



PROJECT TWO DEFENCE PRESENTATION:

DESIGN OF A MANUAL TEA-LEAF PLUCKING AID

ALLEVIATING OCCUPATIONAL HAZARDS ASSOCIATED WITH TEA-PLANTATION WORKERS IN INDIA

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(Name Withheld) Tea Estate, Darjeeling district, West Bengal

TEA PLUCKER INTERVIEWS



WORKER PROFILE:

Name : Mrs. Nikita Tamang (Temporary)
Age : 28 yrs Experience : 1 month

DIFFICULTIES FACED:

- Pain in hands
- Joint pain in the knee
- Abrasion of fingers
- Discomfort in scalp
- Lower back pain

ADDITIONAL INSIGHTS:

Chose this job because :

- Proximity from home
- Allows her to watch her kids
- Company benefits when permanent



WORKER PROFILE:

Name : Indu Rai (Permanent worker)
Age : 33yrs Experience : 4 yrs

DIFFICULTIES FACED:

- Pain on hands
- Pain in the knees, thighs
- Abrasion of fingers
- Burning of Scalp
- Lower & upper back pain

ADDITIONAL INSIGHTS:

- Black deposition on fingers that cannot be washed off.
- Alternate uses of doko include : collecting fire-wood for cooking, grass for goats etc, enclosure for chickens



WORKER PROFILE:

Name : Shashikali Rai (Permanent worker)
Age : 45yrs Experience : 13 yrs

DIFFICULTIES FACED:

- Pain & stiffness on hands
- Pain & stiffness in the knees, thighs
- Abrasion of fingers
- Burning of Scalp
- Lower & upper back pain
- Regular Headaches & burning of eyes

ADDITIONAL INSIGHTS:

- difficulties multiplied after the age of 40
- limited load-bearing capacity & mobility
- Stiffness in joints of the limb



INFERENCE FROM FIELD STUDY

Musculoskeletal Issues

- Hand fatigue , inflammation and stiffness –sustained contraction of muscles.
- Abrasion of fingers repetitive plucking motion.
- Upper and lower back pain -poor working posture.
- Leg Joint pain ,stiffness - long hours of standing & difficult terrain.

Injuries & Ailments

- Injuries from falling.
- Sickle injuries during pruning of tea bushes.
- Costochondritis
- Leeches, insect & snake bites.

Mechanised Tea Harvesting

- Strong opposition by labour union to replacement of workers by machines.
- Existing machines are not manoeuvrable in hilly terrain.
- Existing machines come with their own set of issues-leaf quality etc.

Labourer Housing

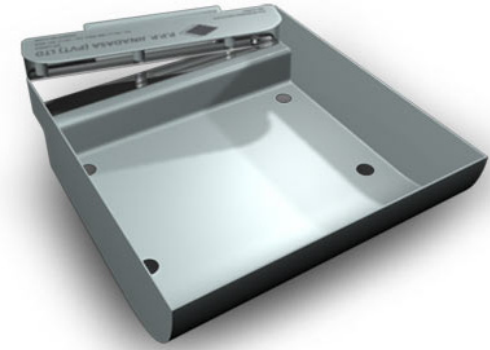
- Discomfort due to cramped spaces.
- Poor utilisation & planning of living spaces.

MARKET STUDY -PARALLEL PRODUCTS

- A) Kawasaki (gasoline operated): One man plucking machines
-imgusr.tradekey.com



- D) P.P.P. Jinadasa (Pvt) Ltd. ,Sri Lanka
Selective Tea Harvester
-www.tmachinery.com



- B) Willames Tea UL750 Selective Tea Harvester
-www.cmeri.res.in



- C) Falcon Garden Tools, Punjab , India:
Tea Leaf Plucking Shears
-www.teaspares.com



INFERENCES FROM MARKET STUDY

Musculo-Skeletal Issues:

- Static Loading on hands results in fatigue.
- Incorrect load bearing posture such as side bending is not recommended.
- Unbalanced distribution of load on hands and body.

Quality of Plucked Leaves

There is substantial degradation in the standard of leaves harvested (in comparison to hand-plucking) using the machines to accommodate higher production rates.

Problems with Usage:

- Catcher tray/bag gets stuck in the tree bushes.
- Machines & their accessories are heavy , bulky and difficult to carry.
- Machines are difficult manoeuvre in hilly terrain.
- require carefully planned paths.

High Initial Investments

- Apart from the shear-type harvesters ,all other types cost upwards of Rs. 1 lakh.
- Large retail gap between categories.
- Regular maintenance of machines have an incurred cost.

Loss of Jobs

- Hundreds and thousands of house holds are dependant on manual tea plucking for their livelihoods.
- The increased use of tea-harvesting machines are replacing the jobs of upto 20 workers at a time.

DESIGN OBJECTIVE

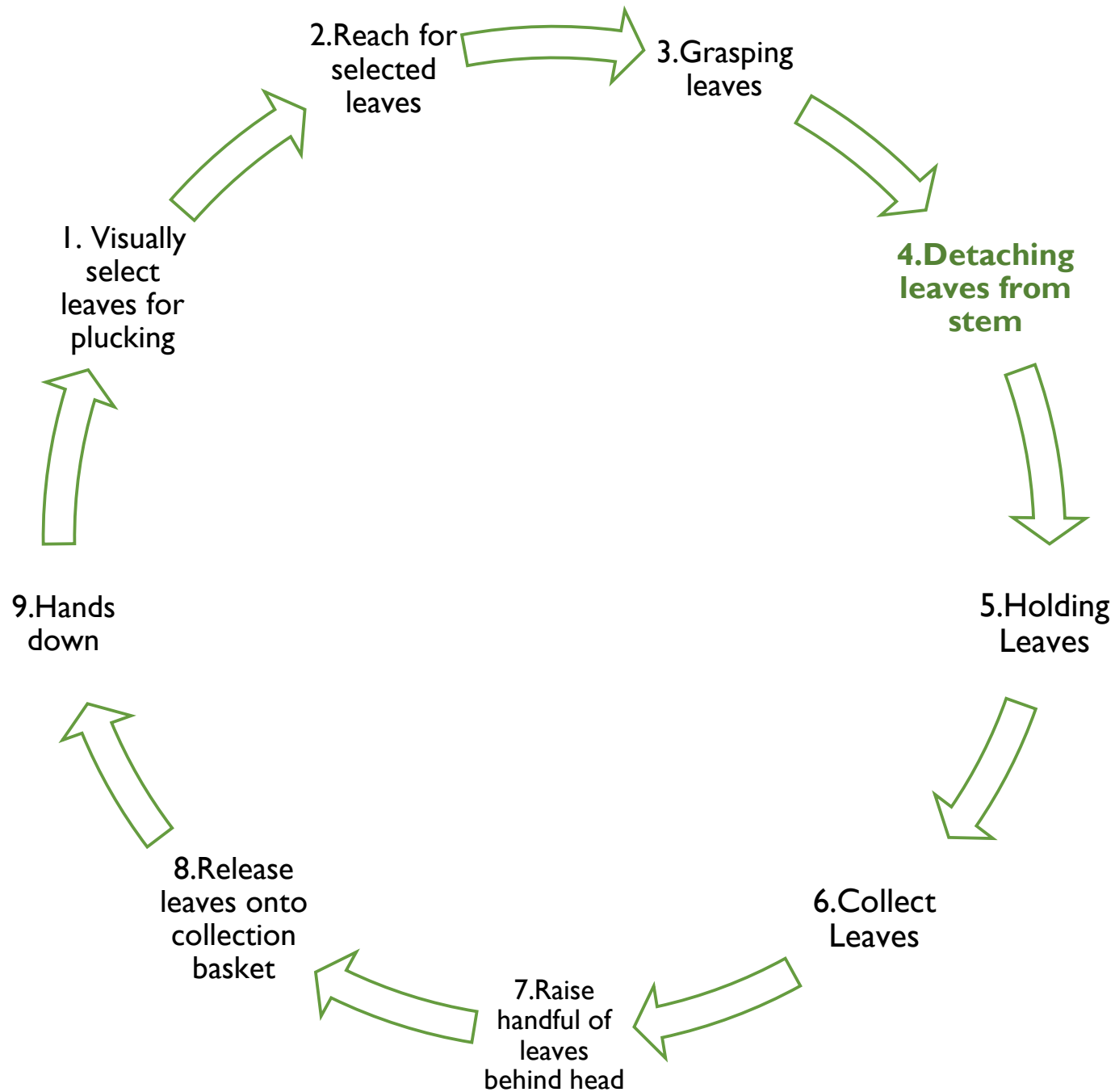
To design a device that is supportive to manual tea plucking. The device must minimise human injury and maintain high leaf standard.

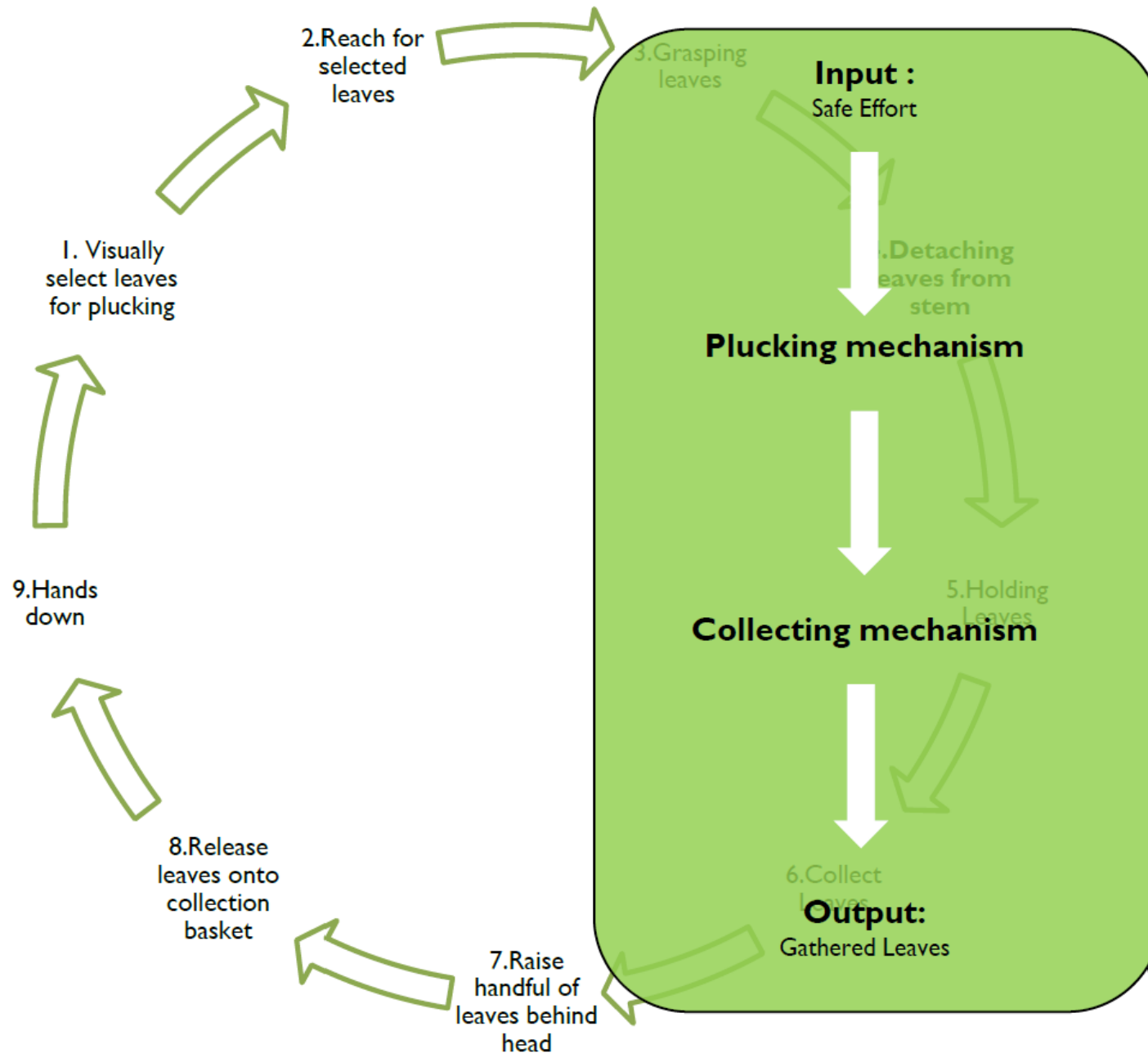
DESIGN BRIEF

The device shall adhere to the following check-points :

1. The device should alleviate musculoskeletal issues associated with manual tea plucking such as muscle & joint pain , inflammation & stiffness.
2. The aid must protect the tea-pluckers hands & fingers from injuries, abrasion , insect bites & deposition of harmful chemicals.
3. Use of the device to pluck tea should not diminish the quality of leaves plucked.
4. The device must be easy to manoeuvre & carry in difficult hilly terrain.
5. The device must be economical to produce.

GATHERING ERGONOMICS INSIGHTS





Manual Tea Plucking Aid

ERGONOMIC ISSUES

1.Plucking of Leaves:

- a) Repetitive Strain Injury
- b) Fatigue
- c) Inflammation

2.Collecting Leaves in hand:

- Sustained contraction of muscles

3.Environment:

- a) Absorption of Alkaloids & pesticides
- b) Insect & snake bites



DESIGN INSIGHTS :

1.Plucking Component

- Effort distributed over more muscles is advisable.
- Dynamic 2 handed plucking motion is recommended.
- Eliminating unnecessary motions will reduce the effort ,time required.

2.Collecting Component

- Should not get caught in the tea bushes
- Should not obstruct device from plucking
- Avoid

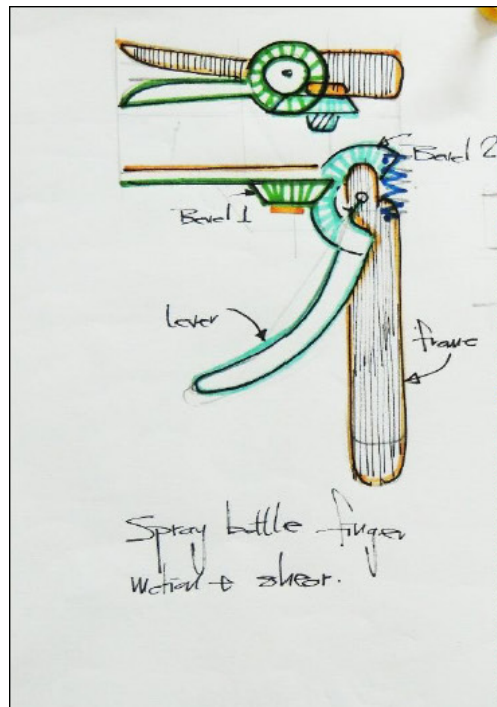
3.Protective Component

- Product weight <1 kg per hand
- Must allow for air circulation.
- Protect fingers to elbow.

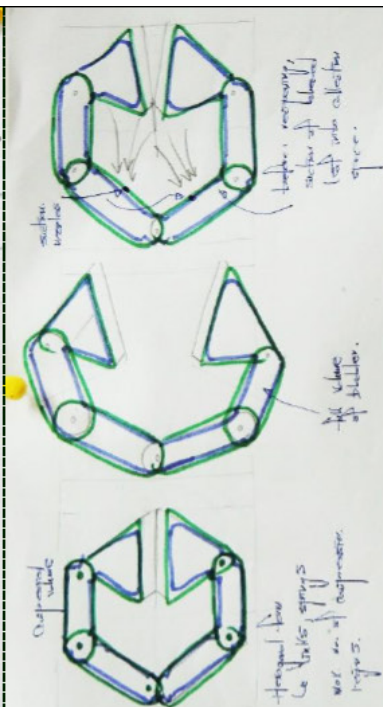
IDEATION & CLUSTERING



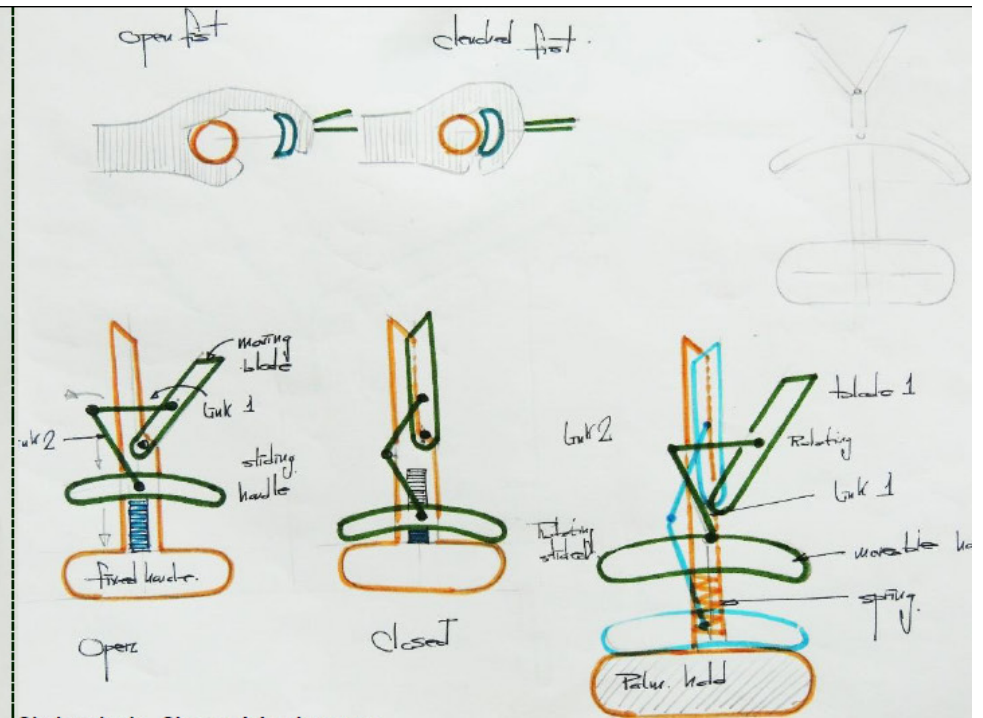
IDEATION :MANUAL MECH.



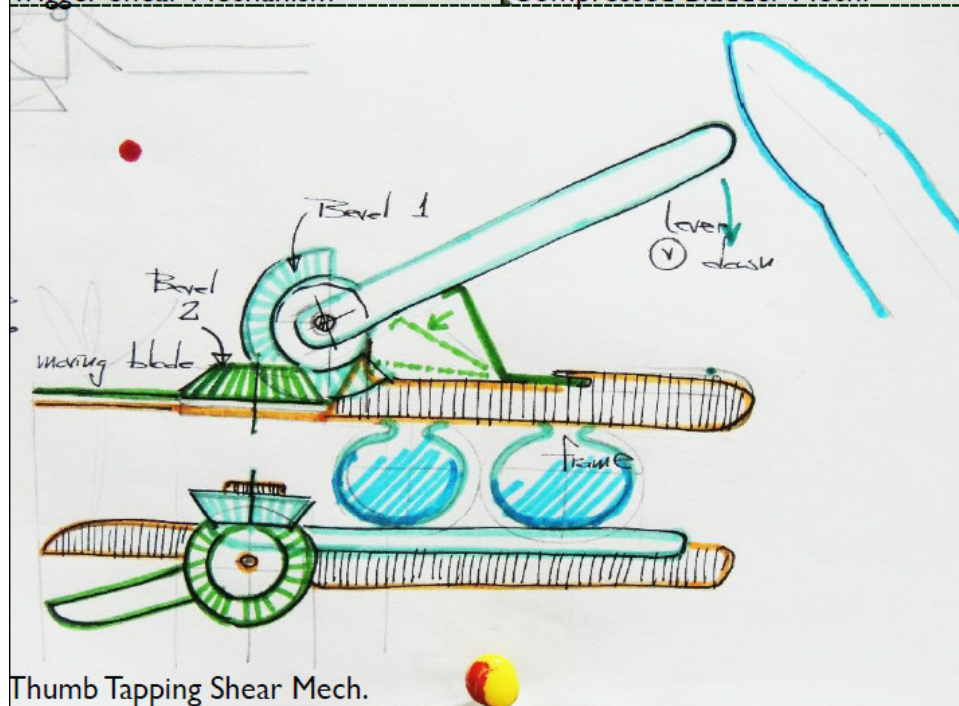
Trigger Shear Mechanism



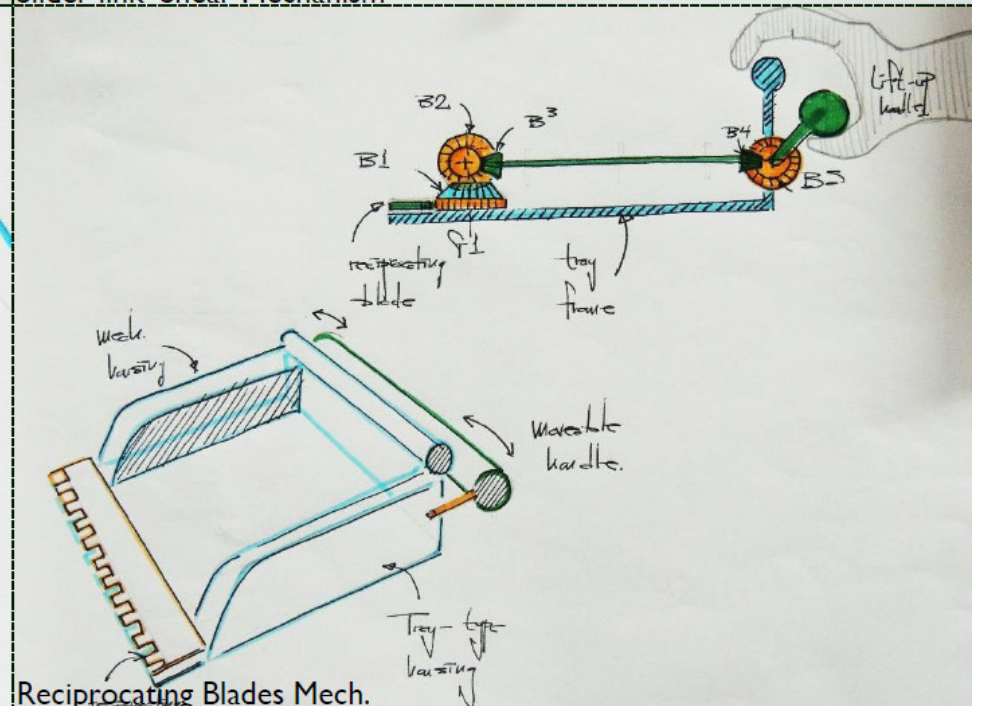
Compressed Bladder Mech.



Slider link-Shear Mechanism

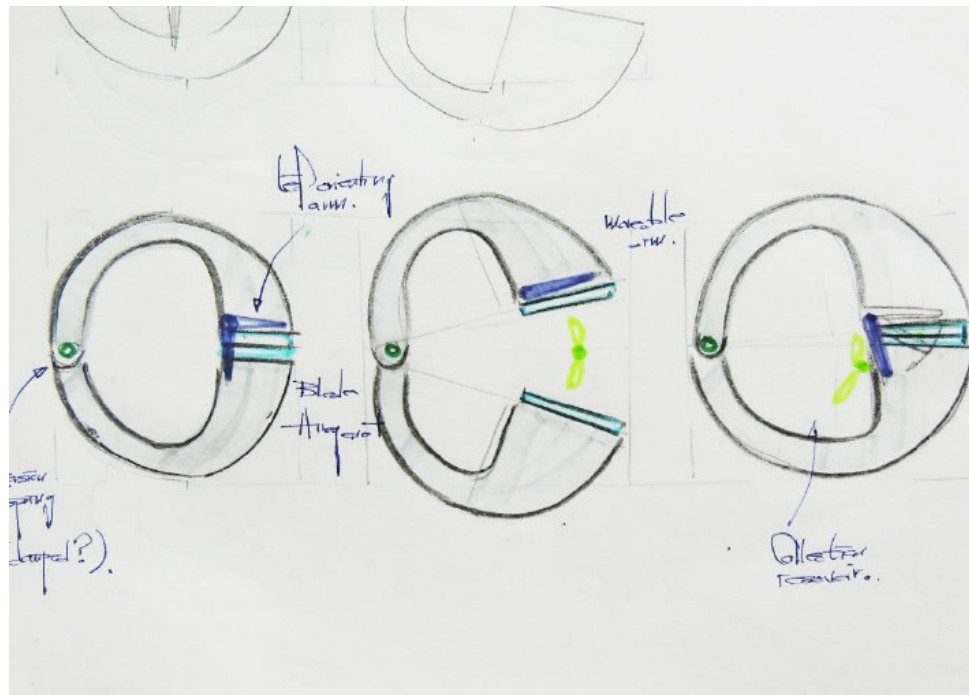


Thumb Tapping Shear Mech.

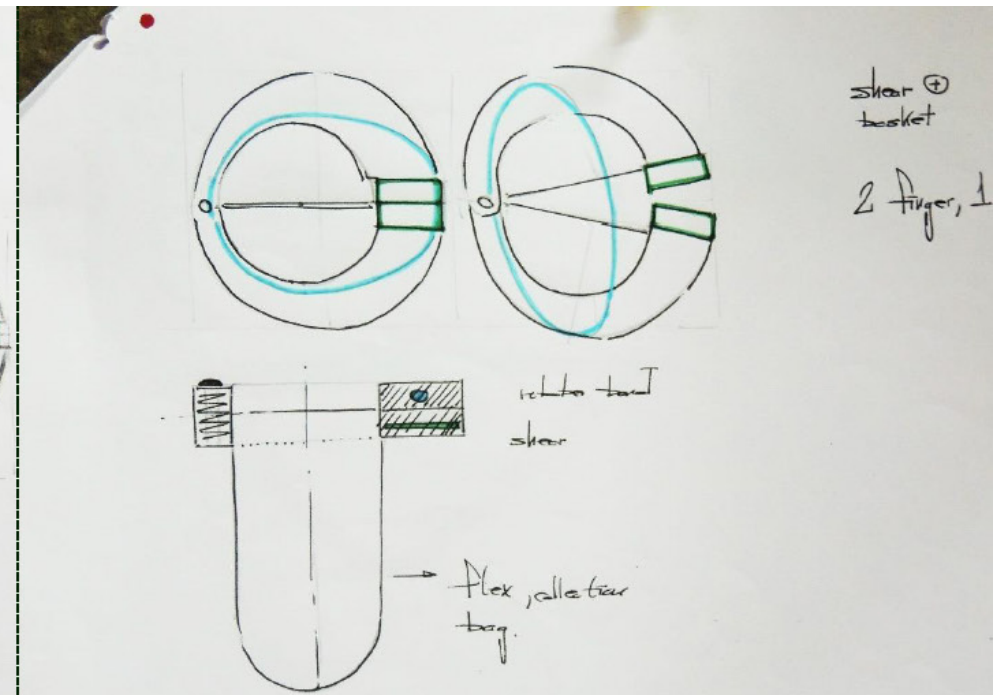


Reciprocating Blades Mech.

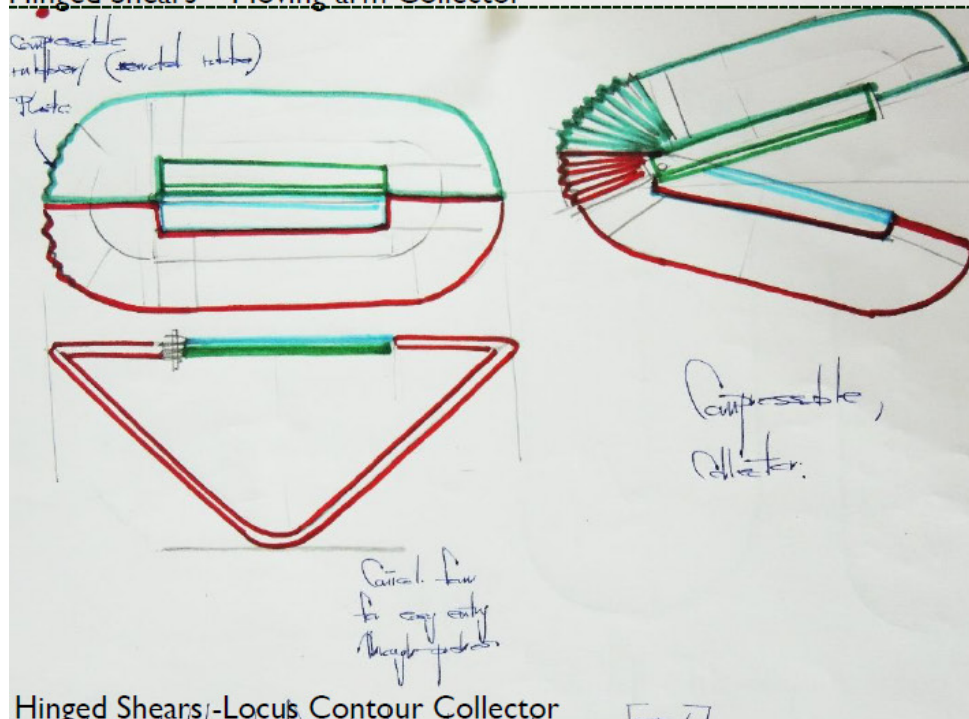
IDEATION :SPRING TYPE



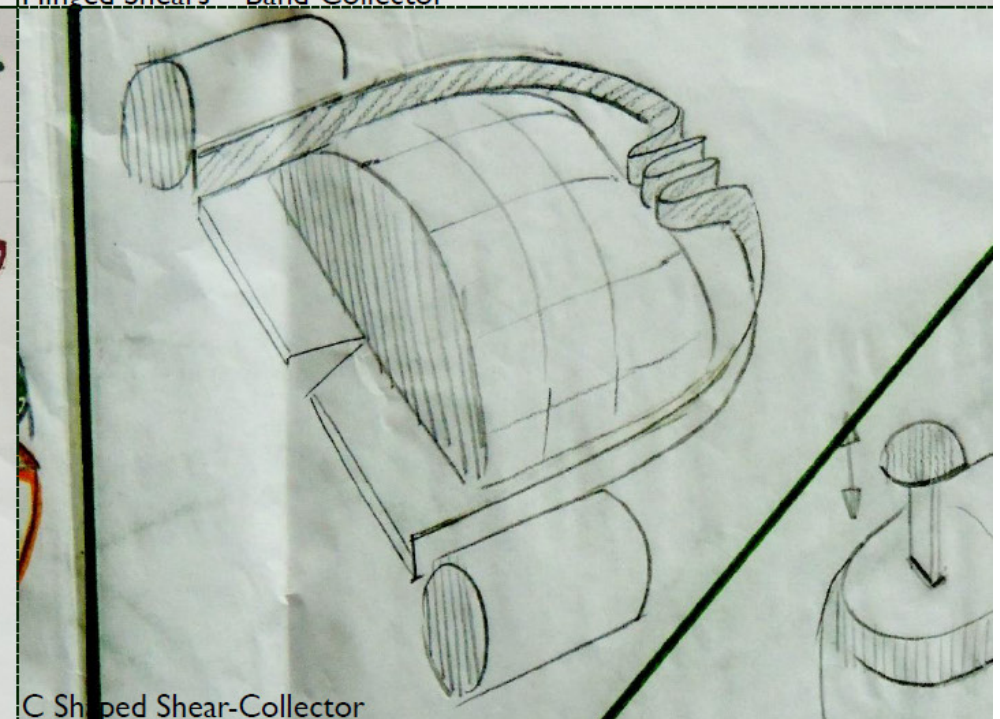
Hinged Shears – Moving arm Collector



Hinged Shears – Band Collector

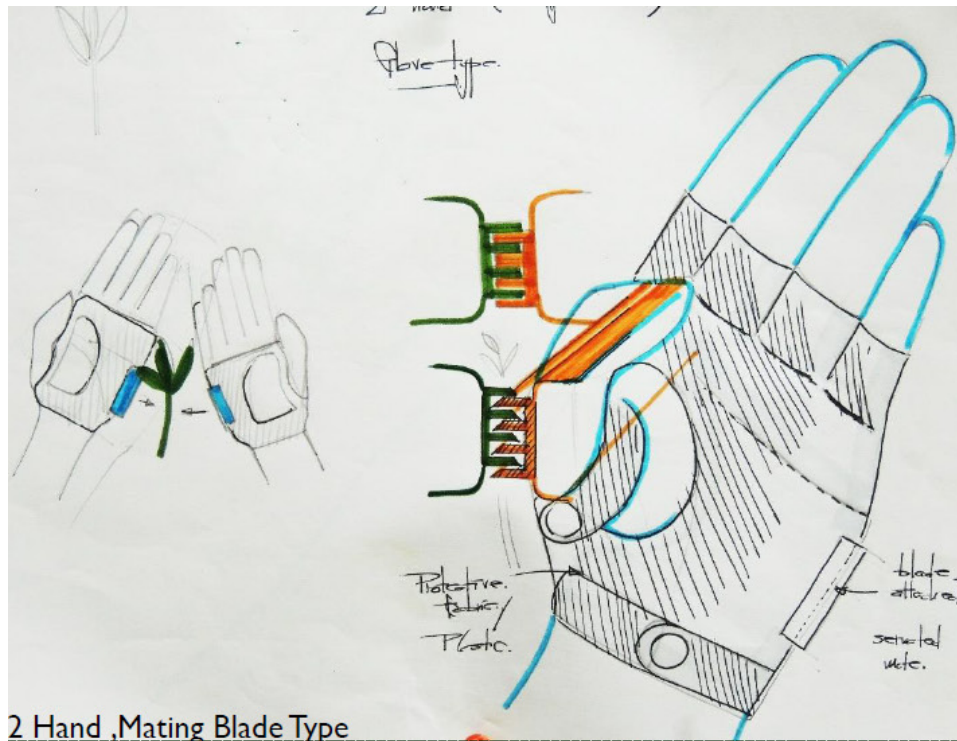


Hinged Shears - Locus Contour Collector

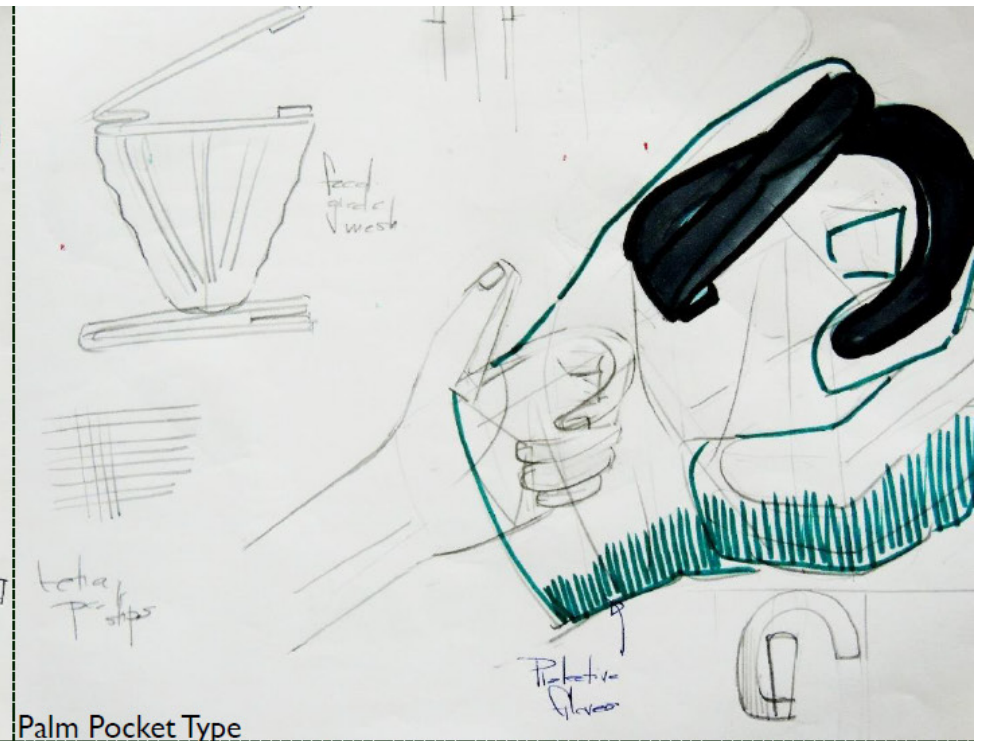


C Shaped Shear-Collector

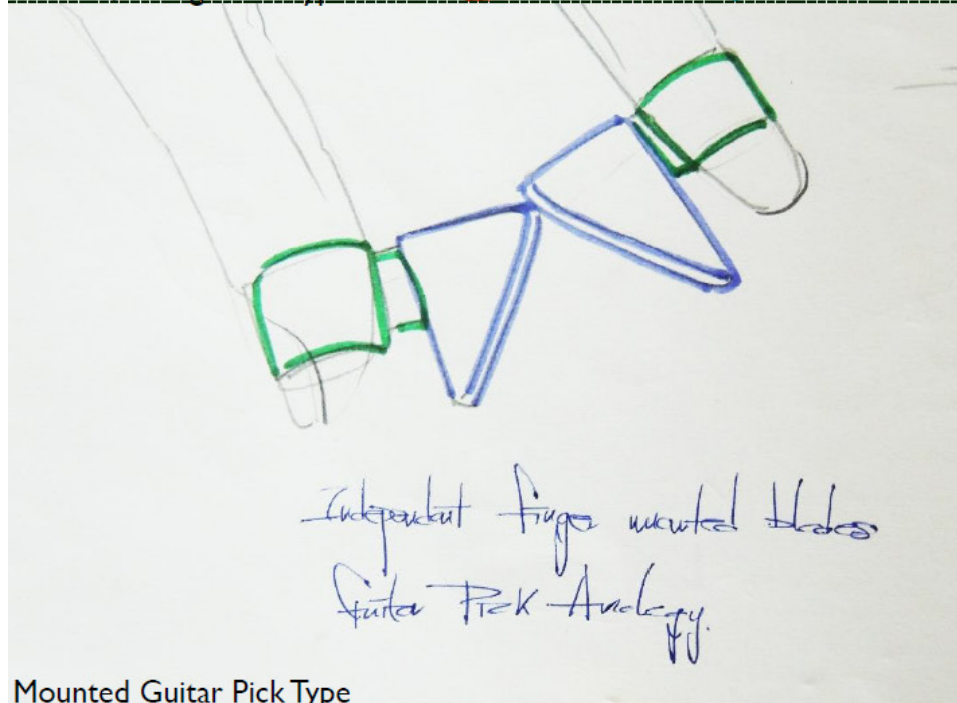
IDEATION : HAND WORN TYPE



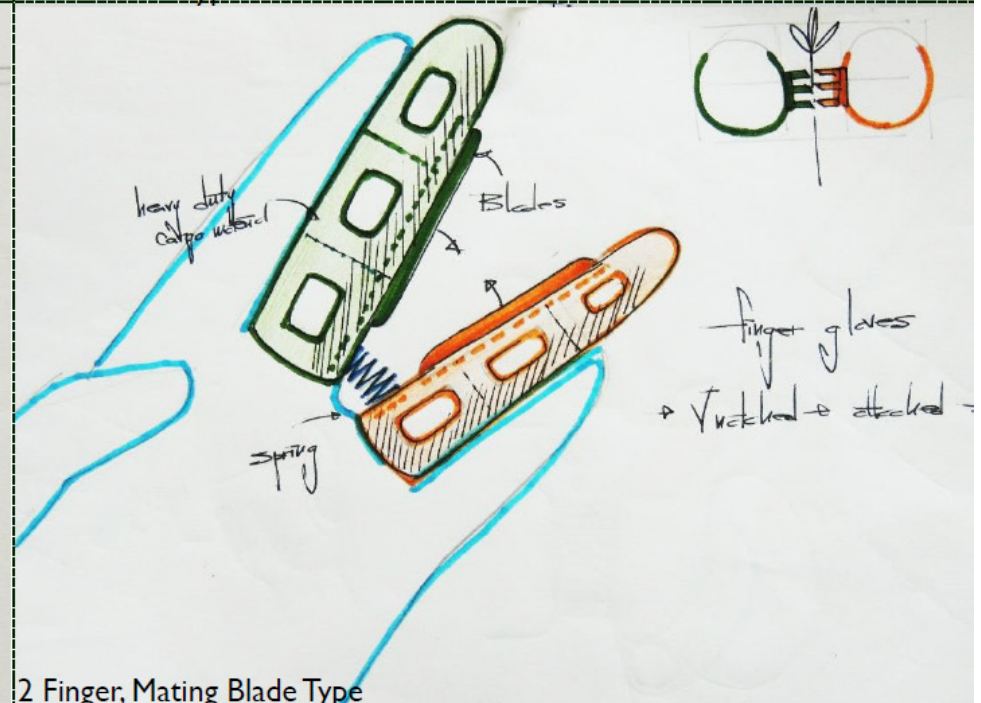
2 Hand, Mating Blade Type



Palm Pocket Type

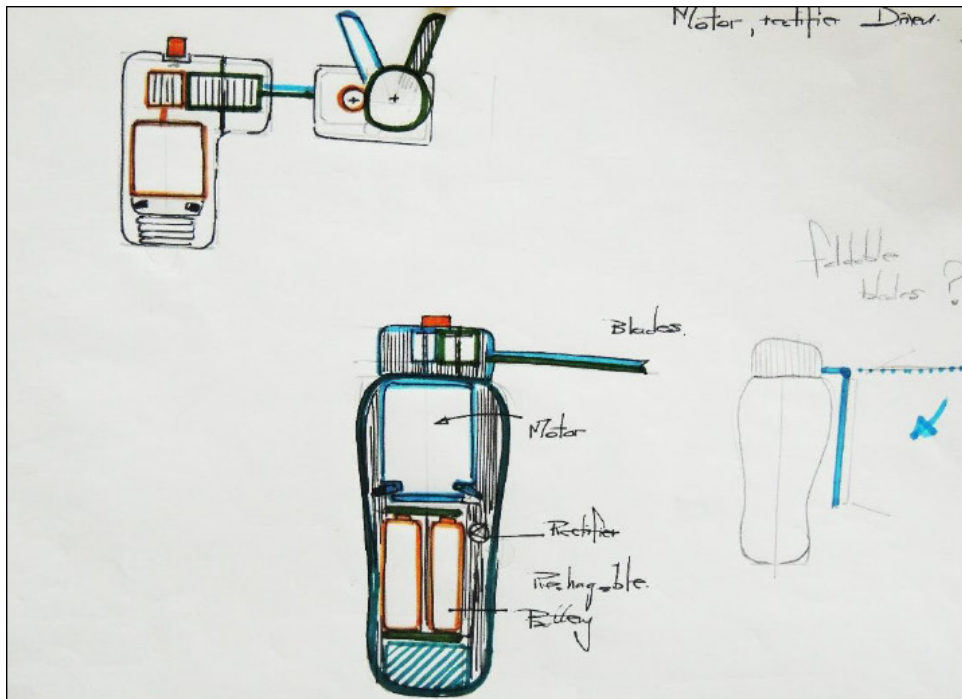


Mounted Guitar Pick Type

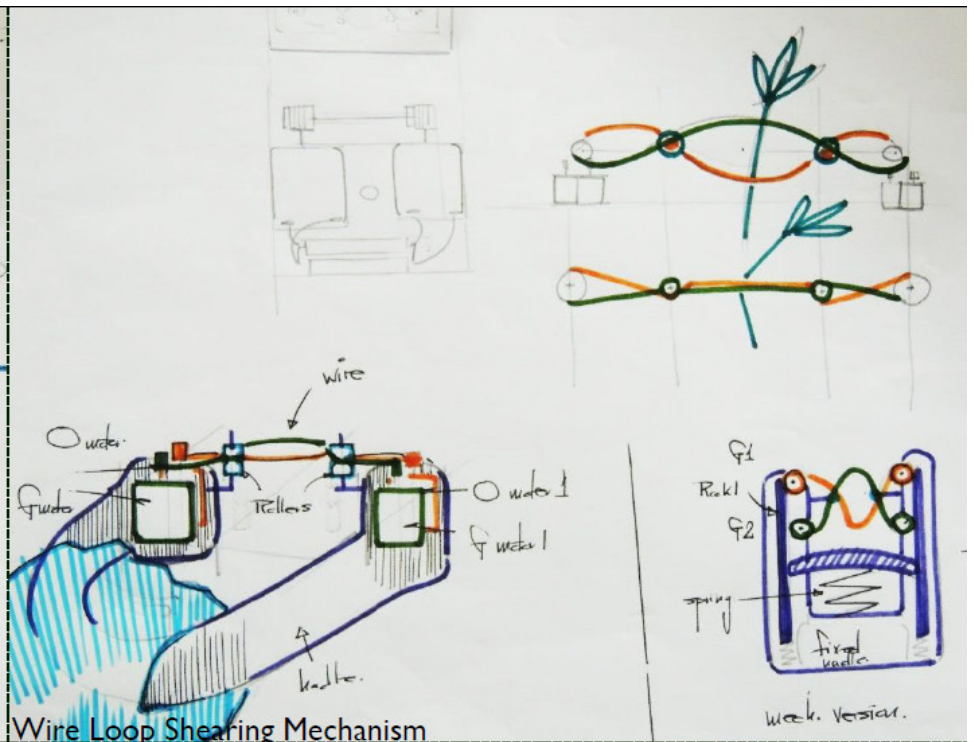


2 Finger, Mating Blade Type

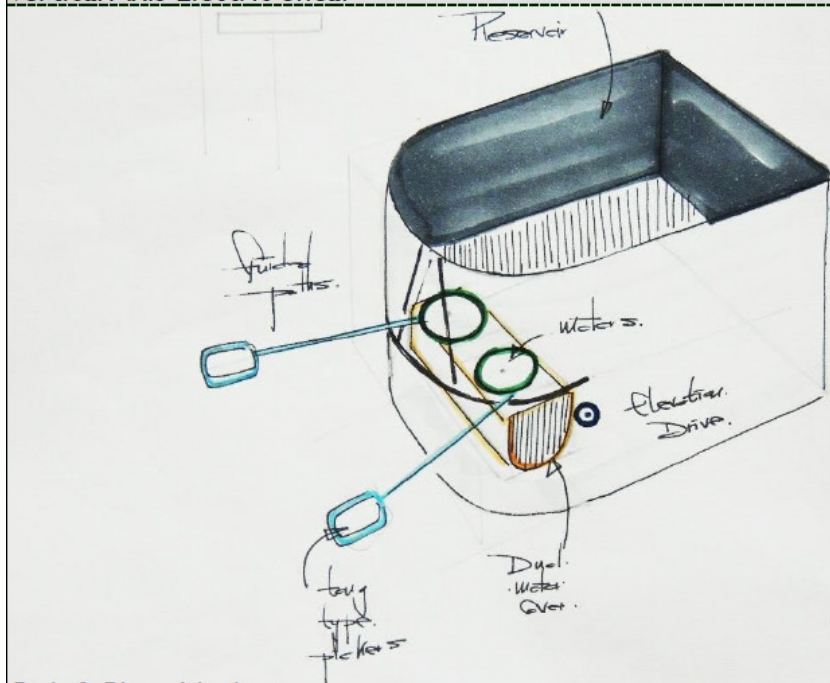
IDEATION :ELECTRIC ASSIST



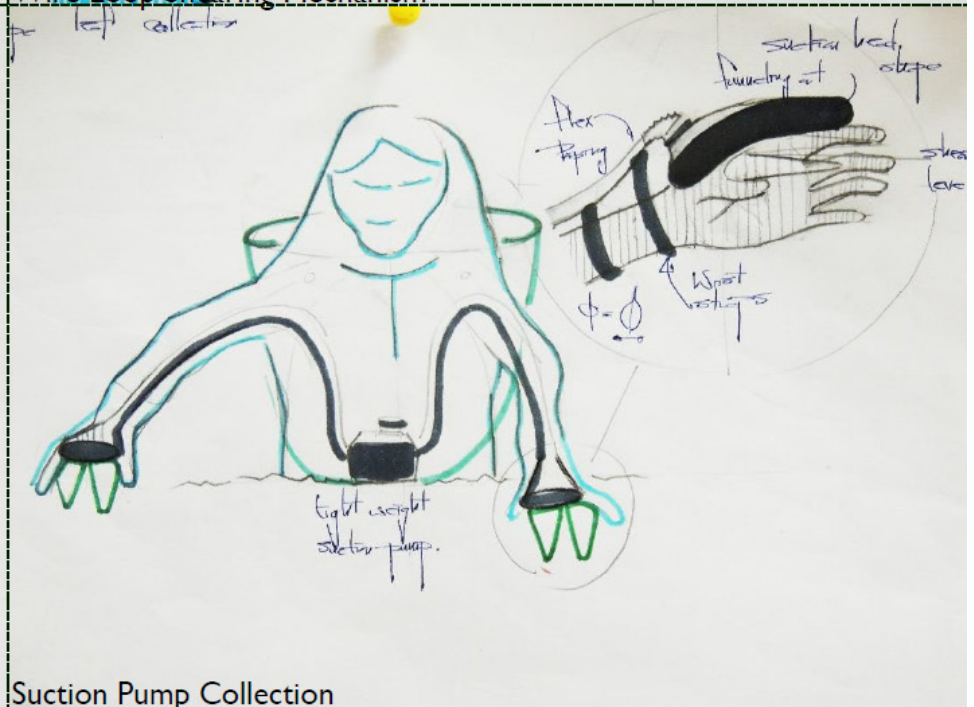
Vertical Axis Electric Shear



Wire Loop Shearing Mechanism

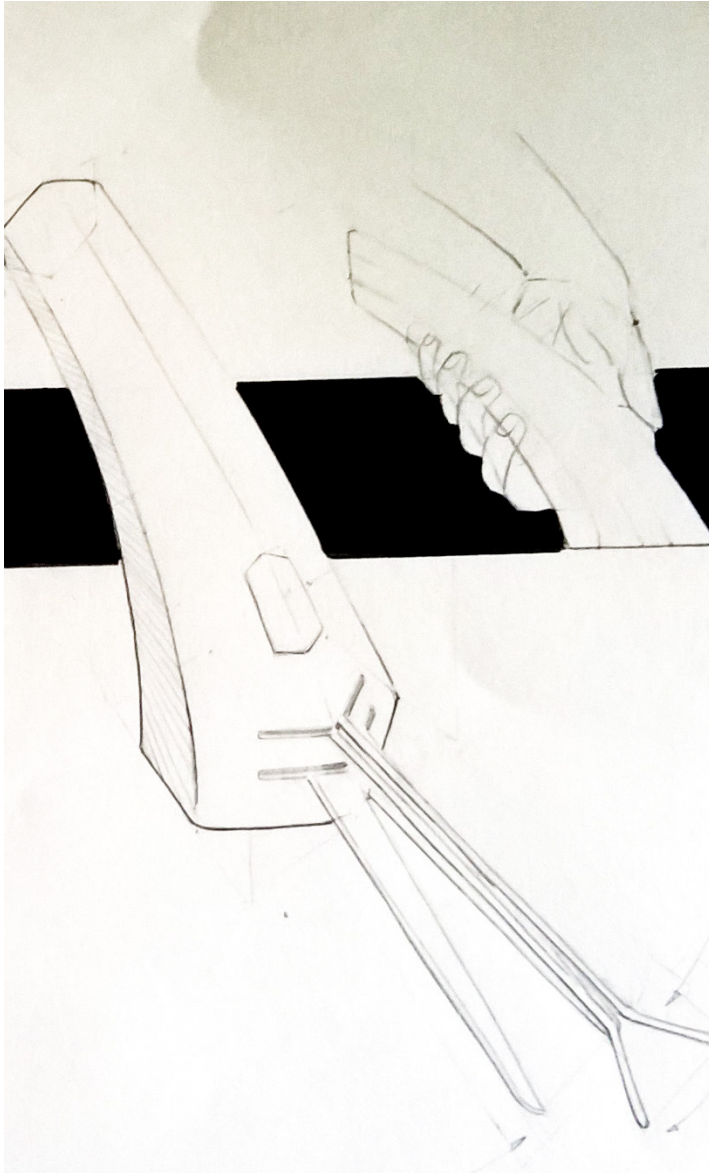


Pick & Place Mechanism



Suction Pump Collection

3 CONCEPT DIRECTIONS



Concept Direction 1: Top Collector Type

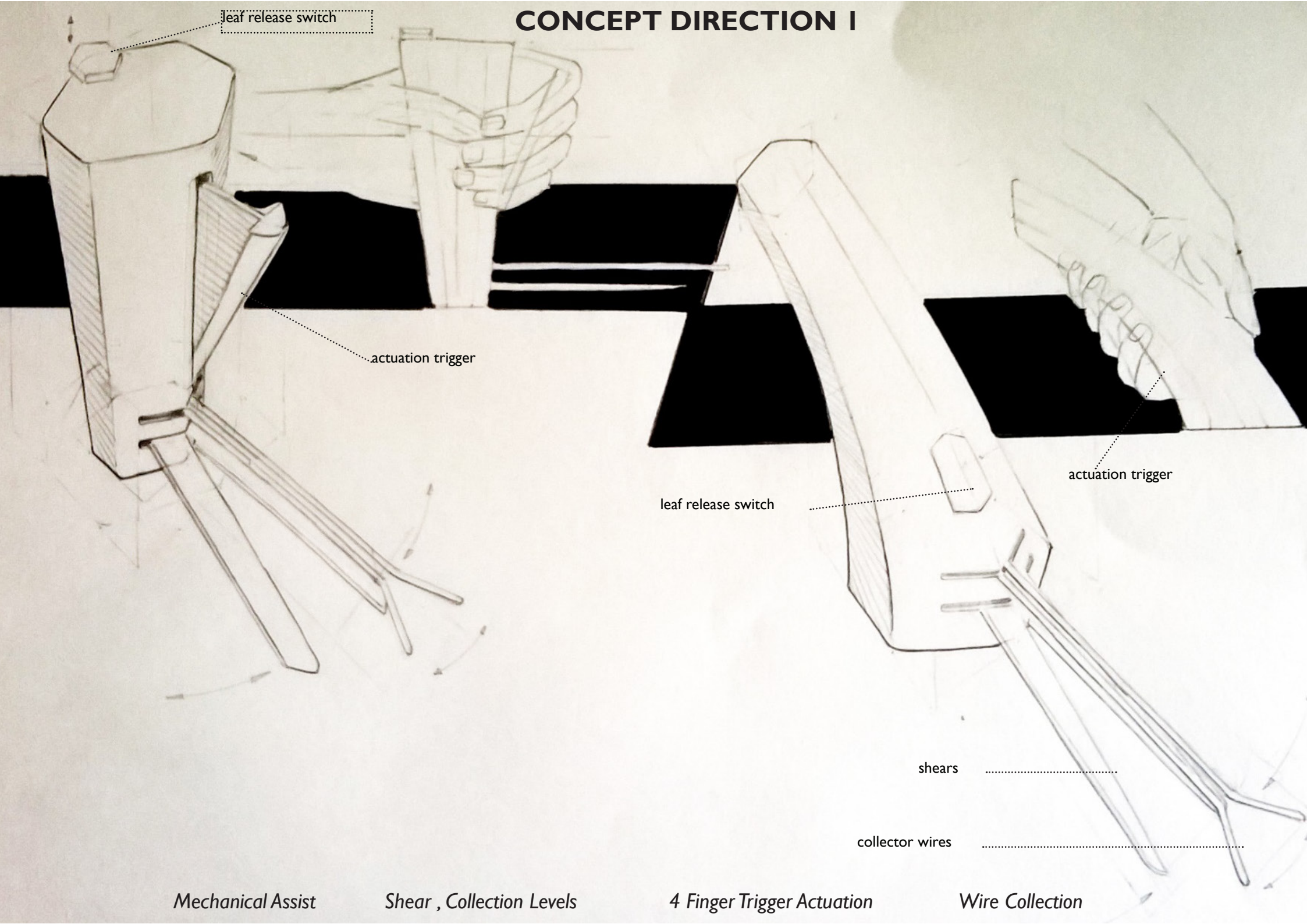


Concept Direction 2: C-Shaped Type



Concept Direction 3: Hand-worn Type

CONCEPT DIRECTION I



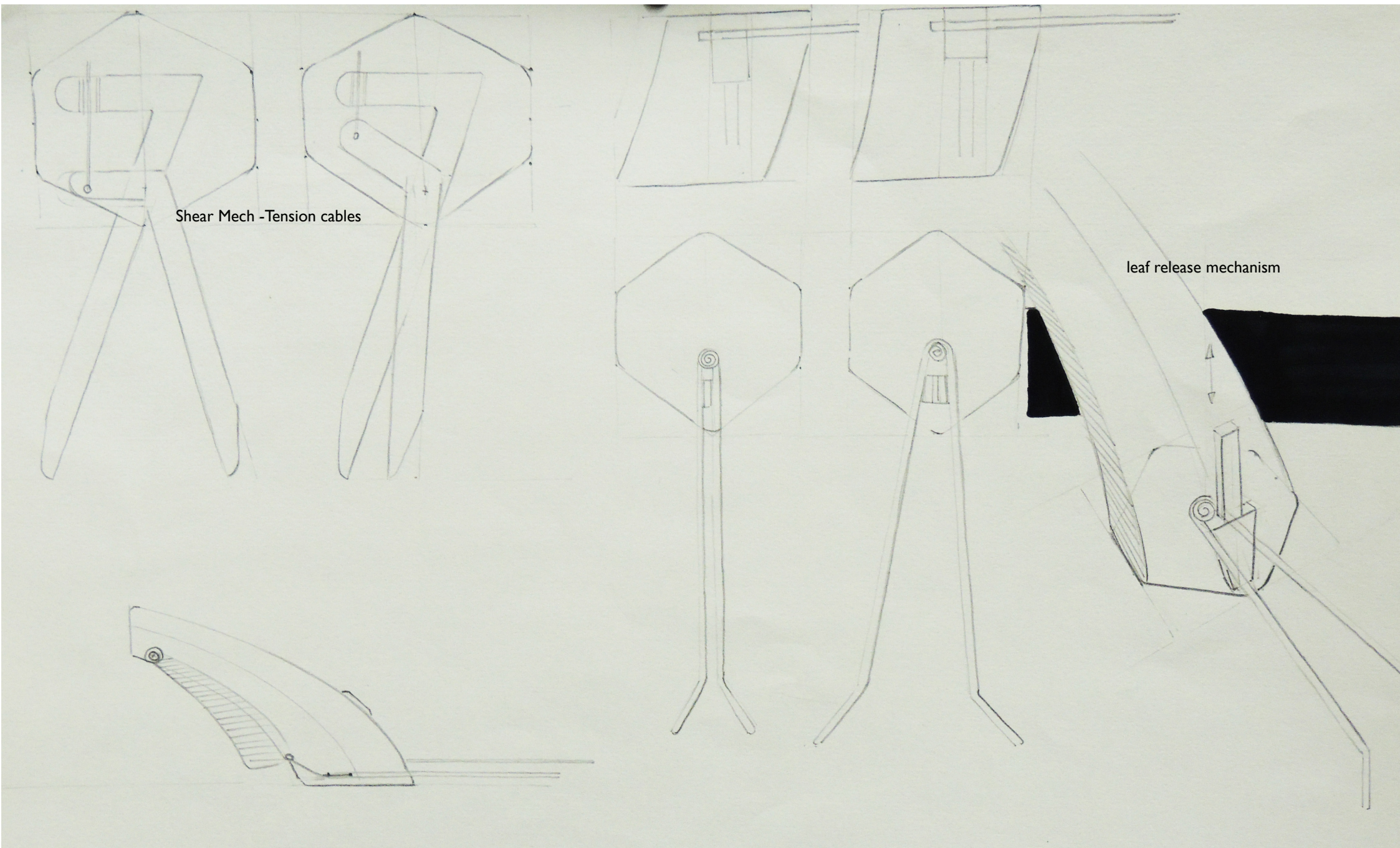
Mechanical Assist

Shear , Collection Levels

4 Finger Trigger Actuation

Wire Collection

CONCEPT DIRECTION I -CONTD.



Orienting Time

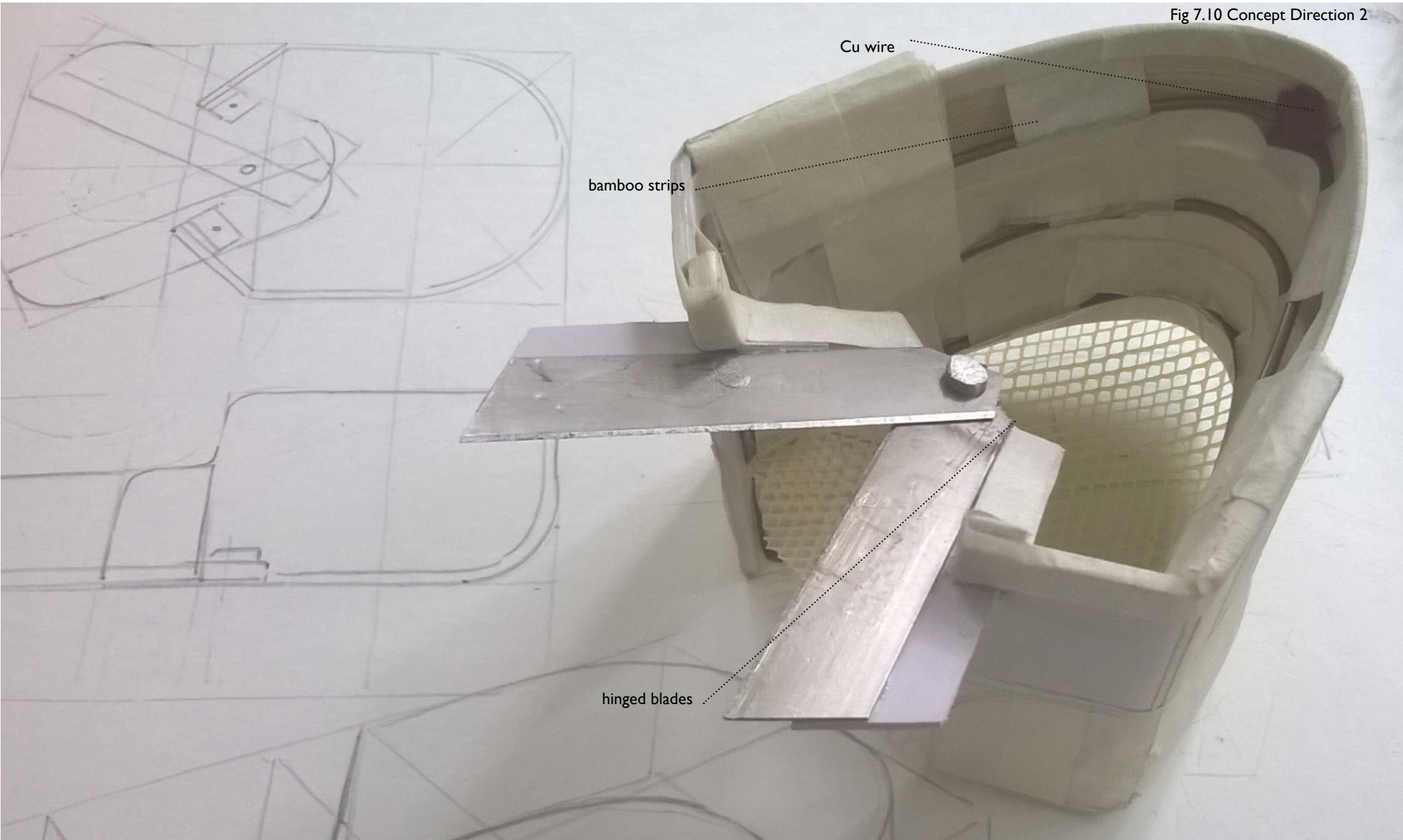
Precision Movements

Unreliable Collection

Complexity

CONCEPT DIRECTION 2

Fig 7.10 Concept Direction 2



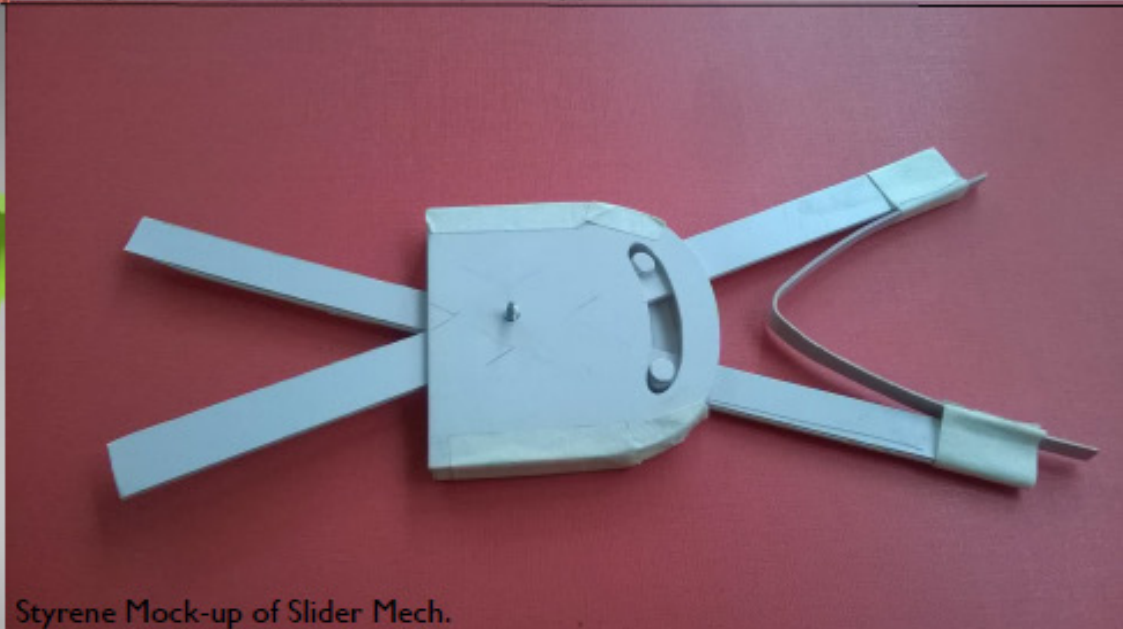
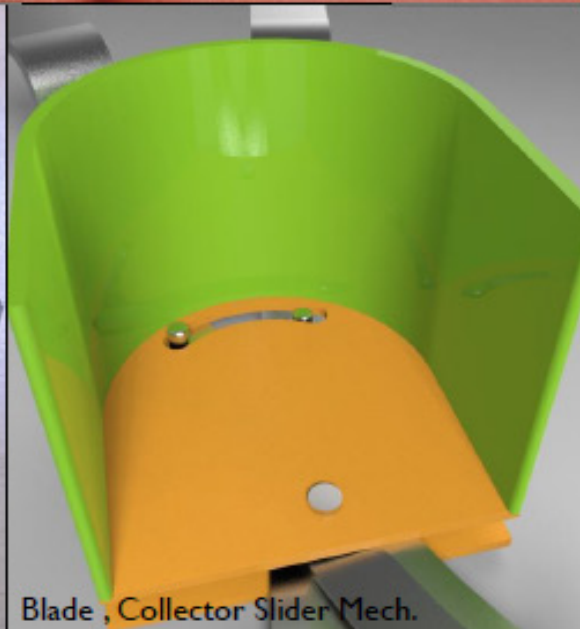
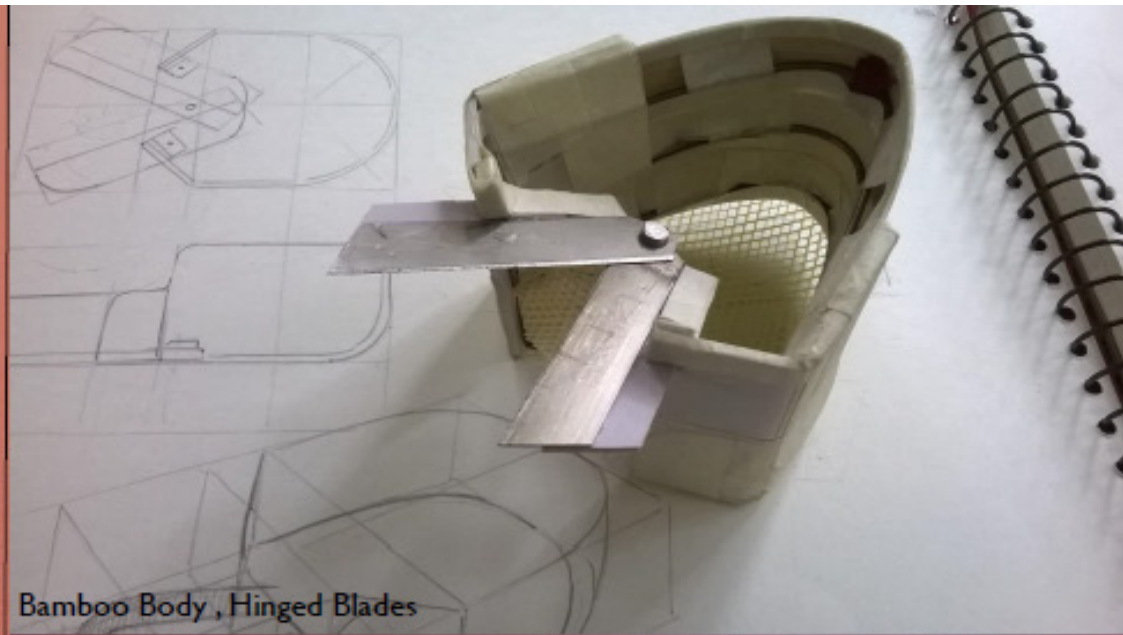
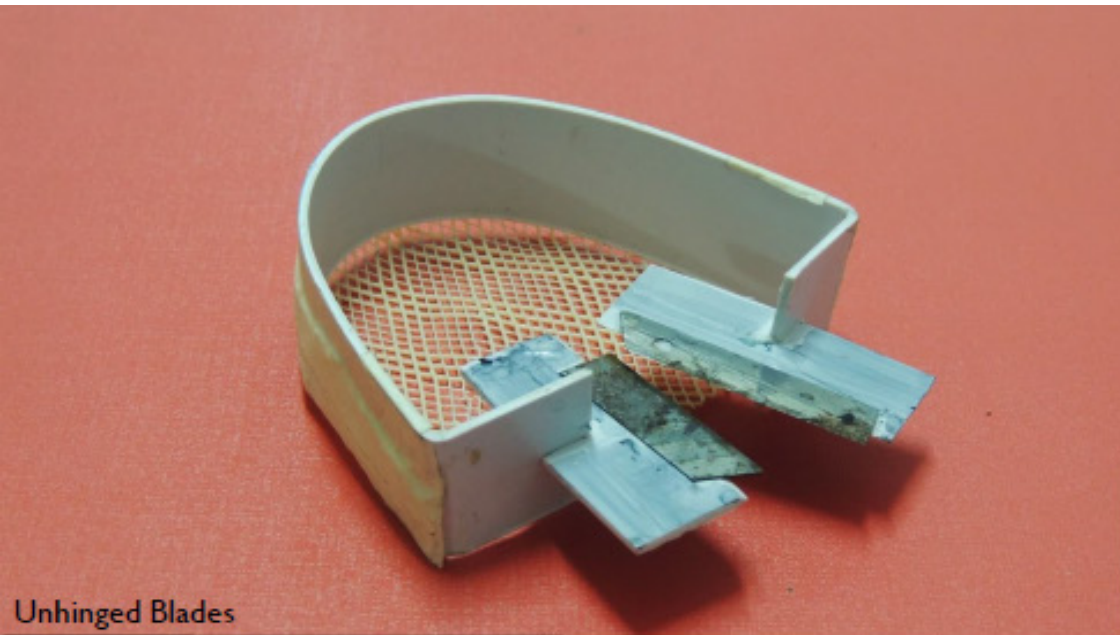
Pre-stressed Frame

Hinged blade shearing

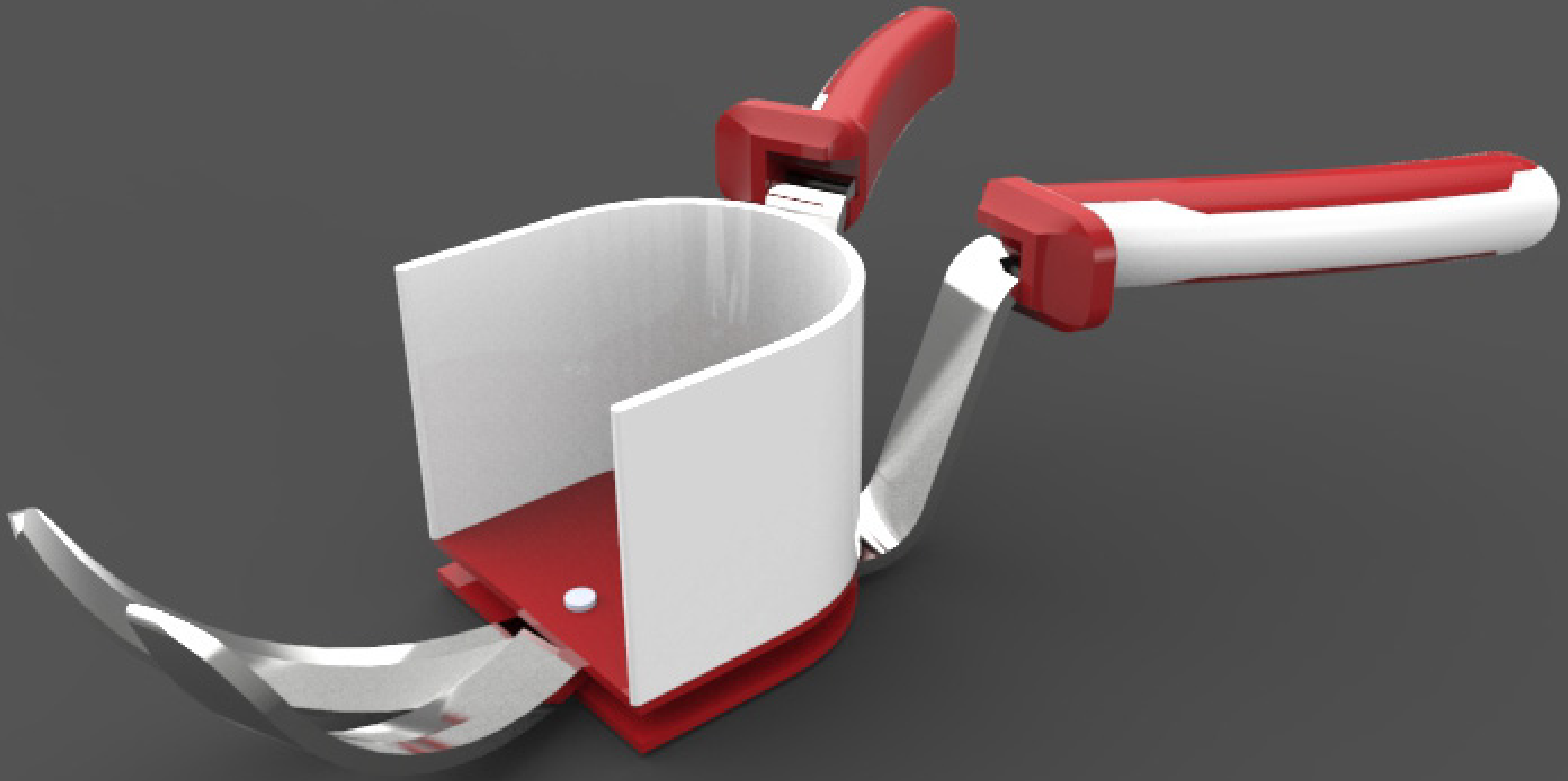
Collection Basket

Larger Muscle Groups

CONCEPT DIRECTION 2 -CONTD.



CONCEPT DIRECTION 2 -REFINEMENT



Handle Stereotype

Torsion Spring Back

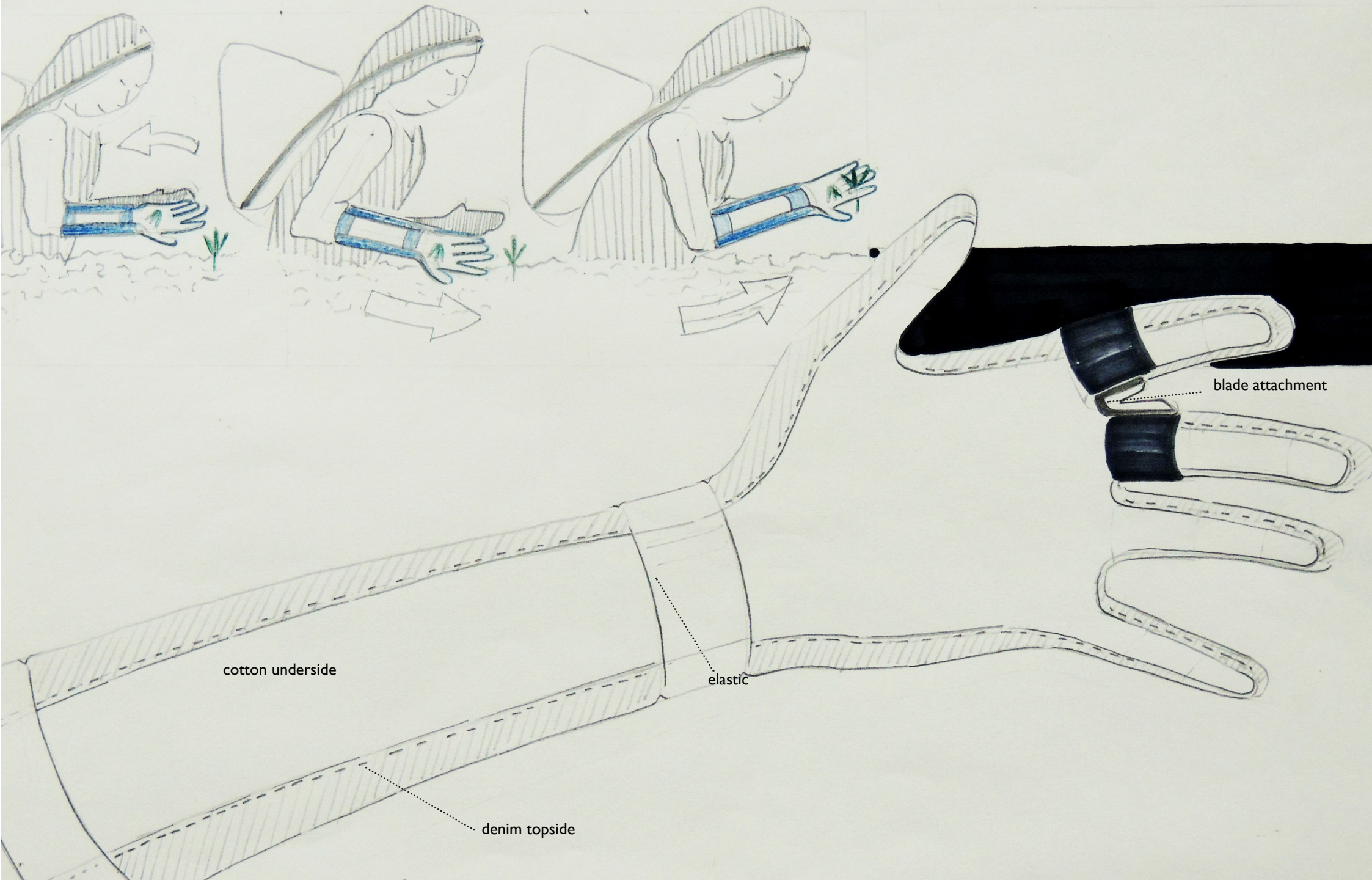
Blade Mount, Scoop

Visibility

CONCEPT DIRECTION 2 -TESTING



CONCEPT DIRECTION 3



Protective Gloves

Wearable Attachment

V-notch Type ,Hinged Blade

CONCEPT DIRECTION 3 -CONTD.



Separated Finger Blades



DIY Jeans-Cotton Glove



Curved Blade with teeth



V-Notch Blade finger straps



Hinged V-notch blade

CONCEPT DIRECTION 3 -REFINEMENT

blade attachment

half razor

thumb-gaurd

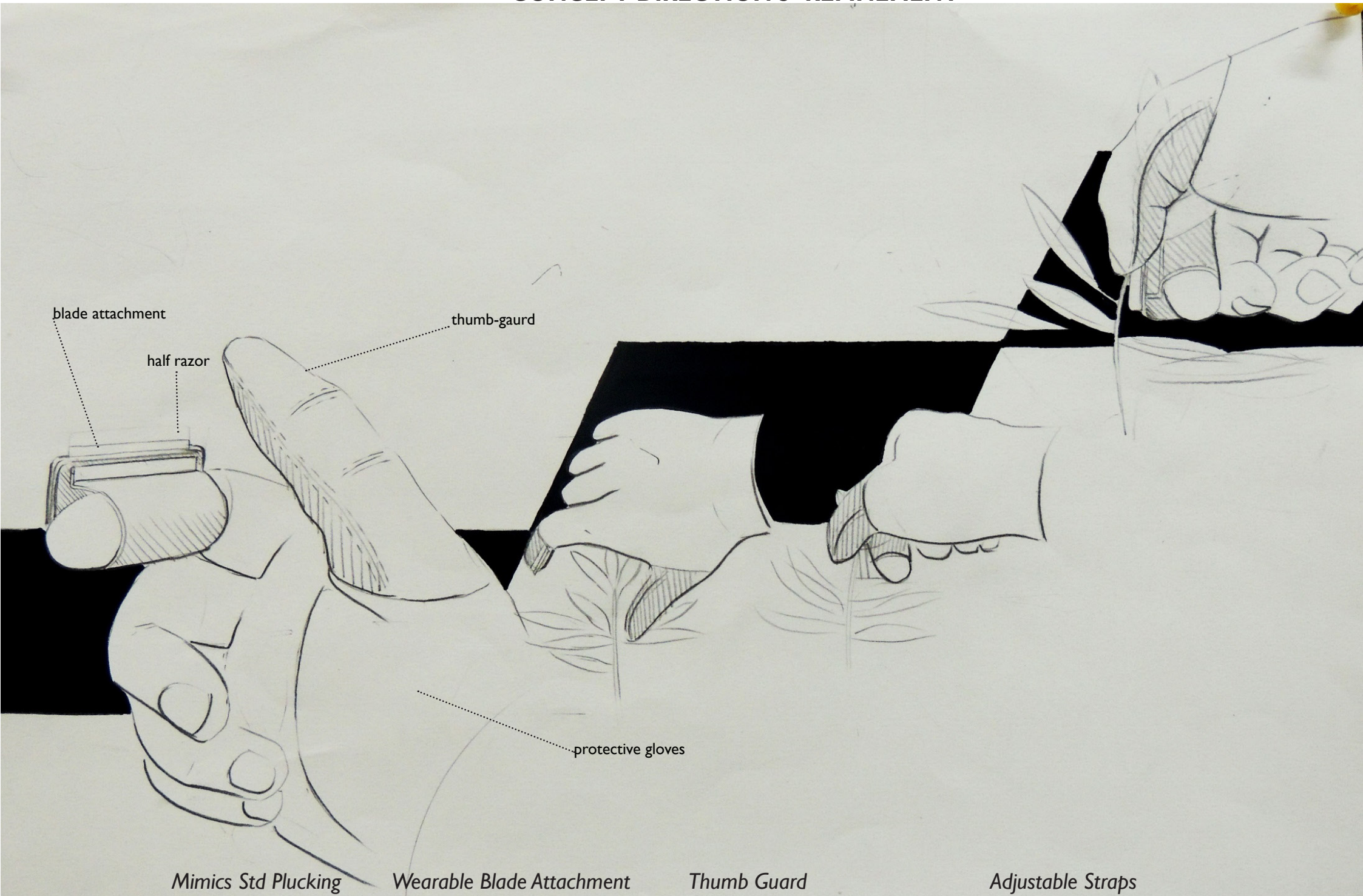
protective gloves

Mimics Std Plucking

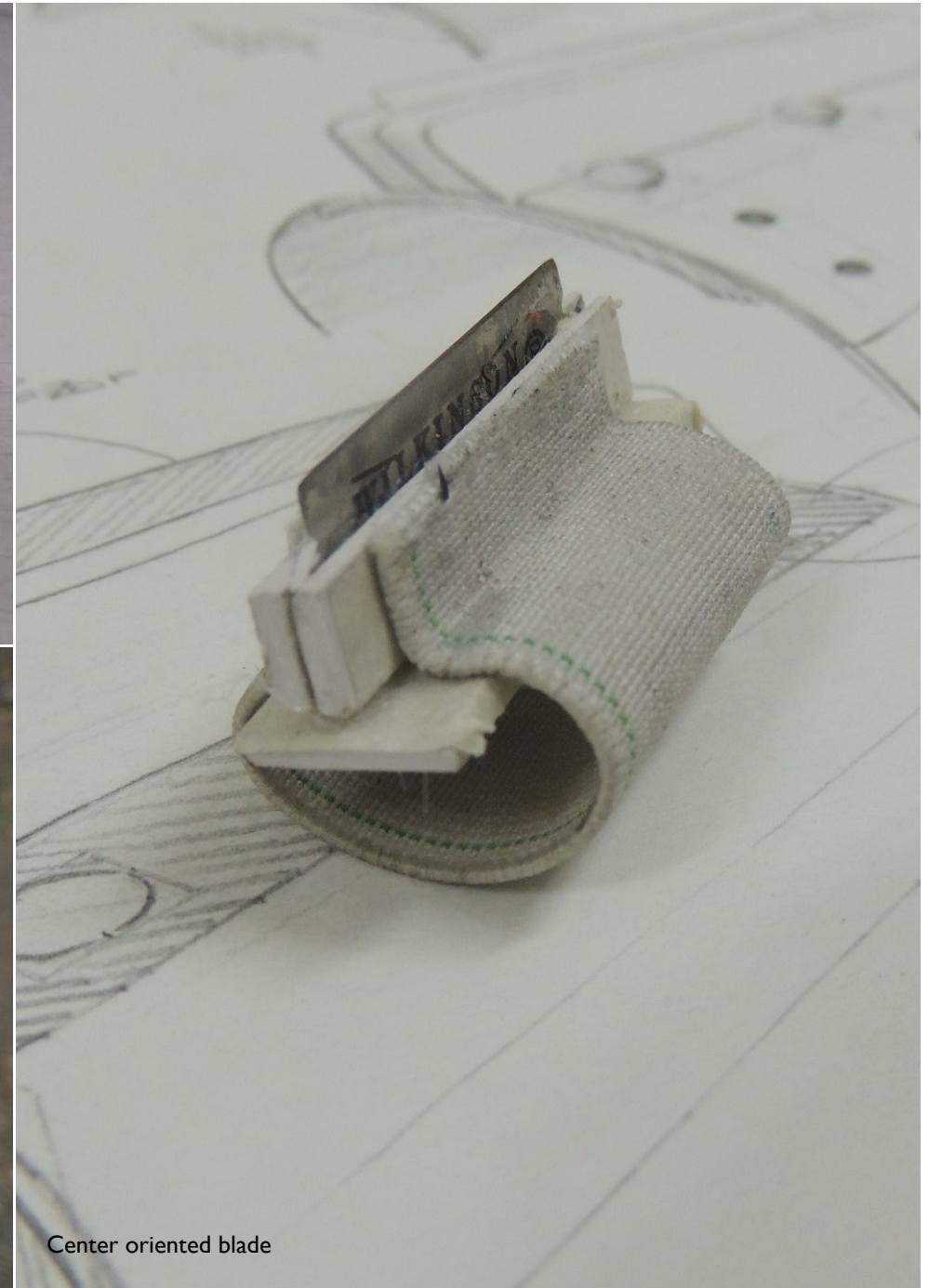
Wearable Blade Attachment

Thumb Guard

Adjustable Straps



CONCEPT DIRECTION 3 -TESTING



5

Force Reduction

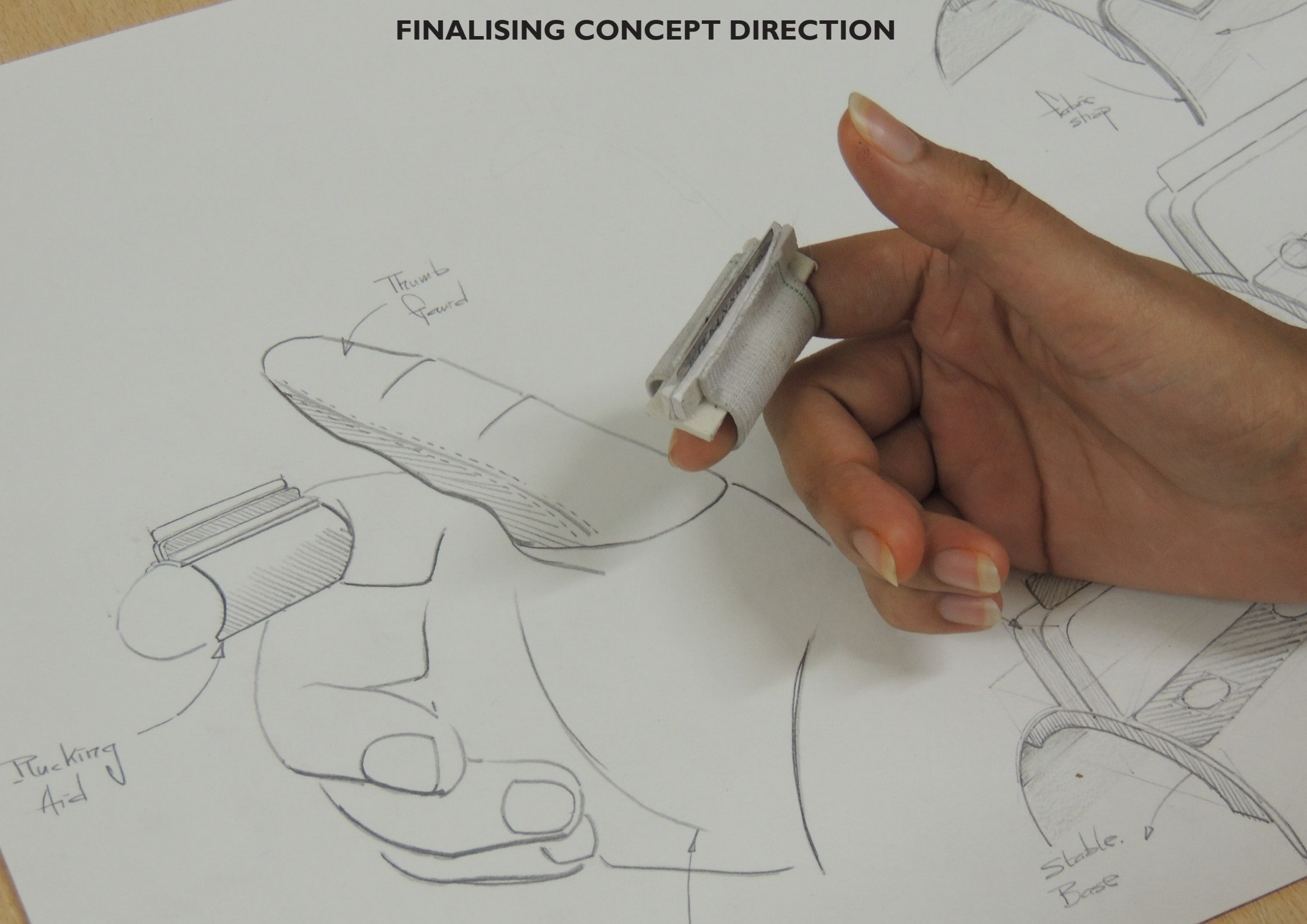
Compareable Speed

Selective Plucking

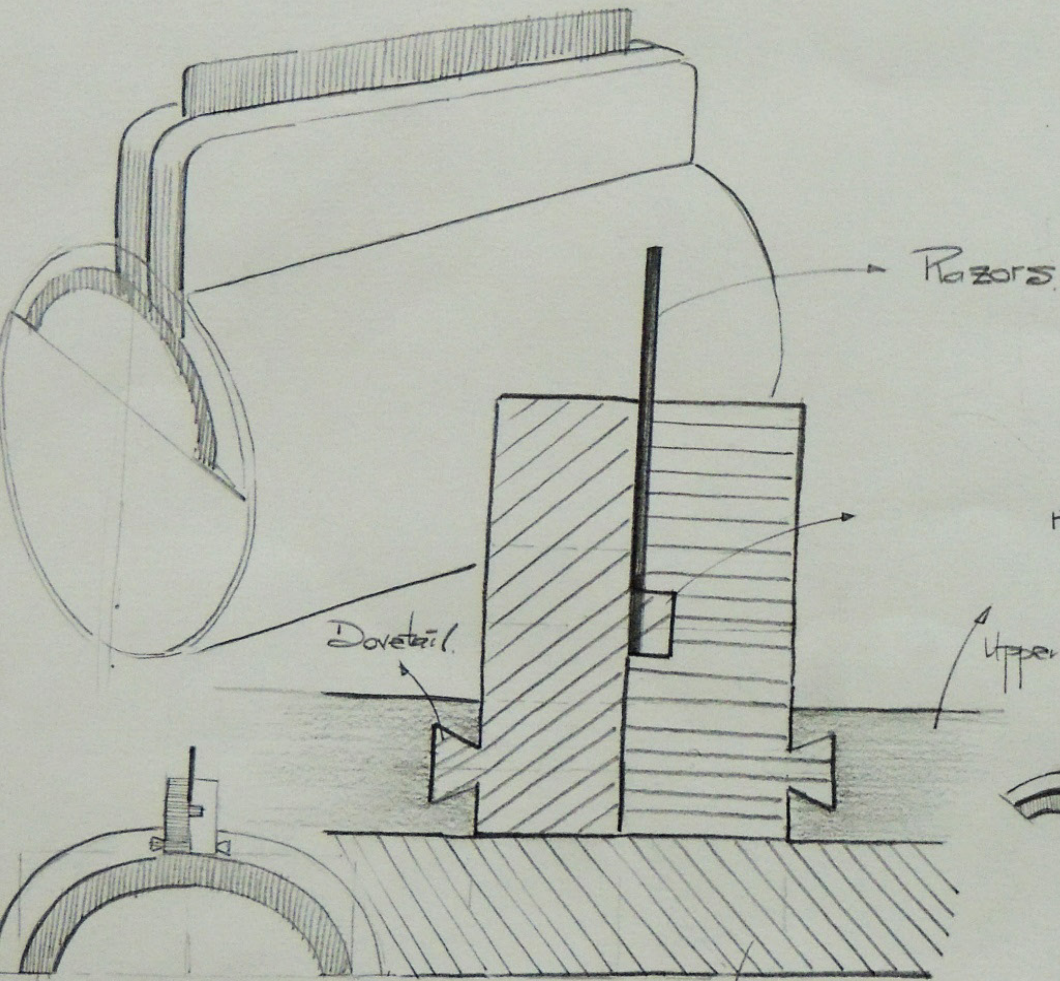
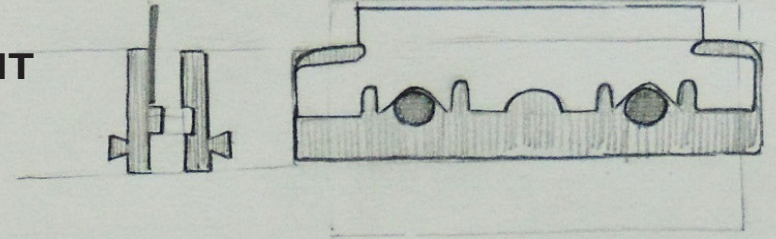
Easy Learning Curve

Variants

FINALISING CONCEPT DIRECTION



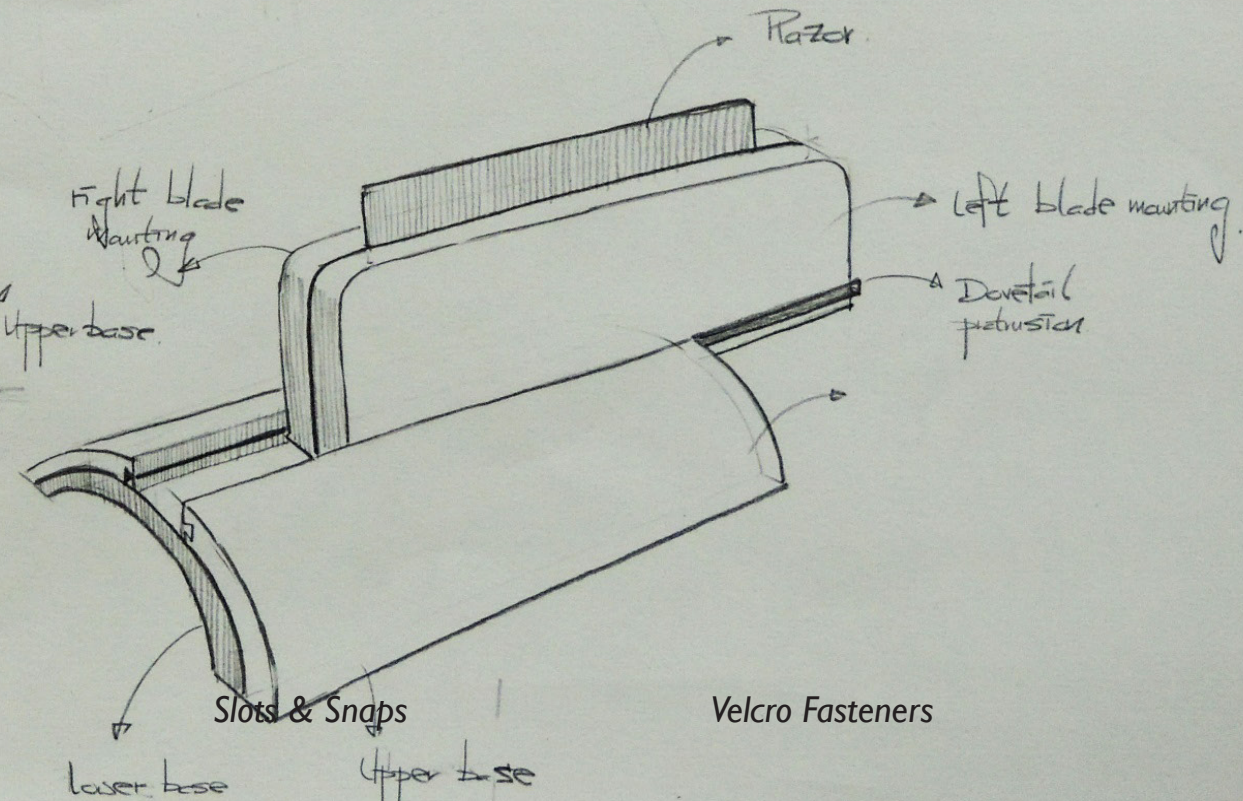
3 PART BLADE ATTACHMENT



3 Part Blade Attachment

Blade Replacability

lower base



Velcro Fasteners

THUMB PROTECTION

Nylon-fabric velcro straps

fabric under layer

- Thick fabric outer

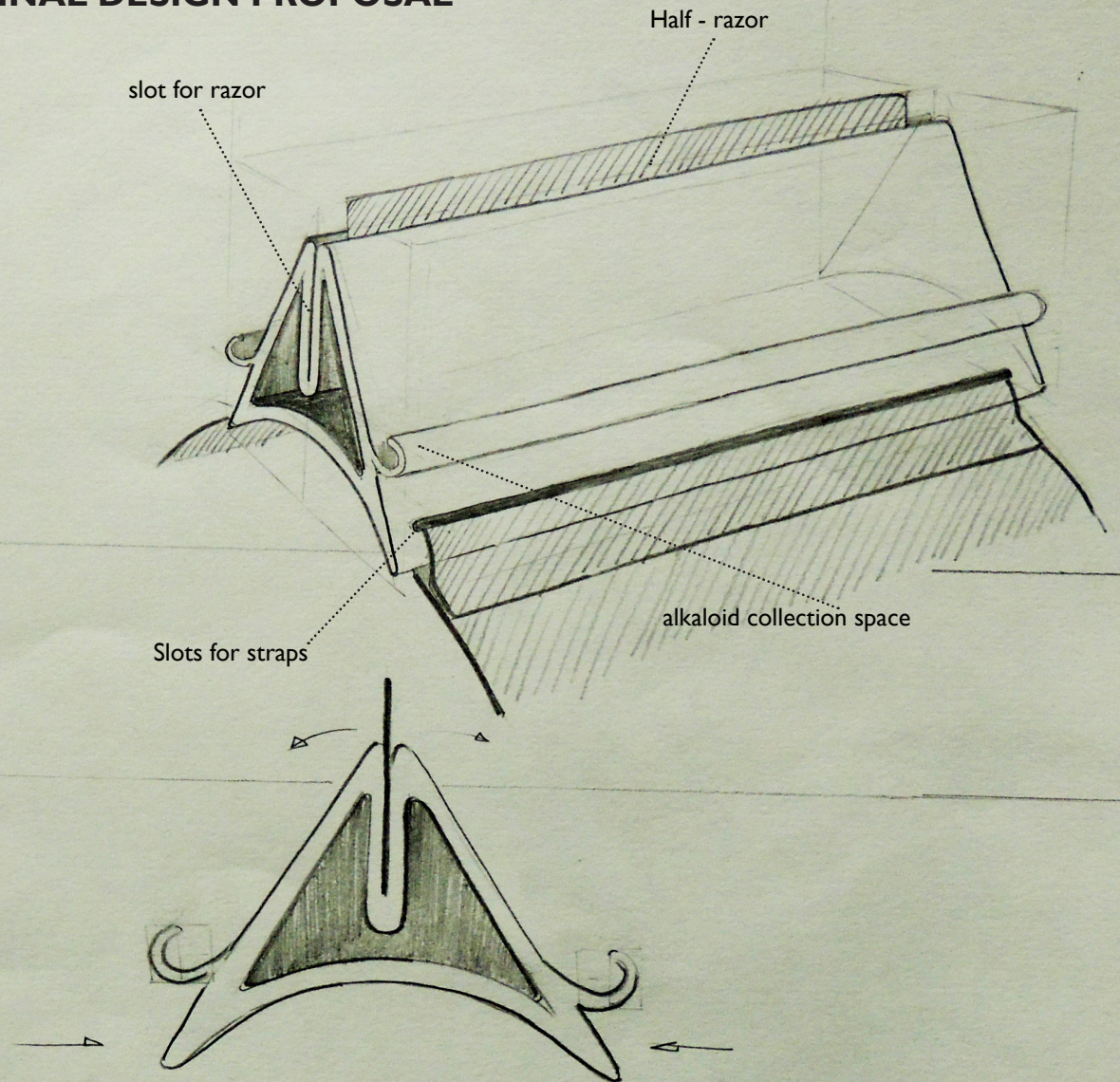
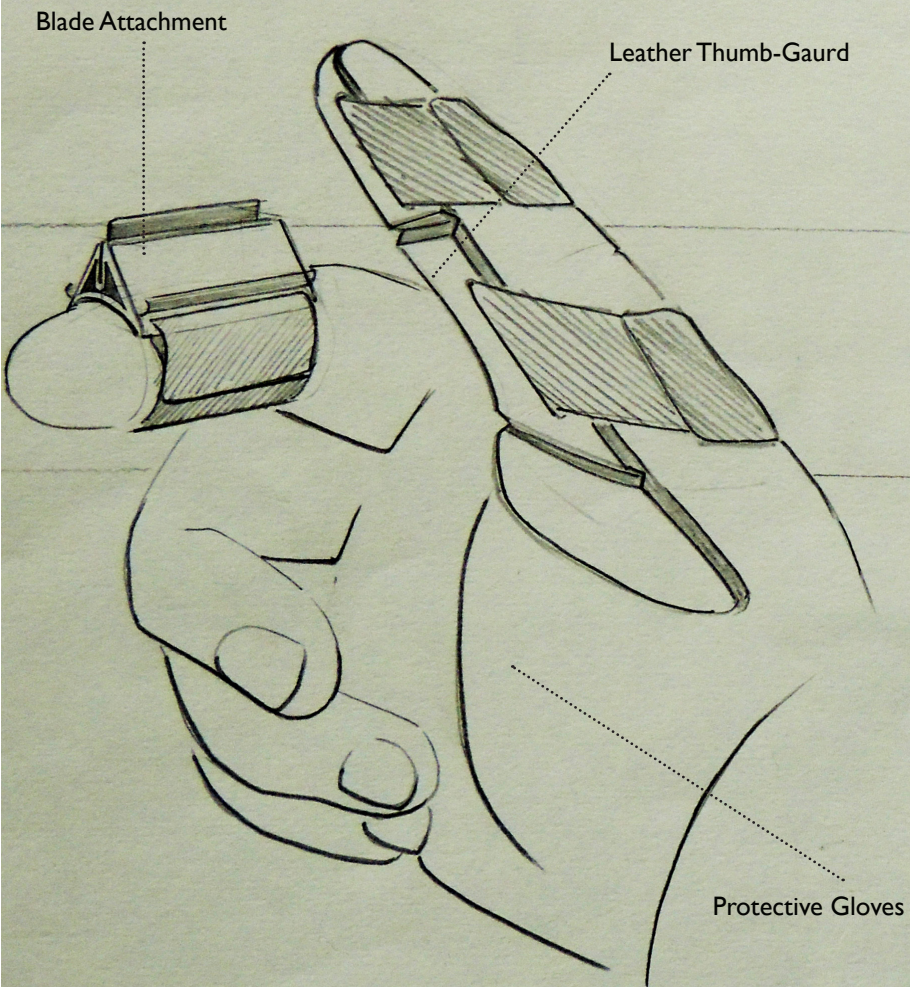
SS fiber layer

Tough Leather Gaurd

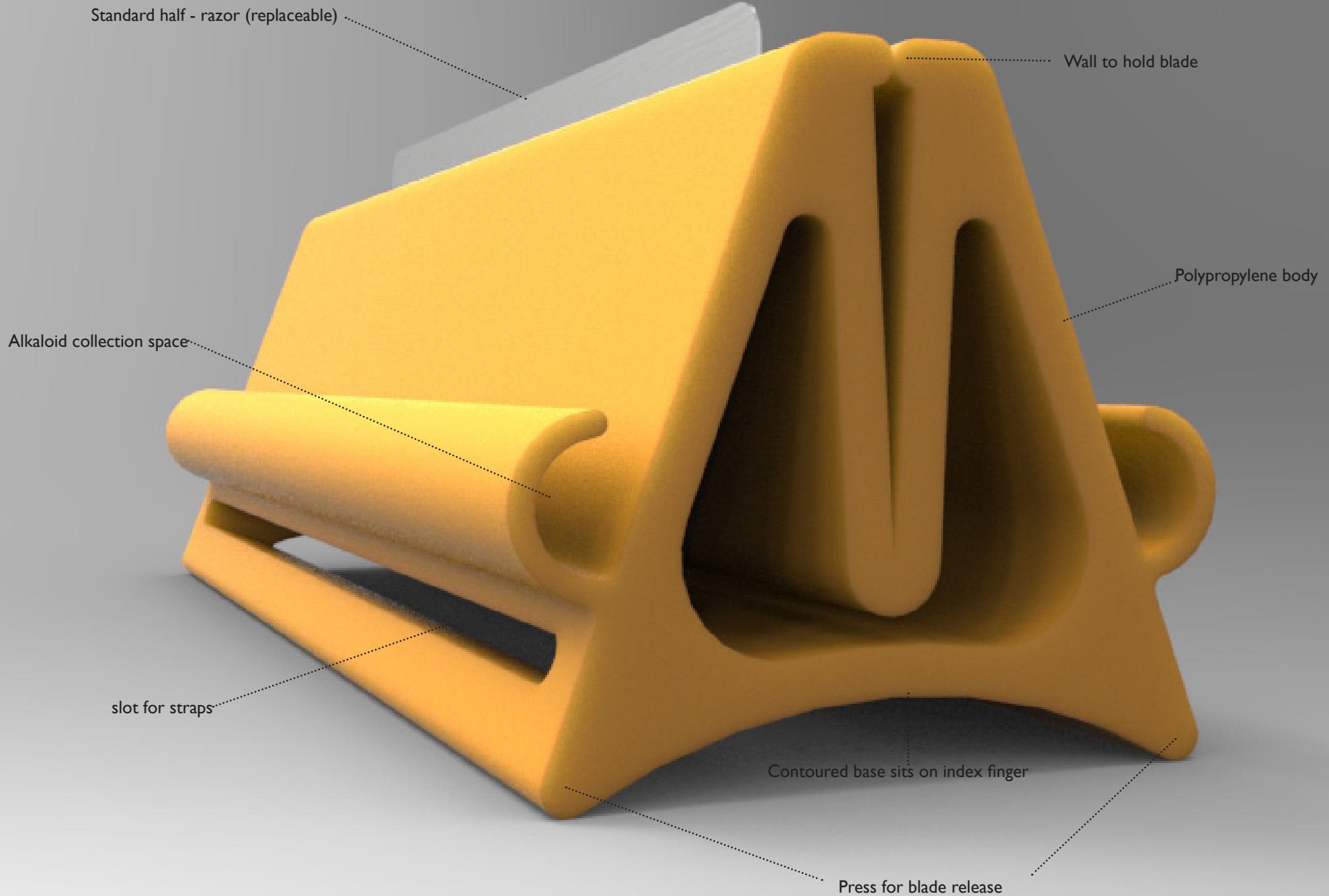
Acrylic PP thumb guard

3-segment gaurd

PRE-FINAL DESIGN PROPOSAL



PRE-FINAL DESIGN PROPOSAL



PROTOTYPING FOR USER TESTING



PROTOTYPE DEPLOYMENT & USER TESTING

- | | |
|---|--|
| 1. No. of test subjects : | 5 tea pluckers |
| 2. Duration of training with prototypes: | 30 minutes / subject |
| 3. Comparison : | 20 min hand plucking v/s 20 min proto-plucking |
| 4. Quantitative data: | Weight of Plucked leaves (Grams) |
| 5. Qualitative data: | Plucking Effort required (Scale of 5)
Pain Experienced whilst plucking (Scale of 5)
Quality of plucked leaves (Scale of 5) |





OBSERVING USER BEHAVIOUR



USER TEST DATA TABULATION

SI #	Name (M/F)	Age	Experience	HAND-PLUCKING (20 MINUTES)				
				Weight of Plucked Leaves (grams)	Average Plucking Rate (grams/min)	Plucking Effort (Score/5)	Pain Experienced (Score/5)	Leaf Quality (Score/5)
1	Kirpa Hasda (F)	27	5 Yrs	1200	60	4	3	4
2	Nancy Khardiya (F)	24	6 Mns	2000	100	3	4	3
3	Anima Indwar (F)	22	4 Mns	1200	60	5	3	4
4	Hasina Sheikh (F)	35	17 Yrs	1500	75	4	5	4
5	Anand Sheikh (M)	21	2 Mns	1500	75	4	3	3

SI #	Name (M/F)	Age	Experience	PROTO-PLUCKING (20 MINUTES)				
				Weight of Plucked Leaves (grams)	Average Plucking Rate (grams/min)	Plucking Effort (Score/5)	Pain Experienced (Score/5)	Leaf Quality (Score/5)
1	Kirpa Hasda (F)	27	5 Yrs	500	25	2	1	4
2	Nancy Khardiya (F)	24	6 Mns	500	25	1	1	4
3	Anima Indwar (F)	22	4 Mns	400	20	2	1	4
4	Hasina Sheikh (F)	35	17 Yrs	500	25	1	1	4
5	Anand Sheikh (M)	21	2 Mns	600	30	1	1	4

COMPARISON OF PLUCKING EFFORT

SI #	Name (M/F)	Age	Experie	HAND-PLUCKING	PROTO-PLUCKING (20 MIN)	PERCENTAGE DECREASE
				<i>Plucking Effort (Score/5)</i>	<i>Plucking Effort (Score/5)</i>	
1	Kirpa Hasda (F)	27	5 Yrs	4	2	50.00%
2	Nancy Khardiya (F)	24	6 Mns	3	1	66.67%
3	Anima Indwar (F)	22	4 Mns	5	2	60.00%
4	Hasina Sheikh (F)	35	17 Yrs	4	1	75.00%
5	Anand Sheikh (M)	21	2 Mns	4	1	75.00%
					AVERAGE REDUCTION % =	65.33%

LEGEND FOR SCORES -PLUCKING EFFORT	
Score/5	Represents
1	Minimal effort required to pluck leaves
2	Lesser effort required to pluck leaves
3	Fair amount of effort required to pluck leaves
4	More effort required to pluck leaves
5	Maximum effort required to pluck leaves

COMPARISON OF PAIN EXPERIENCED

SI #	Name (M/F)	Age	Experier	HAND-PLUCKING (20 MIN)	PROTO-PLUCKING (20 MIN)	PERCENTAGE DECREASE
				<i>Pain Experienced (Score/5)</i>	<i>Pain Experienced (Score/5)</i>	
1	Kirpa Hasda (F)	27	5 Yrs	3	I	66.67%
2	Nancy Khardiya (F)	24	6 Mns	4	I	75.00%
3	Anima Indwar (F)	22	4 Mns	3	I	66.67%
4	Hasina Sheikh (F)	35	17 Yrs	5	I	80.00%
5	Anand Sheikh (M)	21	2 Mns	3	I	66.67%

AVERAGE REDUCTION % = 71.00%

LEGEND FOR SCORES -PAIN EXPERIENCED

Score/5	Represents
1	Minimal pain or discomfort experienced
2	Lesser pain or discomfort experienced
3	Fair amount of pain experiences
4	More pain or discomfort experienced
5	Maximum pain or discomfort experienced

COMPARISON OF LEAF QUALITY

SI #	Name (M/F)	Age	Experience	HAND-PLUCKING (20 MIN)	PROTO-PLUCKING (20 MIN)	PERCENTAGE INCREASE
				Leaf Quality (Score/5)	Leaf Quality (Score/5)	
1	Kirpa Hasda (F)	27	5 Yrs	4	4	0.00%
2	Nancy Khardiya (F)	24	6 Mns	3	4	33.33%
3	Anima Indwar (F)	22	4 Mns	3	4	33.33%
4	Hasina Sheikh (F)	35	17 Yrs	4	4	0.00%
5	Anand Sheikh (M)	21	2 Mns	3	4	33.33%
					AVERAGE IMPROVEMENT % =	20.00%

LEGEND FOR SCORES -LEAF QUALITY	
Score/5	Represents
1	Poor leaf quality
2	Below average leaf quality
3	Satisfactory leaf quality
4	Good leaf quality
5	Very good leaf quality

COMPARISON OF WEIGHT PLUCKED

Sl #	Name (M/F)	Age	Experience	Manual Plucking (2 handed) 20 min	Manual Plucking (1 handed) 20min
				<i>Weight of Plucked Leaves (grams)</i>	<i>Weight of Plucked Leaves (grams)</i>
1	Kirpa Hasda (F)	27	5 Yrs	1200	600
2	Nancy Khardiya (F)	24	6 Mns	2000	1000
3	Anima Indwar (F)	22	4 Mns	1200	600
4	Hasina Sheikh (F)	35	17 Yrs	1500	750
5	Anand Sheikh (M)	21	2 Mns	1500	750

Sl #	Prototype Plucking (1 handed) 20min	Percentage Decrease 1	Percentage Decrease 2
	<i>Weight of Plucked Leaves (grams)</i>	<i>(Comparison Vs 2 Handed)</i>	<i>(Comparison Vs 1 Handed)</i>
1	500	58.33%	16.67%
2	500	75.00%	50.00%
3	400	66.67%	33.33%
4	500	66.67%	33.33%
5	600	60.00%	20.00%
AVERAGE REDUCTION % =		65.33%	30.67%

INFERENCES FROM USER TESTING

SAFETY HAZARDS

- Extremely sharp SS razors would slash through their skin if the pluckers absent-mindedly brush their face or body to remove insects.

BLADE ATTACHMENT

- Makes approach to leaf difficult hence yielding a low collection efficiency - it is difficult to grip the leaves once they are cut.
- Decreasing height would ensure more plucking force applied at shear junction.

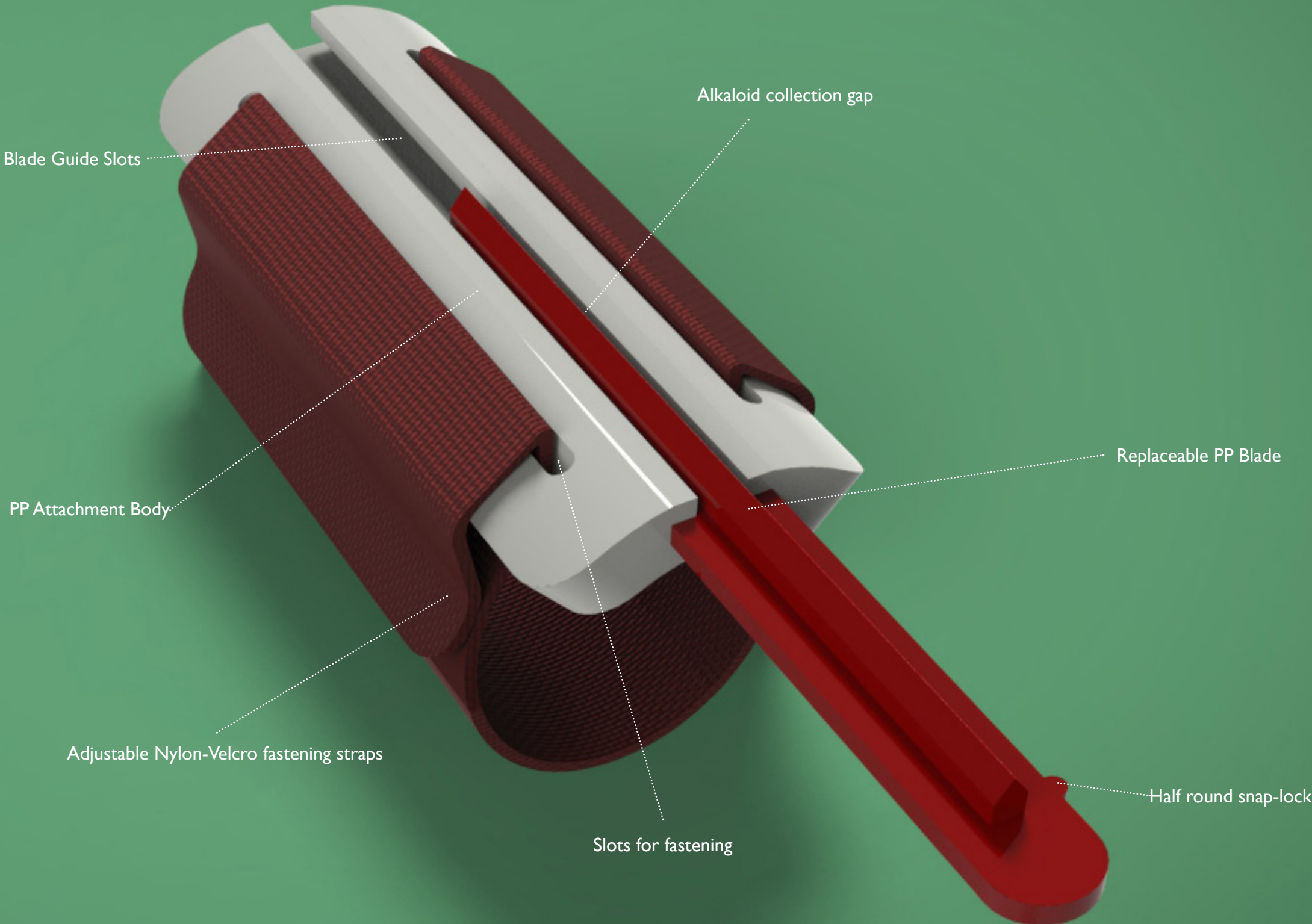
FASTENING BANDS

- Elastic straps taken for the field test eventually loosen and rotate about the index finger and thumb.

TRAINING TIME

Workers need to get accustomed to the aid , prototypes could be deployed for 30 days for deeper insights & more accurate data on usage patterns.

FINAL DESIGN PROPOSAL



Blade Guide Slots

Alkaloid collection gap

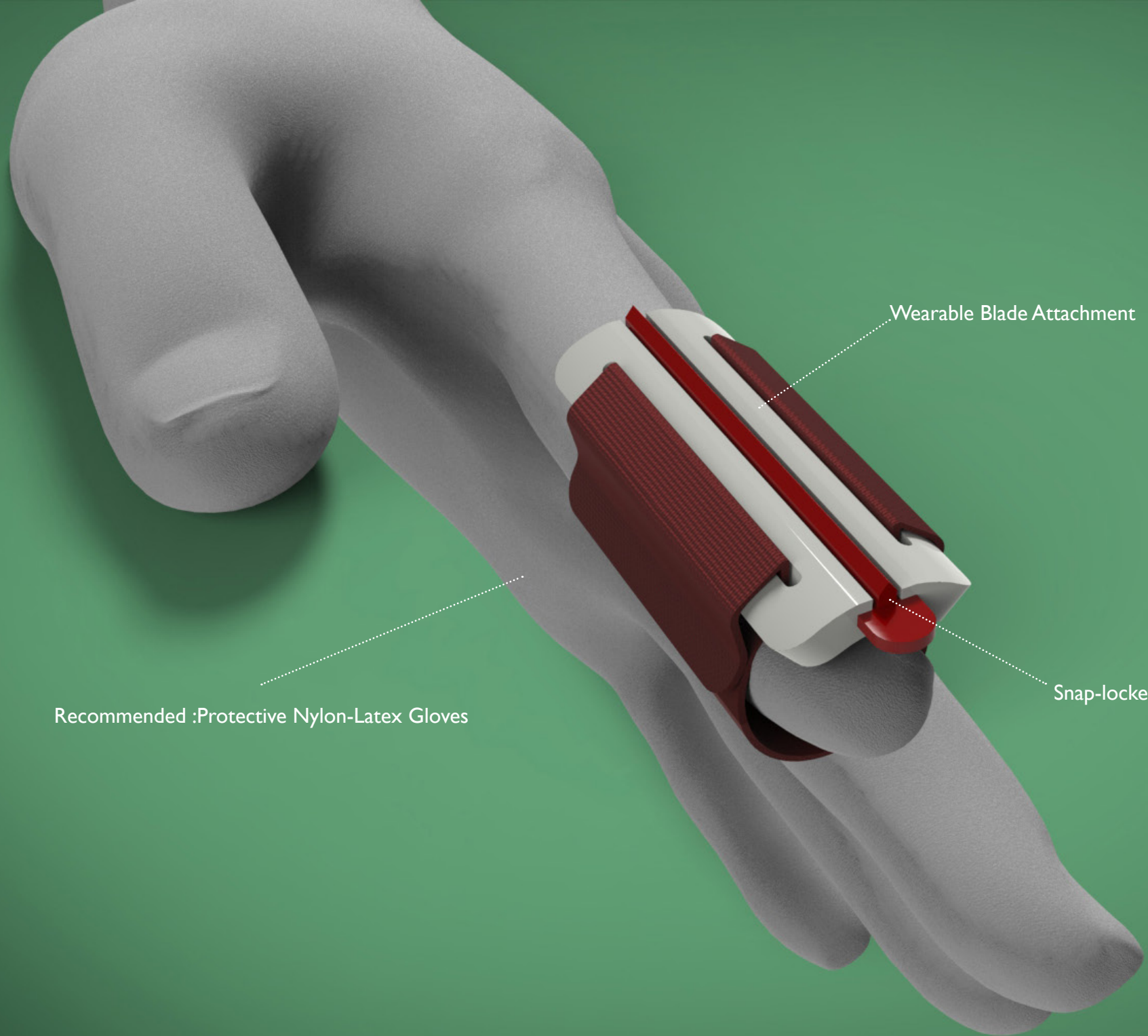
Replaceable PP Blade

PP Attachment Body

Adjustable Nylon-Velcro fastening straps

Slots for fastening

Half round snap-lock



Wearable Blade Attachment

Snap-locked PP Blade

Recommended :Protective Nylon-Latex Gloves

Synthetic Leather Layer

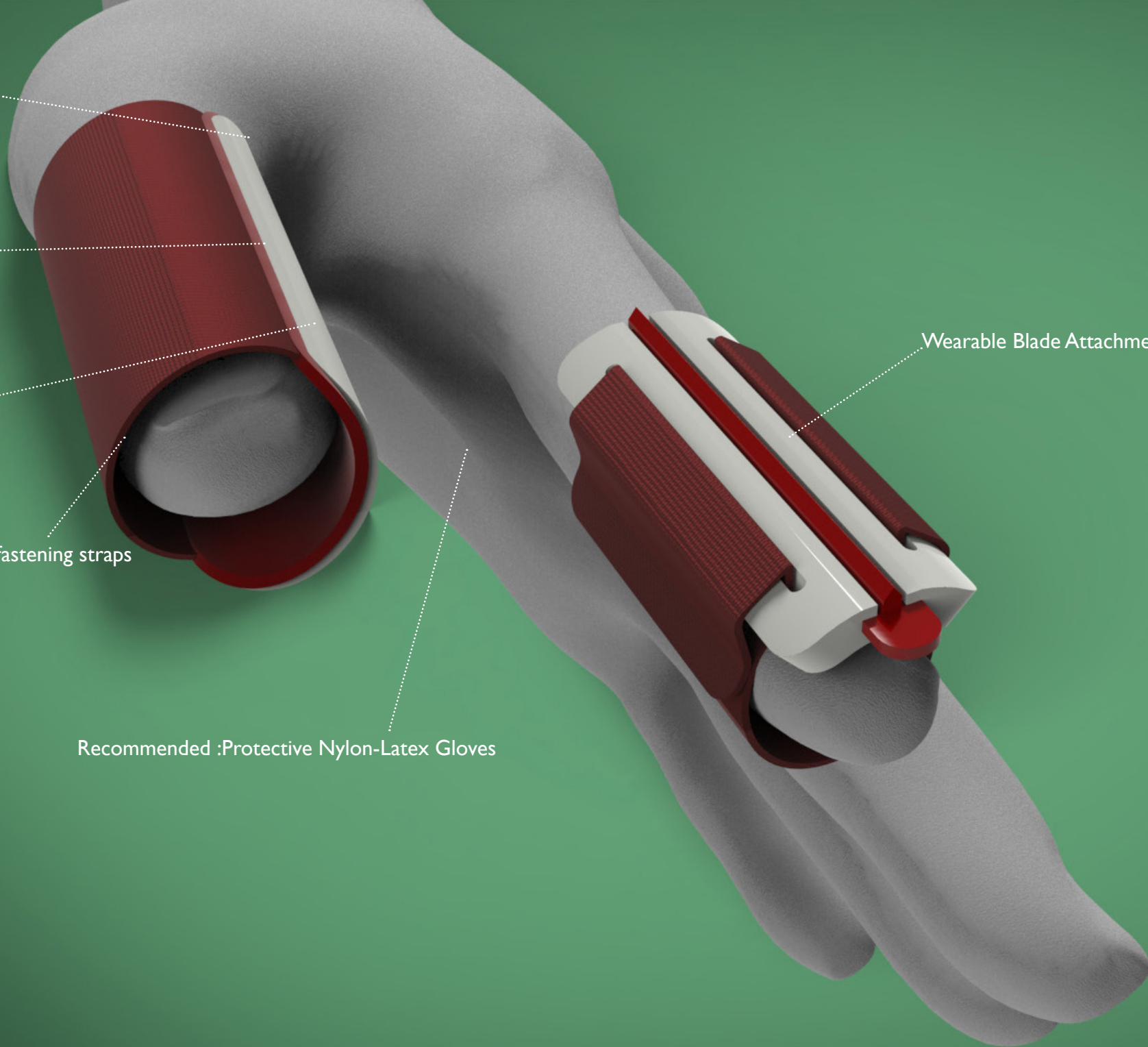
Thin Plastic Inner Layer

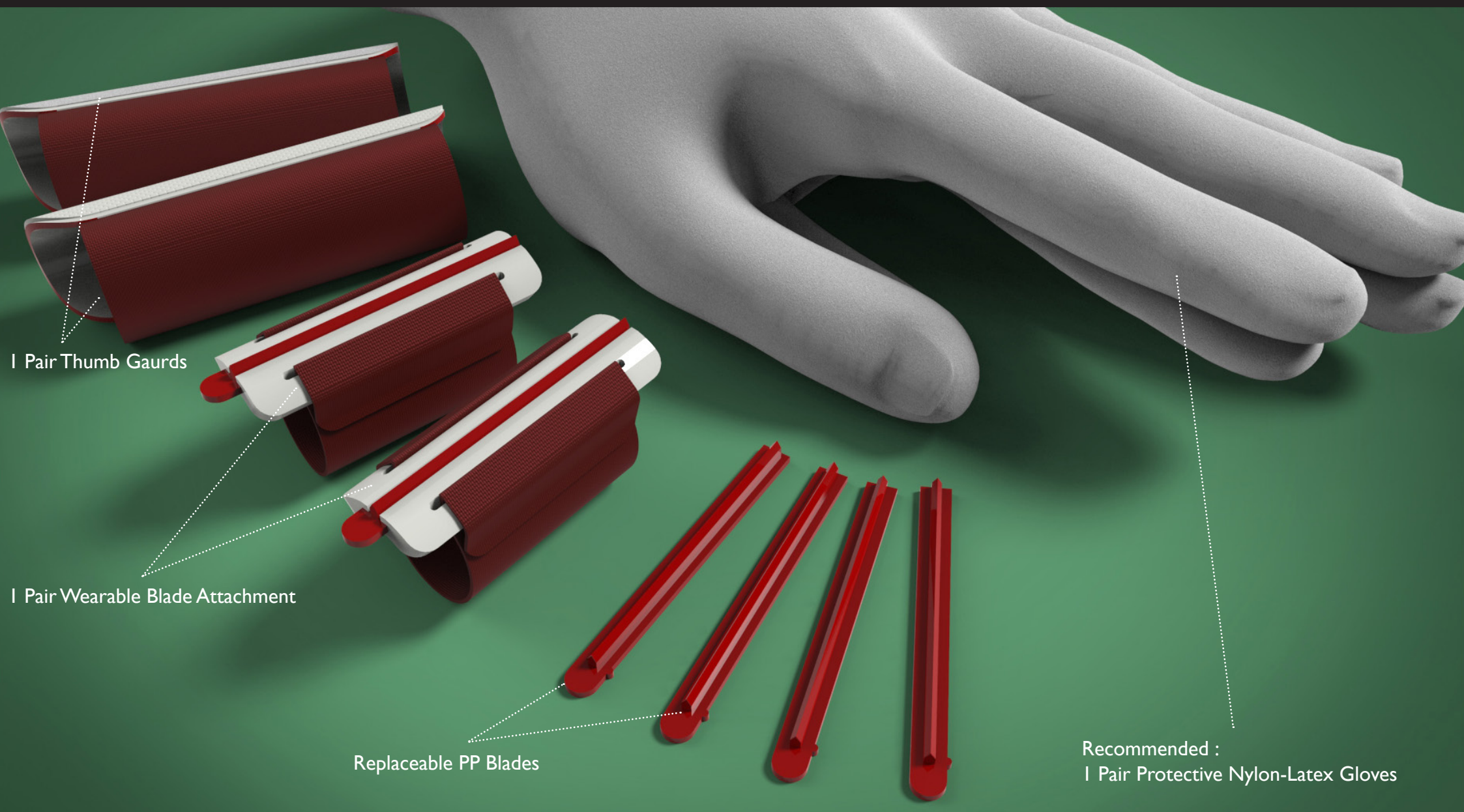
Thumb Gaurd

Adjustable Nylon-Velcro fastening straps

Recommended :Protective Nylon-Latex Gloves

Wearable Blade Attachment





I Pair Thumb Gaurds

I Pair Wearable Blade Attachment

Replaceable PP Blades

Recommended :
I Pair Protective Nylon-Latex Gloves

FURTHER SCOPE

Eliminate blade safety concern completely.
Designing for better collection efficiency.
Address static contraction of muscles.
Strain-gauge testing for plucking effort.
Business model & Branding.

BIBLIOGRAPHY

A preliminary ergonomic study on tea plucking operations.
Sen, R. N.; Ganguli, A. K.; Roy, G. S.; De, A.; Chakraborty, D.

Tea Statistics India (upto 2013)
www.teaboard.gov.in/

Darjeeling tea industry unfair to tea-pluckers
www.business-standard.com/article/pti-stories/darjeeling-tea-industry-unfair-to-tea-pluckers-anthropologist

Tea-plucking machines in India threaten Assam livelihoods
www.bbc.com/news/magazine-20542255

Struggle of Tea Plantation Workers in North East India
www.amrc.org.hk/node/1001

New ways and means to increase tea production
<http://www.sundayobserver.lk/2010/04/04/fin10.asp>

Tea Processing
en.wikipedia.org/wiki/Tea_processing

Developing Situations of Tea Plucking Machine
Yu Han, Hongru Xiao, Guangming Qin, Zhiyu Song, Wenqin Ding, Song Mei

The Life of a Tea Plucker
www.frontiercoop.com/sourcing/plucker.html

Tea Growing Regions
www.indiatea.org/tea_growing_regions.php

Selective Tea Harvester
<http://www.tmachinery.com/selective-tea-harvester.html>

Production of Quality Tea Crop
<http://www.ihbt.res.in/TIM/production.html>

Effects of plucking methods on yield and quality of black tea
Moazzam Hassanpour Asil



END