present invention. FIG. 4 is a perspective diagram of a connecting module **26** shown in FIG. **3**. The electric paper punch **20** comprises a housing (not shown), three punch modules **22** for punching holes, an axle **24** rotatably installed in the housing, three connecting modules **26** installed in the housing in a forward-and-backward slidable manner, and a motor **28** installed in the housing.

Each punch module **22** comprises a punch base **32** fixed in the housing with a paper slot **36** to load paper to be punched and a punch pin **34** slidably installed in the punch base **32** for punching a hole through paper loaded in the paper slot **30** **36**. The axle **24** comprises three eccentric wheels **30** for driving the punch pin **34** forward and backward. The connecting modules **26** are installed under the eccentric wheels **30** and comprises a front end **27** connected to a rear end of the punch pin **34**. The motor **28** is used for rotating the axle **24** so as to make the eccentric wheel **30** drive the punch pin **34** forward and backward.

Each connecting module **26** comprises a wheel groove **38** having a top opening and having a rear end formed by an arc-shaped wall **40**. The punch pin **34** and the connecting module **26** are driven forward to punch paper in the paper slot **36** when the eccentric wheel **30** is rotated forward within the wheel groove **38**. Conversely, when the eccentric wheel **30** is rotated backward, the arc-shaped wall **40** is pushed backward and the connecting module **26** and the punch pin **34** are moved away from the paper slot **36**.

Each connecting module **26** comprises a vertical side wall **42**, two vertical flanges **44**, and a solid angle structure **46**. The vertical side wall **42** is integrally built between the front end and the arc-shaped wall **40** of the connecting module **26** and reinforces the side of the wheel groove **38** to prevent distortion through backward force exerted on the arc-shaped wall **40**. The two vertical flanges **44** are integrally built at two sides of the front end of the connecting module **26** to strengthen it. The solid angle structure **46** is integrally built behind the arc-shaped wall **40** of the connecting module **26** for strengthening the arc-shaped wall **40** of the connecting module **26**.

Please refer to FIG. **5** and FIG. **6**. FIG. 5 is another reinforcement mechanism for strengthening the connecting module **12** shown in FIG. **2**. FIG. 6 is a perspective diagram of a holder **50** shown in FIG. **5**. In this embodiment, the holder **50** is mounted around a bottom side of the connecting module **12** for reinforcement. The holder **50** comprises a groove **52** for stabilizing the front and back sides of the connecting module **12** in the groove **52**. The holder **50** provides added reinforcement to the arc-shaped wall **14** thus preventing its distortion during backward movement of the eccentric wheel **30**.

Compared with the prior art electric paper punch **10**, the connecting module **26** of the electric paper punch **20** according to the present invention has a reinforcement mechanism for strengthening the structure of the connecting module **26**. The connecting module **26** comprises a vertical side wall **42**, two vertical flanges **44**, and a solid angle structure **46** for strengthening the connecting module **26** and preventing distortion of the arc-shaped wall **40**. The reinforcement mechanism can be a holder **50** mounted around a bottom side of the connecting module **12** for reinforcing it. The electric paper punch **20** according to the present invention not only has a reinforcement mechanism for preventing distortion of the connecting module **26**, but also can punch holes through more paper at once.

Those skilled in the art will readily observe that numerous modifications and alterations of the propeller may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

3 CONCEPT DESIGN AND SPECIFICATION

3.1 USER NEEDS AND METRICS

3.1.1 Record of the user needs interview

Project/Product Name: One Step Plant Tissue Sampler with dispenser and tube holder

Customer: Veena Veena Vincenz

Interviewers: Paul Gitau, Andrew Vaughn and Aaron

Type of User: Lab technician

Current Uses: Obtaining samples of plant material

Follow up? : Yes

Date: 6/02/17

Table 1: User Needs Interview

Question	Customer Statement	Interpreted Need	Importance
How many samples are taken from each plant?	One sample per plant	Quick access to plant leaves	3
How many samples can each tube hold?	One sample per tube	Quick access to multiple tubes	4
How thick are the leaves of each plant?	1 mm at most	Doesn't need a lot of force	1
Do the samples need to be dispensed into the tubes one at a time?	Yes, one at a time	Low friction interchangeable tube slide	5
Are the samples tested in the tubes or a different container?	The samples are tested in the tube	Samples must be small enough to fit in tube	4
How do the samples need to be dispensed?	Specimens need to be cut and put in tubes	Plant sample moves in uninterrupted path to	5

		tube	
How fast do the samples need to be taken?	The faster the better	High Cycle Rate	5
How often is this product going to be used?	Multiple times a day	Reliable and Durable	5
Is the design affected by chemical treatment or possible contamination	Design should be ethanol resistant and must use materials that won't contaminate sample	Must use ethanol resistant materials and materials that won't contaminate the sample	5
Does the design need to be manually operated or electric?	Either works as long as it is easy to use	Ease of use	2
How big does the product need to be?	Small enough that it is portable so about 1-2 ft^3	Portability	5

3.1.2 List of identified metrics

Table 2: Identified Metrics List

Needs	Associated Needs	Metric	Units	Min	Max
1	1,11	Plant exchange Time	Seconds	1	30
2	2,4	Tube exchange Time	Seconds	1	30
3	3,10	Force	Pound-force	0.5	2.5
4	2,4	Cycle Time	Seconds	1	10
5	5,6	Diameter	mm	7	12
6	6,5	Dispense Time	Seconds	1	5
7	7	Cycle Time	Seconds	1	10
8	8,9	Usage	Uses per day	5	100
9	9,8	Thickness	mm	1	5
10	10,3	Weight	lbs	1	5
11	11,1	Product Size	Ft^3	0.5	4

3.1.3 Table/list of quantified needs equations

Table 3: Quantified Needs Matrix

Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										1	0.068	0.068
2	Quick access to multiple tubes		0.5		0.5										1	0.091	0.091
3	Doesn't need a lot of force			1											1	0.021	0.021
4	Low friction interchangeable tube slide		0.5		0.5										1	0.114	0.114
5	Samples must be small enough to fit in tube					1									1	0.091	0.091
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								1	0.114	0.114
7	High Cycle Rate				0.5				0.5						1	0.114	0.114
8	Reliable and Durable							0.5	0.5						1	0.114	0.114
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						1	0.114	0.114
10	Ease of use							0.25		0.25	0.5				1	0.045	0.045
11	Portability									0.5	0.5				1	0.114	0.114
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		1
Best Value		1	1	0.5	1	7	1	5	1	1	0.5						
Worst Value		30	30	2.5	10	12	5	100	5	5	4						
Actual Value		1	1	0.5	1	7	1	5	1	1	0.5						
Normalized Metric Happiness		1	1	1	1	1	1	1	1	1	1						

3.2 CONCEPT DRAWINGS

Concept 1

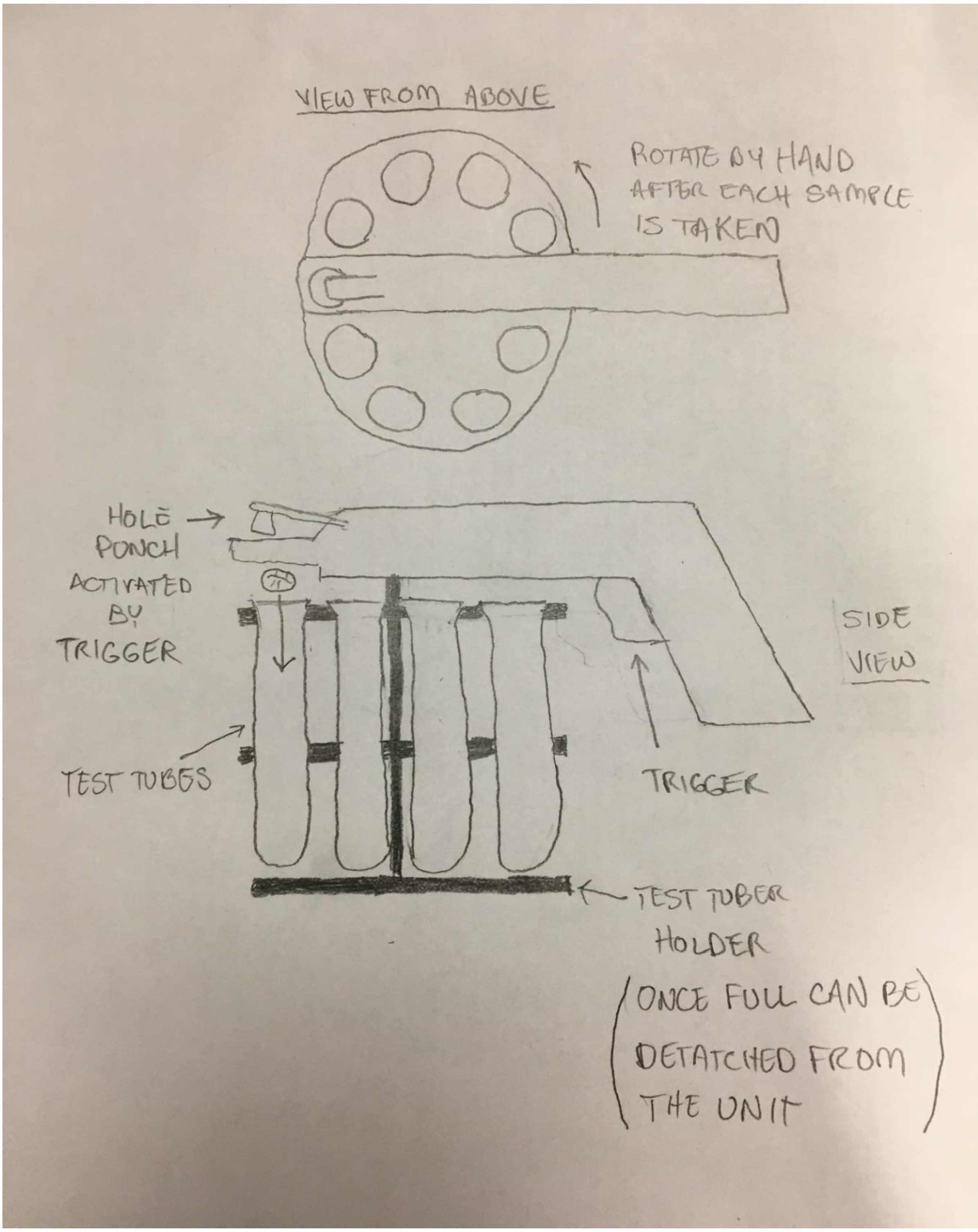


Figure 8: Concept 1

Concept 2

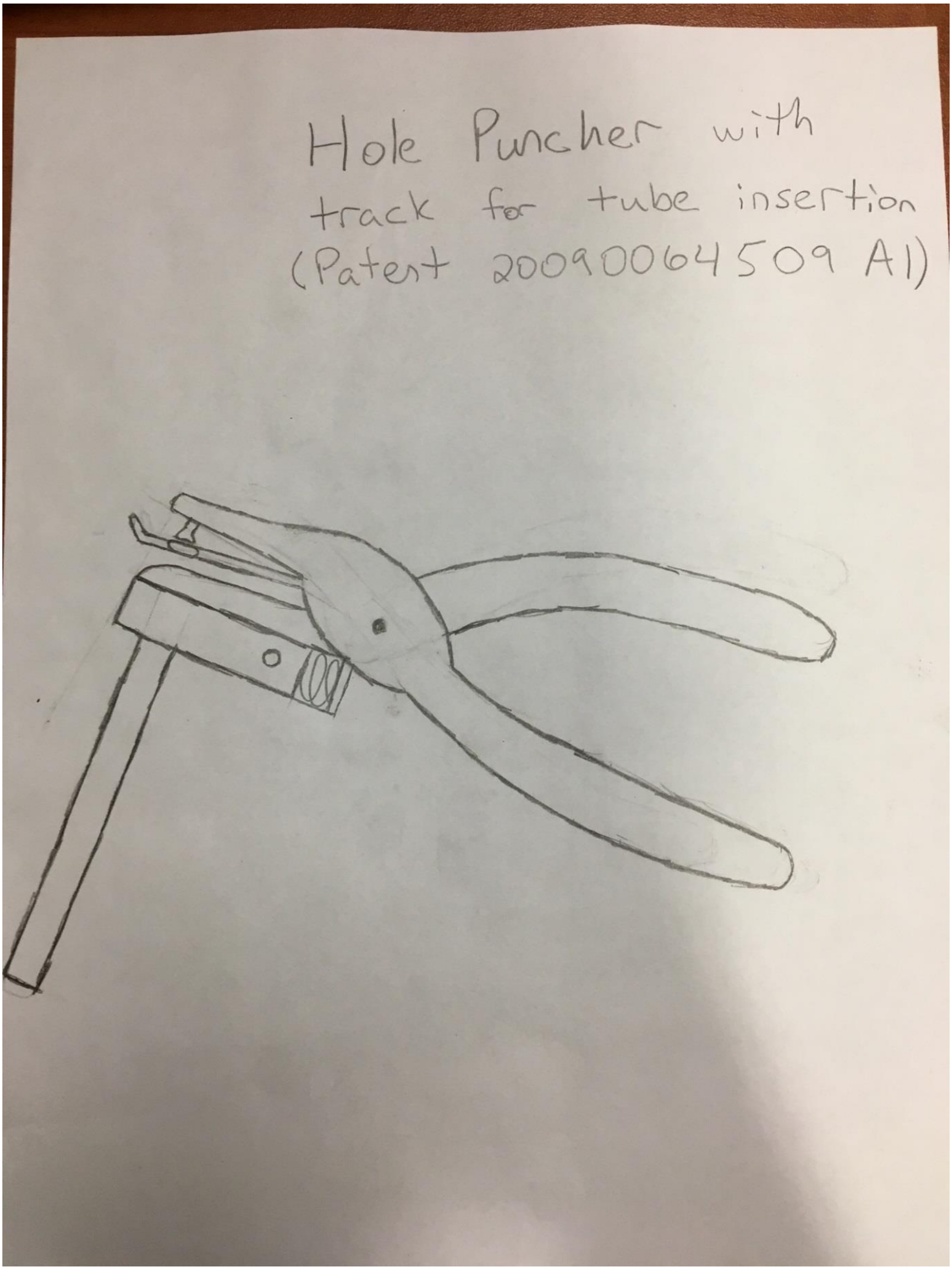


Figure 9: Concept 2

Concept 2 (continued)

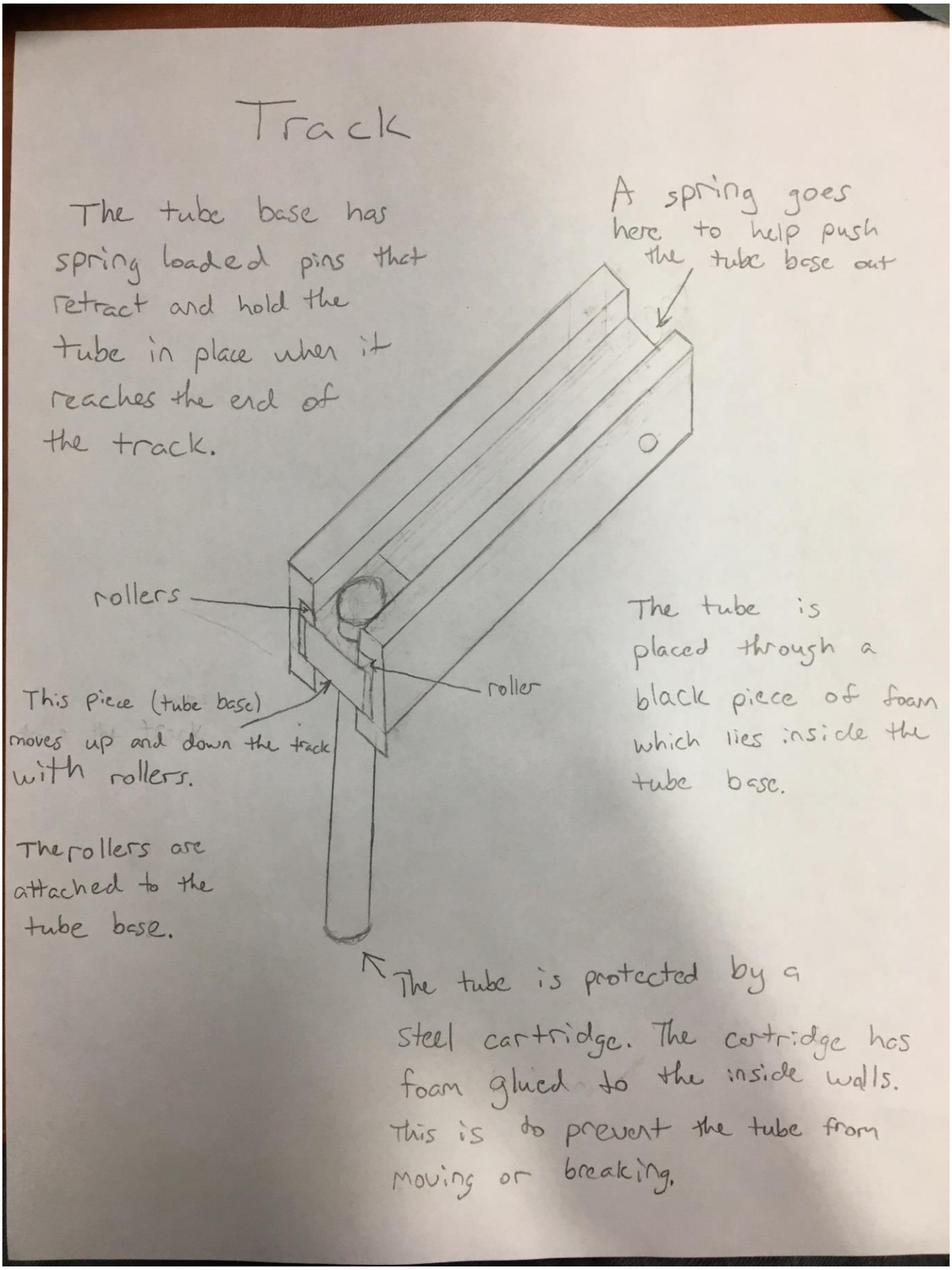


Figure 10: Concept 2 (Continued)

Concept 3

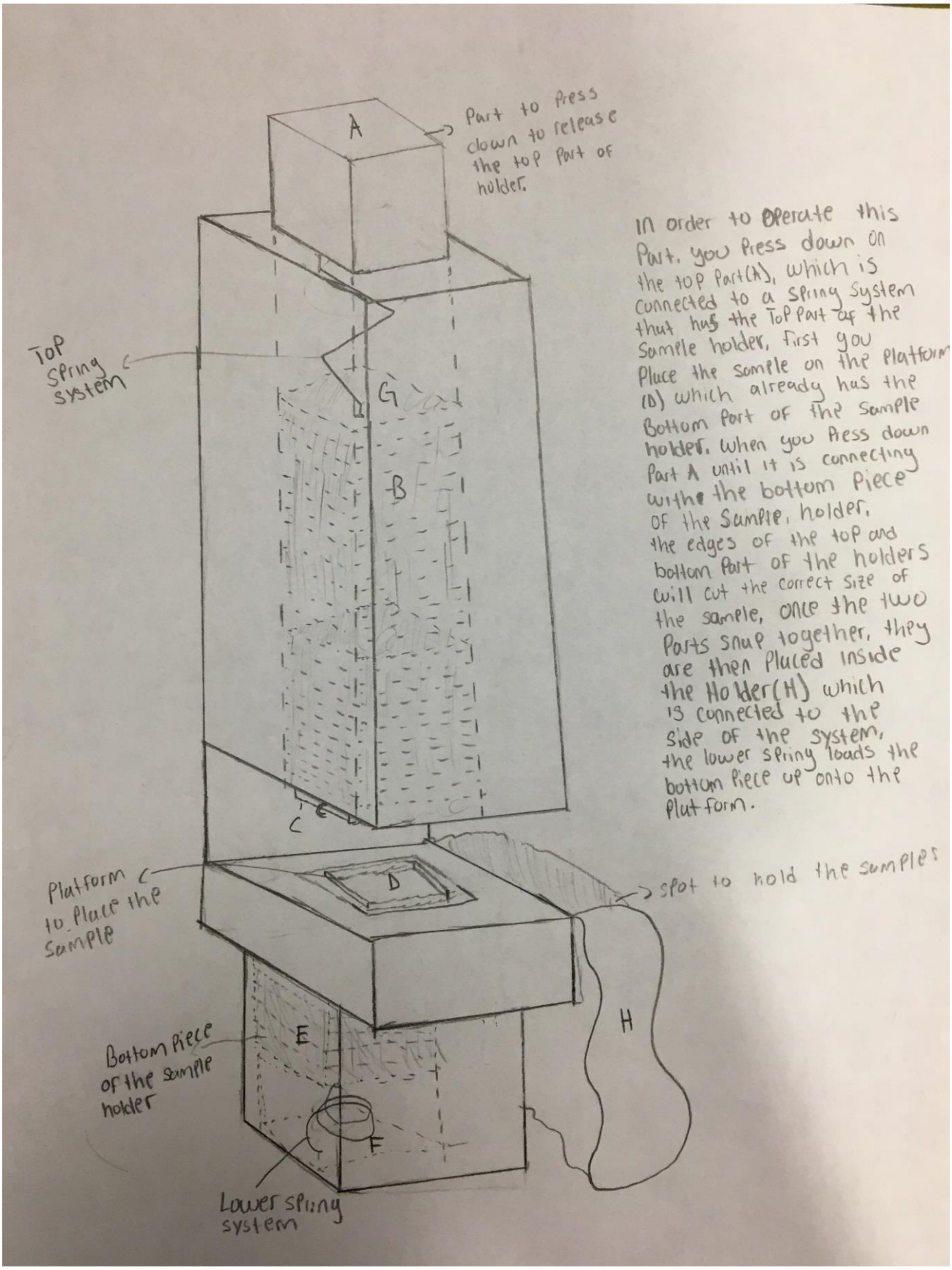


Figure 11: Concept 3

Concept 4

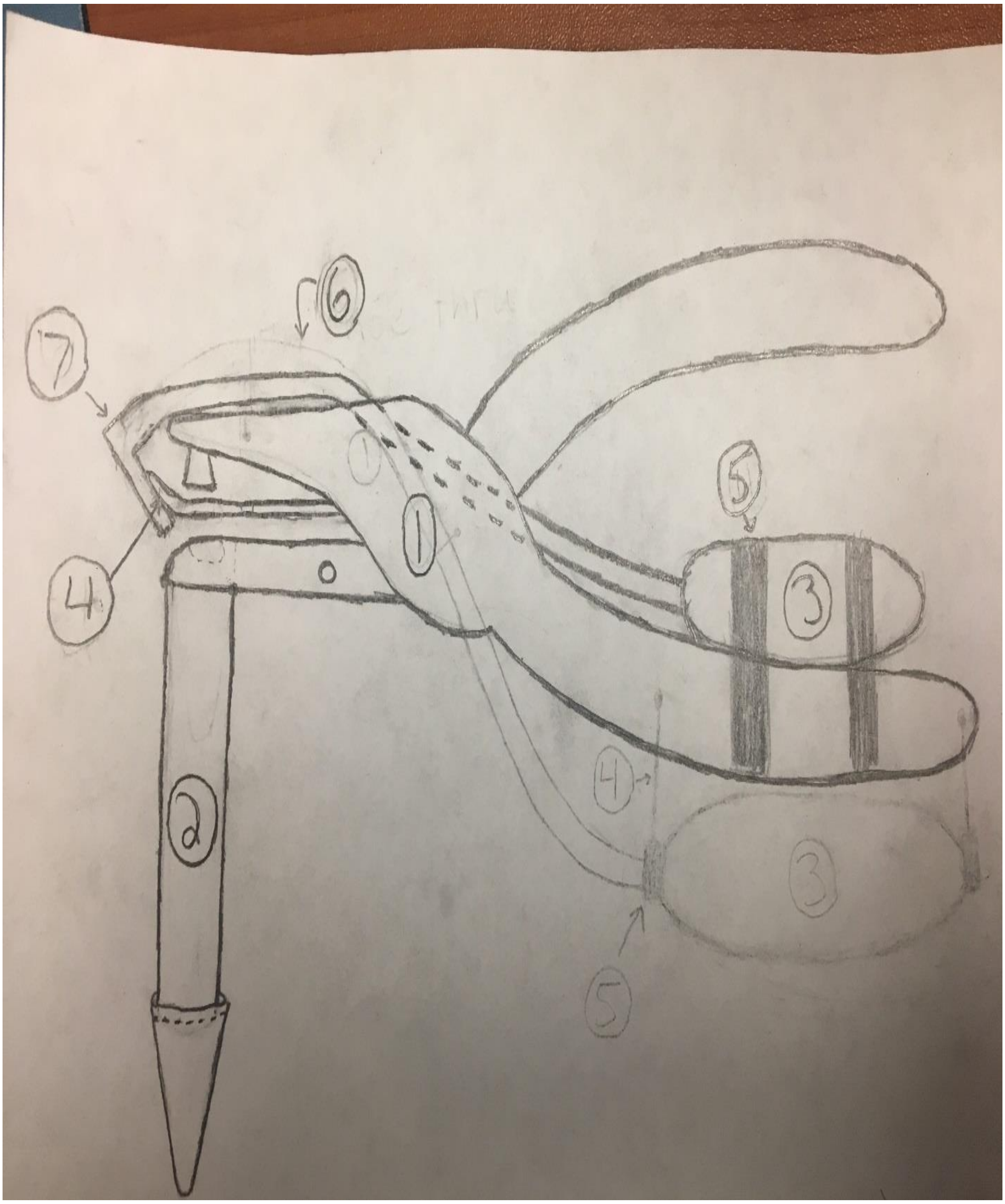


Figure 12: Concept 4 (numbers show parts)

3.3 A CONCEPT SELECTION PROCESS.

3.3.1 Concept scoring

<u>Concept 1 Scoring</u>

Table 4: Concept 1 Quantified Needs Matrix

Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										0.95	0.068	0.0646
2	Quick access to multiple tubes		0.5		0.5										1	0.091	0.091
3	Doesn't need a lot of force			1											0.8	0.021	0.0168
4	Low friction interchangeable tube slide		0.5		0.5										1	0.114	0.114
5	Samples must be small enough to fit in tube					1									1	0.091	0.091
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								1	0.114	0.114
7	High Cycle Rate				0.5				0.5						0.9	0.114	0.1026
8	Reliable and Durable							0.5	0.5						0.8	0.114	0.0912
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						0.8	0.114	0.0912
10	Ease of use							0.25		0.25	0.5				0.8875	0.045	0.039938
11	Portability									0.5	0.5				0.9375	0.114	0.106875
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.923213
Best Value		1	1	0.5	1	7	1	5	1	1	0.5						
Worst Value		30	30	2.5	10	12	5	100	5	5	4						
Actual Value		3	1	1	1	7	1	25	2	1	1						
Normalized Metric Happiness		0.9	1	0.8	1	1	1	0.8	0.8	1	0.875						

<u>Concept 2 scoring</u>

Table 5: Concept 2 Quantified Needs Matrix

Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										0.8665	0.068	0.058922
2	Quick access to multiple tubes		0.5		0.5										0.8665	0.091	0.078852
3	Doesn't need a lot of force			1											0.8	0.021	0.0168
4	Low friction interchangeable tube slide		0.5		0.5										0.8665	0.114	0.098781
5	Samples must be small enough to fit in tube					1									1	0.091	0.091
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								0.95	0.114	0.1083
7	High Cycle Rate				0.5				0.5						0.85	0.114	0.0969
8	Reliable and Durable							0.5	0.5						0.75	0.114	0.0855
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						0.8	0.114	0.0912
10	Ease of use							0.25		0.25	0.5				0.7625	0.045	0.034313
11	Portability									0.5	0.5				0.7375	0.114	0.084075
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.844642
Best Value		1	1	0.5	1	7	1	5	1	1	0.5						
Worst Value		30	30	2.5	10	12	5	100	5	5	4						
Actual Value		5	5	1	2	7	1	35	1	3	1						
Normalized Metric Happiness		0.833	0.833	0.8	0.9	1	1	0.7	0.8	0.6	0.875						

Concept 3 Scoring

Table 6: Concept 3 Quantified Needs Matrix

Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										0.9	0.068	0.0612
2	Quick access to multiple tubes		0.5		0.5										0.95	0.091	0.08645
3	Doesn't need a lot of force			1											0.8	0.021	0.0168
4	Low friction interchangeable tube slide		0.5		0.5										0.95	0.114	0.1083
5	Samples must be small enough to fit in tube					1									0.8	0.091	0.0728
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								1	0.114	0.114
7	High Cycle Rate				0.5				0.5						1	0.114	0.114
8	Reliable and Durable							0.5	0.5						0.75	0.114	0.0855
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						1	0.114	0.114
10	Ease of use							0.25		0.25	0.5				0.726	0.045	0.03267
11	Portability									0.5	0.5				0.751	0.114	0.085614
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.891334
Best Value		1	1	0.5	1	7	1	5	1	1	0.5						
Worst Value		30	30	2.5	10	12	5	100	5	5	4						
Actual Value		6	3	1	1	8	1	50	1	3	0.8						
Normalized Metric Happiness		0.8	0.9	0.8	1	0.8	1	0.5	1	0.6	0.902						

Concept 4 Scoring

Table 7: Concept 4 Quantified Needs Matrix

Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										0.9165	0.068	0.062322
2	Quick access to multiple tubes		0.5		0.5										0.85	0.091	0.07735
3	Doesn't need a lot of force			1											0.8	0.021	0.0168
4	Low friction interchangeable tube slide		0.5		0.5										0.85	0.114	0.0969
5	Samples must be small enough to fit in tube					1									0.8	0.091	0.0728
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								1	0.114	0.114
7	High Cycle Rate				0.5				0.5						1	0.114	0.114
8	Reliable and Durable							0.5	0.5						0.75	0.114	0.0855
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						1	0.114	0.114
10	Ease of use							0.25		0.25	0.5				0.701	0.045	0.031545
11	Portability									0.5	0.5				0.701	0.114	0.079914
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.865131
Best Value		1	1	0.5	1	7	1	5	1	1	0.5						
Worst Value		30	30	2.5	10	12	5	100	5	5	4						
Actual Value		5	7	1	1	7	1	50	1	3.5	0.8						
Normalized Metric Happiness		0.833	0.7	0.8	1	0.8	1	0.5	1	0.5	0.902						

3.3.2 Preliminary analysis of each concept's physical feasibility

Concept 1

The first concept is definitely physically feasible. The concept is fairly simple with a modified hole punch which will be activated by the trigger. The tube holder will rotate on a ratcheted mount that locks each tube in place to receive the plant sample. Each time a sample is taken the user needs only to rotate the holder to the next empty tube. The materials needed will be low and can easily be purchased or fabricated.

Concept 2

The design concept is possible. One of the main components that might not work with our user needs is the foam piece used to protect the tube. Ethanol is used to keep the design disinfected. Ethanol might dissolve the foam. Another potential issue is friction between the bottom of the tube holder and the track. One way to resolve this issue would be to place rollers on the bottom of the tube holder. WD-40 could also be placed under the tube holder for a reduction of friction. The spring at the end of the track could send the tube off the track. A stopping mechanism needs to be added to prevent this from happening. The stopping mechanism needs to be removable to allow the user to easily remove the tube and tube holder when placing a new tube in the holder. I have not determined how exactly the spring loaded pins will operate. Another option would be to place a spring loaded stopper at the bottom of the track instead of the sides of the track.

Concept 3

This design concept should be easy to build, some of the materials that would require to build this concept are every day materials that are not hard to find, and the only complex material is the spring, finding the correct spring size might be difficult. Some of the concerns with this design are, ensuring that the spring mechanism operates correctly, and the sample holders stay connected after being pressed together. Operating this concept is relatively simple, all the user has to do is ensure that the top and bottom cartridge holders are loaded with cartridges, then place the sample on the platform, and press down on the top of it until the top and bottom holders snap together with the sample inside, and then it is placed inside the dispenser.

Concept 4

This concept is similar to concept 2. Instead of having a track for the tube to slide in and out, we cutout that process and decided to attach a tube (part 2) right underneath the hole on the hole punch (part 1) for the sample to travel through. A test tube can be attached to bottom of the tube simply by sliding it on (cone shape on bottom of 2). It will be a snug fit so that the lab technician does not have to hold on to the tube. We decided to use an air pump (part 3) and a tube (part 6) that will shoot air through a nozzle (part 7) at the hole to loosen stuck samples on the rim. The attachment of the pump to the handle and the attachment of the nozzle to the handle (parts 4 and 5) will be either rubber bands or epoxy to keep those things in place. All materials used will be ethanol resistant and should not contaminate the sample. This is the easiest idea and most of the parts can be easily purchased and the fabricated parts easily made.

3.3.3 Final summary statement

The concept that looks the best is concept 4. The main issues with the design is how we attach the tube to hole punch and if the blast of air will be enough to loosen a sample that has got stuck in the hole. Sample collection using a modified hole puncher should be very cheap to recreate or buy. This will help keep our costs low. The design should be relatively inexpensive. The most expensive aspect of the design will be the materials used in air blasting of the hole. Almost all of the needs were met with this concept. One need that is now evident is the protection of the tube from stresses or fracture. The overall performance need is the contamination need. The specimen cannot be contaminated as according to OSHA standards. Concept 4 ensures that the plant leaf specimen will not be contaminated.

The other 3 concepts were much too complicated and would be much more expensive. They are feasible but there are many moving parts and ease of use is not close to the concept that we have chosen.

3.4 PROPOSED PERFORMANCE MEASURES FOR THE DESIGN

The most important performance measure for our design is the risk of contamination and ability to use ethanol to clean the device. All of our materials need to not contaminate the sample being taken and must be ethanol resistant when it comes to cleaning. Another important aspect is that the sample needs to be able to slide freely through the tube without getting snagged on anything. This means we will have to make the diameter wide enough so it doesn’t get stuck. We are confident that the blast of air will loosen the sample at the hole so that is not much of an issue.

3.5 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

We realized that a new need could be the safety and protection of the glass tubes. For our chosen concept we might need to come up with a way to prevent tubes from breaking on the end by encasing it in something such as a metal sleeve lined with foam padding. The new metric for this need will be Mpa with 0 being the min and 80 being the max. This will help decrease the chance of someone breaking a glass tube while moving or inserting/removing the test tubes. The most important need is that the materials used in the making of our product are ethanol resistant and won’t contaminate the samples. For this reason, this need will be our overall performance measure. Some forms of plastic and metal don’t have the resistance to ethanol and some forms may contaminate the samples.

Table 8: Revised Metrics List

Needs	Associated Needs	Metric	Units	Min	Max
1	1,11	Plant exchange Time	Seconds	1	30
2	2,4	Tube exchange Time	Seconds	1	30
3	3,10	Force	Pound-force	0.5	2.5
4	2,4	Cycle Time	Seconds	1	10
5	5,6	Diameter	mm	7	12
6	6,5	Dispense Time	Seconds	1	5
7	7	Cycle Time	Seconds	1	10
8	8,9	Usage	Uses per day	5	100
9	9,8	Thickness	mm	1	5
10	10,3	Weight	lbs	1	5
11	11,1	Product Size	Ft^3	0.5	4
12	12,3	Stress	Mpa	0	80

Table 9: Revised Needs

Need Number	Need	Importance
1	Quick access to plant leaves	3
2	Quick access to multiple tubes	4
3	Doesn't need a lot of force	1
4	Low friction interchangeable tube slide	5
5	Samples must be small enough to fit in tube	4
6	Plant sample moves in uninterrupted path to tube	5
7	High Cycle Rate	5
8	Reliable and Durable	5
9	Must use ethanol resistant materials and materials that won't contaminate the sample	5
10	Ease of use	2
11	Portability	5
12	Glass tube safety	5

Final Concept Revised Scoring

Table 10: Final Concept Revised Scoring

Revised Quantified Needs Matrix		Metric															
		Plant Exchange Time	Tube Exchange Time	Force	Cycle Time	Diameter	Dispense Time	Usage	Thickness	Weight	Size	Stress	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Quick access to plant leaves	0.5			0.5										0.8665	0.07	0.060655
2	Quick access to multiple tubes		0.5		0.5										0.8665	0.08	0.06932
3	Doesn't need a lot of force			1											0.8	0.03	0.024
4	Low friction interchangeable tube slide		0.5		0.5										0.8665	0.1	0.08665
5	Samples must be small enough to fit in tube					1									1	0.08	0.08
6	Plant sample moves in uninterpreted path to tube				0.5		0.5								0.95	0.1	0.095
7	High Cycle Rate				0.5				0.5						0.95	0.1	0.095
8	Reliable and Durable							0.5	0.5						0.85	0.1	0.085
9	Must use ethanol resistant materials and materials that won't contaminate the sample								1						1	0.1	0.1
10	Ease of use							0.25		0.25	0.5				0.7625	0.04	0.0305
11	Portability									0.5	0.5				0.7375	0.1	0.07375
12	Glass Safety		0.5									0.5			0.9165	0.1	0.09165
13	Need 13														0	0	0
Units		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.891525
Best Value		1	1	0.5	1	7	1	5	1	1	0.5	0					
Worst Value		30	30	2.5	10	12	5	100	5	5	4	80					
Actual Value		5	5	1	2	7	1	35	1	3	1	0					
Normalized Metric Happiness		0.833	0.833	0.8	0.9	1	1	0.7	1	0.6	0.875	1					

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING

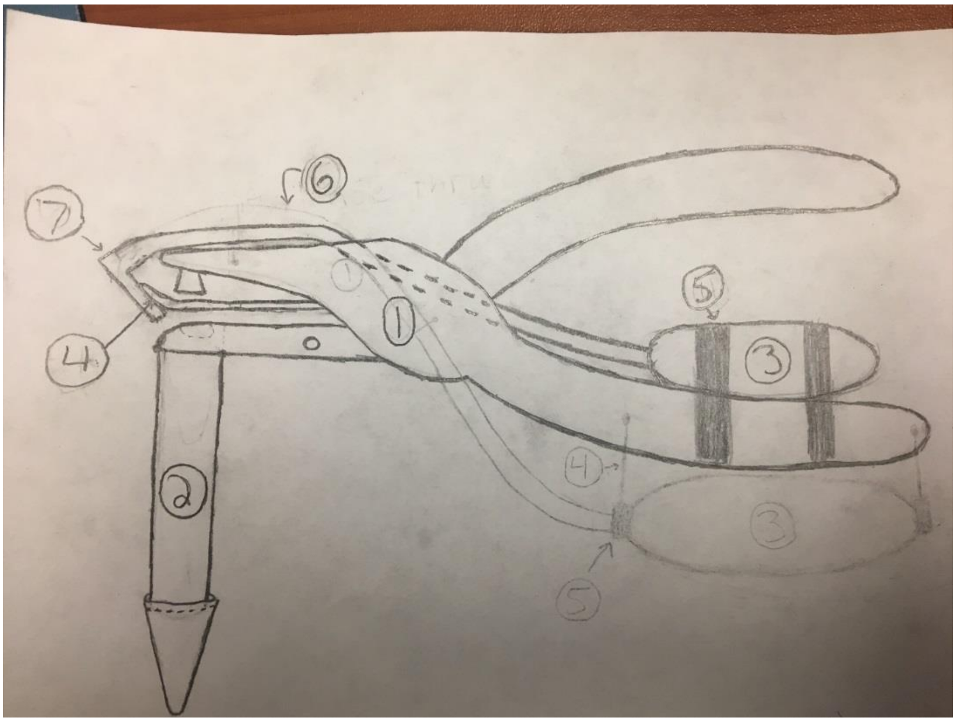


Figure 13: Embodiment Drawing (numbers show parts)

4.2 PARTS LIST

Table 11: Parts List (Look at Embodiment Drawing for numbers)

Part Number	Description
1	Paper Hole Punch
2	Aluminum Tube
3	Air Bulb
4	Epoxy
5	Rubber Bands
6	Silicon Tubing
7	T-Shaped Tube Fitting

Table 12: Order List

Part Number	Description	Quantity	Vendor	Vendor Number	Amount Per Order	Price
1	Paper Hole Punch	1	McMaster Carr	12885T35	1	$5.13
2	Aluminum Tube	1	Speedy Metals	3/8" {A} Rd 2011-T3 Aluminum	1	$0.27
3	Air bulb	1	Amazon	Prestige Medical Inflation Bulb w/ End Valve 1.05 ounce	1	$4.50
4	Epoxy	1	Goldkamp	18090	1	$2.35
5	Rubber Bands (2 types)	2	McMaster Carr	12205T55 & 12205T82	490 & 320	$9.90 & $9.90
6	Silicon Tubing	1	McMaster Carr	6516T17	1 (25 ft)	$13.75
7	T-Shaped Tube Fitting	1	McMaster Carr	5372K631	10	$7.40

Total: $53.20

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

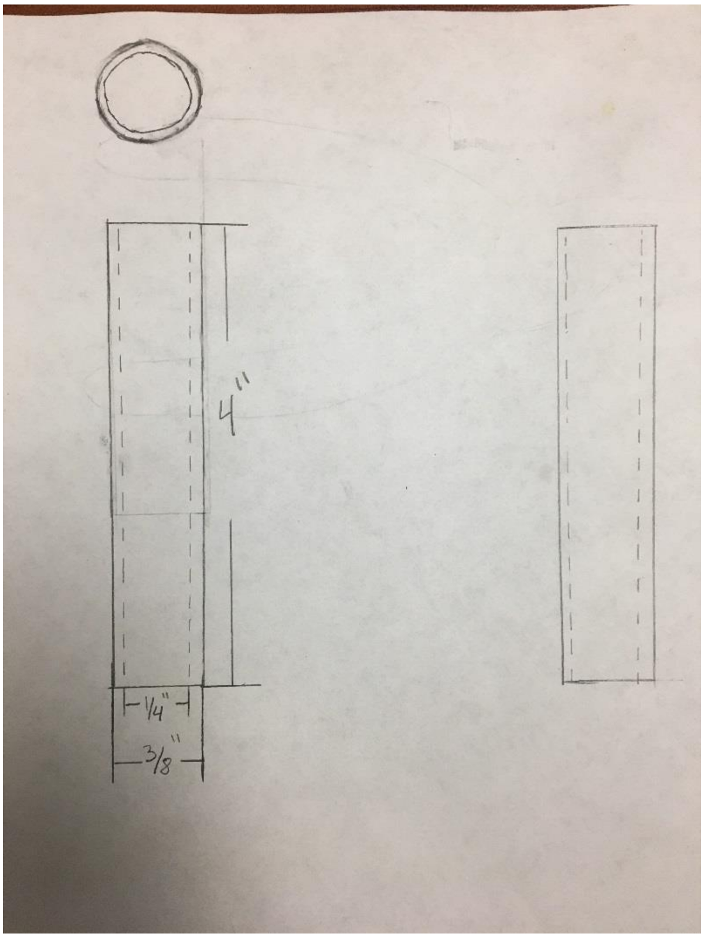


Figure 14: Fabricated Aluminum Tube

4.4 DESCRIPTION OF THE DESIGN RATIONALE

1. **Paper Hole Punch** – We decided to use the paper hole punch due to the fact that is what they are currently using but we are modifying it. We are going to remove the paper hole tray on the bottom and attach our assembly to it.

2. **Aluminum Tube** – This will be attached to the bottom of hole punch beneath the hole via welding. The outside diameter will be 3/8 inch and will have a thin wall so that the plant sample can pass through the tube easily. The test tubes will be able to fit on the aluminum tube so the sample can go right into the test tube. We used aluminum so it won't contaminate the sample and is ethanol resistant

3. **Air Bulb** – This will be attached to the bottom handle and it will be used to blow air through tubing connected and out of the tube fitting to blow out the hole in case a sample gets stuck. It will be connected with heavy duty rubber bands or epoxy.

4. **Epoxy** – This will be used to mount the tube fitting to the guide on the front of the hole punch and be used on the handle to attach the rubber bands to the pump and to the handle as well. We will also use this to close the other side of the T tube fitting.

5. **Rubber Bands** – These will be wrapped around the bulb to keep it on the handle. They will be attached to the bulb and to the handle using epoxy. We chose thicker rubber bands to make sure they hold the bulb in place. We don’t know which will work so we are ordering two different types.

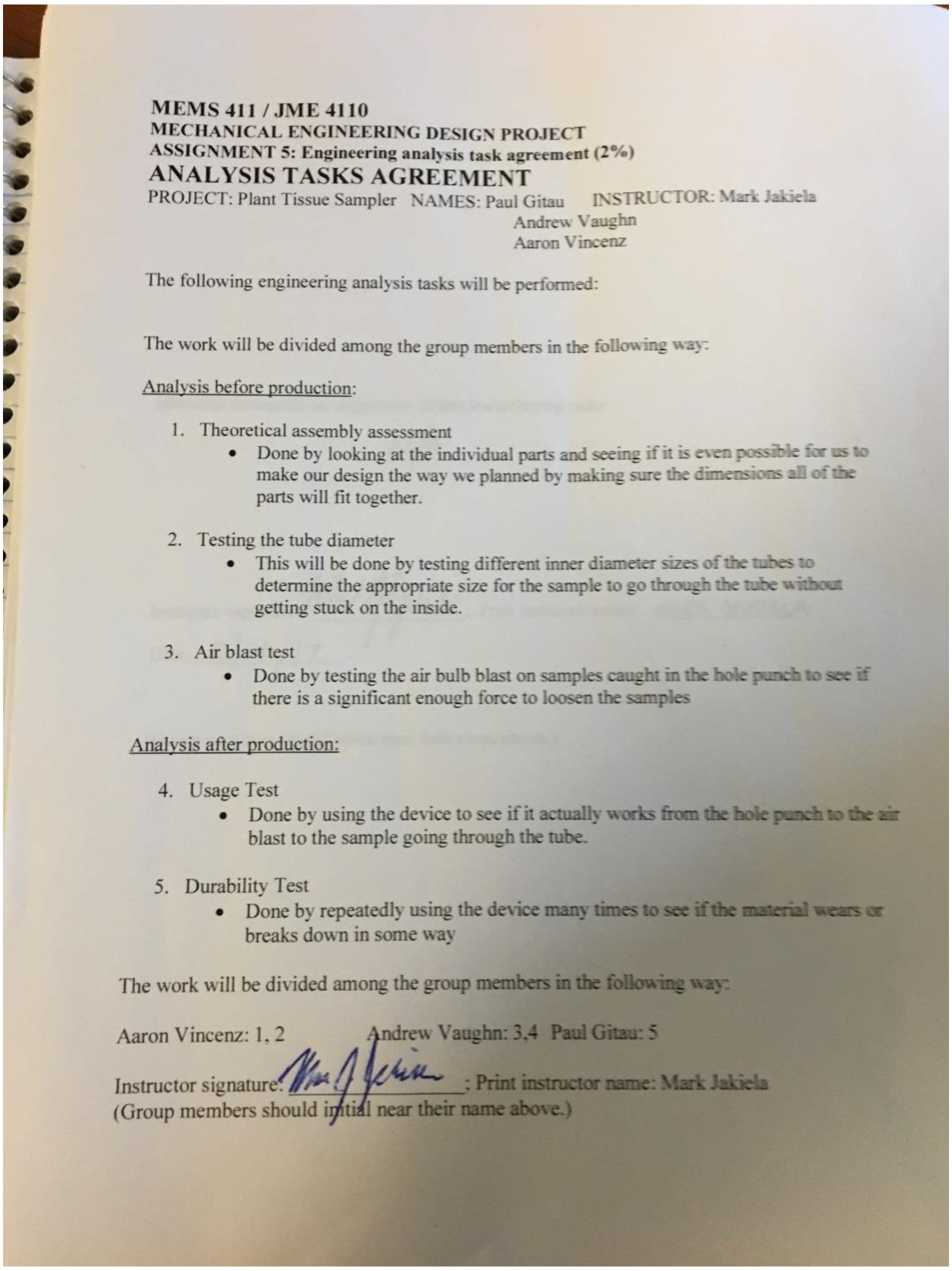
6. **Silicon Tubing** – This will be used to transport the air from the air bulb to the tube fitting. We decided on silicon because it is ethanol resistant and it won’t even touch the sample so contamination is moot

7. **Tube Fitting** – This will be a T-shaped tube fitting with one side open facing the hole so the air can blow the sample into the aluminum tubing. The other side of the T will be closed off using epoxy. The tube fitting is also connected to the silicon tubing coming from the air bulb. This will be mounted to the guide using epoxy.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

5.1.1 Signed engineering analysis contract



MEMS 411 / JME 4110
MECHANICAL ENGINEERING DESIGN PROJECT
ASSIGNMENT 5: Engineering analysis task agreement (2%)
ANALYSIS TASKS AGREEMENT
PROJECT: Plant Tissue Sampler NAMES: Paul Gitau INSTRUCTOR: Mark Jakiela
Andrew Vaughn
Aaron Vincenz

The following engineering analysis tasks will be performed:

The work will be divided among the group members in the following way:

Analysis before production:

1. Theoretical assembly assessment
   - Done by looking at the individual parts and seeing if it is even possible for us to make our design the way we planned by making sure the dimensions all of the parts will fit together.
2. Testing the tube diameter
   - This will be done by testing different inner diameter sizes of the tubes to determine the appropriate size for the sample to go through the tube without getting stuck on the inside.
3. Air blast test
   - Done by testing the air bulb blast on samples caught in the hole punch to see if there is a significant enough force to loosen the samples

Analysis after production:

4. Usage Test
   - Done by using the device to see if it actually works from the hole punch to the air blast to the sample going through the tube.
5. Durability Test
   - Done by repeatedly using the device many times to see if the material wears or breaks down in some way

The work will be divided among the group members in the following way:

Aaron Vincenz: 1, 2 Andrew Vaughn: 3,4 Paul Gitau: 5

Instructor signature: ____________; Print instructor name: Mark Jakiela
(Group members should initial near their name above.)

Figure 15: Signed Engineering Analysis Tasks Agreement

5.2 ENGINEERING ANALYSIS RESULTS

5.2.1 Motivation

In order to ensure that our prototype will work as expected, several analysis tasks were chosen and carrier out before the prototype was built. Before any manufacturing or fabricating was done, we needed to make sure that the dimensions of our parts we are going to order will fit together as planned. We also needed to see if the air blast would be strong enough to loosen a sample if it was to get stuck on the rim of the hole. Next we had to see what inner diameter of the tube was sufficient in order for the sample to go through it without being wedged along the way. Finally, we needed to make sure all of the materials used would not contaminate the sample, at least anything that touches the sample. Once the prototype was manufactured, several tests were done ensuring that it was strong enough for many uses each day and would continue to work.

5.2.2 Summary statement of analysis done

There was no relevant equations used in our analysis. We just analyzed the size of the parts including length, width, inner diameter, and outer diameters to see if everything could fit together like in our embodiment drawing. We also tested different tubes to find the right size of inner diameter. We tested the air bulb blast on the hole in the hole punch. Finally, we researched the materials for contamination and ethanol resistance

5.2.3 Methodology

There were no calculations that needed to be made for this prototype. Before construction we got all of our pieces together and made sure the bulb would fit inside the handle as well as the tube through the joint on the hole punch. We also made sure the diameter of the tube fit the fitting and the air bulb. We tested multiple tubes in order to find what inner diameter would work for the tube. We tested the air blast through our air bulb, tube, and nozzle combo aimed at the hole with a stuck sample. We also researched all of the materials being used to see if they would contaminate the sample and if they were ethanol resistant

These tests were done before the prototype was made and a durability test was done afterwards to ensure reliability and endurance.

5.2.4 Results

We were able to determine that all of dimensions worked together and that the prototype would come together as planned. We determined that the size of the tube’s inner diameter must be at least 1/8” in order for the sample to not get stuck. The air blast was tested on the hole with a stuck sample and it proved to have enough force to loosen the sample. We also made sure that all of our materials, especially those that came in to contact with the sample would not contaminate it. All of the materials used are ethanol resistant. These results make sense because we ordered our parts carefully and with precision to see that all pieces would work together, the air bulb force, and risk of contamination / ethanol resistance.

5.2.5 Significance

These results prove that our final prototype will work as we hoped. Nothing during the analysis will really change the prototype outcome. The dimensions of the tube will be affected since it must be at least an 1/8” and the material used must be ethanol resistant and not contaminate the sample. Since all went to plan, nothing really change between the embodiment drawing and the final documentation drawing except for the size of the tube which can be smaller than anticipated.

6 RISK ASSESSMENT

6.1 RISK IDENTIFICATION

For the product design of the Plant Tissue Sampler, there have been some areas of concern that have been identified. The factors listed below are the areas that could cause a problem to safe and effective way of producing our final product. There is no order to the factors below and there may be unforeseen factors that may arise in the future. These are the factors that could completely stall production of our final product.

- Supply
- Funding
- Fabrication
- Availability of Workshop
- Availability of Materials
- Product Safety

6.2 RISK ANALYSIS

Supply

The risk associated with supply can be that the parts don’t get to where they are supposed to go or get delayed along the way. This could mean that are project doesn’t start on time or never gets started if the parts do not show up.

Probability: Low

Impact: High

Funding

The risk associated with not having the funding to order our parts or not having enough funding to cover all of expenses. This could hinder the production process and could prevent the completion of the prototype

Probability: Low

Impact: Medium

Fabrication

This risk is associated with not having the skills to create the parts, use equipment, and put everything all together. This could prevent the completion of the prototype or even the ability to start.

Probability: Medium

Impact: High

Availability of Workshop

Risk associated with not having the workshop at our disposal or at a certain time to fabricate our parts and create our prototype. This could slow down the production process and could prevent the completion of our device.

Probability: Low

Impact: Medium

Availability of Materials

The risk associated with not having access to the materials required to complete this project. This is related to supply risk but also includes materials that were not ordered. This could stop the project completely if all the materials were not accrued.

Probability: Low

Impact: High

Product Safety

The risk associated with the user being injured by the product.

Probability: Low

Impact: High

6.3 RISK PRIORITIZATION

Supply

In order to reduce the risks associated with supply, we ordered parts from multiple vendors in order to get our parts. This is important in case one of the companies is delayed in getting our parts or they are unable to supply the parts altogether. If we had only one vendor there would have been a risk that none of our parts arrived or they all arrived late. We also only ordered basic parts that we could then manipulate in fabrication so we did not need to order specialized parts which would ensure that the vendors would have them.

Funding

In an attempt to keep the risks of funding low, we decided to keep our budget low enough to allow so that it would be covered by the client/university. The parts used in our particular design were not very costly and the total cost was low enough to ensure that the risks associated to funding were minimal at best

Fabrication

In an attempt to keep risks of fabrication low, our team members must all be trained on the machines used to make our prototype. This will ensure that if someone can't make it to the workshop, due to unseen complications, that the others will be able to do the work. It is also important to note that the machines could be down for maintenance or cleaning and this could prevent us from finishing our prototype. For our prototype, there will not be much fabrication and so these risks seem low.

Availability of Workshop

In order to reduce the risks associated with workshop availability, we need to make sure that we talk to the coordinator of the workshop and make sure that we can get the time we need in the workshop and make sure to set dates for the time we need. This also has to do with the times that the machines are down for maintenance/cleaning so we need to be made aware of when that occurs. As stated previously, we don't have much fabrication work that needs to be done so these risks are low.

Product Safety

We obviously should avoid altogether the possibility of injury or death from use of our product. Documentation of how to properly use our product should be given to the user. We could keep track of all of those who use our products in case of recalls and modification for an unforeseen safety issues. We need to make sure that materials used in the fabrication of our product are not harmful to those who use our product. For our product, the risk of someone being injured or dying using our product is virtually non-existent. In order for someone to harm themselves from using our product they would have to want to be injured on purpose.

7 CODES AND STANDARDS

7.1 IDENTIFICATION

1. Codes and standards for preventing contamination with plants.
    - Guarino, Rebecca. "Preventing Contamination in Cell Culture." American Laboratory, Incubators and Cell Culture Consumables, Eppendorf North America, 2 Sept. 2015, www.americanlaboratory.com/Lab-Tips/177647-Preventing-Contamination-in-Cell-Culture/.

2. Codes and standards for aluminum/stainless steel.
    - "Aluminum Alloys 101." *Aluminum Alloys 101 | The Aluminum Association*, Aluminum Association, 31 July 2017, www.aluminum.org/resources/industry-standards/aluminum-alloys-101.
    - "UNITED STATES DEPARTMENT OF LABOR." Occupational Safety and Health Administration, OSHA, www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767.

3. Codes and standards for using ethanol.
    - "OSHA Standards." Chemical Sampling Information | Ethyl Alcohol, OSHA, www. https://www.osha.gov/dts/osta/otm/otm_iv/safety.pdf osha.gov/dts/chemicalsampling/data/CH_239700.html.

4. General safety hazard codes and standards.
    - "UNITED STATES DEPARTMENT OF LABOR." *Occupational Safety and Health Administration*, OSHA, www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767.

7.2 JUSTIFICATION

1. There is a high risk of contamination when obtaining plant samples, ensuring all the equipment is sterilized.
2. Aluminum and stainless steel standards are important because, they are the two main materials being used to build the product. Also ensuring that materials will not contaminate the sample and can withstand being in contact with ethanol.
3. Ethanol is used on the plant samples.
4. General safety hazard standards have to be used while taking plant samples.

7.3 DESIGN CONSTRAINTS

1. The types of material used to build the product, to ensure they do not contaminate the plant samples.
2. The aluminum and stainless steel, need to be able to withstand being in contact with ethanol and not contaminate the sample itself.
3. The materials being used have to be ethanol resistant.
4. General safety hazard standards do not place a constraint on the design

7.4 SIGNIFICANCE

1. The two types of the materials that will be used are stainless steel and aluminum.
2. Stainless steel and aluminum are ethanol resistant and will not contaminate plant samples.
3. Stainless steel and aluminum are resistant to ethanol.
4. General safety hazard standards do not place a constraint on the design.

8 WORKING PROTOTYPE

8.1 PROTOTYPE PHOTOS

Figure 16: Plant Tissue Sampler Prototype

Figure 17: Plant Tissue Sampler Being Used

8.2 WORKING PROTOTYPE VIDEO

Below is a link to a demonstration video of our prototype:

https://www.youtube.com/watch?v=speojeLCT3k

8.3 PROTOTYPE COMPONENTS

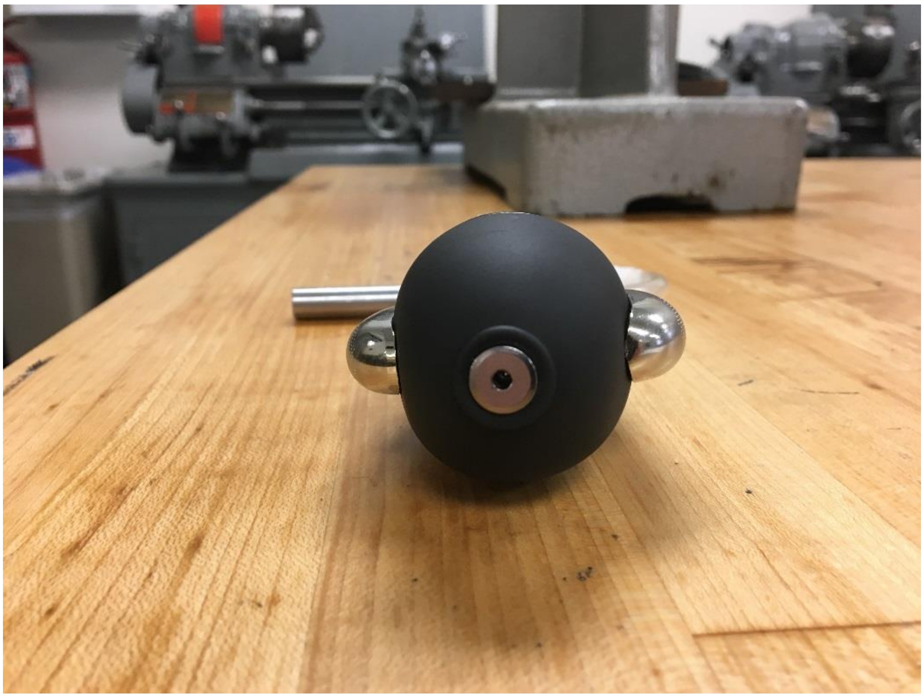


Figure 18: View of Air Bulb on Prototype

This photograph shows the how the air bulb fits into the hole punch between the handles. This provides the air blast which travels through the silicon tubing to the tube fitting at the front of the hole punch.

Figure 19: View of Silicon Tubing and Tube Fitting Mounted On Hole Punch

The air blast from the air bulb travels through the tubing and tube fitting to blow air directly at the hole to loosen samples that are stuck. We had to attach the tube fitting to the guide on the hole punch using epoxy.

Figure 20: View of The Steel Tube Fitting and Detachable Steel Tube

This steel tube fitting was attached to the hole punch by clamping and spot welding. The tube screws into the fitting and the sample travels through both and out the opposite end of the tube. The tube was sized so that the test tube can be secured on to the bottom of the tube which the sample will end up in. We made it detachable for cleaning purposes and possibly to make other tubes that would fit other size test tubes.

Figure 21: Bottom View of the Tube Showing Hole That Sample Goes Through

This shows the hole that the sample goes through. The sample starts at the hole punch hole, goes through the metal fitting and tubing and comes out here. This is also where you attach the test tube. The size of the hole needed to be big enough to allow the sample to slide through easily and not get stuck.

9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 Engineering Drawings

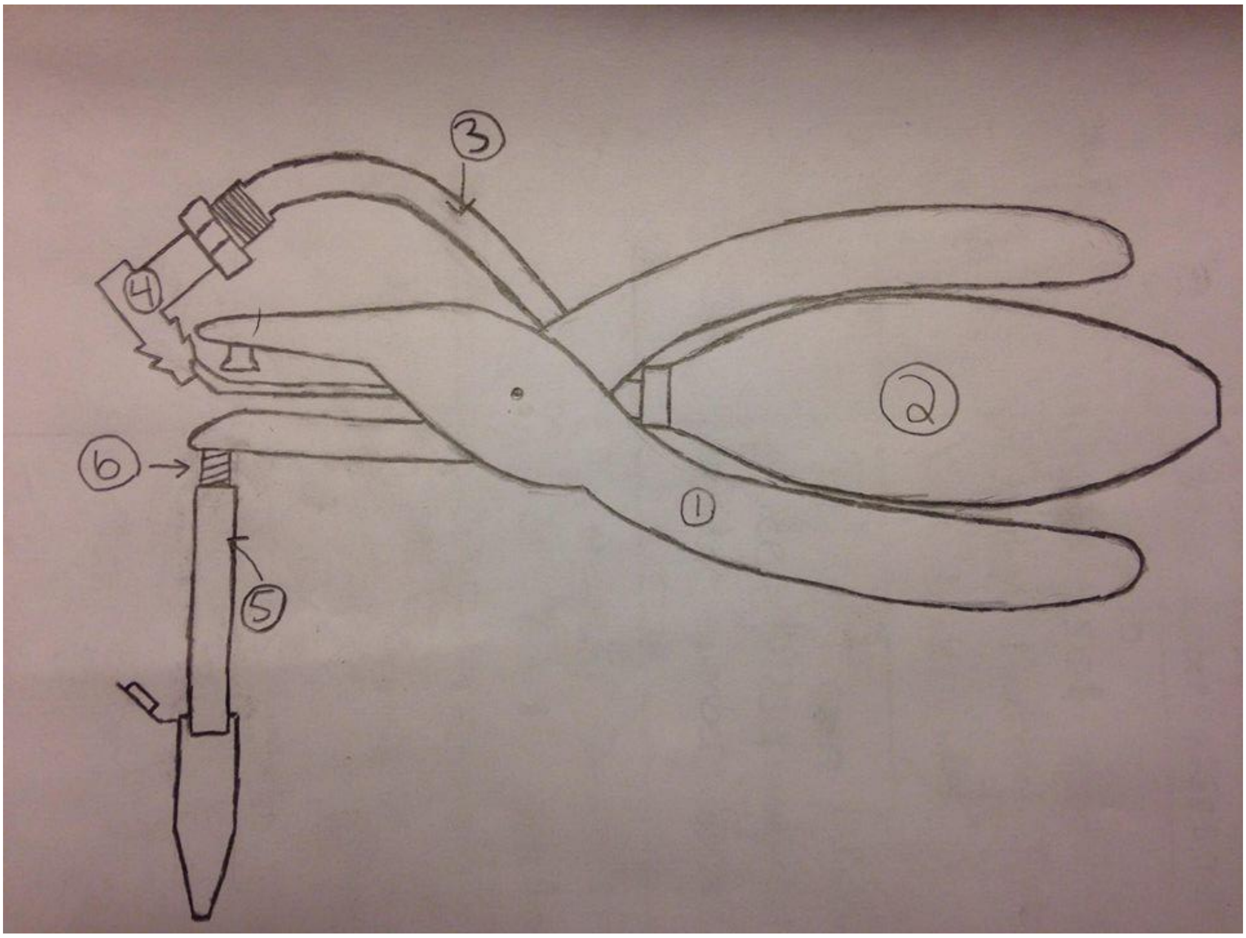


Figure 22: Engineering Drawing For Prototype

Part 1

Figure 23: Paper Hole Punch

Figure 24: Air Bulb

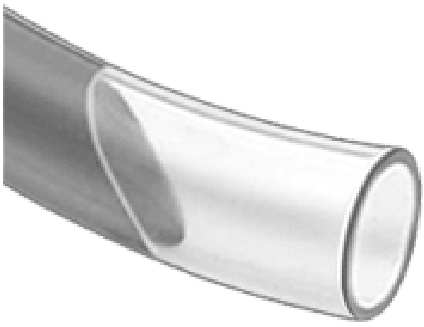


Figure 25: Silicon Tubing

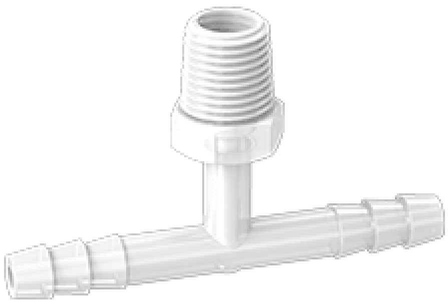


Figure 26: Silicon Tube Fitting

Part 5

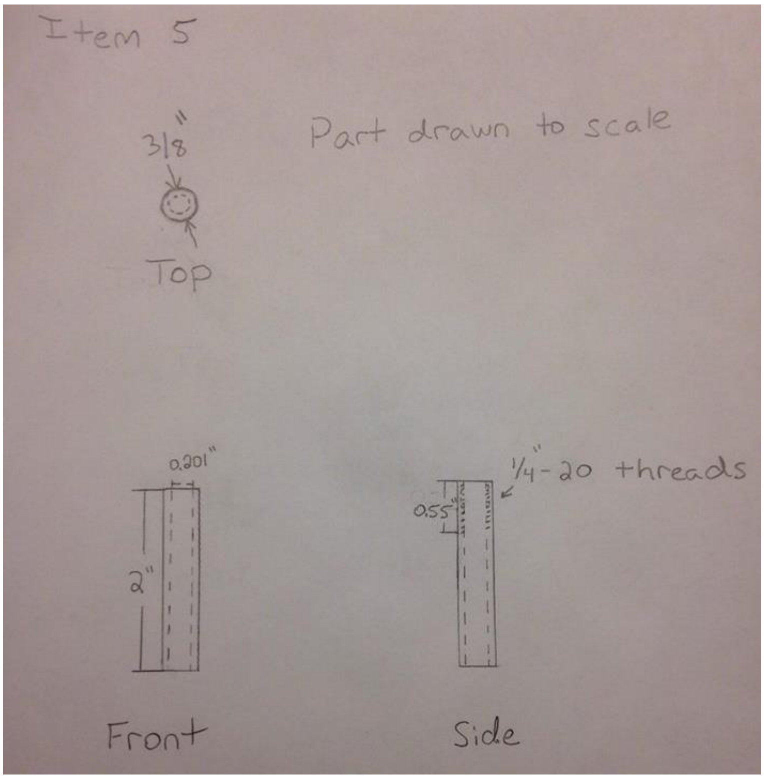


Figure 27: Steel Tube

Part 6

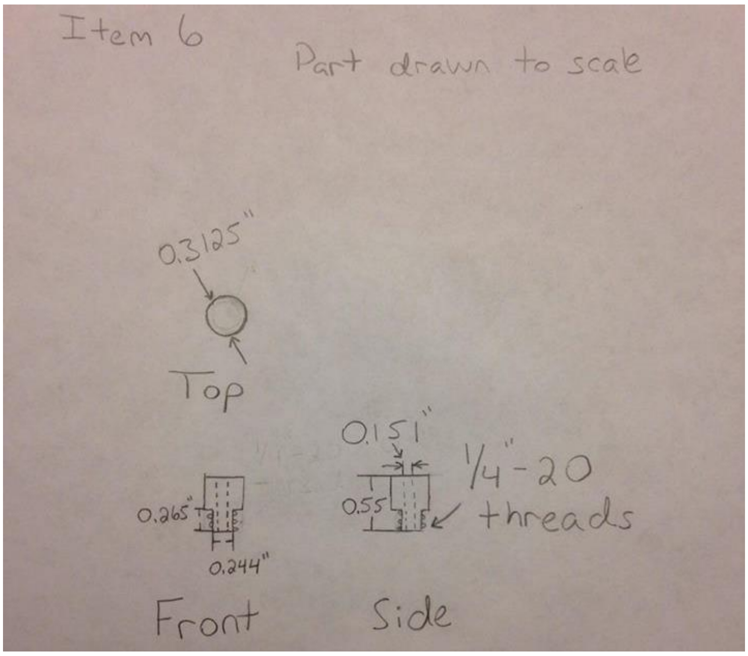


Figure 28: Steel Tube Fitting

9.1.2 Sourcing instructions

Part 2 fits inside the upper and lower hand grip of Part 1, the hole punch. Epoxy can be applied to keep the bulb in place. Part 3 is inserted into the female hole of part 2. Epoxy is applied between the bulb and the tubing to seal the bulb. This ensures that all the air compressed in the bulb is released through the tube. Part 4 is attached to the end of the silicon tube. The T joint is held in place with epoxy also. Part 5 screws into part 6. Part 6 fits into the lower grip of Part 1, the hole punch, and is spot welded into place. Assembly for the design begins with part 6. Next part 2 is attached to part 3. Then part 2 is placed in the proper location. Part 4 is attached to the tongue of the hole puncher by cutting a notch in the T joint. The notch allows the T to slide into place along the tongue. Part 7, Epoxy, is applied to hold the T joint in place. Lastly, part 5 screws into part 6.

Evolved Bill of Materials

Table 13: Evolved Bill of Materials

Part number	Part Name	Vendor and Vendor Number	Price
1	Paper hole punch	Hole puncher with 1/8" hole Vendor: McMaster Carr Vendor number: 12885T35	$5.13
2	Air bulb	Prestige Medical Inflation Bulb w/ End Valve, 1.05 Ounces Vendor: Amazon	$4.50
3	Silicon tubing	1/4" silicon tubing (25') Vendor: McMaster Carr Venfor number: 6516T17	$13.75 for roll of 25 ft
4	Silicon tube fitting	T shaped Tube Fitting (10 count) Vendor: McMaster Carr Vendor number: 5372K631	$7.40 for count of ten
5	Steel tube fitting	3/8" Diameter Steel Tubing Vendor: Speedy Metals	$1.20 for 2 ft
6	Steel tube	3/8" Diameter Steel Tubing Vendor: Speedy Metals	$1.20 for 2 ft
7	Epoxy	Gorilla Glue Epoxy 8.5 oz	$5.82

9.2 FINAL PRESENTATION

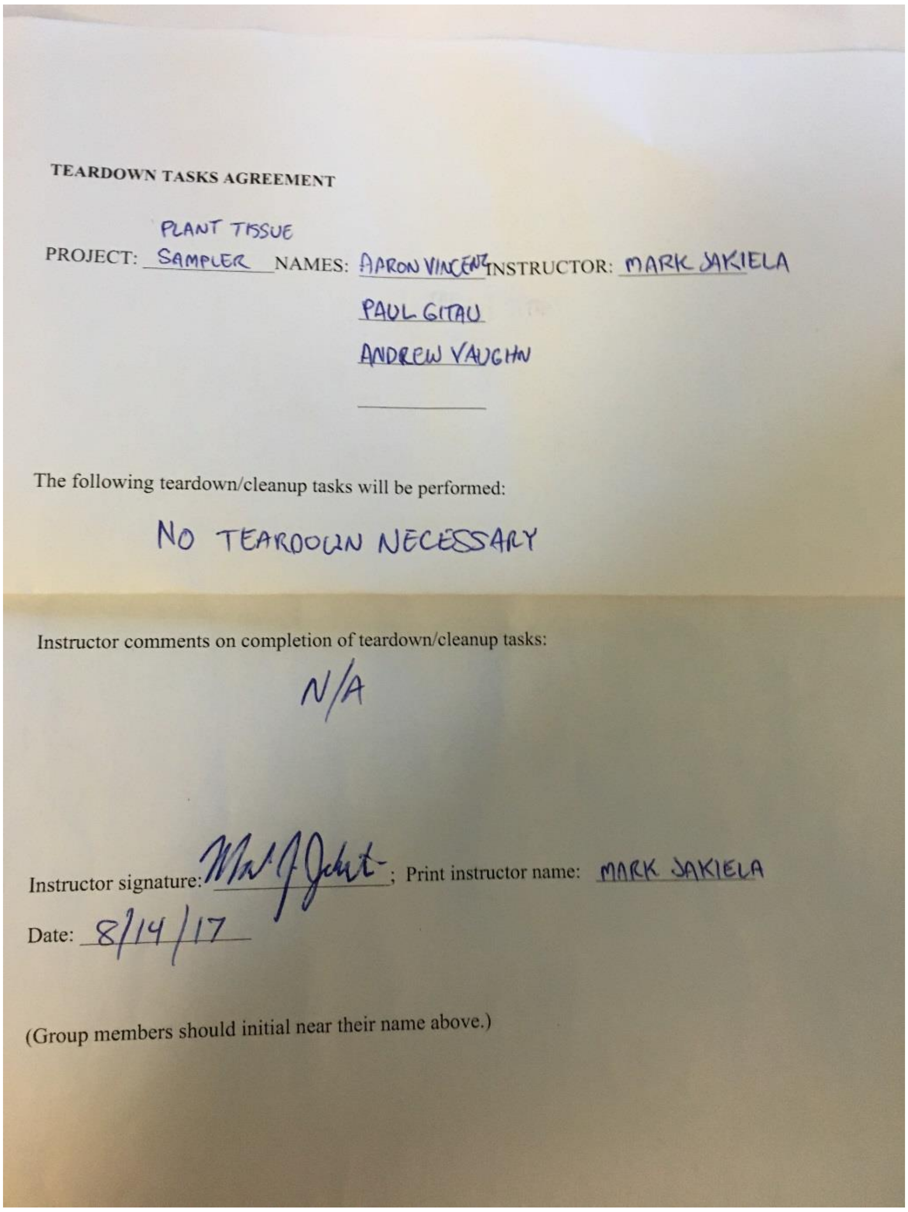
Below is a demonstration video for our prototype.

https://www.youtube.com/watch?v=speojeLCT3k

Below is a presentation video for our prototype.

https://www.youtube.com/watch?v=x--n7JS0KDY&t=2s

10 TEARDOWN



TEARDOWN TASKS AGREEMENT

PROJECT: PLANT TISSUE SAMPLER NAMES: AARON VINCENT INSTRUCTOR: MARK JAKIELA

PAUL GITAU

ANDREW VAUGHN

The following teardown/cleanup tasks will be performed:

NO TEARDOWN NECESSARY

Instructor comments on completion of teardown/cleanup tasks:

N/A

Instructor signature: ; Print instructor name: MARK JAKIELA

Date: 8/14/17

(Group members should initial near their name above.)

Figure 29: Signed Teardown Tasks Agreement

11 APPENDIX A - PARTS LIST

Table 14: Initial Parts List

Part number	Part Name	Vendor and Vendor Number
1	Paper Hole Punch	Hole puncher with 1/8" hole Vendor: McMaster Carr Vendor number: 12885T35
2	Air Bulb	Prestige Medical Inflation Bulb w/ End Valve, 1.05 Ounces Vendor: Amazon
3	Silicon Tubing	1/4" silicon tubing (25') Vendor: McMaster Carr Venfor number: 6516T17
4	Silicon Tube Fitting	T shaped Tube Fitting (10 count) Vendor: McMaster Carr Vendor number: 5372K631
5	Steel Tube Fitting	3/8" Diameter Steel Tubing Vendor: Speedy Metals
6	Steel Tube	3/8" Diameter Steel Tubing Vendor: Speedy Metals
7	Epoxy	Gorilla Glue Epoxy 8.5 oz

12 APPENDIX B - BILL OF MATERIALS

Table 15: Bill of Materials

Part number	Vendor and Vendor Number	Price
1	Hole puncher with 1/8" hole Vendor: McMaster Carr Vendor number: 12885T35	\$5.13
2	Prestige Medical Inflation Bulb w/ End Valve, 1.05 Ounces Vendor: Amazon	\$4.50
3	1/4" silicon tubing (25') Vendor: McMaster Carr Venfor number: 6516T17	\$13.75 for roll of 25 ft
4	T shaped Tube Fitting (10 count) Vendor: McMaster Carr Vendor number: 5372K631	\$7.40 for count of ten
5	3/8" Diameter Steel Tubing Vendor: Speedy Metals	\$1.20 for 2 ft
6	3/8" Diameter Steel Tubing	\$1.20 for 2 ft

	Vendor: Speedy Metals	
7	Gorilla Glue Epoxy 8.5 oz	$5.82

13 APPENDIX C – COMPLETE LIST OF ENGINEERING DRAWINGS

Part 1

Figure 30: Paper Hole Punch

Part 2

Figure 31: Air Bulb

Part 3

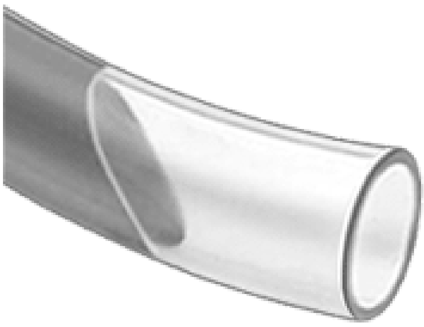


Figure 32: Silicon Tubing

Part 4

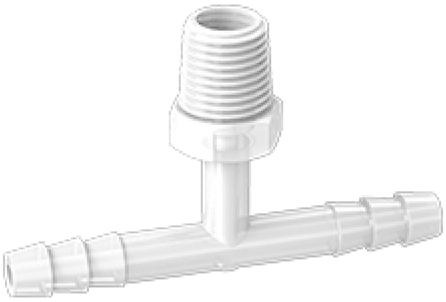


Figure 33: Silicon Tube Fitting

Part 5

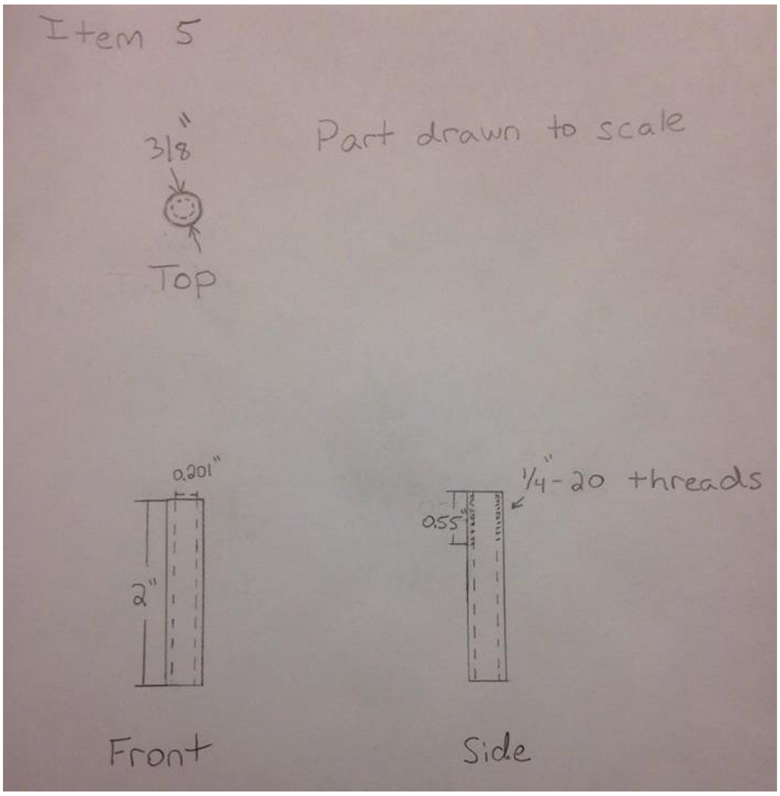


Figure 34: Steel Tube

Part 6

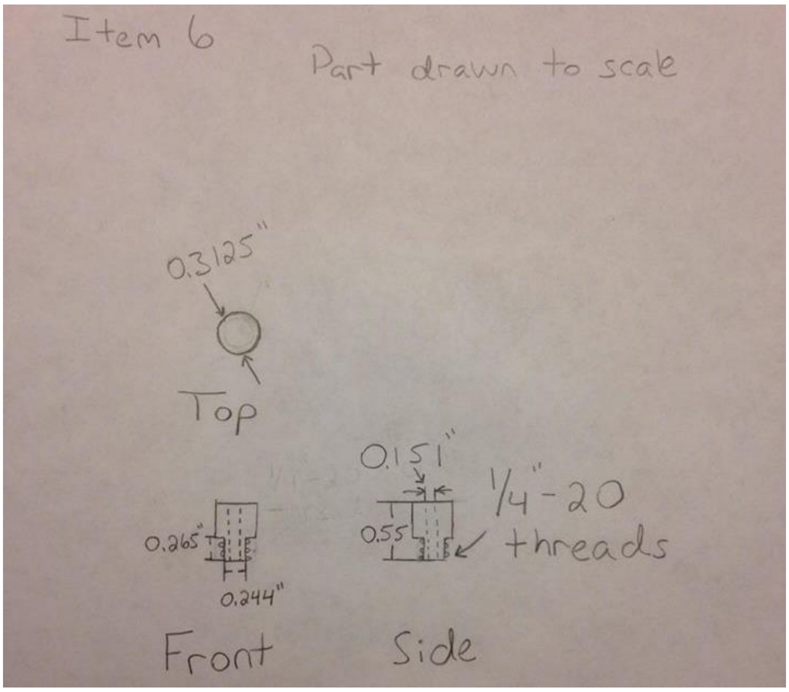


Figure 35: Steel Tube Fitting

14 ANNOTATED BIBLIOGRAPHY

1. Codes and standards for preventing contamination with plants.
    - Guarino, Rebecca. "Preventing Contamination in Cell Culture." American Laboratory, Incubators and Cell Culture Consumables, Eppendorf North America, 2 Sept. 2015, www.americanlaboratory.com/Lab-Tips/177647-Preventing-Contamination-in-Cell-Culture/.

2. Codes and standards for aluminum/stainless steel.
    - "Aluminum Alloys 101." *Aluminum Alloys 101 | The Aluminum Association*, Aluminum Association, 31 July 2017, www.aluminum.org/resources/industry-standards/aluminum-alloys-101.
    - "UNITED STATES DEPARTMENT OF LABOR." Occupational Safety and Health Administration, OSHA, www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767.

3. Codes and standards for using ethanol.
    - "OSHA Standards." Chemical Sampling Information | Ethyl Alcohol, OSHA, www. https://www.osha.gov/dts/osta/otm/otm_iv/safety.pdf osha.gov/dts/chemicalsampling/data/CH_239700.html.

4. General safety hazard codes and standards.
    - "UNITED STATES DEPARTMENT OF LABOR." *Occupational Safety and Health Administration*, OSHA, www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767.