Quick Step

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The problem

Safety

Safety at home is a big issue, approximately 6000 people die from home accidents every year in the UK. Falling is one of the most common accidents and is a major cause of injury particularly for people over 65 and people with lower mobility. Falling often occurs when someone either trips, slips, or loses their balance.

Step stools are a great tool allowing people to reach up for objects stored high and clean hard to access areas. However, people are often scared of falling off ladders and step stools. According to a survey by the National Accident Helpline, 21% of injuries in the home occurred whilst using a ladder [1]. They are a great cause of anxiety for people with lower mobility and vertigo.

Lack of space

According to the UN, 55% of people live in urban areas as of 2018 however this is set to only increase in the coming years with a projected 68% of people living in urban areas in 2050 [2]. With most people in these urban areas living in flats and small houses, storage space will continue to be at a premium. People are going to have to make the most of the space they have.

The problem

Most step stools that are on the market currently aren't safe to use for users with lower mobility as they offer no grabbing handles and become a tripping hazard when not in use. On the other hand, products that are designed for this user group are often unaesthetic as the designers focus on functionality and ease of cleaning rather than how the product fits inside the user's home. These products also tend to take up a lot more space when not in use.

The brief

Make it easier for people with bad balance & lower physical ability to access objects or clean the top of kitchen furniture. The product should be easy to stow away whilst being easy to get out at any point.

Sources:

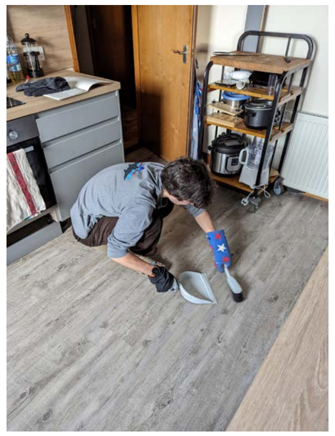
[1]"National Accident Helpline," 6 May 2020. [Online]. Available: https://www.national-accident-helpline.co.uk/news/post/accidents-home. [Accessed 6 April 2022].

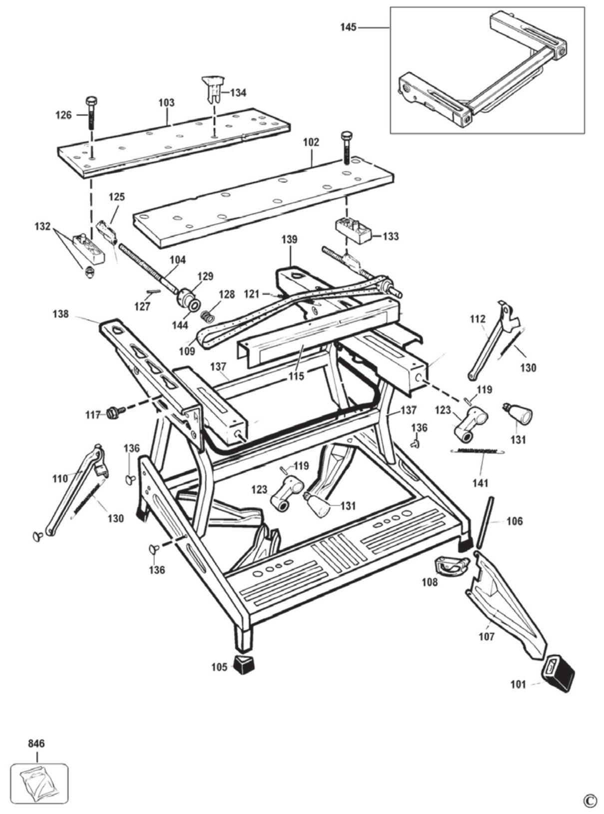
[2]"UN.org," 16 May 2018. [Online]. Available: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html. [Accessed 5 April 2022].

Research

Empathic modelling and user journeys

Empathic modelling allowed me to get in the shoes of the elderly and people with lower mobility. Elderly people often suffer from reduced mobility due to joint pain, back pain and arthritis. In an effort to mimic this I wore 5 jumpers, a jacket, 4 pairs of trousers, 3 pairs of gloves, 3 pair of socks and a backpack loaded with coconut milk tins. Doing this gave me many insights into the problems they face when cleaning their homes and whilst performing other daily tasks namely: crouching is difficult, reduced dexterity and loss of balance.
Documenting the user journey of current step stools allowed me to find the common issues and identify when they occur in the use cycle and why.





Taking inspiration

Throughout this project, I looked at various existing products to find inspiration on form, mechanisms and function. Early on in the project I looked at machines and devices that can lift objects or people upwards. Later on I looked at products that fold and the mechanisms they use including folding beds, telescopic ladders and folding pushchairs. The Black and Decker Workmate proved to be a valuable source of inspiration as it is a product that fold down onto itself and has been designed to be extremely sturdy when deployed. From afar it also looks like a step stool with a lower step and the top step being the workbench area.

Primary research and anthropometric data

From pictures of friends and families kitchens I was able to study how people store their food and kitchen equipment and where things are stored. Talking to my study group gave me insights into how often objects are used. This informed me that the product I created should be easy to deploy and tidy.
By measuring the space below my kitchen cabinets and researching kitchen cabinet industry standards I was able to set volumetric design constraints.
Looking up existing product sizing and anthropometric data informed the final dimensions used in Quick step.

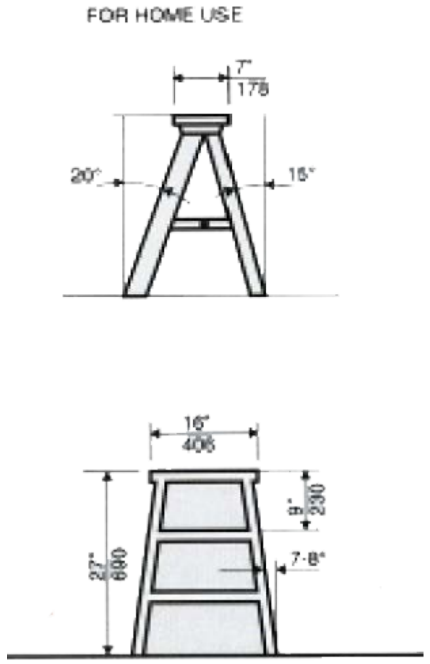
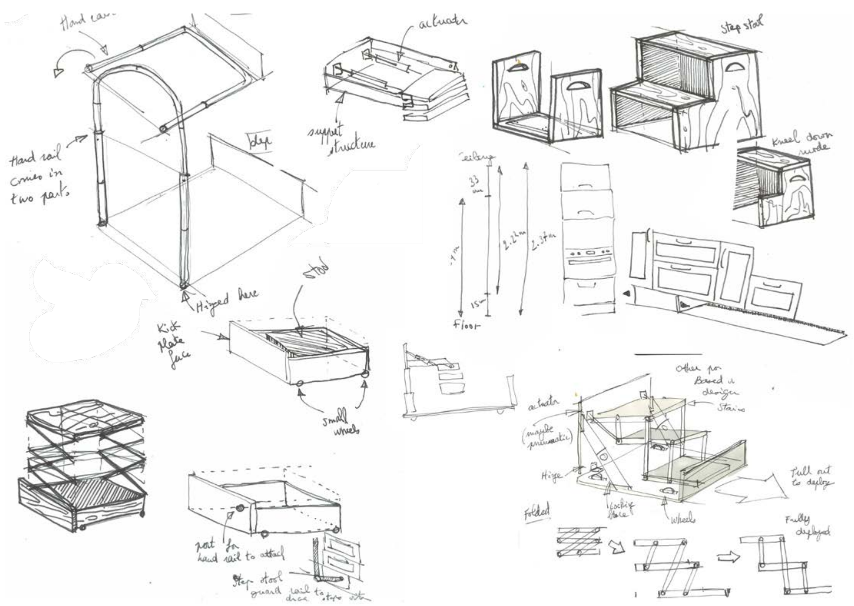


Image from The Measure of Man and Woman: Human Factors in Design by Alvin Tilley

Concept development

2D exploration

I started my design process by making quick sketches of all the potential solutions to the problem I could think off. Sketching allowed me to communicate my ideas easily with all my stake holders and rapidly evaluate ideas.
Initial ideas focused on easing access to hard to reach areas. No idea was deemed too far fetched with hydraulic human lifts, moving kitchen cabinetry and robotic arms being considered. Some of these ideas were then combined together and evaluated against research insights.
Creating detailed user journeys for each short-listed concept allowed me to decide which concept to pursue. As my product was aimed at the elderly I moved away from technologically complex solutions to focus on something that most people are already familiar with: the step stool. Drawing out what I think would make a really bad step stool highlighted what a good step stool should achieve.



Physical prototyping

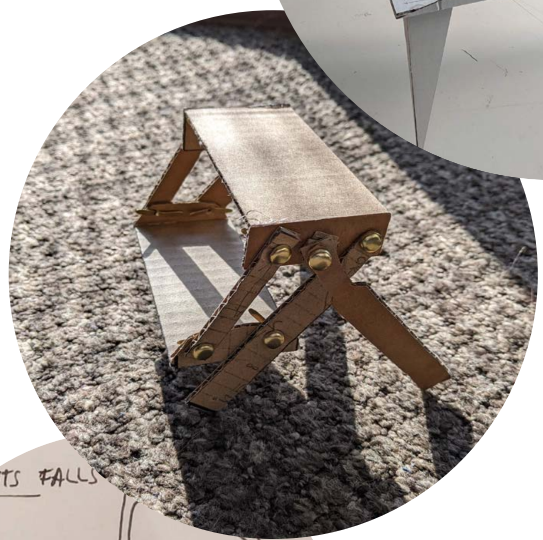
Creating small cardboard models of existing step stools gave me a sense of how they are built and how I could design my own. Using brass split pins and cardboard models helped me identify where a step stool could fold and how.
Making a 1:1 cardboard model allowed me to integrate and test the general shape and function of my concept. Again this was a cardboard model as they are a cheap and relatively fast way to identify problems and see how things would fit. Interference problems are often hard to spot on paper but become evident when a model is created.
Transforming my cardboard model into a steel prototype meant I could physically test the step stool. A change of material tends to also flag up new problems and new opportunities. In my case, making a steel prototype showed me that I could used smaller thicknesses and have less margin between the edge of a part and a hole.

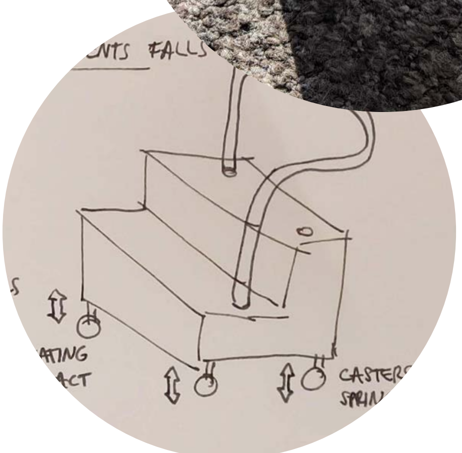
Engaging with stakeholders

Talking to potential customers and family & friends allowed me to find the key problems with current step stools and what my stakeholders were after in a new solution. Mainly my re-design should:

- have a handle for a person to hold onto
- avoid narrow steps as these are easier to miss particularly when coming down
- two steps is all that is required
- not induce vertigo in the user and minimize the risk of falling.
- fold down to make it easier to store.

Concept evolution





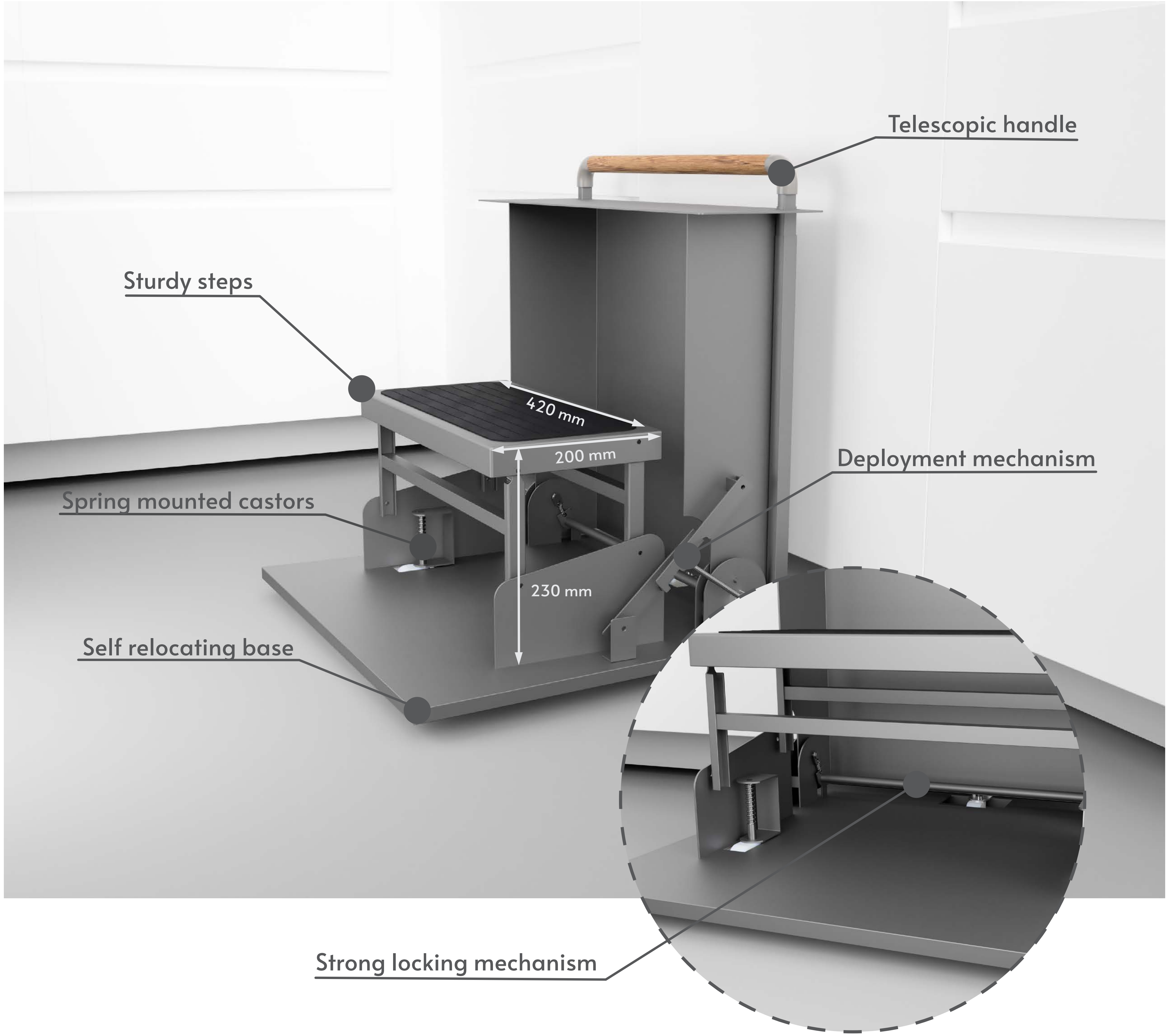
Product Overview

Quick Step is an easy to deploy folding step stool. It makes the most of underused space by storing below kitchen cabinets giving users more space for their kitchen equipment.

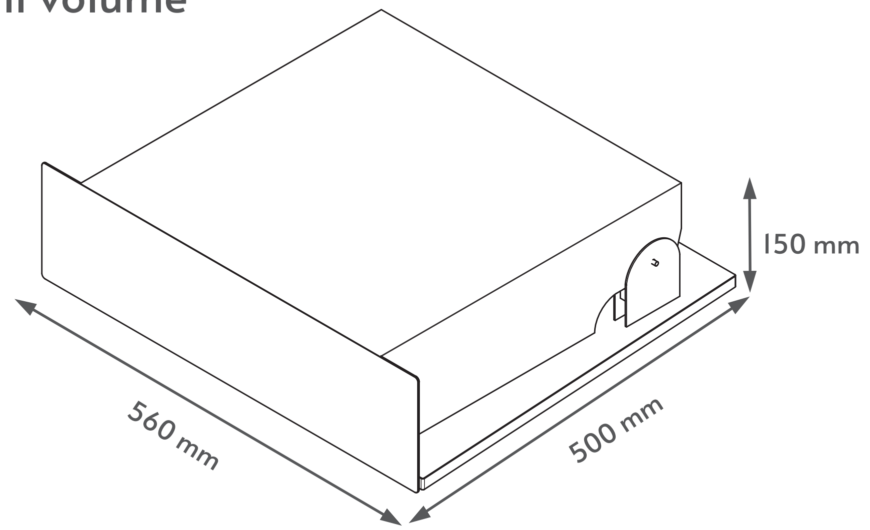
No need to crouch down to get the steps out, they come to you. To deploy, the user simply kicks the frontage.

The combination of sturdy steps and a telescopic hand rail makes Quick step easier for people with lower mobility to reach for objects stored up high. Spring mounted wheels mean the steps can be accurately placed wherever they are needed.

A strong and reliable locking mechanism insure the steps won't fold when the steps are in use.
When its time to store Quick step away, the locking mechanism can be released by pressing down on the lock bar.



Folds down into a small volume



How the mechanisms work

Folding mechanism

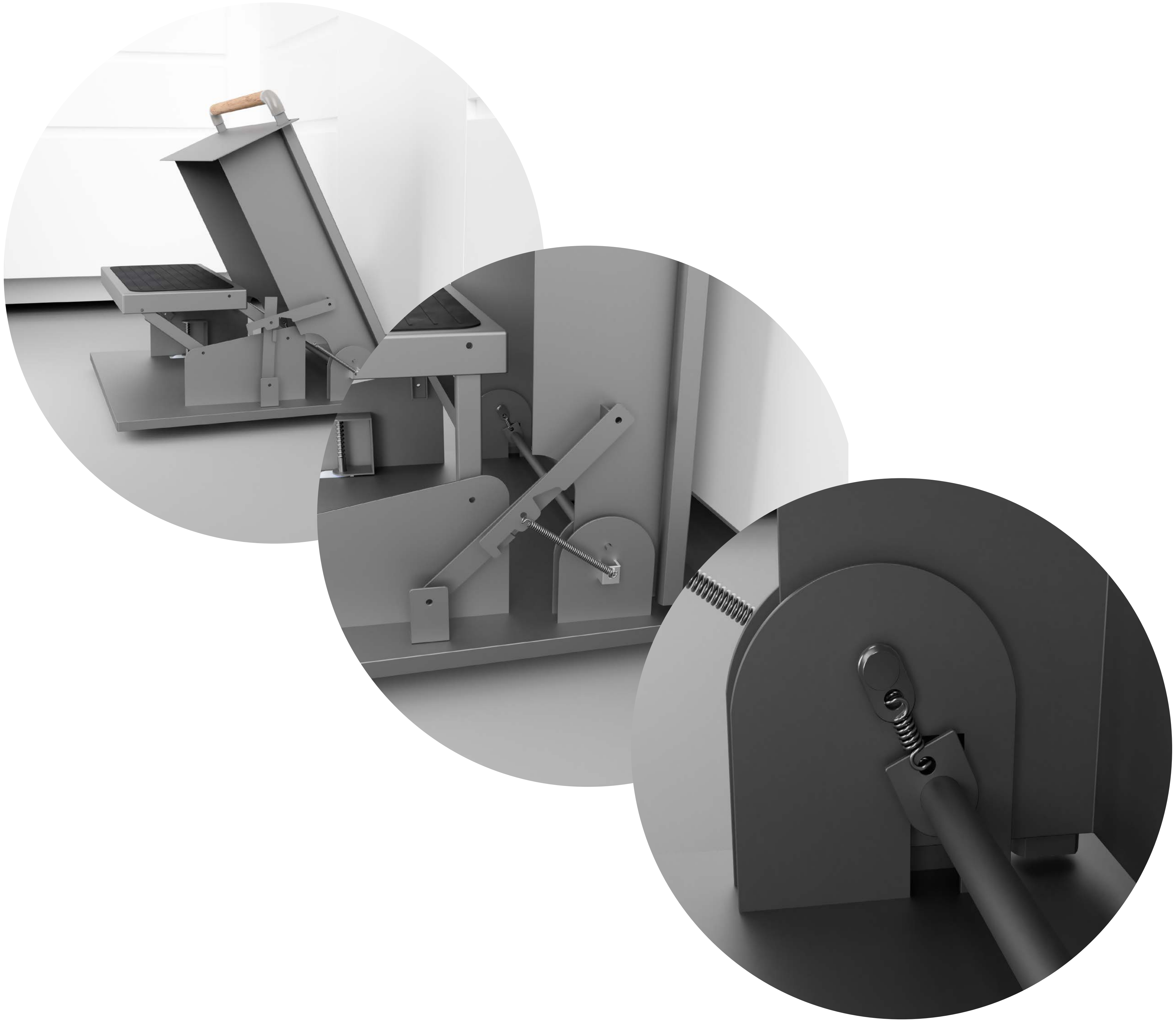
The step stool folds down easily thanks to its construction. The plinth frontage is also the top step saving space and reducing part count. The smaller step is nestled inside the top step. A parallelogram linkage system allows the small step to fold up and down.

Deployment mechanism

Two spring loaded braces on each side of the step stool deploy the steps . The spring is at rest when the steps are open and gets extended when the steps are closed meaning the steps naturally want to be open.

Locking mechanism

A spring loaded locking bar connected to both hinge points prevents the step stool from rotating. Depressing the locking bar compresses the springs allowing it to fold.



Technical analysis & validation

Hand calculations were performed to determine whether the design would fail under load.
Initial calculations were only performed on the lower step. It was treated as a fixed beam with a 1000N load in the middle. The beam was taken to be a flat sheet of material. Using beam bending theory the maximum stress applied to the lower step was calculated to be 333 MPa. The yield stress of steel is 250 MPa, in this scenario the step would fail.

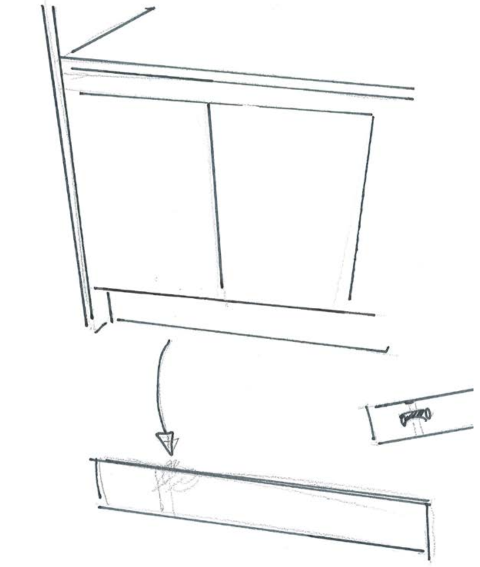
In response to these calculations, the geometry of the steps was redesigned from a simple plate to a box shape. A new set of calculations was realised where the beam was fixed at both ends and had a uniformly distributed load in the centre. Maximum bending stress for the top step was calculated to be: 4.70 MPa and 3.85 MPa for the small step. The new geometry would not fail under load.

Further calculations were performed to test whether the columns supporting the steps would fail under direct stress or buckle. It was found that both the lower and upper set of columns would not fail from direct stress. Buckling would not occur either as the calculated buckling stress was far greater than the applied stress.

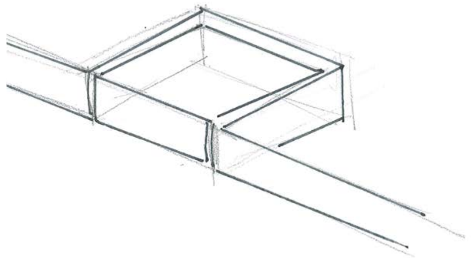
To validate these calculations a mild steel prototype was built and tested. Two people where able to stand on it without the step experiencing any noticeable deflection and without failure proving the calculations.

User journey

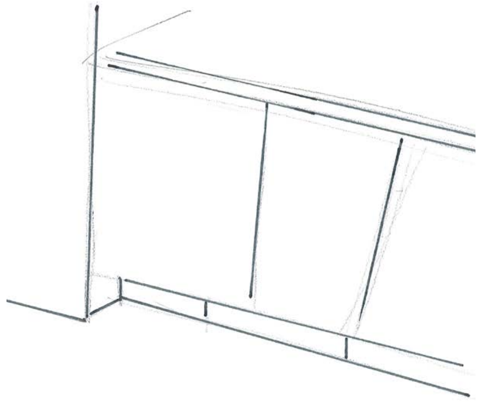
To install a quick step system the user first removes the plinth. Plinths are usually clipped onto the kitchen cabinet legs.



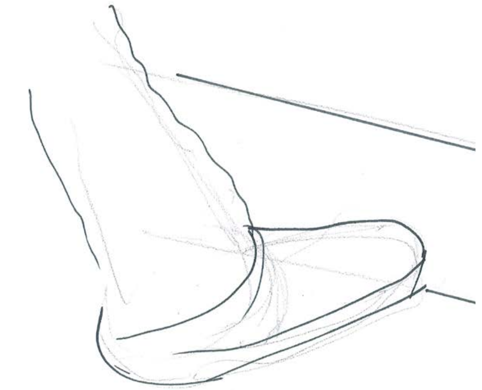
The quick step system is then slid under the cabinets and clipped to the legs. The existing plinth is cut to allow the steps to pop out.



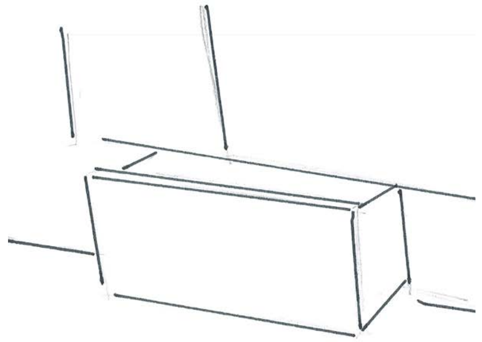
Quick step is now fully installed. User can choose to make it visible by choosing a contrasting colour frontage or match colour to plinth.

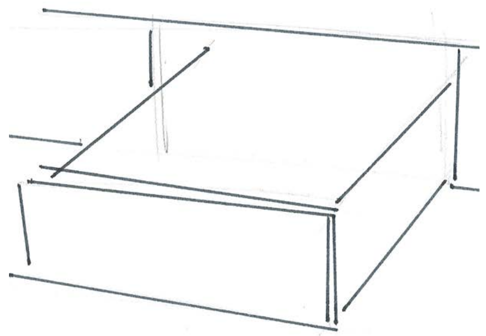


Quick step is now ready to use. To deploy user kicks the front plate in actuating the push open mechanism.

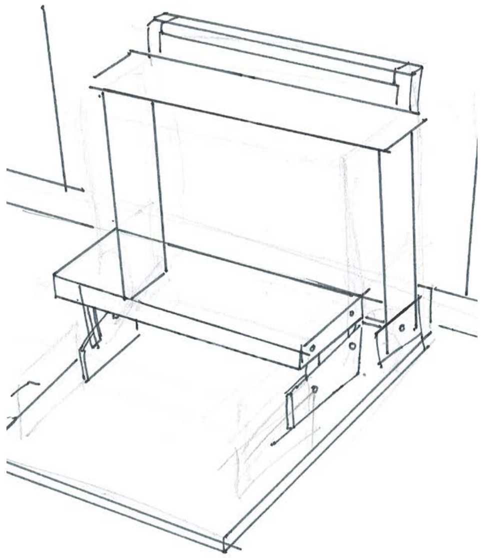


Steps are gradually pushed out by the spring deployment system.

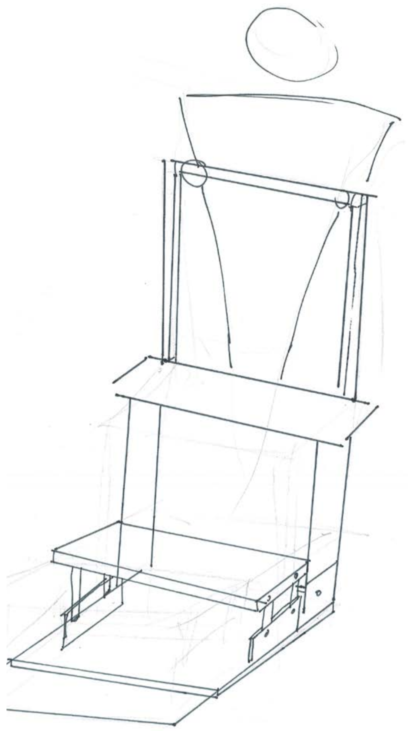




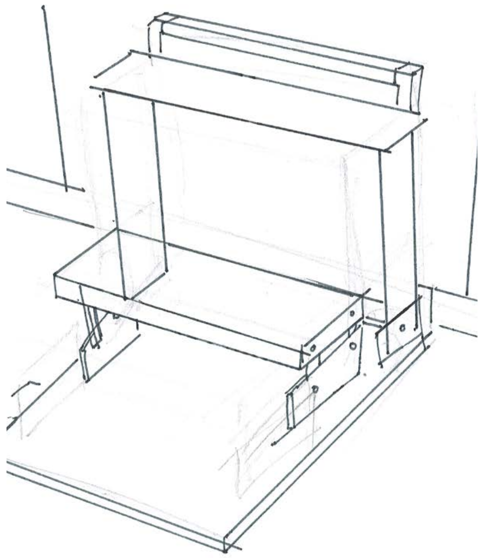
Steps are now fully deployed.
Depressing the foot pedal locks the steps
User then deploys and locks the



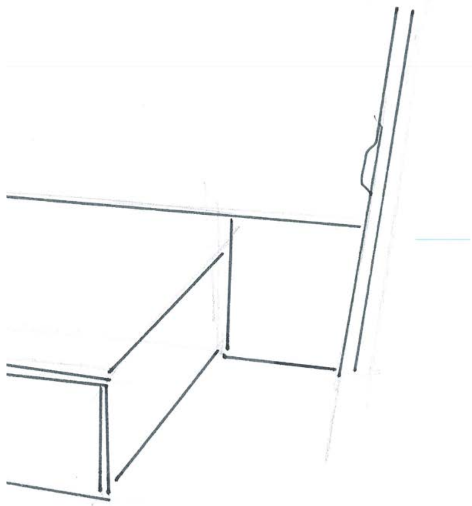
Handle allows user to move the steps wherever they are needed within the kitchen

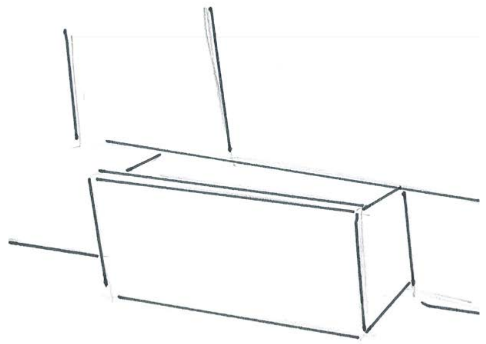


To put the step stool away user unlocks handle and fold it down. Steps are then unlocked by depressing the foot pedal

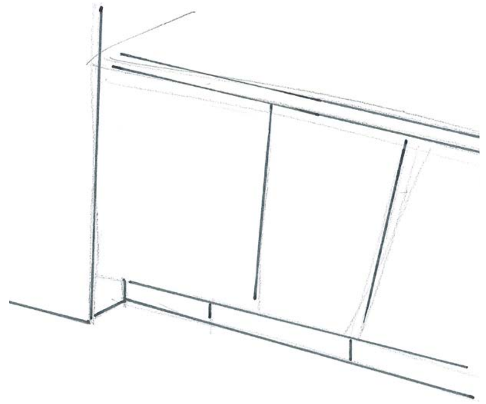


Quick step can now be kicked back into it storage slot.





Quick step is now stored away ready to be used when needed.



Material selection and manufacture

Non age hardening aluminium will be used for the Quick step as it is strong, light and easy to process during manufacturing.

My design uses the same thickness of aluminium throughout it's construction. This is to reduce the amount of processes needed and reduce costs. All parts are made from flat sheets.
The parts will first be punched. Punching is relatively cheap way to accurately cut many parts to size. The punched parts are then deburred, oiled and then stamped into shape.
After being formed the parts would be sanded and then anodized. Anodizing creates a hard oxide layer that protects the aluminium parts. Some of the parts such as the small tread would require welding to attach parts together. TIG welding would be used as filler material can be easily added.
The springs, castors and handle mechanism will be bought as off the shelf parts.

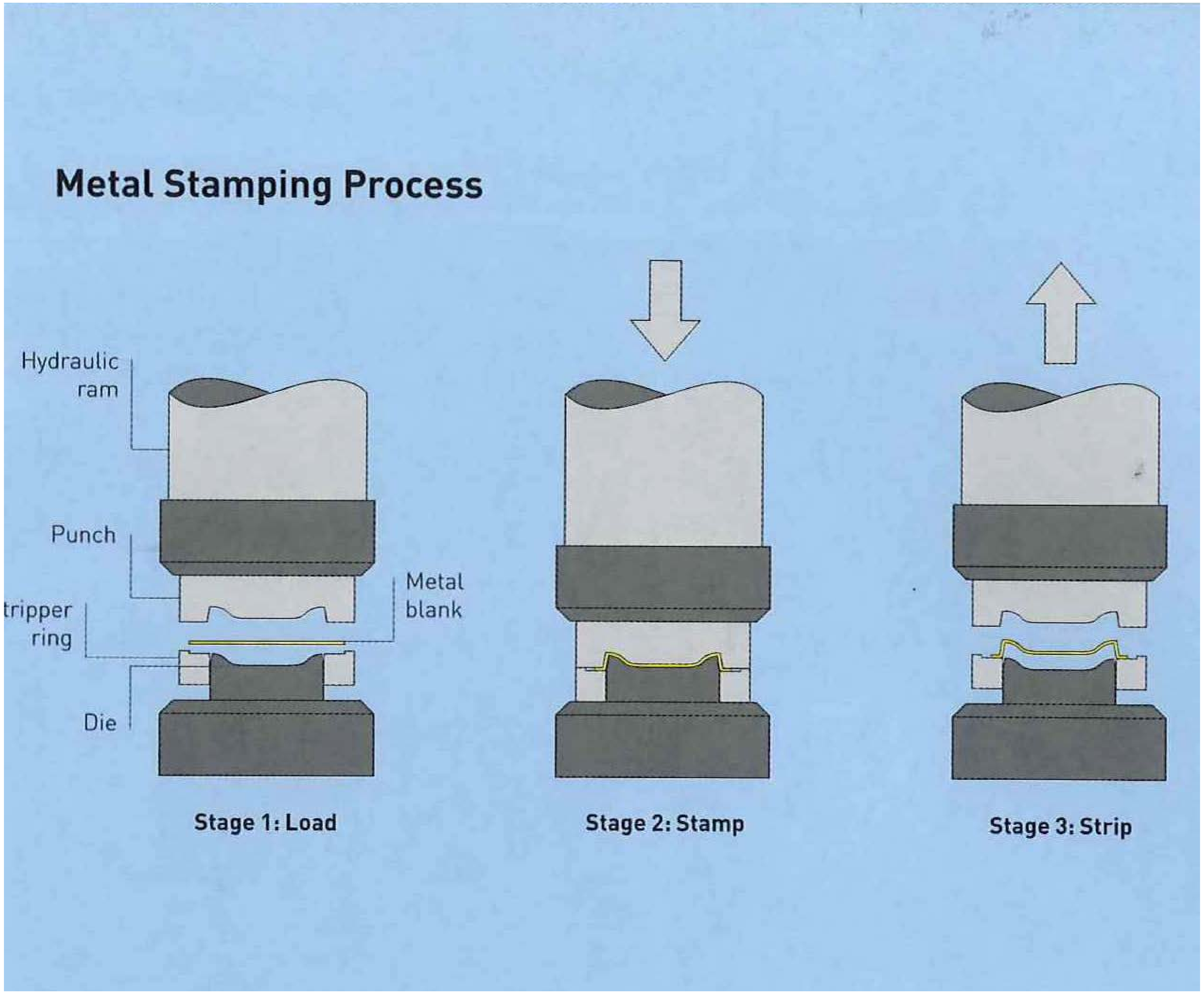


Image source: "Manufacturing Processes for Design Professionals" by Rob Thompson