TALLINNA TEHNIKAÜLIKOOL
INSENERITEADUSKOND
MEHAANIKA JA TÖÖSTUSTEHNIKA INSTITUUT

AGO: ADAPTIIVNE KODUKASUTAJA FILMIILMUTUS SÜSTEEM

AGO: ADAPTIVE HOME USER FILM DEVELOPING SYSTEM

MAGISTRITÖÖ

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Lõputöö teema:

AGO: Adaptiivne kodukasutaja filmiilmutus süsteem

AGO: Adaptive home user film developing system

Lõputöö põhieesmärgid:

1. Aru saada analoog fotograafia väärtusest, mis tal on pakkuda praegusel digiajastul.

2.Identifitseerida probleemid mis valdkonda hetkel vaevavad ja piiravad arengut.

3.Pakkuda välja lahendus mis neid probleeme kõrvaldaks ning oleks teostatav hetke turuolukorras.

Lõputöö etapid ja ajakava:

Nr	Ülesande kirjeldus	Tähtaeg
1.	Uurimustöö, et saada aru probleemisdest mis on analoogfotograafia ümber.	15.02
2.	Kontseptsiooni arendamine	15.03
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CONTENTS

LIST OF ABBREVIATIONS

C-41- Color process

B&W- Black and white process

ISO- light gathering ability

PTO- Power take-off

RF- Radio frequency

SBC- Single board computer

API- application programming interface

ABSTRACT

The aim of this theses is to research current analog photography scene and look ways how to support its revival. Closer look was taken to further understand what are the benefits of analog photography from photography perspective and what it can teach us in the 21st-century fast life. After analyzing literature and empirical studies opportunity was discovered on a field of film developing at home.

Next focus shifted to understanding the problems and how to solve them through physical prototyping and software design. The outcome of this thesis is easy to use but effective film developing system meant for home users which eliminates the potential errors and detach operator from constant attachment.

1 PREFACE

1.1 Introduction

There is analog photography revival going on at a moment. As the younger generation has started to explore it and old users turn back as they see value in it despite multiple digital solutions available. On one side we have convenience of seamlessly integrated digital technology. Yet on the other side we have an increasing number of people who enjoy experiencing what analog process has to offer. Considering aging analog machinery and socio-digital technologies surrounding every human we need solutions to support and direct analog photography to a more secure future.

From my own perspective, when few years ago I made my first steps in analog photography I was instantly hooked of the process and of the outcome but the same time there were many questions that needed to be answered. Like where to get film, where can I develop black and white or color film, why is it so expensive and why does it take so long to develop especially with black and white films. Also, I was thinking how to do it at home, but it seemed too complicated at first to do by myself. This made me attached to different developing labs which suited my wallet and taste of quality.

After diving deeper into the subject and few darkroom experiences, I started to look at what equipment I need to do it at home. It turned out that choices of what you can use are in both extremums, either automated- lab or prosumer equipment or archaic developing tank with its myriad of tools. I was not too excited bringing that mess to home and made me think about how to make this process more pleasant.

During the theses, this first notion will be further studied to identify pockets of possible design interventions in order build a solution from which analog community would benefit.

1.2 Objective and scope

Analog photography now is a niche market taking maximum out of emotionally old and depreciating technology. Since the downfall of analog photography, we have also had rapid technological growth, which has given new possibilities in solutions and to produce small batch products for niche markets like it is now. Objective of this paper is to develop a solution which would excite analog photographers and would be a viable option for everyone who develops their films at home.

The work of this paper aims to understand analog photography post golden age paradigm in its problems and explore ways to make analog film developing more accessible for the people in need. This is done through literature research, interviews with different stakeholders and a survey.

1.3 Outcome

Outcome of this theses is a concept of film developing system which eliminates current home user problem like, scattered information, continuous physical attachment during the processing and alternating quality. Proposed concept is in a form of physical processor compatible with Paterson System 4 tanks and a web platform to extend the user experience and bring together all the intelligence to develop roll of film.

2 METHODOLOGY

This section aims to describe the procedure adopted to conduct research and development in this thesis. Overall structure follows a double diamond model. (Design Council, 2020)

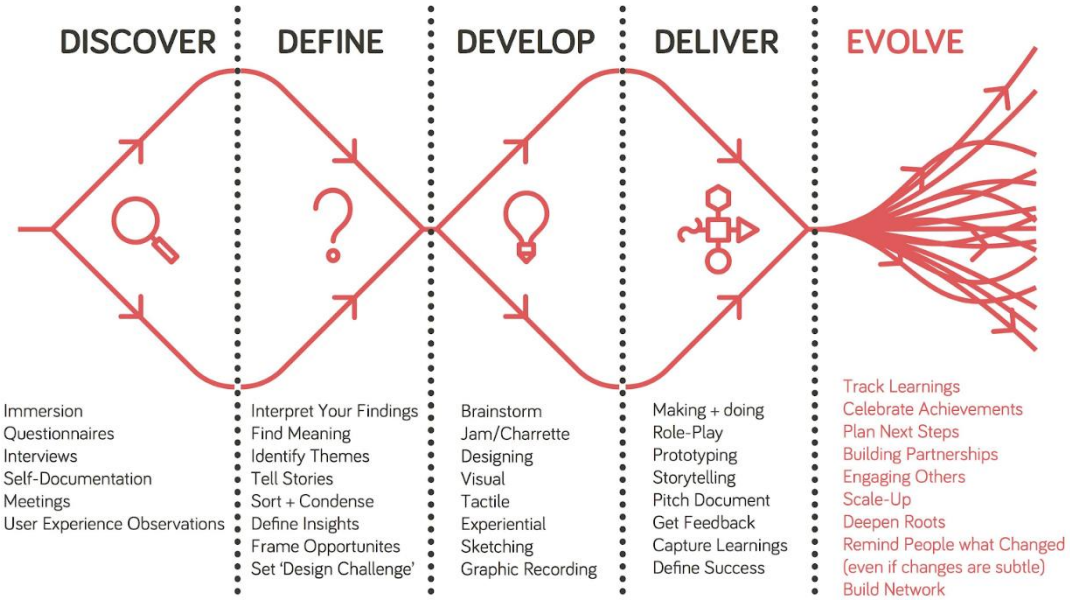

Figure 1.3.1. Double Diamond Model (Design Council, 2015)

2.1 Double diamond model

Double diamond model(Figure 1.3.1)is a framework created by Design Council which graphically represents a simplified design process. Process is divided into 4 phases where the first stage is Discovered where aim is to get as deep and wide understanding about the field surrounding the problem as possible. Second phase is Define where information gathered from the Discovery phase is synthesized into problem definition. Third phase is Develop where concepts and possible solutions are explored. Last phase is Deliver where final solution is presented. (Design Council, 2020)

2.2 Discover

At first a literature review was conducted, including research papers, community articles and manufacturers process description to gain fundamental information about the research topic. Objective was to acquire sufficient understanding about the topic to develop argumentation for upcoming user research.

Second part included interviews and online questionnaires of users. Information is gathered to illustrate user behavior in different user groups to see different patterns of experiences. (Figure 2.2.1)

Objectives	Tools & Methods
• Identify the problem, opportunity or needs to be addressed through design. • Define the solution space. • Build a rich knowledge resource with inspiration and insights.	• Literature research • Interviews with stakeholders • Survey

Figure 2.2.1. Discover Phase – Objectives, Tools and Methods

2.3 Define

Information gathered from research are analyzed and structured into sets on problem statements. These problem statements are aligned with writer motivation and objectives to decide which to take forward. Outcome of this phase is a clear outline of fundamental problems and challenges in a form of design brief. (Figure 2.3.1)

Objectives	Tools & Methods
• Analyze the outputs of the Discover phase. • Synthesize the findings into a reduced number of opportunities. • Define a clear brief for sign off by all stakeholders.	• Mapping • Brainstorming • Design Brief

Figure 2.3.1. Define Phase – Objectives, Tools and Methods

2.4 Develop

The develop phase aim is to develop products from the information gathered in the design brief. Taking it through an iterative process of developing and testing, refines the product until it is ready for implementation. Final solution components should be detailed forming holistic solutions. Part of the develop phase is a constant feedback loop of information through users. (Figure 2.4.1)

Objectives	Tools & Methods
• Develop the initial brief into a product for implementation. • Design service components in detail and as part of a holistic experience • Iteratively test concepts with end users.	• Prototyping • System mapping

Figure 2.4.1. Develop Phase – Objectives, Tools and Methods

2.5 Deliver

While usually the Deliver phase means the launch of the product to the market, in this thesis we limit ourselves with final prototypes potentially ready for market as the theses ends before the product launch. Final concept takes information presented in the discovery phase and communicates it through prototype. (Figure 2.5.1

Objectives	Tools & Methods
• Share lessons from the development process. • Further development plans.	• Process roadmap • Physical prototype

Figure 2.5.1. Deliver Phase – Objectives, Tools and Methods

3 DISCOVER

3.1 Objectives

Goal of this phase is to get a broad overview of the current analog photography scene and more specifically developing part of the process. Data gathered here is used to identify problems surrounding analog photography scene to later generate new concepts and deliver the final solution.

Discovery phase objective is to answer some of the questions listed below:

- Why do analog photographers still use this medium?
- In which areas is it beneficial and where not?
- What is the current situation with analog photography?
- What is the motivation behind different film developing possibilities?
- What are the qualities of analog photography that users appreciate and should stay the same in tools they use?

3.2 Literature research

3.2.1 Film production

Analog photography was a superior form of capturing photos until first Kodak itself developed digital technology started to emerge on the market. While digital gained slowly popularity already earlier, the 2003 was the breaking point when 6MP cameras disrupted consumer market. Compared to film cameras its instantaneousness, shareability, cost, and total freedom made them enormously popular.

Digital advantages were so decisive and came so rapidly that the analog industry did not have time to adapt with new situations. Sales just dropped off. Factories designed for production were just too large, meant for much bigger production and could not handle this kind of decrease in production. In the United States alone, 800 million rolls of film were produced in 1999. By 2011, that dropped to just 20 million rolls. Polaroid went bankrupt in 2002, Ferrania the year after, followed by Britain's Ilford and Germany's Agfa in 2005. Eastman Kodak filed Chapter 11 in 2012, and now has only eight thousand global employees, compared with over 145,000 at its peak. (Sax, 2016)

After restructuring of those massive companies, film production stabilized at 100 million rolls made annually in 2015 worldwide. Harman Technology (Ilford) has reported a 5%

growth in film sales per year the last 5 years. Kodak Alaris (in effect what is left of Kodak) is seeing a similar trend and has developed films that are ideal for scanning, and at CES 2017 they announced the return of Ektachrome. (Camera rescue, 2020)

3.2.2 Why do we shoot on analog film?

It is the question that many ask about analog photography. It seems inconvenient compared to digital photography and in many ways, it is that. With digital you do not pay for pixels, it is much faster, you do not have to know what kind of film you want and gather it from the store, there is no developing and scanning. All above are things that any rational person would consider why not to shoot film.

As usual there are many philosophies around what analog photographers spread to justify their hobby of shooting on film. With the following I do not want to diminish the value of digital photography; both have their weaknesses and strengths, but I want to show what kind of experiences analog can offer to us in order to learn from analog to use in digital photography.

As Estonian Academy of Arts darkroom lecturer Tanel Verk said in the Academy context about why: "For two reason: because of the process behind it and for its practicality to be more exclusive". About practicality he stated that pictures made in darkroom have bigger value in viewers eyes because the analog process differs from mainstream art production and makes it more exclusive in that sense.

The process: If a photographer has not structured his work in a meaningful way, they are usually straight jumping into editing after shooting which usually is a burden instead of creative practice. Professional photographers structure their process, extending the time period between making photos and editing and printing them. This gives them time to forget the picture and rediscover their picture with new eyes and even remember better ones. Another aspect is how amateurs and professional photographers differ is how many shots they take of the subject. Instead of concentrating into taking one good picture, amateurs tend to take more pictures of the same subject which converts into noise and needs to be filtered out along the way.

It is the way to maintain meaningfulness in your work. It is the process behind it and you have to maintain it yourself and make this as your habit. Otherwise, it becomes meaningless data on your hard drive.

In many ways the analog process forces you to do the same thing as professionals do, it slows you down with its limitations. There is the value of one shot and limited exposures which greats the feel that you want to make best out of it. After the shooting there is a time when it is in development and which makes you forget the pictures and the same time makes itches regarding what came out of it. After getting back your photos generally pictures need minor editing because you choose the look of the picture before the shoot with the film you have chosen. Therefore, analog users frequently mention that they enjoy the process. In the end it surprises and rewards the user for his work with almost finished photos.

This is the reason why institutions who teach photography still have darkrooms and knowledge to spread about analog photography. To carry through the analog process from start to finish needs significantly more time and manual handling in a quite fixed way, it makes windows of time where you see the picture and must decide whether to move forward and invest more time in it or ditch it.

As with any graft to get a deeper level of connection you need to spend more time with it. People crave for something finite and tangible in this world of data and noise, but it does not mean that it is always for everything. As it came out of the interview that analog photography is usually done for personal projects and digital solutions were used for commercial purposes. Same in vinyl record context: "Digitization is the peak of convenience, but vinyl is the peak of the experience," (Sax, 2016)

3.2.3 Social dilemma and slow movement

The digital world has given us access to great quantities of data and possibility to interact seamlessly with everyone just a few clicks away. In consequence, information has become the most valued asset in the world and IT companies like Apple, Alphabet and Facebook are now one of the most valued companies out there. This comes with fierce competition over people's attention to consume media in the favor of these firms. (Forbs, 2021)

Average person spends 3 hours and 15 minutes on their smartphone consuming free content specifically designed for them. (SPAJIC, 2020) It is apparent that these firms use different kind of tools to hack human brain, weather it is artificial intelligence which understands psychology of persuasion or algorithm which decides what we view. Ex Google design ethicist Tristan Harris brought out in documentary The Social Dilemma how big platforms hold their users engaged to feed them with advertisements and the consequence

of human wellbeing. Documentary explains that technology manipulates our evolutionary need to relate to other people and as a reward it gives us dopamine, while real connections are rarely made. Its goal is to optimize it´s technology and cause addiction in users to the extent that their self-worth and identity is tied to their products by dosing approval every five minutes. In consequence it uses up all attention a person has. There is the realization that if you are not paying for the product then you are the product. While in modern society it is hard to completely avoid digital infrastructure surrounding us it is apparent that we need to mindfully tackle the problem of information overload coming in through our smart devices.

While it is suggested to limit screen time, take digital detox from social media or work with your hobbies, more deliberate movements have also emerged to tackle the problem of fast life and become more connected with people around you and the culture you live in. Like all different kinds of slow movements: Slow food, Slow photography, Slow morning, Slow home etc. which address the issue of time poverty through making connections. All of them start from common ground by emphasizing on making connections to other people and to the natural world, prioritizing quality over quantity and experiences over material things. Slow food movement which was the first of its kind started in Italy in 1989 with a protest against McDonald's opening a restaurant in the center of Rome. The idea was to counter the idea of fast food, fast life, non-sustainable mass production and the erosion of local economies and culture. Slow Food Foundation for Biodiversity was founded to bring together local contributors and on global scale gain influence and lobby EU in trade and agricultural policy to save endangered foods. Mission of this foundation is to organize and fund projects that defend the world's heritage of agricultural biodiversity and gastronomic traditions. Year after the McDonald's protest Folco Potinari wrote the Slow Food Manifesto (Andrews, 2008)

The Slow Food Manifesto highlights the threat of the "Fast Life" and argues that Slow Food is the "only truly progressive answer" to the perils of fast food:

- We are enslaved by speed and have all succumbed to the same insidious virus: Fast Life, which disrupts our habits, pervades the privacy of our homes and forces us to eat Fast Foods.

- To be worthy of the name, Homo sapiens should rid himself of speed before it reduces him to a species in danger of extinction…Our defense should begin at the table with Slow Food. Let us rediscover the flavors and savors of regional cooking and banish the degrading effects of Fast Food. (Andrews, 2008)

Slow food practitioners argue that not that long ago families were a real live entity often living under the same roof. Children growing up it was natural to make bonds with close relatives and other people living in villages to successfully prolong in their life. Same with the food, everyone had vegetables, fruits or even a cow for milk in the backyard to nourish their family. Everyone was involved in growing, making traditional food or making money on them. This desire for connectedness to people and things around us is not something new. Traditionally, in times past, our lives were inevitably connected through most of our activities. Most traditional cultures still live like that. These people do not have the virus of fast life, are connected to their culture, people, place and to their self-identity. (The Slow Movement, 2021)

In essence a modern slow life is about avoiding distractions and finding balance and time for: silence, planning, observing, reflection, caring, friendship, loving... things that make us human. Savoring the hours and minutes rather than just counting them. Doing everything as well as possible, instead of as fast as possible. And escaping the western dogma of chronological time, instead adopting the idea of non-linear time, the here and now, time that works for you, extraordinary time.

So, if you must hurry, then hurry slowly. "Festina Lente!"

3.2.4 Analog qualities

When I first met Tallinna Polütehnikum photography teacher Rain Tirul and asked why people still use analog photography he said: "It's like women knit scarves and socks the same way people like to make their photos with their own hands". Work done by hands in analog photography context refers to creative decisions made throughout the process and executing those ideas physically through tangible objects. The result is what Jyrki Siukonen described in his book "Vasar ja Vaikus" 'Influence of doing something with hands is mental. Result of work is not only the object what was made but also contribution to one's understanding. By using your own hands, a person becomes more human. (Siukonen, 2016)

Furthermore, he points out the relationship between thinking and tools that we use for our work: 'If you are responsible for objects form and quality then whatever you are using is rather tool then machine. If your responsibility decreases it becomes more and more a machine, until when you do not have any responsibility and you yourself become a machine, robot, an instrument that is included in the employer's production costs. (Gill, 1983)

Technological tools like digital cameras or even advanced developing or scanning have been subject to the same criticism. Analog photography is about imperfection and celebrating that, in the end it is a choice, like Film Ferrania owner Nicola Baldini said: "It's just like art," "I'm Michelangelo and I have the idea to do a sculpture of David. I have two choices today: I can scan David's body and print out the perfect proportions on a 3-D printer, or I can start from a block of marble and chip away. The process is different, and I have to be more creative with marble to achieve a result that becomes a masterpiece," (Sax 2016, p.50)

How a photographer feels about the pictures and tools is important in the picture making process since it helps to shape the overall experience.

3.2.5 Maker movement

What made homo sapiens differ 1.8 million years ago from other species was the ability to make tools to amplify human ability. Fast forward to 21-st century and we are in a world of mass production where our ability to make things is not any more necessary. Fortunately, curiosity about how things work and how to make something is human and still lives on. It's called maker movement which is an umbrella term for independent inventors, designers and thinkers who usually don't see the product they want, so they make it. In short: the maker movement is founded on "learning by doing "principles (Papert, 1994). From early on, STEAM subjects (Science, Technology, Engineering, Arts, Mathematics) have recognized the value of maker education for these subjects by offering hands-on learning activities. (Dougherty, 2016)

Maker movement is a carefully designed pathway which encourages collaboration, sharing results and going beyond from just making things for yourself. Different ideologies and platforms have been adopted to democratize making, like open-source mindset, which is widely adopted, from the standpoint that by sharing with the community participants can develop their projects much faster and make greater things. You are going to be slow if you spend your time just coping. Maker movement celebrates great ideas and has instruments to kickstart them. From platforms which teach and inspire, to those that provide access to manufacturing and mentorship to those that connect great ideas with financing and customers. With the scalable idea it is reasonable to apply to incubators which offer a roadmap to success and first funding with the expense of shares in a startup. While they are for all kinds of startups there are also specific technology incubators, like Tehnopol in Estonia. For funding platforms like Indiegogo and Kickstarter make it possible to organize crowdfunding campaigns, just a video is required to pitch this great idea. Also, if the

outcome is successful projects not only get funding but also get a knowing that their product has product market fit and has potential to live on and flourish. Even for manufacturing and outsourcing there are maker friendly platforms which arrange 3D printing or laser cutting to PCB design and production. While these are specific services, there are also institutions which provide direct connection to a wide variety of contractors. Like Maker's Row or MFG - Custom Manufacturing Marketplace, which brings together maker friendly manufacturers under one platform. Lastly if you are not into entrepreneurial journey but still interested that your creation lives on it is possible to sell your idea on a site called Quirky and earn commission from products sold.

Maker movement is expected to be economically disruptive as ordinary people become more self-sufficient and have more impact through their creation. If the right tools, inspiration, opportunities and access to technology are available to normal people, the maker movement can become an important movement to foster innovation and erode the mass production market. Makers serve the "long tail" of demand with niche products that embody a range of customization and/or localization. With the tools of production becoming easier to use and access, makers can produce products that can be personalized to individual consumer preference and needs. Recursively, we expect to see consumer demanding customization across an increasing number of products segments, driving greater growth for maker businesses (Deloitte, 2021)

3.2.6 Developing infrastructure

There are two options how to process film, either choosing a lab service or doing it at home. While for black and white film 76% of people have tried it at home, 9.7% say that they don´t do it because they lack knowledge and 34.9% lack equipment. 12.9% say that they would always use a lab and 10.4% would do it at home if they would shoot more. (Ilford, 2020)

Commercial lab

Developing lab is where you would go if you had a roll of film at hand and no equipment and previous experience. They provide services to turn your exposed B&W and color film to light-resistant negative and they will digitize it if needed. In the lab they use dedicated machines for each process. While B&W is done by less productive semi-autonomous machines like JOBO CPP3 Processor which are still sold, C-41 color processing is done by fully automated high productive machines like Noritsu minilab V50 which can develop up to 100 rolls of film per day.

While film producers survived through restructuring, this change in sales made professional grade machinery producers discontinue their production and are only available on the secondary market. This applies to large-scale c-41 processing equipment and digital film scanners. Big manufacturers like Kodak, Fujifilm, Agfa and Noritsu who produced film developing machines are about to stop support or already stopped services for their analog processing machines. Only the bigger labs will survive for now as they have good technicians but in 10-15 years they also will run out of spare parts. (Camera rescue, 2020)

Home lab

Choosing home development to post process you negatives has a benefit of controlling the entire process from choosing the film to shoot with, until how you process it to give a different look if wanted. This is kind of a hidden gem where a person can dive in to get a deeper understanding about the process and of your own work, which can be quite rewarding.

Sometimes it is the only solution to process your film. Depending on where the person lives developing labs can be far away since usually, they exist in bigger cities. Postal service is a solution to send it via post to the commercial lab but still it is extra cost, and it takes more time.

When developing at home most used hardware is a simple Patterson or Jobo developing tank where you can install, depending on the size, mostly two or sometimes up to 8 rolls of 35mm film. Then you need a thermometer, measuring cup, chemical bottles, chemicals which are different for black and white or color film, film clips for hanging negative and if doing color processing heating system must be in place. On top of that scanner is needed to digitize negatives in order to further interact with them.

The process is highly manual and can take up to 60 minutes to carry through. During the process one must pour t different chemicals in, hold them there for a certain amount of time and agitate film inside the tank with the same way every time to get consistent results. After developing film must be dried in a minimally dusty environment.

3.2.7 Developing process

Film processing can be divided into two groups, one is black and white processing, and another is color processing which itself is divided into color negative(C-41) and color positive(E-6) film developing. We will concentrate into B&W and C-41 processes because those are the most common types of film shot.

While the processes share the same principal steps: developer, stop, fix and final rinse bath they are different in terms of chemicals used, developing times and temperature ranges at which the chemicals must be during the process.

B&W

- The first step in developing your freshly exposed roll of film is to treat it with a developing solution, which creates your gray tones or colors. In black and white film, the developer converts the silver halide crystals in the emulsion layer into silver particles.
- The second step in the development process is to stop the action of the developing solution. In the black and white process, an acetic acid solution known as a stop bath is typically used to neutralize the alkaline developing solution.
- Following the stop bath is the treatment with a fixer. Fixer dissolves and removes the remaining silver halides making the image permanent and light resistant.
- The final step is rinse with distilled water, which protects the dyes from fading.

Color C-41

- In color film, the developer is oxidized when reacting with the exposed silver halide crystals. This oxidized developer then reacts with dye couplers resulting in the formation of color dye. Color film consists of multiple emulsion layers, each sensitive to a specific type of light and containing a specific set of dyes.
- In the color process, a bleach step is used to indirectly stop development by converting the silver halide crystals into soluble silver halides, effectively breaking down the silver image and stopping the formation of color dyes.
- Following the stop bath/bleach is the treatment with a fixer.
- The final step is rinse with stabilizer, which protects the dyes from fading.

Flexibility and temperature

Biggest difference between two developing processes are the temperatures at which range chemicals must be and time each step spent in the chemical. While black and white processing can be done at room temperature (20…24°C) and developing times depend on the ambient temperature you are carrying it through. Black and white processing tends to be much more forgiving in its temperatures and times then color film processing. This gives a room for experimentations and makes it interesting for photographers to process B&W film at home. By playing with temperatures, times, and dilution factors of the chemicals, the

final look of the developed film such as sharpness, grain, and shadow detail can be changed. Additional variation can be introduced by swapping out and combining different manufacturers chemicals.

Color film processing on the other hand is more fixed in its process. Developing chemicals are more temperature sensitive and should be closely maintained throughout the process. Chemicals used in color processing are maintained at a higher temperature range: Developer - 37.7±1 °C, Bleach fixer 37.7±3 °C, Rinse (water) 30…40°C, Stabilizer 30…40°C. (Tetanal, 2021)

If temperature is not strictly under suggested range the time film being in developer should be compensated. If temperature is higher than suggested time should decrease and vice versa according to Figure 3.2.1.

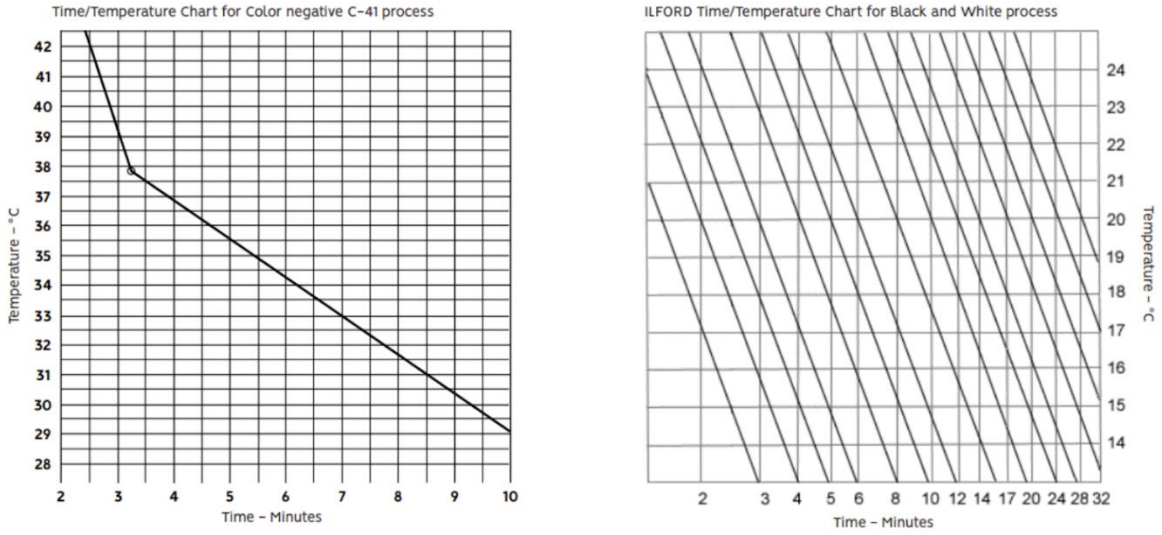

Figure 3.2.1.Time/temperature compensation chart

While looking the figure above it seems that if such time control would be implemented on some machine an operator would not need to deal anymore with the temperature of the chemical- it isn't so straight forward. When developing C-41 negatives at room temperature it will bring up some slight color change, degreased contrast and results can be inconsistence between negatives. (Emulsive, 2020)

Push and pull

Push and pull process is a term used when film is shot in different ISO settings and afterwards compensated in the lab to push exposure up or pull it back. For instance, if a person has ISO 100 film but the light conditions are too dark to get a normally exposed photo, the person can decide to shoot his film at ISO 400 setting which gives him 2 stops more light. Afterwards this film must be processed differently to PUSH it from ISO 100 to ISO 400. It is done by extending (push) or decreasing (pull) time spent in the developer solution. While B&W film is more prone to pushing, it is common to push it up to 3 stops. Color film with few exceptions like Cinestill 800T film are less pushable, up to 2 stops but this can already bring some color change.

There are also side effects which sometimes can be a creative decision to do so. While color film pushing adds saturation and possibly brings up color change. In general, for both film types pushing will increase contrast and grain on the picture. With pulling its quite opposite results, it will mute colors, flatten the image with less contrast and shadow details are brought out.

While push/pull for B&W is commonly done at home and in commercial labs, for color film it is not so common. Simply because C-41 needs manual handling and machines commercial labs use are fully automatic which can´t change its speeds how fast they carry through film. (Petapixel, 2021)

Chemicals

Photographic chemicals are toxic by skin contact and highly toxic by inhalation and ingestion. Black and white process is less toxic since the chemicals used are not so toxic and the processing temperature is at room temperature. Still developer solutions, powders used in developer and stop bath are often highly toxic by inhalation and moderately toxic by skin contact.

While B&W development can be done in a sufficiently ventilated room with open chemicals, the C-41 process needs to eliminate vapors getting into the air. Chemicals used in developer solutions such as Para-phenylene diamine are highly toxic by skin contact, inhalation and ingestion. They can cause skin irritation, poisoning and allergies. Color developers have also been linked to lichen planus; an inflammatory skin disease characterized by reddish pimples which can spread to form rough scaly patches.

To reduce the risk of getting toxicated it is recommended to do these things. Order pre-mixed chemicals. If mixing powders wear gloves, goggles and local exhaust ventilation or wear NIOSH-approved toxic dust respirator. Same precautions must be followed when processing C-41 at home, on top it is suggested to follow those steps:

- Don't use stabilizers containing formaldehyde.
- When diluting solutions always add solution to the water, especially with concentrated acids.
- A water rinse step is recommended between acid bleach steps and fixing steps to reduce the production of sulfur dioxide gas.
- Do not add acid to solutions containing potassium ferricyanide or thiocyanate salts.

(McCann, 2020)

Another aspect with developing chemicals, it is inconvenient to do it at home because chemicals have shelf life. Unopened concentrate bottles can last for 18 months, once they are exposed to air, they should be used in 2 to 3 months. Once diluted with water, a developer mixture should be used on the same day. It becomes apparent when developers get in contact with air which makes them oxidize, water used to dilute developer has air dissolved in it which makes it oxidizes rapidly. It is recommended to squeeze air out from stored canisters or use CO2 or some other heavy inert gas to extend shelf life.

Agitation

Agitation is done by rotating or inverting the development tank so that film receives fresh developer. With a developing tank it is manual work done by hand, automated machines do it autonomously. While there are some chemicals which do not need agitation like Rodinal, specified as "stand developer" with most it is still necessary to get desired results. Usually, it is different how manufacturers suggest doing it but for instance with Kodak D-76 developer you should invert the tank 4 times every 30 second. In order to get consistent results, it is important to do it consistently the same way every time with the right technique. (Pictorial Planet, 2021)

Agitation styles:

Inversion agitation- Style mainly used by hand developing, eliminates the effect of local developer exhaustion. Therefore, suitable for all chemicals. Tank should be inverted and rotated at the same time to avoid emulsion washing away near perforation holes.

Stick agitation- Style used with Paterson tanks, easiest to automatize. Drawbacks are that some, mainly C-41 developers need better replenishment to avoid local developer exhaustion.

Rotation agitation- Most suggested style of agitation, suits to all developers except stand developers. Avoids well local developer exhaustion and half of the amount of chemicals are needed for the process. (film, 2020)

3.2.8 Changed interaction.

Before the digital age analog photography process path took developed negative to darkroom to print them with enlarger. Since digital solutions emerged into our everyday life analog photos also started to be present more and more in digital channels. Solutions to digitize negatives were done by the same manufacturers who made developing processors, but since they went bankrupt, it is the same story that equipment is soon to be retired or even worse as they are hard to manage, and they are running on Windows XP. While we have companies emerging and some Kickstarter campaigns whose products make it easier to digitize negatives, they still are highly labor-intensive solutions meant for prosumer or small lab environments. (Camera rescue, 2020)

3.3 Interviews

Several interviews were conducted with different stakeholders to get in-depth understanding of their experience. Information gathered will give us deeper insight about user interaction and problems they are facing.

3.3.1 Fotomeister pluss OÜ

Fotomeister pluss is a small lab located in Tallinn city center providing all the basic analog film services, photo printing and selling different photographic materials. Compared to other labs in Tallinn, Fotomeister Pluss has the widest technical capabilities to develop and digitize customers' negatives. We went there to spend half of a day there to see how they do their work:

For c-41 development they use fully automatic processors which can develop up to 100 rolls of film per day. Process of developing is quite straightforward, only insert rolls of negatives in the machine and dry developed negatives come out. Machine itself needs minimal

maintenance, the user only has to pure new chemicals in and drain exhausted out, the machine lets the user know when to do it.

Black and white development is separately done with hand developing methods, it is done once per week to collect as many rolls as possible since every B&W film has different developing times therefore you can develop the same films together. Also, that is why it is more expensive because of the extra labor that goes into developing them.

About the hardware they just had an experience that they needed a new RA-4 photo printer, which is the way most 10x15 photos are made in labs. Since those machines are not produced anymore it was quite a long process to acquire one. As they said you can easily find old machines which are over their exploitation period but to find a machine what you can be sure of is only through connections and a lot of research.

Another equipment related problem they had was how to scan 120 film, as they had one old scanner dedicated for that but since it runs on windows XP, they do not have computers anymore to run it. So, they are forced to use Epson V800 flatbed scanner which makes the process labor intensive.

Generally, as they described older generations want to get prints and younger are more directed to digital copy of their negatives.

Generally, they are positively minded about the future of analog photography. In their experience analog photography and the quantity of their services bought has raised the last two years.

3.3.2 Fosgrafe OÜ

Fosgrafe started in 2010 as a photography equipment rental, now they print photos, sell film and about two years ago they also started to provide film developing and scanning services. For developing they use a desktop processor called Filmomat. It is an automatic film processor released in 2015 and is the only available fully automated system that is sold right now. It is capable of processing B&W, C-41 and E-6 films with possibilities to push and pull film. While the overall process is automated it is still quite labor intensive compared to old school processors. For instance, you must spool film in dark on reels and put them in a developing tank. Also, you must follow yourself that chemicals are not exhausted and drain manually liquids out of the processor. After the developing process is done film is wet and needs another device to dry it. In result they can process around 14 rolls of film per day.

For digitizing they use the Negative Supply system which recently started from Kickstarter champagne. It is a new kind of solution where 4 components are used: Light source- which is placed under negative, Negative carrier- to hold negative flatly in place and to move frames, digital camera- to take pictures of negatives, copy stand- to hold camera in place. From the software side it is needed to have software to convert negatives into positives and to process and manage all the pictures. To conclude, the process is quite labor intensive since the user must at first blow dust particles off, then he must manually advance every frame and also crop and make some color adjustment in the computer. Also, it is not a turnkey solution, since there are many different components, and software solutions that need to be put to work by the user. From the good side it is possible to get good quality scans and right now Fosgrafe scans are best in Estonia you can buy.

Fosgrafe no doubt has the best service in terms of quality and adjustability you can get in Estonia. That is something they communicated out to customers and I have heard that customers are happy about it. On the other side those new less productive but better-quality machines make service more expensive and customers' lead time can start to accumulate quite easily. From my own experience, developing color film in Fotomeister takes about one day after which negatives are on e-mail, in Fosgrafe it took one week, it was during September 2020.

3.3.3 Nõmme fotoklubi experience

Nõmme Fotoklubi is the oldest consistently operating photography club in Estonia. It was established in 1952 when Tallinn Nurme streets Pioneeride Maja started its operations, the same year photo club also started. Nõmme fotoklubi is a place which practices the analog way of making pictures. Photo club has all the equipment needed to develop and enlarge pictures on photographic paper in the darkroom. Members of the club come with their exposed films, develop them and then dive into the art of darkroom printing which is the main activity there. While it was a fun experience working with enlarger, our main objective was to collect experiences around developing film.

The equipment we used were the same as normal home user use: Paterson System 4 tank, film reels, thermometer, measuring vessels, changing bag, film clips and timer:

First, inserting film on reel- it was done in a changing bag. With no previous experience it took quite an effort to get it on reel in total darkness. You must feel with your fingertips that film is entering from the correct position on the reel and then advance it until all of it is on

the reel. After that reel is placed in the tank and funnel on top which makes the developing tank light tight.

Second collecting data about developing times. We used Rodina as a developer and Ilford HP5+ B&W. Then it is 11minut developing time (1/50 dilution), 1 minute for stop bath, 7 inutes for fixer, 25-minute washing and last 1 minute with a wetting agent. (Massive Dev Chart, 2021)

Third, measured chemicals into measuring vessels according to developing tank size and dilution factors. Water had to be carefully measured on 20°C to guarantee correctly exposed negatives.

4th developer path- developer was poured to tank and agitations started. It was done by rotating the reel inside with an agitation stick first 1 minute continuously after that 10 seconds every minute until the end. After 11 minutes chemical was poured out

5th Stop path- tap water for 1 minute was used to wash off the developer.

6th Fix path- 7 minute of fixer solution with agitation the same way like with developer.

7th Wash path- For 20minutes tap water was let to flow through the tank.

8th Wetting agent is added to water for 1 minute to avoid drying marks on film.

9th Film is placed with film clips to dry for 30min.

10th Everything is cleaned up.

To conclude, while the motivation to see the developed negatives was high the downside was that the process was intensely labor intensive. It took well over one hour to get everything done. The most annoying thing was that you are attached throughout the process, especially the agitation part of the process which can take a total of 40 minutes of the time where you must manually twist or shake the developing tank instead of doing something smart. Also acquiring the information at first needs quit a lot of reading and research. What kind of developer and fixer to use, how to dilute them, what equipment is needed and what are the times takes certain amount of effort to but the picture together?

3.4 Market analysis

In this part further investigation about products that are on the market is done to look at those which are more advanced than simple Paterson tanks and that solve some of the problems which came up through the survey as most annoying things when developing film

at home. These were: It takes a lot of time- person must agitating and changing chemicals throughout the process, loading film reels- It must be done manually in darkroom, drying the negatives after developing- dust free environment is needed and exposure to chemicals- open system where chemical vapors can escape and harm the person. Following products are:

3.4.1 Ars-imago: Lab-box

Lab-box is the only available daylight developing tank, meaning loading film does not need a darkroom or changing bag. This developing tank can develop one 35mm or 120 film roll at a time. All the operations are manual, so a person must agitate and change chemicals when needed. With an extra investment professional lid is also available which adds a timer and temperature sensor to the same package. Since developing is done manually these added functionalities are only informal. Utilizes rotation agitation which avoids local developer exhaustion, and half the amount of chemicals are needed if person rotates device constantly. (Ars-imago, 2021)(Figure 3.4.1)

Figure 3.4.1.Lab-box developing tank

3.4.2 Heiland Electronics: TAS film processor

TAS film processor is essentially an agitator which agitates like a person using inversion technique. It has a timer built in and stops when the process is over. Overall, it eliminates the need for the person to be mentally attached throughout the process. Chemicals still need to be changed manually. Device can be used with most common developing tanks. (Heiland electronic, 2021)(Figure 3.4.2)

Figure 3.4.2. TAS film processor

3.4.3 Bot henry- Paterson tank agitator

Bot henry is Paterson tank addon which takes away the need for the person to agitate throughout the process. It is battery powered and rotation speed can be adjusted. While it is good for most b&w developers, C-41 process usually needs inversion or rotation agitation. (Ebay, 2021)(Figure 3.4.3)

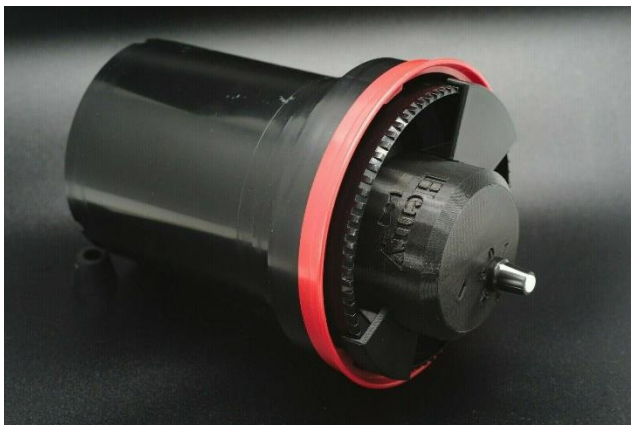

Figure 3.4.3. Bot henry agitator

3.4.4 Filmomat automatic processor

Filmomat is a fully automated processor which agitates, controls the temperature and pumps chemicals in and out autonomously. Machine can be used for the B&W, E-6 and C-41 process. Device utilizes roll agitation which ensures good quality and minimal use of chemicals. While in the middle of process it operates autonomously there is still need to but negatives into the tank in darkroom and after the process washing the film must done separately because foaming effect occurs when wetting agent is pumped through pumps, also films must be dried afterwards. (Filmomat, 2021)(Figure 3.4.4)

Figure 3.4.4. Filmomat automatic processor

3.4.5 Jobo: CPP-3 Processor

CCP-3 is a semi-automatic processor which agitates and controls the temperature autonomously. Chemicals must be poured in and drained manually. Machines can be used for the B&W, E-6 and C-41 process, also with bigger tank photo paper development is also possible. Otherwise, like Filmomat. (Jobo, 2021)(Figure 3.4.5)

Figure 3.4.5. Jobo CPP-3 processor

3.4.6 Market analysis conclusion

The market analyzes draw out two main categories of products (Figure 3.4.6). One of which is consumer aimed and other more expensive prosumer equipment. Consumer based equipment like Ars-Imago: Lab-box and Bot Henry eliminate one hurdle what came up in survey but in the end do not add much value since they are restricted in their specification or need extra equipment to make whole experience. On the other hand, prosumer equipment is order of magnitude more expensive, much bulkier, need certain amount of experience to operate. While they operate some parts of process, they still need some extent of interaction like pouring liquids in and out and counting time. At a moment there is no product on a market which would bring the same automation as prosumer equipment have to the consumer level with smaller capacities and footprint.

	Autonomos Agitation	Autonomous chemical exchange	Daylight film loading	Timer	Temperature control	Max. rolls of 35mm film per cycle	Formats	Price
1. Ars-imago: Lab-box	NO	NO	YES	YES*	YES*	1	35mm & 120	€278.00
2. HEILAND ELECTRONIC TAS	YES	NO	NO	YES	NO	5	35mm, 120 & 4x5	€1,199.00
3. Bot henry- paterson tank agitator	YES	NO	NO	NO	NO	3	35mm, 120 & 4x5	€99.95
4. Filmomat automated processor	YES	YES	NO	YES	YES	4	35mm, 120 & 4x5	€3,999.00
5. Jobo: CPP-3 Processor	YES	NO	NO	YES	YES	5	All formats	€3,671.00
* Value is displayed to user, any operation doesent follow with that inteligence								

Figure 3.4.6. Product comparison

3.5 Questioner

The aim of the questionnaire was to understand how and what equipment people mostly use to developing film. Also, to define all the problems what they face during the development process. It was done to connect all the information fragments into numbers to see different trends and validate real problems. Questionnaire was shared in two Facebook groups, in Film Photo Gear with 30k followers and Analog photography group with 28.3k followers. In result participants gave 85 answers to 26 questions.

Most interesting takeaways from survey were:

- According to this survey 35.6% of analog photographers are under 30 years old and 50.7% of photographers have shot on film under 5 years. This means that new generation who do not have previous experience with film cameras are adopting this medium in their creative practices and can be considered as good news for film photography.
- B&W and color film are equally as much shot.
- 64.7% of B&W and 36.5% of color film are developed at home.
- People develop their film at home because it is Cheaper (23), have more control over the results(quality) (23), is faster than lab service (11) and because they enjoy the process, it deepens personal connection (12)
- 62,1% have had problems with quality, 43,9% had used exhausted developer and 24,2% had poured chemicals in wrong order.

- Reasons for bad quality were lack of knowhow about chemicals (9), used exhausted chemicals (7), wrong time/temperature ratio (6), Learning curve (4)
- Only 8.2% of people use darkroom methods of delivering their photographs, majority digitize their photos.
- 93.7% of people use simple developing tank like Paterson System 4 to develop film at home.
- The most annoying part of developing were time it takes for it (22), loading the reels (7), trying the negatives (7), Exposure to chemicals (5).

Questioner fulfilled its purpose by giving an in-depth overview of user behavior. In terms of the progress of this thesis, questionnaire together with market analysis specified spaces where further design intervention would generate most value for the analog community. Specifically, it brought out the home user equipment and problems they face.

3.6 Conclusion

Analog photography has finally found its ground as digital natives have discovered analog photography and its value in it. Digital revolution what we have witnessed has been so fast and transformative, changing how our societies work and exist. Technology has enormously decreased the need to be present in physical world, which also has been valuable tool to decreased spreading the corona virus, inevitably it has bushed us even more to be locked to our window of outer world. On the other hand, distancing humans from physical connection and offering them shallow virtual alternative of belonging has brought up many 21st century illnesses like increased trend of fighting with anxiety, depression, living the fast life the same time being over 3 hours in their smartphones draining all the attention person has. To tackle this people have started to look ways to distance themselves from full package offer of virtual reality. Like the Maker movement or also analog photography, with the aim to enjoy tangible experience, learn through doing it and use digital infrastructure to leverage the experience and influence.

Since digital dominance in photography analog way of capturing pictures saw drastic decrease in sales to the point that companies went bankrupt, and products are no longer made to support evolvement of it. Now film sales are approximately 40 times less than during the golden age of analog photography. Film is still alive and reported to be growing 5% per year which is only good thing about it. From the other side analog infrastructure

heavily takes advantage of devices produced during golden age, like cameras and lab equipment which for the most part is discontinued after the fall of the market.

Besides the size of the market the way how people interact with it have also changed. Analog has been heavily adopted into digital ecosystem, as it came out from the survey that 98.8% of users digitize their pictures which is understandable because even grand moms share their pictures in social media platforms like Instagram and Facebook which have become the norm of 21st century society. This trend has but most immediate pressure to analog community as there are not many machines anymore what can be exploited for the purpose of digitizing the films. To extinguish the fire big companies like Kodak, Fujifilm etc. who produced such machines previously have not done much. Instead, analog community and Makers inside it have emerged with different solutions through crowdfunding platforms like Kickstarter and Indiegogo to provide solutions which help but still are not yet sufficient for labs.

Another technical issue that community is facing or soon to be worrying about besides aging cameras is film developing infrastructure. As it came out during with the interview with Fotomeister Pluss OÜ, it is becoming harder and harder to get good lab grade equipment. While only 28.3% of B&W and 47.1% color films are being developed at lab it is wildly important that labs as such in some way still exist. Mainly for two reason, first that every newcomer or a person who is making its first steps in analog photography will not develop film at home. It needs time and financial investment with is not feasible for a thing what you are trying out the first time. Secondly labs remain valuable partners to save time and efforts producing high quality pictures for professionals and artisans alike.

Another way to tackle the problem of where to developing film would be through local hobbyists. As it turned out these kinds of connections are rarely made as 3.5% of B&W and 2.5% of color films are develop like that. When diving into why people do not offer service to others in their community it turns out that the process of developing with home equipment has many bottlenecks. First of which is time it takes, it can take up to one hour to develop one patch, also person is throughout the whole time attached to process. Second thing is as profit what you can is not so much and the possibility to ruin the result people are not willing to risk for others.

While it may seem weird to fight against the convenience of digital way on taking pictures, analog photography has proven its place. No one cannot be sure that it will survive and be alive in 50 years, but it deserves the support of new developments to cohesively tie it to the digital infrastructure we are living in today.

4 DEFINE

In this part further work is done with information gathered to identify possible opportunities for future design. Result of this is a design brief where certain problems are defined and ready to investigate through specific solutions in the development phase.

4.1 Choosing the direction

From the Discover phase three distinct user groups draw out which are: home users, prosumer/small lab users and big lab users. In the next part we will try to give a short overview of their problems and analyze possible outcomes through objectives of this paper. In the end a distinct user group is chosen.

Lab

Labs which are developing hundreds of rolls per week are essential for analog photography to survive since some groups of users do not have desire to develop at home (20% B&W and 53% of color film photographers develop at lab) and with few exceptions every person who is starting with analog photography will go first to lab. It is understandable also to develop at lab since they are professionals with good equipment and experience to deliver fast and with consistent quality.

The Problems that labs are facing are rather tough to overcome, as they are surviving on technically complex equipment which was produced a minimum of 10 years ago. Support from producers to maintain these machines are generally ended and smaller labs do not have expertise to repair them in coming years.

Since digital solutions rule the market and analog is a niche market, it makes it hard to develop and produce solutions that are economically viable. Next decade will show what happens with developing labs after those highly automated machines retire. Probably they will start to use less productive devices which will raise the price of developing and if the market size will stay the same with the new norm of developing pricing the initiative to develop new solutions will rise.

Prosumer/ small lab

Users who qualify under this group are taken care of the most with new solutions emerging and bit older ones still sold. They are using devices which are less productive, involve more man hours to operate then professional lab equipment but also are more diverse in their operations. Compared to home users developing tanks, it has a similar tank, and some

operations are automated. Like Jobo CPP3 which can do all the different processes like C-41, E-6, B&W and RA-4. Difference between home users developing tanks and Jobo CPP3 is that it automatically agitates, has a timer built in and has temperature control. Compared to fully automated professional lab equipment with semi-automatic Jobo CPP3 users have to manually pour in chemicals and drain them out, follow that chemicals are not expired, load film reels manually and dry the negatives with some other solution. The same time since professional lab equipment is for only one process, usually either C-41 color negative processing or RA-4 color printing CPP3 can be used for all the different processes.

Another similar device is Filmomat difference with Jobo CCP3 is that it also uses pumps to pump chemicals in and out and users must interact after the process is done.

While these machines solve all the main shortcomings of simple developing tank, at the same time all these machines cost well over 1000€ and rather meant to make money with or to community centers/schools. For hobby photographers these solutions would be ideal but regarding the average analog photographer shooting 1 to 4 rolls per month it isn´t viable to own such an expensive machine.

Home

67,7% of B&W and 36,5 of color films are developed at home, while 93,7% of time simple Paterson or Jobo developing tanks are used. Acquiring one with all the things which needed costs less than 100€. (Figure 4.1.1) (https://analoguewonderland.co.uk/products/the-film-developing-starter-kit)

Figure 4.1.1. Paterson tank and supportive equipment

When looking into the survey done for this thesis it turns out there are many things that could be solvable through simple engineering or IOT solutions. In essence there are not many tools on the market right now that solve more than one problem facing the use of

home equipment. Doing it at home is highly manual and needs full attention throughout the process. From one side it is good to be manually attached to process and learn through it, but it can quickly become bourdon instead of joy. As it turned out most annoying things developing with Paterson tank are- time it takes, loading film reels, trying the negatives and exposure to chemicals. Reasons for bad quality were- knowhow about chemicals, exhausted chemicals, wrong time/temperature ratio.

4.2 Personal experience

Home user's equipment and developing with it at Nõmme Huvikool gave me most vivid experiences during a research as it gave the opportunity to but my freshly acquired knowledge about the process into practice. While I had read about different nuances of the process, still butting it all together by myself the first time would been difficult because there is a lot to follow. Fortunately, I had experienced Nõmme Huvikool teacher Tanel Verk in my disposal. First thing looking what are the developing time and dilution ratio form manual or The Mass Dev Chart. It was tricky because it is not plain and simple. It is possible to do it with different dilution ratios and it gives different result in theory, something for professionals, I chose something in middle and hoped it will be good. Next was preparing the chemicals, important here was to find out how much liquid is needed for the Patterson tank, measuring it out and adjusting temperature to be precisely 20 degrees. Also working with new equipment from scratch was not something that you can do blindfolded, but you must, for instance butting film on reels is done in total darkness. Fortunately, it was only part which was done only using cognitive skills. Once everything set up and ready for developing it was straight forward. Surprising were how long the process takes and that there was not chance to do something other because constant agitation is needed. It was interesting to learn how to develop film, all the equipment and knowledge needed to carry through the process reminded the operations in Walter White van rather than some well thought through home appliance.

4.3 Help of digitization.

Web platform could be valuable tool to extend the value offering of the whole package tackling the problems what home users face. During the research came out that acquiring

correct data and managing stock is key to good quality. These could be the points which combined into platform would form a holistic experience decreasing potential mishaps:

- Most chemicals have shelf life and using exhausted chemicals can give bad or no result at all. As survey pointed out that 43.9% of persons have had problems with exhausted chemicals.
- Acquiring data and know how to use different chemicals is divided and comes through different channels. It needs certain amount of experience to but whole picture together about the process. In survey, most common reason for bad quality where lack of knowhow about chemicals, 9 answer out of 44 and the learning curve, 4 answers.
- Experimentation and making notes about the results is mainly done using notebooks.

4.4 Conclusion

This chapter of define gave an extensive overview of the analog film developing equipment in the context of aging infrastructure and how to optimally move ahead in the niche of analog photography. Through my own experience in Nõmme Fotoklubi and insight gathered through multiple other channels gave an in- depth overview of the current developing ecosystem and its problems through different stakeholders. More importantly it defined a certain user group with its problems to tackle in the format of this theses.

Considering how much people develop film at home and my own expertise as mechanical engineering it would great most value if this thesis would solve some bottlenecks what home users are facing in their equipment they are using. Therefore, this thesis will concentrate on developing solution to home environment, considers specific problems with current equipment and macro trends specific to analog photography.

5 DESIGN BRIEF

Based on the conclusions made in previous chapters focused decisions need to be taken to tackle identified pain points. Market analysis gave an understanding what is already on market and how other have tried to solve the issues which were identified through interviews and survey. It is apparent that most of the solutions try to automate few tasks but do not look the whole picture. What is missing is one holistic system which combines available knowledge and home user aimed hardware under one umbrella to form unified experience. Aim is to build a working hardware prototype which can afterwards validate its usefulness through user testing. In this coming chapter functionalities to be included in the proposed solution will be unveiled.

5.1 Positioning

Proposed solution target audience is a person who develops film at home and does it for himself. When considering the form and functionality of proposed solution, certain amount of balance is needed between the functionality, form and the pricing to adapt proposed solution precisely in consumer grade application category.

Another consideration is that proposed solution should be adaptable to current tools what people have at home. This minimizes the cost for customer, also he still can use familiar tools and practices to develop film. Every person knows the bottlenecks of the tools they use, also they know the techniques to acquire different results. By building something on top of this knowledge in familiar form it guarantees the understanding of the purpose and adoptability of this solution.

5.2 Functionalities to be included in concept.

5.2.1 Physical device

These aspects were identified during the literature review, interviews and survey as opportunities to transform the experience of film development in home environment.

- **Automated agitation:** Majority of film developing processes need agitation to get a desired result. For now, it is done manually which does not let the person leave

throughout the process. By applying simple rotary motor to turn the film reels in the tank will save processor operator from the work of manual agitation.

- **Roll agitation functionality:** To facilitate C-41 process good developer replenishment is needed during the process. Easiest way to acquire it is to facilitate roll agitation functionality in the processor design. It means development tank must be turned horizontally and tank itself or reels inside must rotate.
- **Timer function:** Chemicals have their precise times how long they must stay in tank, which is especially important with developer solution. While rotary motor gives a person a chance to do something other, than alarm function calls for action to interact at the right time.
- **Temperature monitoring:** From the temperature depends on the time how long each solution must stay in tank. While during B&W process it is easier to maintain the temperature, which is around 20°C, C-41 process is much harder to acquire precise solution temperature of 37.7±1 °C and to maintain it. Temperature monitoring gives a chance to adjust the process time when temperature changes. Moreover, it eliminates the need to be precise with chemical temperature before pouring it in the thank. This is hypothesis that it will work and give much more consistent results because there are no examples on market which utilize such a technology at a moment.

5.2.2 Web platform

To tackle other problems whether process or aging infrastructure specific, a web platform is proposed. Specifically, how to eliminate following process specific problems: 1. Knowhow about chemicals, 2. Wrong time/temperature ratio 3. Process learning curve 4. Use of exhausted chemicals And aging infrastructure specific, how to give access to the processor for wider community. The core purpose of the platform is to collect all the data about the process under one umbrella, make it digestible for operator and communicate that with processor. So that processor operator can program each process in advance in his computer, get program specific recipe to prepare the chemicals and send all the setting to processor that he does not need to make new program manually.

Recipe creations Before every process certain number of dots need to be connected. In combination with film type, chemicals on shelf and development tank specific recipe are born. From the recipe operator gets the amounts of chemicals and dilution ratios necessary for certain process and can start preparing solutions to vessels. The same time recipe specific program is sent to processor specifying agitation type, time and temperature. Also

pushing and pulling film can be addressed here through simple visual representation. To facilitate such a seamless functionality following things need to be in place:

- **Stock monitoring:** The idea is to list different chemicals what person has purchased will be added to the databased. Afterwards system can account different parameters like when chemical will be exhausted- eliminating the chance to use it in process, deduct amounts used in process- to forecast how many processes can be done more.
- **Process times database:** This gathers all the film and developer developing combinations information into one place. Like development times, dilution ratios, development temperatures and bush and pull information. Like Massive Dev Chart (Massive Dev Chart, 2021)
- **Public processing:** A database which lists all the places where public processing is available. So that community centers can invite analog photographers to their premises to develop a film for some fee.

6 DEVELOP

Proposed solution consists of two parts: a physical device and a web platform. This chapter deals mainly with physical device and briefly go over the main functions of web platform. Input for the develop phase come from brief and data flow diagram. The diagram explains briefly what elements are needed for nodes to function properly. Based on these analyses concept is generated which will be implemented on physical prototype. (Figure 5.2.1

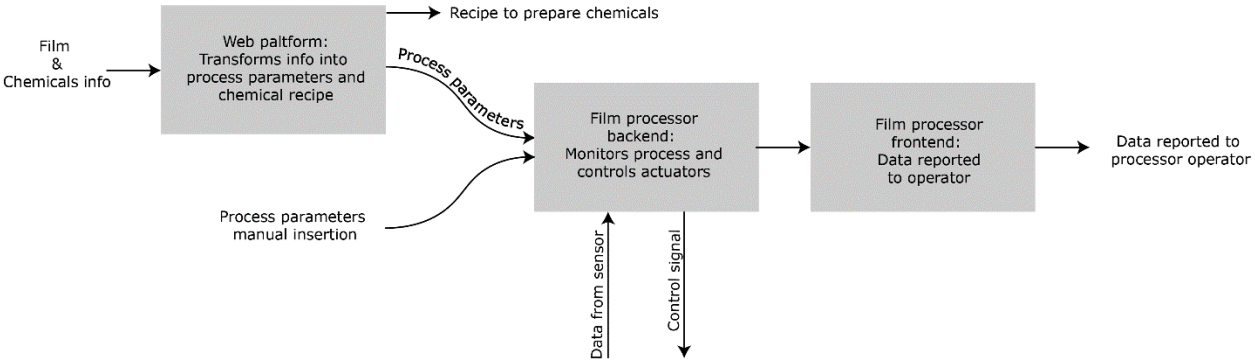

Figure 5.2.1 Data flow diagram

6.1 Development tank

As our proposed solution aims to automate some tasks what occur during film development at home environment it is not necessarily needed to develop totally new solution as the aim is to build the solution on top of existing hardware what people already own. Therefore, the question is which kind of development tank offers the most opportunities to implement different functionalities. In comparison most common development tanks are compared through different criteria. (Figure 6.1.1)

	Paterson Super System 4	Jobo 1500 series	Jobo 2500 series	Ars-Imago Lab-box
Ease of implementing motorized agitation	Easy, since Paterson facilitates stick agitation functionality inside it	Easy, inside reels don´t rotate, so the whole tank must rotate to agitate	Easy, inside reels don´t rotate, so the whole tank must rotate to agitate	Easy, since Lab-Box facilitates roll agitation functionality inside it
Ease of implementing temperature monitoring	Hard to get contact with fluids behind a funnel without modifying funnel	Extremely hard in combination with roll agitation since the tank must rotate	Extremely hard in combination with roll agitation since the tank must rotate	Easy, pro lid has it already

Capacity	From 1 to 8 35mm film rolls, 120, 4x5	From 1 to 3 35mm film rolls, 120, 4x5	From 1 to 8 rolls of 35, 120, 4x5,6x9 9x12,	One 35mm or 120mm roll
Popularity	Most popular developing tank	Second most popular developing tank	Mainly used together with processor	New solution, not so popular
General use case	Hand development	Hand development and compatible with Jobo CPP-3 and CPE-3 processor	Hand development and compatible with Jobo CPP-3 and CPE-3 processor	Hand development
Problems	Hard to attach something on top of the tank	Hard to measure temperature and agitate the same time	Hard to measure temperature and agitate the same time	Doesn´t always wind film properly on the reel

Figure 6.1.1 Development tanks

6.1.1 Ars- Imago Lab-Box

Starting from the last, Ars- Imago would be the easiest platform to implement motorized agitation, temperature control and timer function. There is easy access to measure temperature, also as an addon it is already possible to buy lid with temperature sensor. Motorized agitation instruments would be easy to add on the tank as there is PTO connection already on the side of the tank where removable handle is placed. The problem with Lab-Box is that it only develops one roll of 35mm or 120 film at a time which limits the practicality of proposed solution. It is only solution which enables daylight film insertion, meaning no need to have changing bag or darkroom but reading the reviews it is not also perfect, it needs some experience to wind film correctly on the reel to avoid film layers getting in contact with each other. (Figure 3.4.1.Lab-box developing tank)

6.1.2 Jobo 1500 & 2500 series tanks

Jobo tanks all can be used for hand developing process or connected to Jobo processor, either on CPE-3 with magnets from bottom of the tank or on CPP-3 through intake of the tank. Later solution enables improved chemical insertion and draining which makes changing the chemicals easier but does not do it automatically. Jobo idea of the process regarding temperature management and agitation is to store chemicals and place developing tank partially in the heated water bath and rotate tank in it. This is trusted solution as it maintains temperature very well. Downside is that it makes whole system clumsy in size and in usability as it takes time to heat up the water before the process. When considering our technical objective, it would be hard to engineer temperature sensor

inside the tank as the only possibility to agitate with Jobo tank is to constantly rotate it during the process.

6.1.3 Paterson Super System 4 tank

Paterson developing tank is most used tank on market since it offers great price, ease of use and great variety different sized tanks. For agitation it is meant to use inversion or stick agitation method. Later one is ideal for our concept since it gives a change to connect motor drive to the inside reels and rotate them. The downside of Paterson tank is that it is hard to attach device on top of the tank without attaching it permanently to the tank funnel. By attaching it to the tank funnel interchangeability will be lost, meaning that this device must be attached during film insertion in darkroom and can be removed after the process is done. Another engineering challenge is how to measure the temperature of the liquids inside as all the equipment would be on top of the device and liquids will be closed inside behind the funnel. (Figure 4.1.1. Paterson tank and supportive equipment)

6.1.4 Conclusion

Considering the tank options, it seems Paterson Supers System 4 tanks is the most suitable option according to the brief objectives. It enables easy motorization of the agitation process by placing compact device on top of the tank. Measuring the temperature can be done if the funnel will be modified. Maybe the most important is that Paterson Super System 4 series tanks are the most affordable and common developing tank on the market. Meaning this product adopted to Paterson tank could reach larger numbers of home user's then other less common tank systems.

6.2 Agitation methods and functional design

Speaking of agitation, it is one of the most crucial tasks what this system is going to execute. Paterson Supers System 4 tanks are meant to utilize stick and inversion agitation methods- first, it's hard to motorize and second is not sufficient for C-41 process. Mainly C-41 developers need better replenishment to avoid local developer exhaustion then what stick agitation method offers.

Solution to avoid developer exhaustion is to utilize roll agitation method with Paterson tank. To execute it, Paterson tank must be turned from vertical orientation which is for stick

agitation to horizontal orientation to facilitate roll agitation functionality. While it sounds easy to turn tank 90° it brings up problems like how to seal the tank from running empty, how to fill the tank while being horizontally and how to maintain easy access to user interface with its buttons and screen. (Figure 6.2.1)

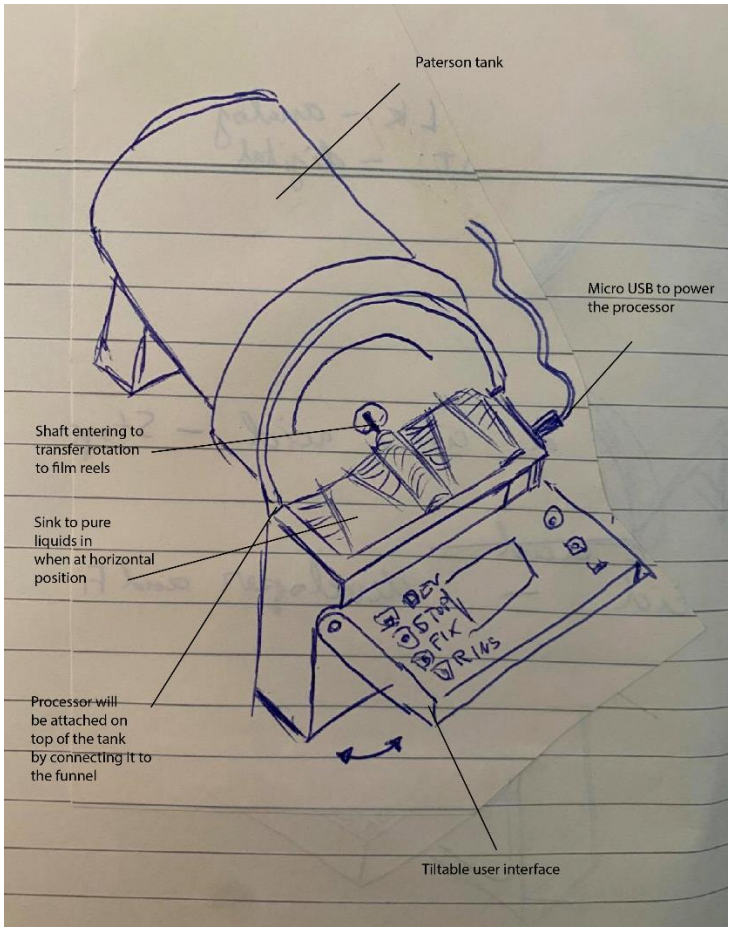

Figure 6.2.1 Processor concept

6.2.1 Sealing

To facilitate roll agitation method on Paterson tank half of the circumference of the tank opening must be covered and sealed to keep chemicals inside of the tank. For inversion agitation method Paterson tank is equipped with injection molded rubbery lid which is used to seal whole top part to invert tank during the developing process. It is good starting point how to develop solution for this prototype. Problem with that is how to reproduce such a rubbery part for the prototype. One solution could be to use FDM 3D printer and NinjaFlex filament which has shore hardness 85A properties and great chemical resistance. Other solution could be to use simple O-ring seal and glue it on the manufactured part. Late

solution is mass produced in many different sizes and materials. Most harmful chemical for material is acetic acid (2%) used in B&W stop bath and boric acid (1…20 g/L) used in many developers and fixers. (Wikipedia, https://en.wikipedia.org/wiki/Photographic_processing, 2021)

After identifying these corrosive chemicals suitable material can be chosen for given application. Most common seal material used for O-ring is nitrile, commonly known as NBR. While with acetic acid NBR is not perfect it is still having decent resistive properties against it. (Mykin Inc, 2021)(Figure 6.2.2)

	Nitrile	EPDM	SBR	Silicone	Polyacrylate	Hypalon	Viton	Polyurethane	Fluorosilicone
Acetic Acid, 5%	2	1	2	1	4	1	1	4	2
Boric Acid	1	1	1	1	4	1	1	1	1
LEGEND: 1 = Satisfactory, 2 = Fair, 3 = Doubtful, 4 = Unsatisfactory, X = Insufficient Data									

Figure 6.2.2Rubber Chemical Resistance

6.2.2 Ergonomics of liquids management

Paterson tank is meant to be used in vertical position, by turning it to horizontal orientation it should maintain its functionality. Question is how to pour liquids in and out of the developing tank in a way that minimum manual steps are needed to execute the process. Since I decided to cover half of the tank opening to keep chemicals in the tank, the other half keeps the Paterson tank functionality to easily pour chemicals out.

To pour liquids in the tank, first solution could be to do it in vertical position and then turn tank to horizontal position for processing. While it would be the easiest way to solve the problem, from the process ergonomics perspective it would not be ideal since after pouring liquids in the tank must be turned to horizontal position. This is extra step at the time when the person also needs to interact through user interface to start the timer and motorized agitation. Another thing is that bottom film reels will be developed longer than top reels.

Another way to tackle the problem is to keep tank always at horizontal position. This brings up two aspects what need to be solved: First how to pour liquids in a way that it is not messy and second how the liquids get through the funnel into the tank. For the first, sink is proposed, this adds 15° surface with sidewalls through which it is easier to pour chemicals

into the tank. This also keeps the possibility to use tank vertically, with stick agitation method. (Figure 7.1.7 AGO back view)

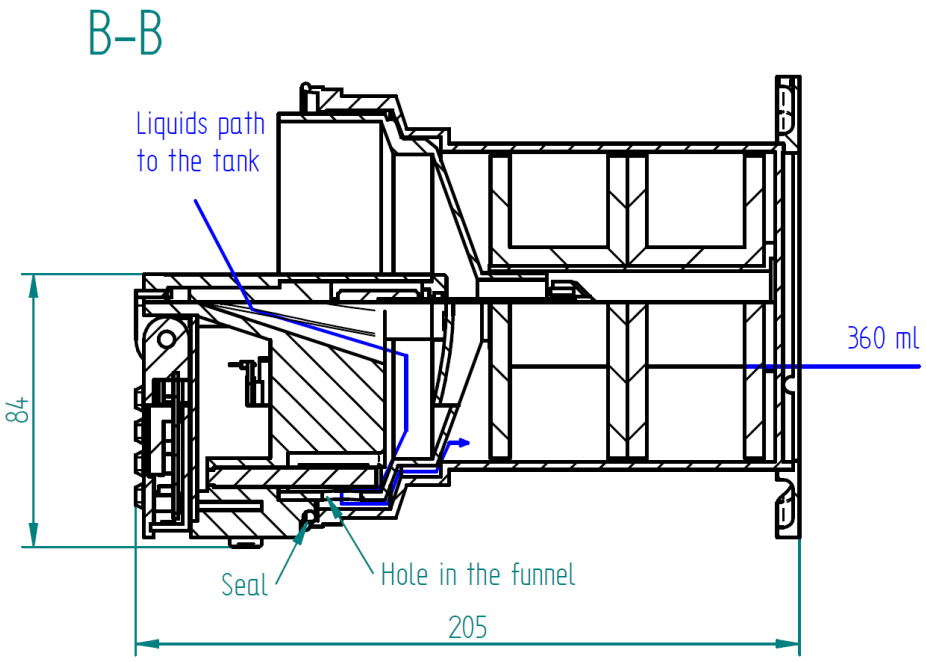

Figure 6.2.3 Section B-B

Second, how liquids enter the tank. During normal use liquids enter the tank through the hole, which is in the center of the tank, when tank is turned horizontally it is harder and takes more time to fill it through it. There are two reasons why it is hard, first shaft which transfers rotation to film reels enters from the same hold and acts as a restriction for the flow in the tank. And second it makes the design of the sink harder as the sidewalls should be risen relatively high from the hole to keep the flow through the central hole and all the operations nice and tidy. Instead, modification of the funnel is proposed to enhance the flow to the tank. Three holes on the bottom side are made into Paterson tank funnel. As before it was already decided that tank funnel must be attached to processor to seal it, modifications can be also made since funnel will be sold together with the processor. This gives an easy access from outer side to inner side of the funnel for the liquids, making two reservoirs connected. It makes the filling process faster as it is important to cover all the film with relatively short time to avoid developing film some parts longer than other. Also, level of the liquids inside the tank can be seen from outside to be sure that enough of it got in the tank. Opportunity for light getting in is also under control as processor itself covers the holes and they are near the edge of the funnel which wound let light get in the tank.(Figure 6.2.5)

Another upside of connection inner and outer reservoirs is that it gives a chance to place temperature sensor to the processor body. While it will work only when roll agitation is executed as it would not be in contact with liquids while tank is placed vertically to stick agitation mode. Still, since temperature control is only used during the first- developer bath, all the major developers can be used with roll agitation method and roll agitation method uses less chemicals then stick agitation method, it justifies the loss of temperature control during stick agitation.

As mentioned already roll agitation mode is more efficient in the sense that less chemicals will be used. On the bottom of the Paterson tank, it is written that 290ml of liquids is required to execute the process, times two if two rolls of film are developed, which is 580ml of liquids. When tank turned horizontal, roll agitation mode the test showed that 360ml of liquids is required. It is 62% of less chemicals what is required to execute the process then during stick agitation mode. (Figure 6.2.3 Section B-B, Figure 6.2.4 Section C-C)

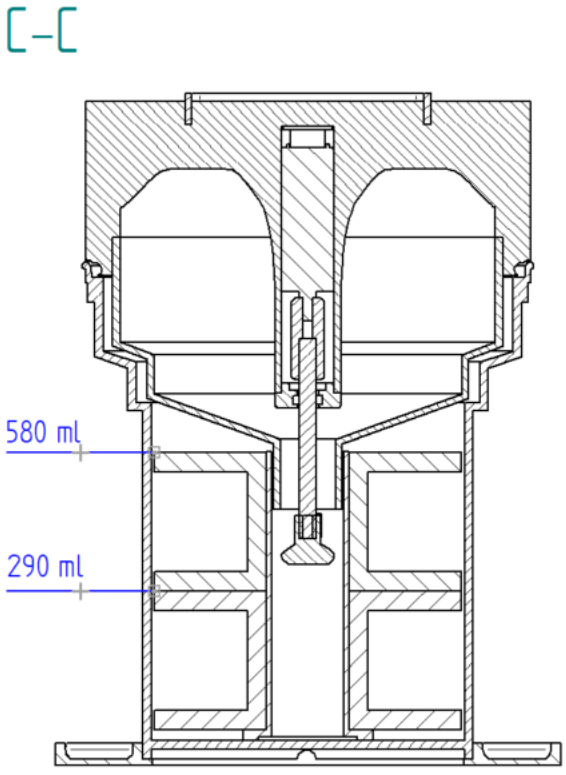

Figure 6.2.4 Section C-C

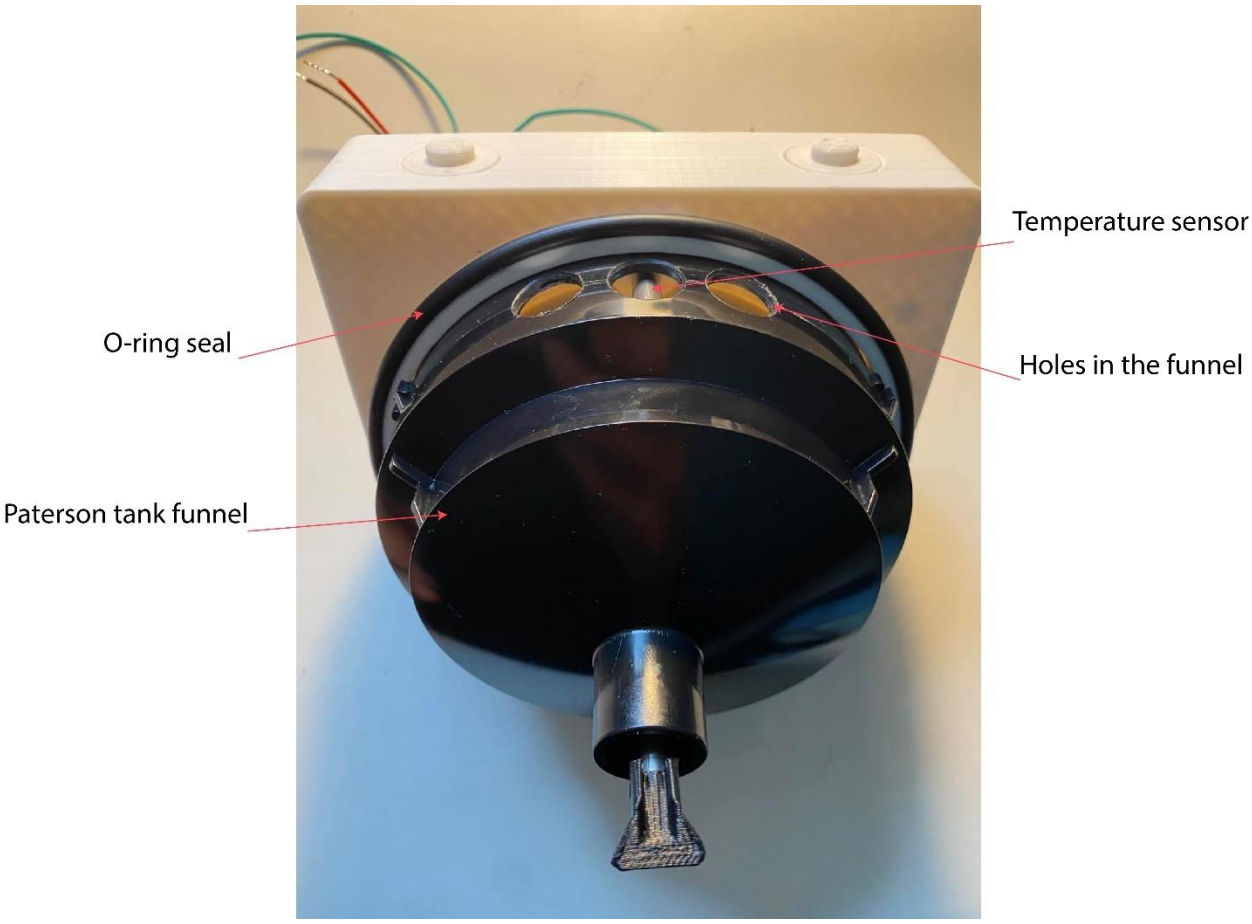

Figure 6.2.5 Modified funnel.

6.2.3 User interface

User interface is a part of the processor which is where operator can give and have commands from the processor. As this concept has grown into versatile tool with many use cases user interface also must be easily accessible during these operations. Easiest way would be to mount the buttons and display to the front of the processor. This would be ideal when processor is at stick agitation mode but when turned to roll agitation mode the screen would be hard to reach and interact. Therefore, 90° tiltable user interface was chosen, this makes the design and construction of the processor much harder but on the other hand also more pleasant to use during roll agitation mode. (Figure 6.2.1 Processor concept)

6.3 System control

Design of electrical circuitry is driven from functionalities of the device and nodes which need to be connected. Processor functional structure describes interaction between these nodes. Overall idea is that it is possible to use processor as standalone unit and as an extension to web platform. Therefor program input can be sent from computer via Wi-Fi through a router to the film processor or it can be inserted manually. Further argumentation will be done on system power consumption, developing boards selection and temperature compensation. (Figure 6.3.1)

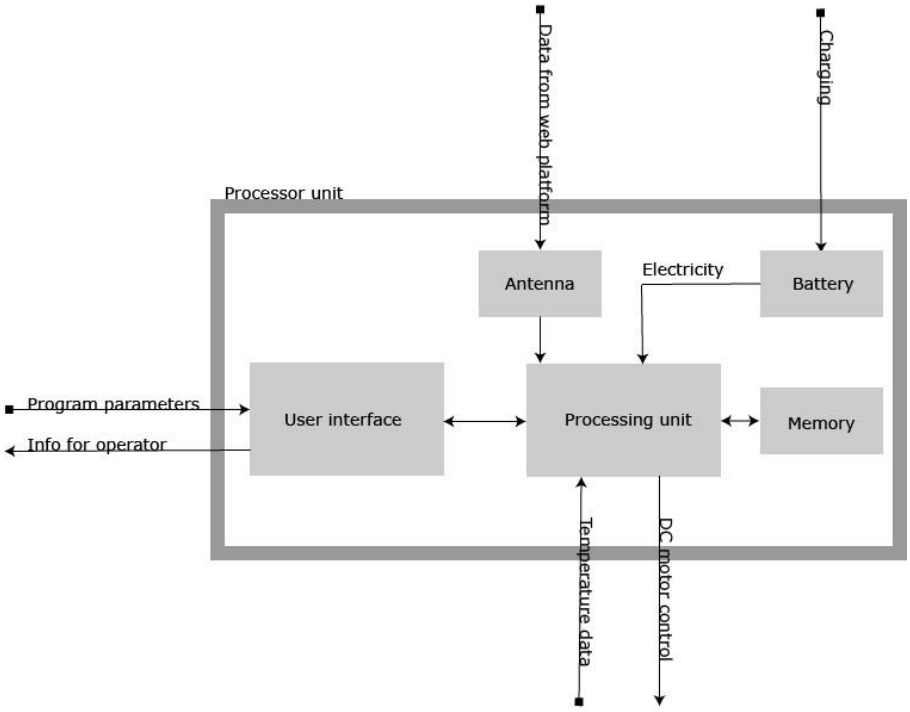

Figure 6.3.1 Processor functional structure

6.3.1 Power consumption

Power consumption is calculated mainly for two reasons. First to validate the choice to use Micro-USB connector to power the system and second to choose sufficiently sized battery to power the processor for one cycle in future use. Maximum amount of power which can be drawn out from Micro USB is 5A, common USB wall charger give out around 2,2…2,5A of current. (Wikipedia, 2021)

Components	mA
ESP32-S2 -Wi-Fi Transmit 802.11g	220
DC motor 16GA25	710
DRV8836 DC motor driver	1.5
ST7735S screen- Normal mode	2
DS18B20 temp. sensor- sink + active current	5.5
Buzzer	30
TOTAL	969

Figure 6.3.2 Power consumption

In the calculations all the major energy consumers were summed up. The biggest consumers are development board and DC motor. As a example ESP32-S2 development board was taken, during RF mode board consumes the most of energy which is 190mA in 802.11g setting. With DC measurement was conducted, during normal use, meaning rotating dry tank assembly, it draws 45mA and when stall resistance was applied it draw 710mA of current. Other consumers are marginal compared to these two. Through these calculations it is certain that powering all the processor nodes through micro-USB powered development board is sufficient.

For the rechargeable battery calculations one more value must be determined. The length how long the battery must last. From the Nõmme Huvikool experience average one cycle time was around 1 hour during which person uses the processor functionalities. Therefore, the battery capacity is 939mA x 1h = 969mAh. (Figure 6.3.2)

6.3.2 Development board

Development board is the heart of the operations and connects all the nodes together into one system. Choosing one can be daunting task as there are either microcontrollers like Arduino Uno or microprocessor-based single board computer (SBC) like Raspberry Pi, both can used for the purpose of building prototypes like this. First microcontroller-based boards take less power are cheaper and runs on firmware which instructs microcontroller what task to do. Generally, these are used to blink a lamp, drive a motor or read data from a sensor. Microcomputer based development boars on the other hand are bit more expensive, have more processing power and run operating system like Linux. Generally, these are used to develop software solutions using Python or more complex systems, which doesn’t mean that these can’t control motors and read data from sensors. Also, SBC-s can´t cope with power loss as it can damage the bord while microcontroller-based boards just do a normal restart

during a power loss. While from the cost and system requirement side it is obvious that microcontroller-based development board is way to go, another consideration is what is the purpose of this prototype. If it would be done only for the theses to validate the concept and further development ends after the theses is done, then SBC would be best possible choice as it is easier to program and control. On the other hand, if the prototype is made to validate a concept and is part of the longer development which in the end will go into production then microcontroller-based development board is way to go.

When compiling electrical system developing board is final part of the buzzle as then it is known what the specific characteristics of the system are. After compiling these are the requirements on choosing development boards:

- Wi-Fi- to connect with web platform.
- 5V output- to get as high current as possible from Micro-USB to power the DC motor.
- 20 GPIO pins
- Supports SPI and I^2C protocol- which are two main protocols to connect different components.
- Micro-USB or Type-c connector- to keep it compact.

After some researching of available options these development boards were found- Figure 6.3.3 Development board comparison. From the research one clear winner draw out, which is ESP32-S2 board. ESP32-S2 is a cheap Wi-Fi and Bluetooth enabled developing board which suits the best this project because it has enough GPIO pins, 5V pin is directly connected to Micro- USB connector meaning maximum amount of current is possible to use. ESp32 board is cheap and widespread used in maker community, meaning a lot of information is available in internet. From memory and processor side it has enough to implement graphical design on menu systems which will be also one objective of this theses. (Figure 6.3.3 Development board comparison, Figure 6.3.4 ESP32 board in processor)

				
Developm-ent board	ESP32-S2	ESP8266	ARDUINO MKR WIFI 1010	Adafruit Feather M0 WiFi
Processor	Dual core Xtensa L6 32-bit	L106 32-bit RISC	SAMD21 Cortex®-M0+ 32bit	ATmega32u4
Processor speed	240 MHz	80 MHz	48 MHz	48MHz
GIPO pins	34	16	21	20
Memory	4MB + 16MB external	2MB	256KB	256KB
Operating voltage	3.3V	3.3V	3.3V	3.3v
Output voltage	3.3V, 5V	3.3V	3.3V, 5V	3.3V, 5V
Wi-Fi	Yes	Yes	Yes	Yes
Bluetooth	Yes	No	Yes	No
LiPo battery connector	Some models	Some model	Yes	Yes
Price	13.37€	5.45€	27.90€	28.57€

Figure 6.3.3 Development board comparison

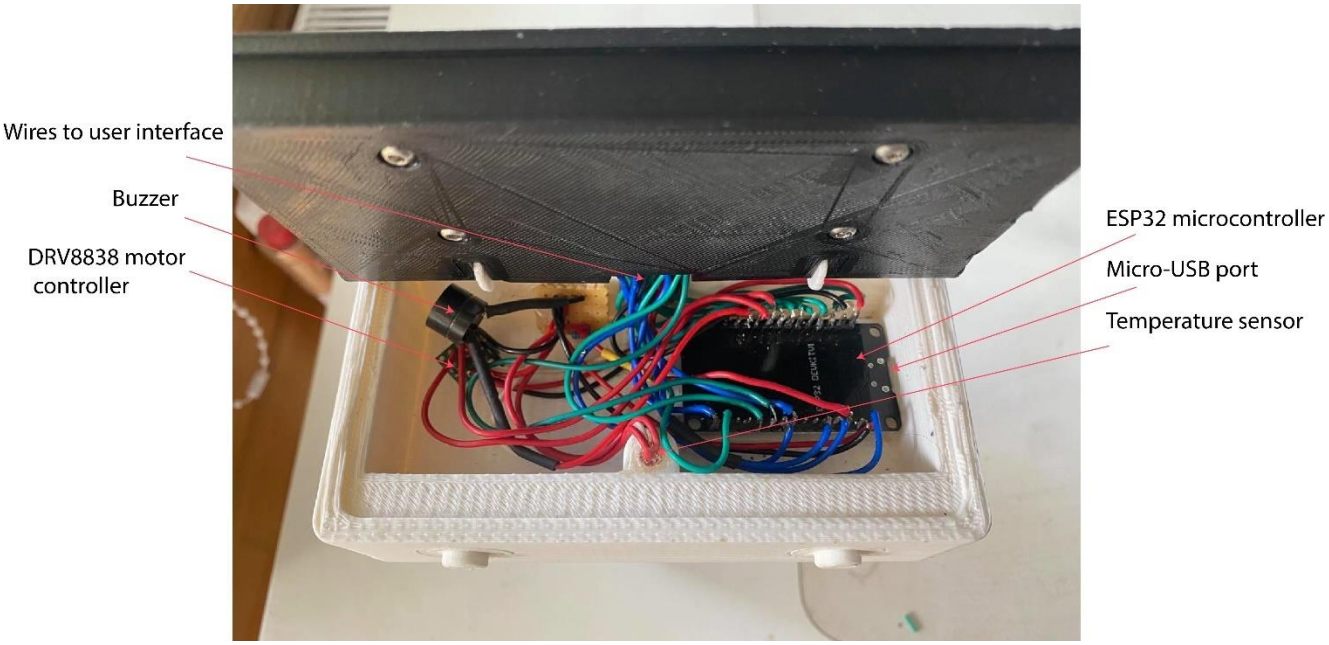

Figure 6.3.4 ESP32 board in processor

6.3.3 Temperature control

Liquid's temperature control is second main functionality besides autonomous agitation. Aim of the temperature control is to help the processor operator with the temperature management to produce consistent and better-quality negatives. While all the other processors deal this problem in proactive way meaning water is heated up which heats up all the other liquids, here it is done in reactive way, meaning time will be compensated according to temperature change. In consequence all the bulky equipment is eliminated. It does not eliminate the need to insert chemicals with right temperature in the processor but it will add an extra security for the operator that inserted chemical temperature do not have to be spot on and temperature drop during the process is compensated.

As C-41 is standardized process, fixed graphs can describe the relationship between temperature and time. It consists of two equations, first will be used when temperature is over 37.8 degrees and second if under. Idea is that system monitors the temperature change and adjust development time according to these two graphs. When Push process is used, it will be possible to alter the equations in a manner that for 1 stop change time is multiplied x1.3 and for 2 stop change x1.75. These are the two equations: (Freestyle photo, 2020)(Figure 6.3.5 Temperature compensation)

37.8 °C ≥ -5.25x + 55.125

37.8 °C ≤ -1.3077x + 42.115

For B&W its different since development times vary and the graphs are different but all of them share common line inclination angle. With simple calculations it is possible to get suitable equation. Only what is needed is development temperature and development time at that temperature. Since the inclination angel of the line is constant it will be the same every time. The calculation is following: (Welovemath.ee, 2020)(Figure 6.3.5 Temperature compensation)

y_1 = Temperature; °C

x_1 = Time; Min

k= Constant; -3.5

$$y = kx - kx_1 + y_1$$

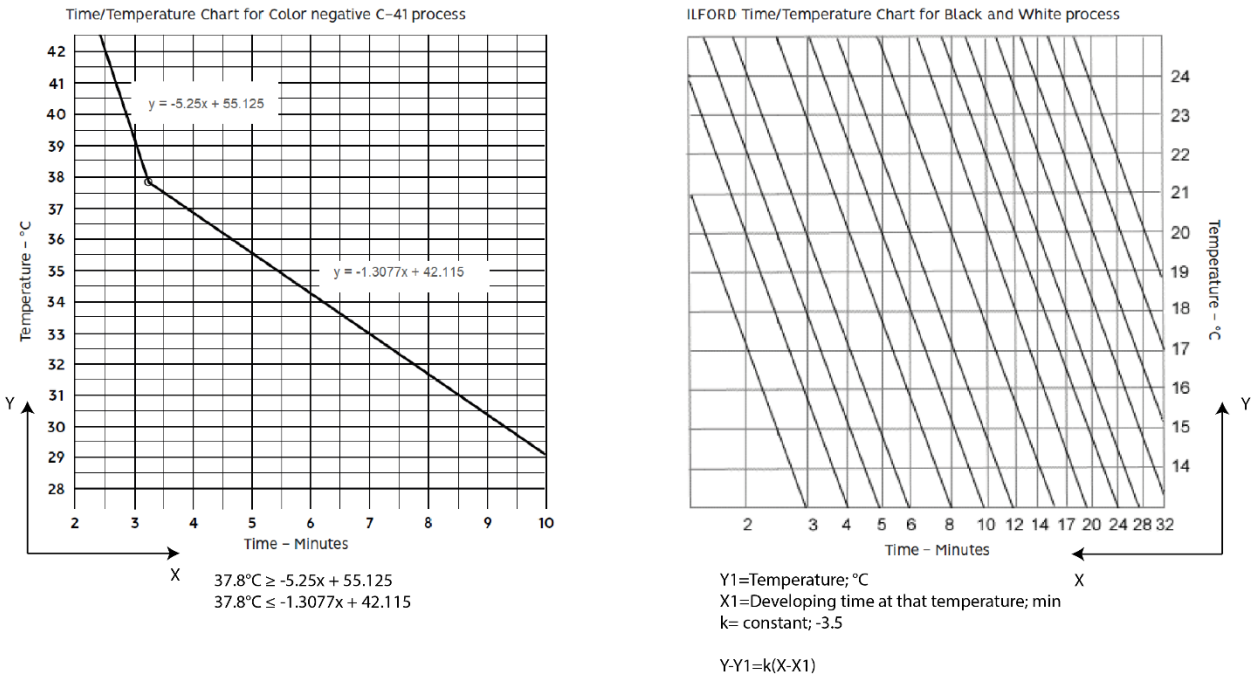

Figure 6.3.5 Temperature compensation

6.4 Web platform

While is it possible to great programs manually in the processor, web platform will be developed as addon for the film processor to create one ecosystem which supports process operator on eliminating potential mishaps and on finding all the information needed to develop film. Also, platform address the problem of how to find place where to develop a roll of film. These parts will form the core functionality of web platform:

Stock monitoring: Having a stock accounting functionality will address these two problems. Frist, after every process chemical used can be deducted from the stock. This gives quick overview how much chemicals are in stock and how many more rolls of film can be developed in future. This is helpful if someone has many different chemicals for specific processes and if the processor is used for commercial purpose. Second, chemical expiry will be accounted and deducted from the system. It avoids using exhausted chemicals and ruing the film.

To implement this functionality database driven web application must be built. To do that database like MySQL server can store all the information. Previously to build such database a lot of technical programming was needed, today it is possible to use platforms like Amazon We Service or Microsoft Azure to synchronize webpage with cloud database. To connect the information and display it to user AngularJS can be used, which is framework first releases by google to build frontend web applications.

Program creation: Before starting the developing process, program must be sent to processor. To create program, following variables must be specified: process type- B&W, C-41 or E-6; with B&W what specific film was shot, at what ISO film was shot, what chemicals will be use, what format and how many rolls will be developed. To make a program out of that different databases must be connected to program generator. Like above mentioned personal stock to identify what chemicals will be used, and the biggest database will be like The Mass Dev Chart which specifies developing temperatures, times and dilutions ratios. Combining all this data will automatically create a program which is sent via Wi-Fi to processor. Meaning all the info is at one place and can be seamlessly sent to processor, eliminating the need for manual data insertion.

Preparation of liquids: Before every process developer, stop, fix and other chemical solutions must be prepared to execute the process. This means liquid volume, dilution rations and other specific info of different liquids must be acquired. The aim of this system is to connect stock database and The Mas Dev Chart database to give precise step by step

instruction / recipe to prepare the liquid before using them. This will be displayed in web platform to operator on simple step by step graphical manner.

Find a processor: Is an informal page where community centers and other public spaces can notify others that they have film processor and other equipment to hire. Aim of it is to bring film developing closer to the people in need and support creating a simple film developing business model for these spaces.

6.5 Conclusion

Objective of this sections was to clearly define the elements outlined in design brief. These elements were explained and elaborated how one must work in the system. While some functionalities were hard to solve, in the end all of them are still in the concept. In the next deliver part these solutions will be implemented. Processor concept will be implemented on physical prototype and through visual representation, web platform only through visual representation.

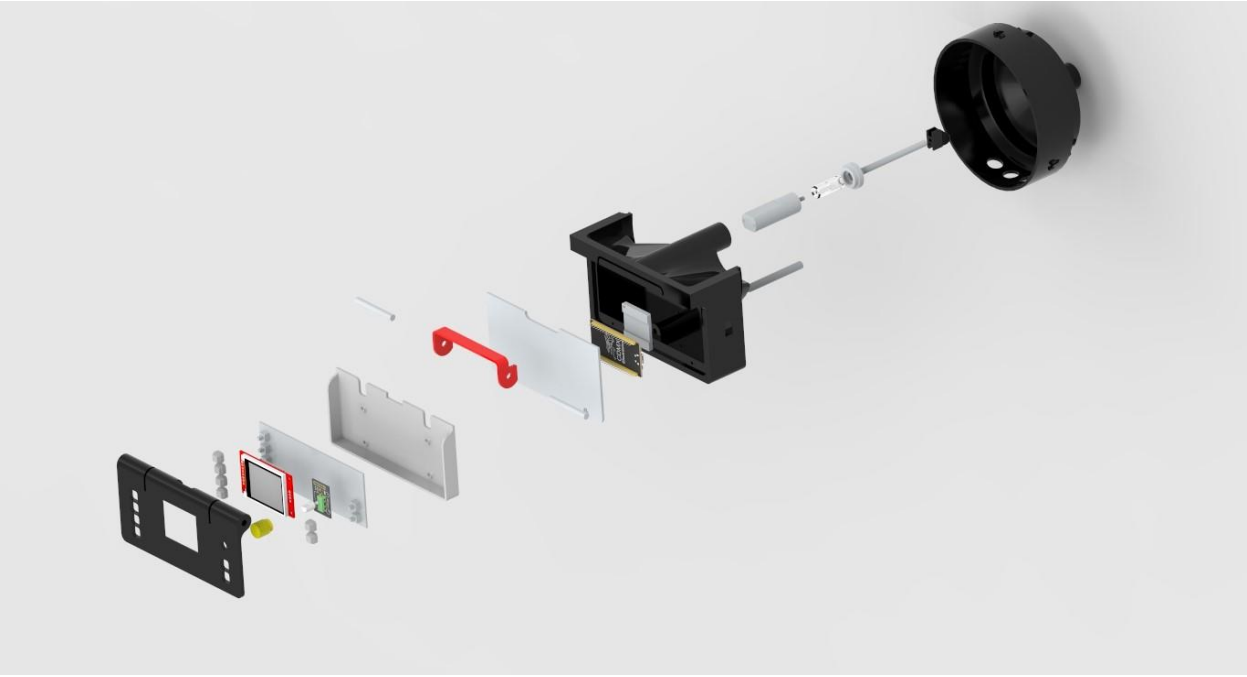

Figure 6.5.1 Processor

7 DELIVER

7.1 AGO ecosystem

AGO ecosystem consist of web platform called AGO+ which gathers all the information to develop film and AGO Film processor which turns Paterson Super System 4 tank into film processor.

7.1.1 AGO+ web application

AGO+ web application is where AGO experienced starts. It collects all the data needed for film processing and turns it through simple step-by step process into chemical recipe and program usable in AGO processor. Also, it includes other features whether to improve quality, bring people together, share the knowledge or to promote AGO for commercial use. (Figure 7.1.1)

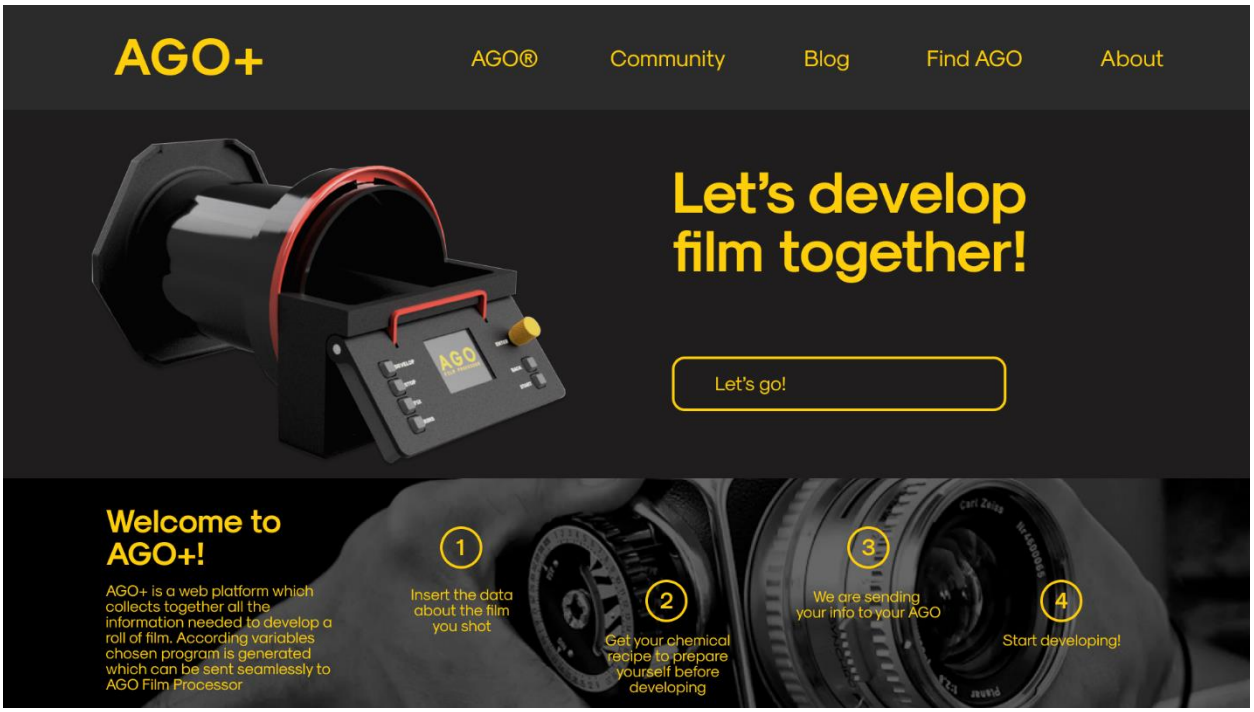

Figure 7.1.1 AGO+ 1. page

AGO+ user journey to developing film starts from the main page which directs through step-by-step process where operator will specify different parameters needed for AGO specific and general film processing. Develop-Chemical's page (Figure 7.1.3 AGO+ 2. page)(Figure 7.1.3) (Figure 7.1.2) will determine what process will be executed: B&W, C-41 or E-6. This will specify what kind of developer, stop and Stabilizer chemical can be

chosen from drop-down menu. All the chemicals what appear in drop-down menus are inserted before into Stock module. Stock module is also accounting the expiry date for chemical to eliminate the chance of using it.

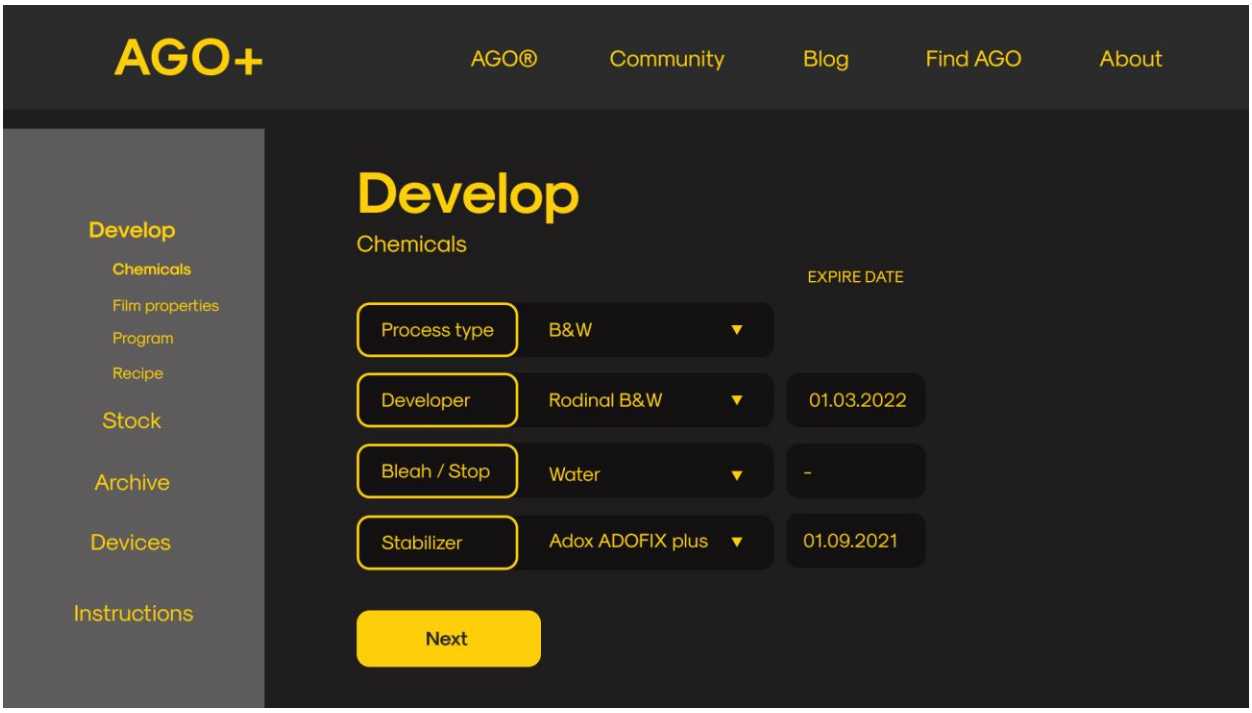

Figure 7.1.3 AGO+ 2. page

On the next page operator will specify film and development tank related variables. When it is done program is generated, which can be sent straight to AGO processor eliminating the need to insert data manually.

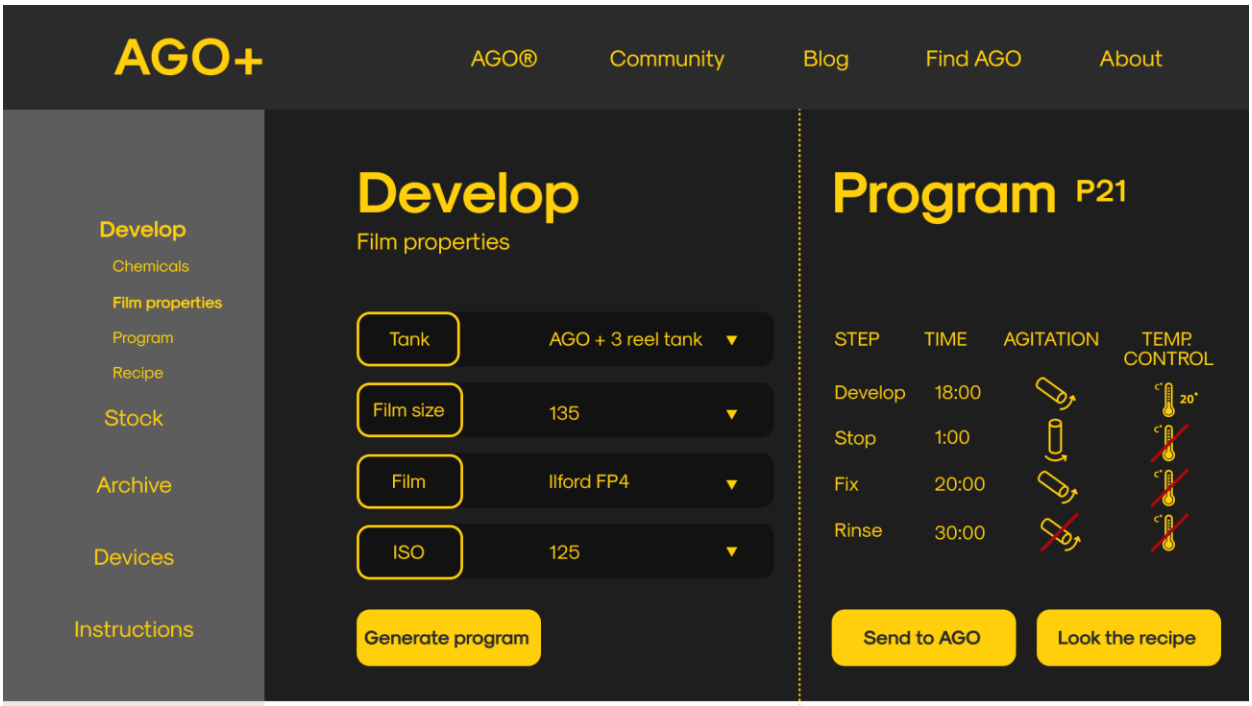

Figure 7.1.4 AGO+ 3. Page

Altogether this is what forms the AGO+ experience. So far with every processor on market the data needed to develop film is collected through datasheets or MasDevChart. AGO

experience combines processing and intelligence into one ecosystem which makes the process seamless and easier to start with.

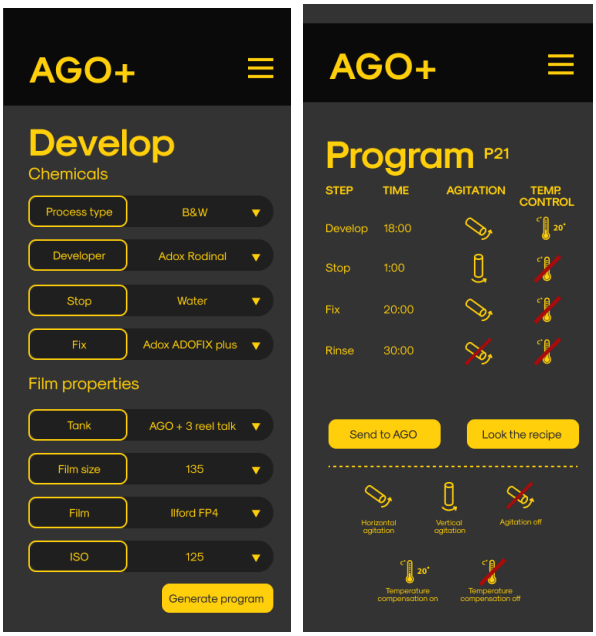

Figure 7.1.5 AGO+ mobile optimized pages

7.1.2 AGO film processor

To start processing program is needed, it be inserted either from AGO+ or manually through the user interface. Buttons through which operator can interact are separated into to two groups, right side buttons are for navigating the menu and starting the process and left side buttons are meant to move between different representative process pages. It's made to simplify user interaction between every step, after pouring in new chemical operator only must press next process page button and start button to start next stage. (Figure 9.5.1)

Figure 7.1.6 AGO front view

To maintain user interface accessibility and ease of use it is tiltable. Since processor has integrated both roll agitation and stick agitation functionalities tiltable user interface maintain the processor usability when it is horizontally or vertically. For vertical position removable rear stand is also necessary to hold the tank perfectly level.(Figure 7.1.6, Figure 7.1.7)

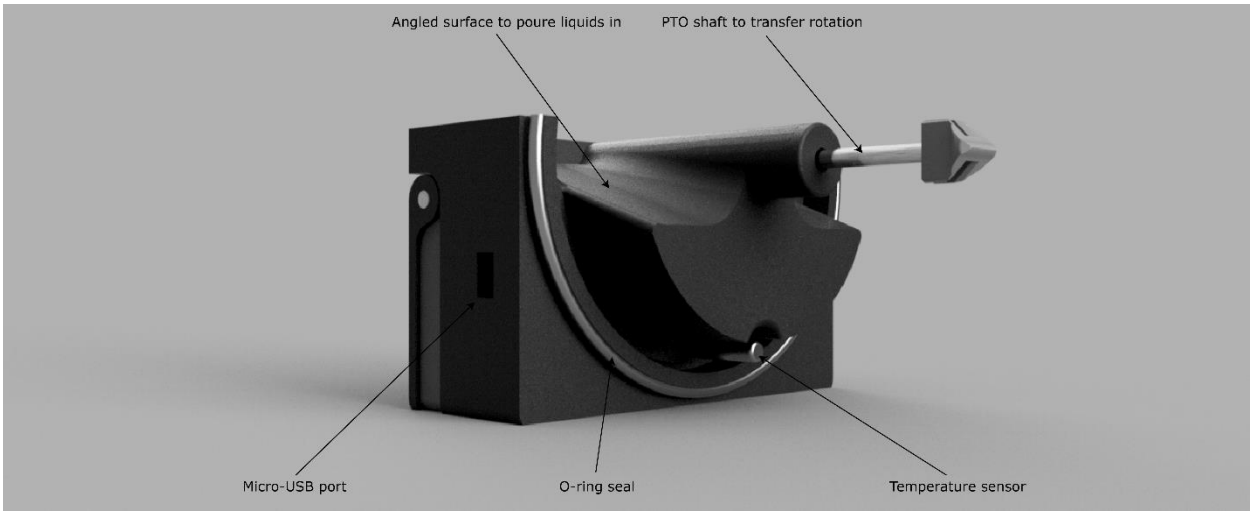

Figure 7.1.7 AGO back view

AGO comes in a package which includes AGO processor unit, modified funnel and a rear stand. Everything is 3D printed and hand grafted for the purpose of this theses. To operate the processor, one must order desired size Paterson Super System 4 tank and film reels. (Figure 7.1.8)

Figure 7.1.8 Roll and stick orientation.

7.2 Further development

In the close future the aim is to complete the AGO prototype, test the concept in real life and collect user feedback from analog photography enthusiast to validate the concept. After

which further developments and decisions can be made. If feedback is positive wider approach can be taken to form a team who starts working towards bringing this concept closer to reality.

Producing prototype like this cost around 350€ to produce at a moment. To bring it to market all the systems must be developed in a way that cost is fraction of this. When thinking about the future price it is too early to tell but considering other similar solutions, cost of AGO processor should be around 360€. AGO+ should also have its business model, most probably subscription-based solution would be appropriate here with different packages for different use cases. When considering funding, Kickstarter or Indiegogo based marketing campaign seems most appropriate. If successful it validates the product market fit and gives an access to speak with community. To do it successfully everything needs to be thought through, product design and production technology must be sure, supply chain in place, sales and marketing are plan figured out so when campaign gets funding then there are no more misconceptions how things come together and what is the production price, everyone know their part and just hustle.

7.2.1 Interface

User interface screen graphical design is crucial component forming the user experience and should be next design challenge. As AGO is aimed to consumer market the menu system must be result oriented, intuitive, and easy to use. To illustrate the processor menu system, needed functionalities and how the buttons can be used Figure 8.5.1 was made to simplify the collaboration with graphical designer. The main functionalities are: Saving new programs, editing old programs and process journey. Although there is obscure understanding how the interface should work no real tests and user research have been conducted yet to find out what are the best ways to fill these objectives mentioned above. These visual representation and system what is laying behind it is subject of further research and development guided by interaction design principles. After which graphical design can be outsourced from graphical designer and then it can be posted to sites like upwork.com or fiverr.com to hire service to turn it to C code suitable for ESP32 chip.

7.3 Conclusion

This section dealt mainly with the designing user experience and explaining it in the context of this thesis. Explaining the benefit of Web platform called AGO+ and AGO film processor

and interaction between those two environments. Rest of the elements and their functionalities are similar and explained in chapter 6.

Finally, as I see value in this solution for analog community and possibilities to go further with this concept further development was laid ahead to march towards validating the concept after which chapter 3.2.5 Maker movement knowledge can be implemented on it.

8 THESES CONCLUSION

The study is intended to understand post analog golden age paradigm, realize the value what it has to offer to current world and look for possibilities to support this new wave of analog photography. Literature research cave the understanding of the technical undertaking of the film development, the importance of agitation method and temperature control for C-41, B&W and E-6 process. Also, it gave an understanding about the shire amount of information, experience and equipment needed to execute the process. Interviews and community blogs draw out wider problems weather aging infrastructure specific or case of disappearing development labs. And lastly survey cave all these problems the scale on which to build proposed solution and find innovating ways to solve these problems. Specifically home users' equipment was taken under investigation to transform the interaction by bringing more clarity and less labor to execution the process.

But before, what analog photography can teach use on 21st century? It is apparent that has something to offer that digital don´t, it is the process behind it. Process which needs financial and time investment to execute gives value to each frame and makes pictures reappear as time goes on, so person can learn from them and take better ones until the end. It is tangible and slow process, which perfectly fits with the ideas what Slow movement is trying to explain. The idea that ever-growing fast life, digital hyperconnectivity is not in accordance with human nature. Instead of connecting people, devices and technology lead us into isolation and newer ending reward-seeking anxiety loops. Solution is to slow down, be present in the physical world and make real connection to implement the idea of localization. Analog photography in a sense is a window to more present and slower world, since mainly analog photos are made for yourself, it is a good tool to observe, learn and get more connected to the physical world around. The process itself offers a chance to break out of the digital bath and carry out slow picture making process which in the end gives the observer freedom to see and make meaningful connections.

Analog photography is having its revival, 2003 everything went down when photography market saw consumer purposed digital cameras taking over the analog photography for good. Since then, there have been few new developments and majority of equipment production has been discontinued. Things have changed in las few years, films sales are going up and some Kickstarter campaigns have emerged to produce digitizing, developing or other analog photography needed equipment, but vast majority of the industry is still heavily relied on old, depreciated equipment. This thesis decided to investigate film developing infrastructure and map the problems of it. Biggest discovery in this work was

that around 50% of films are developed at home with the equipment which was developed 40 years ago. The idea was to take points of concern what people face when developing film at home and propose a solution which adapts to current infrastructure in order to support the revival of analog photography.

Proposed solution: AGO ecosystem- it consists of AGO+ web platform and AGO film processor. AGO+ is web platform collecting all the intelligence to develop film and accounting features to count and manage consumables. Ensuring simple use even for beginners and possibilities to manage bigger undertakings for lab environment. After data is processed the outputs of AGO+ are program which is sent via Wi-Fi to the AGO processor and a chemical recipe/instruction of liquids to be prepared before the process.

Next AGO film processor is a device which is attachable to Paterson Super System 4 tanks. AGO automates agitation process, informs operator at the right time when chemical exchange is needed and measures temperature to compensate time to improve development quality. AGO transforms how film will be developed at home, it detaches the person form constant presence and giving operator pockets of free time between every chemical exchange.

Further development will take place on finalizing the prototype to collect feedback from the community in order validate the concept. After which further operation can take place to form holistic AGO experience, irresistible for everyone who develop film at home.

The biggest learning from this design process was the importance of numerical data representing real life situation. Specifically, survey which erased misconceptions, draw out less important problems and raised up the elephant in the middle of the room.

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LIST OF FIGURES

9 APPENDIX

9.1 Appendix I - Analog roadmap

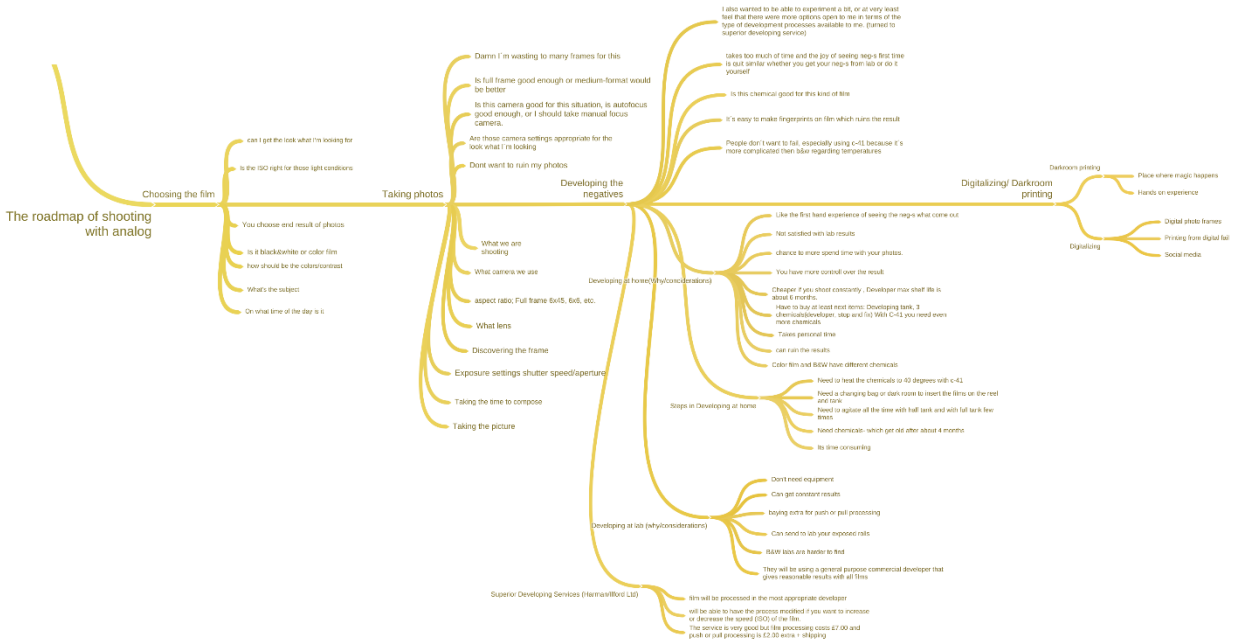

Figure 8.1.1 Analog roadmap

9.2 Appendix II- Questioner

9.2.1 Gender

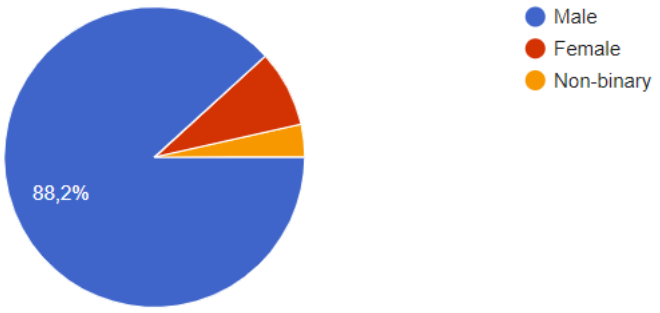

Figure 9.2.1. Gender

9.2.2 Age

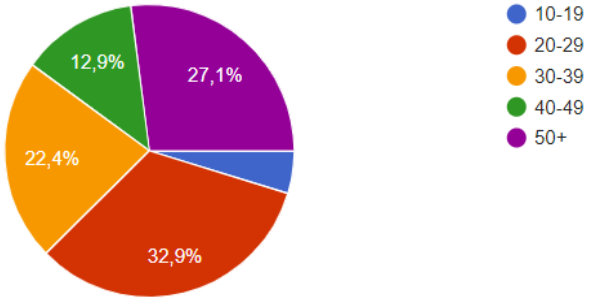

Figure 9.2.2. Age

9.2.3 Place of residence?

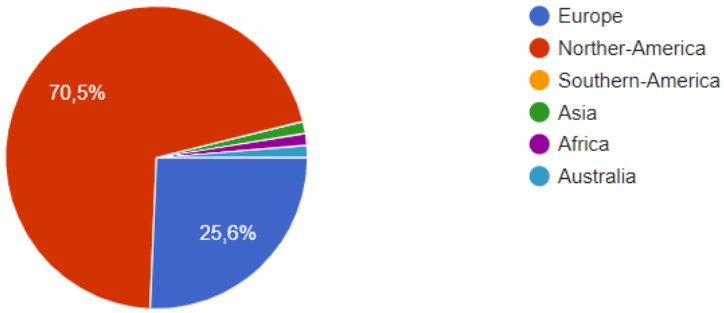

Figure 9.2.3. Place of residence?

9.2.4 How would you categorize yourself?

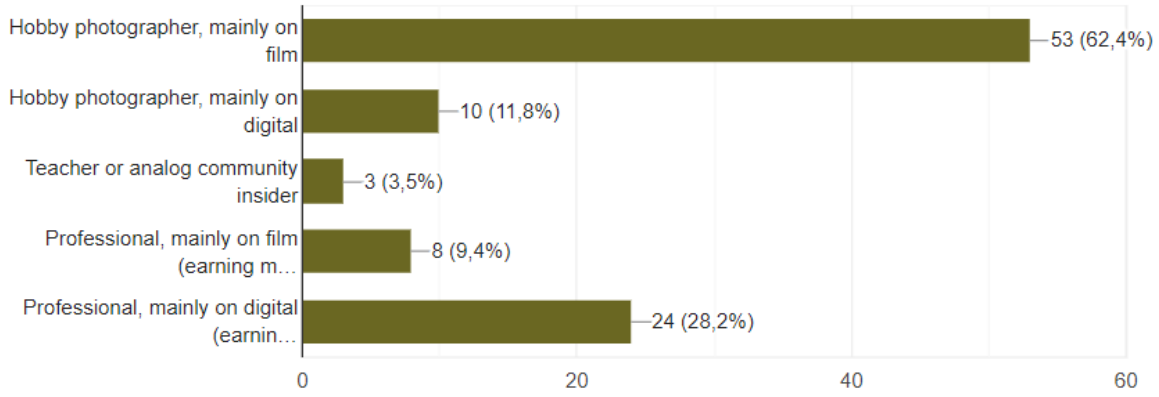

Figure 9.2.4. How would you categorize yourself?

9.2.5 How long have you been shooting on film?

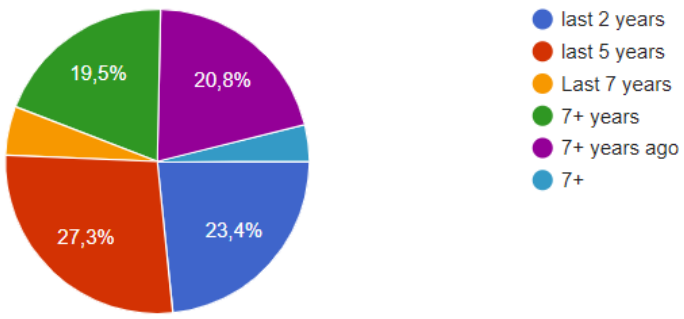

Figure 9.2.5. How long have you been shooting on film?

9.2.6 How many analog enthusiasts do you know in person?

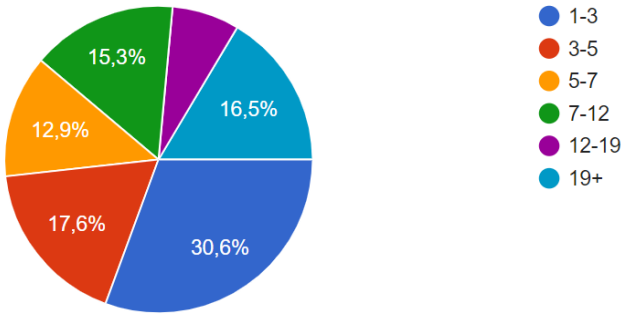

Figure 9.2.6. How many analog enthusiasts do you know in person?

9.2.7 How many rolls of film do you shoot per month?

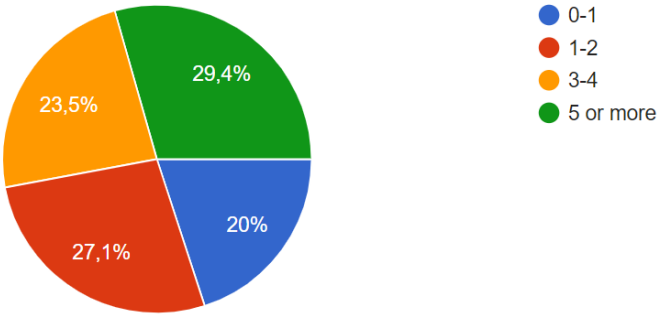

Figure 9.2.7. How many rolls of film do you shoot per month?

9.2.8 Do you shoot more color or black and white film? (Color - B&W)

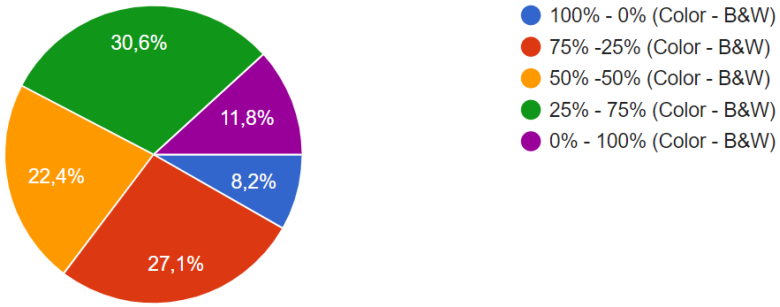

Figure 9.2.8. Do you shoot more color or black and white film? (Color - B&W)

9.2.9 What format do you use? (35mm or 120 film)

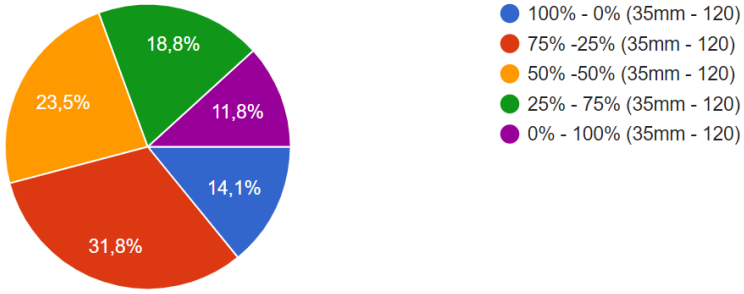

Figure 9.2.9. What format do you use? (35mm or 120 film)

9.2.10 Have you developed B&W film by yourself?

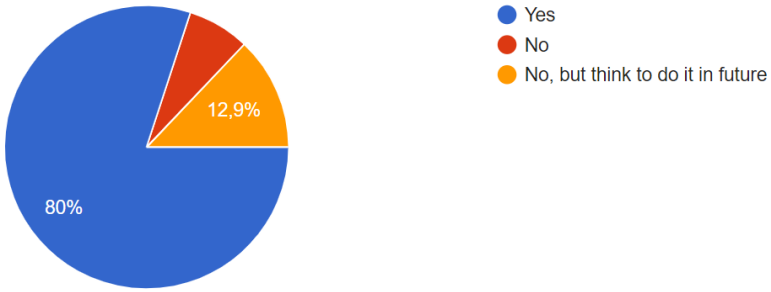

Figure 9.2.10. Have you developed B&W film by yourself?

9.2.11 Have you developed color film by yourself?

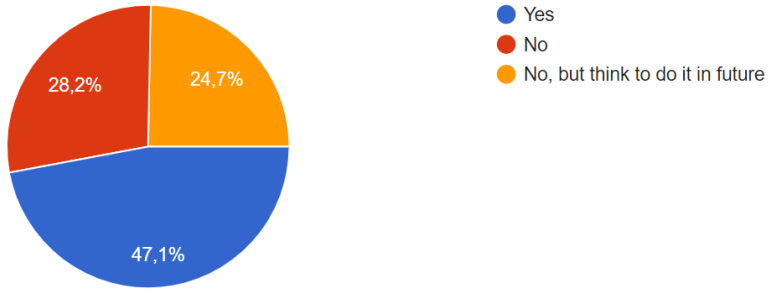

Figure 9.2.11. Have you developed color film by yourself?

9.2.12 If you have done developing yourself, why do you prefer it to the lab?

59 answered- most common answers were:

1. Cheaper (23)
2. Control over the results(quality) (23)
3. Faster (11)
4. Just like the process, deepens personal connection (12)

9.2.13 Where do you usually develop black and white film?

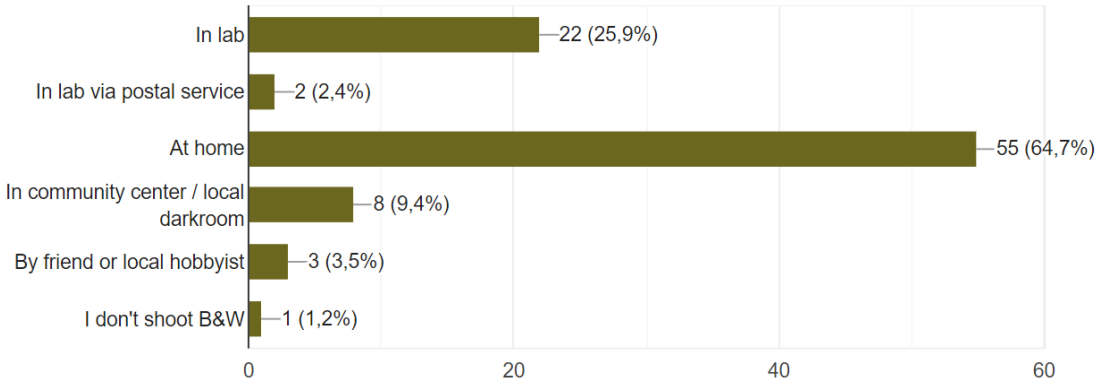

Figure 9.2.12. Where do you usually develop black and white film?

9.2.14 Where do you usually develop color film (C-41&E6)?

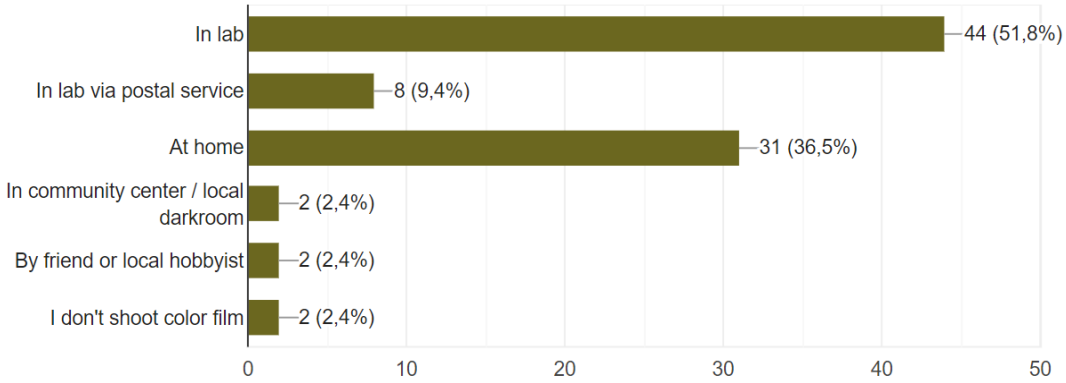

Figure 9.2.13. Where do you usually develop color film (C-41&E6)?

9.2.15 What do you do with negatives after development?

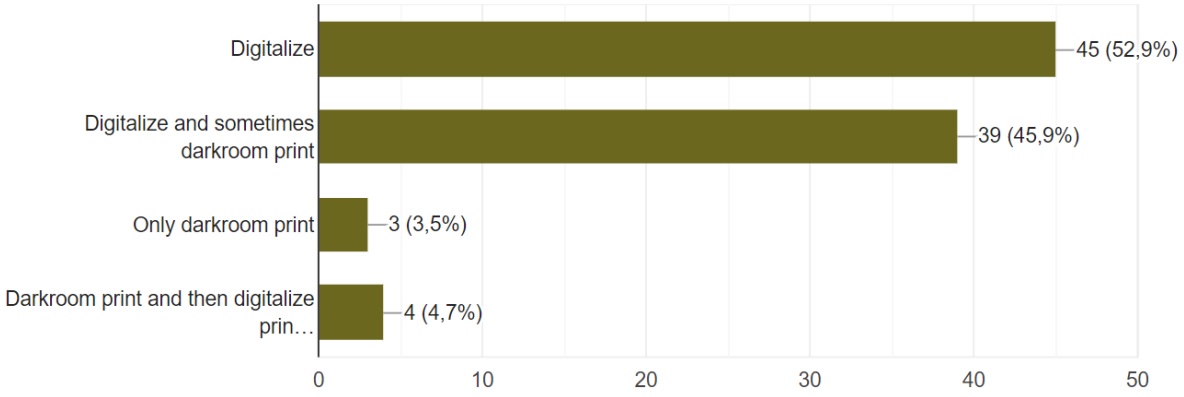

Figure 9.2.14. What do you do with negatives after development?

From here on I asked to answer people who have developed film by themselves.

9.2.16 What equipment do you use?

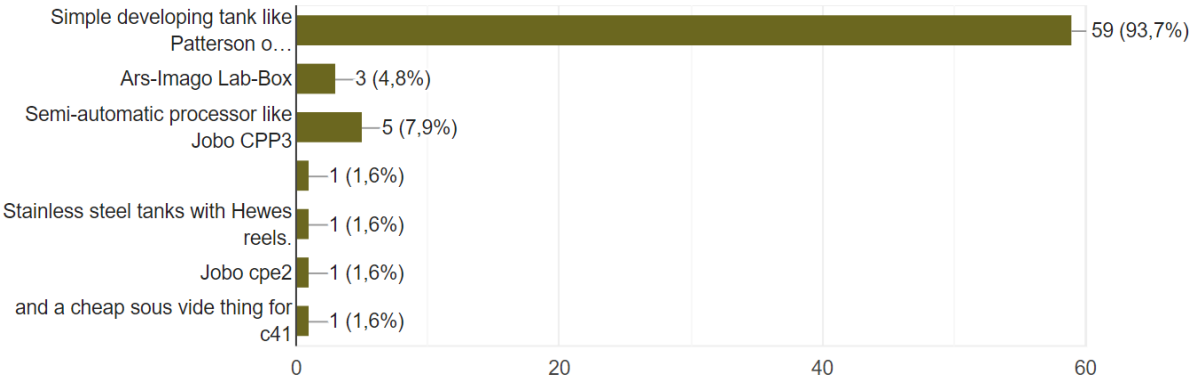

Figure 9.2.15. What equipment do you use?

9.2.17 Have you pushed/pulled film?

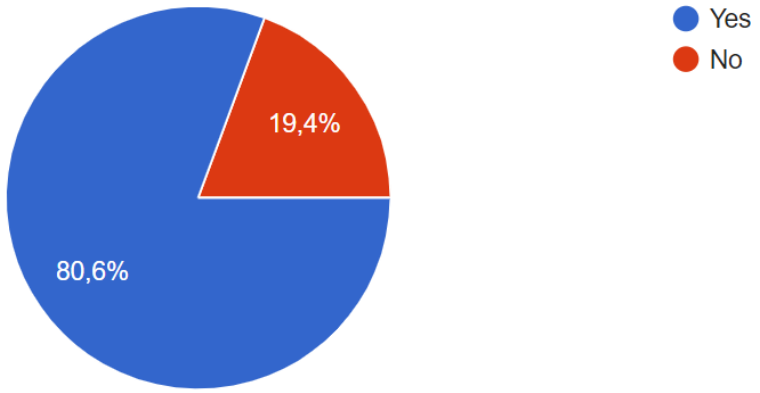

Figure 9.2.16. Have you pushed/pulled film?

9.2.18 Done cross processing?

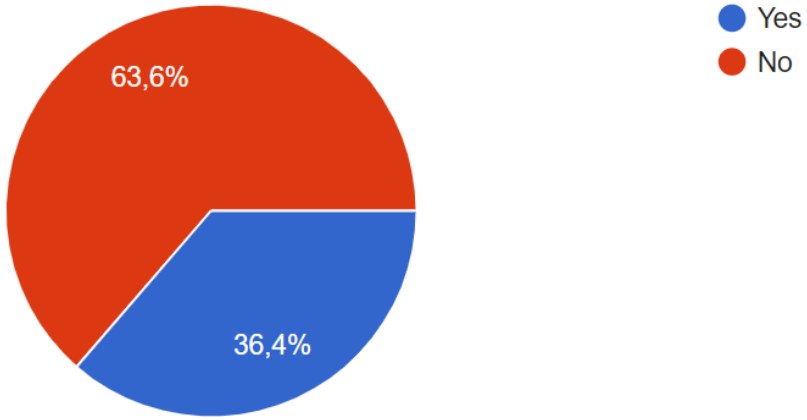

Figure 9.2.17. Done cross processing?

9.2.19 Poured chemicals in wrong order?

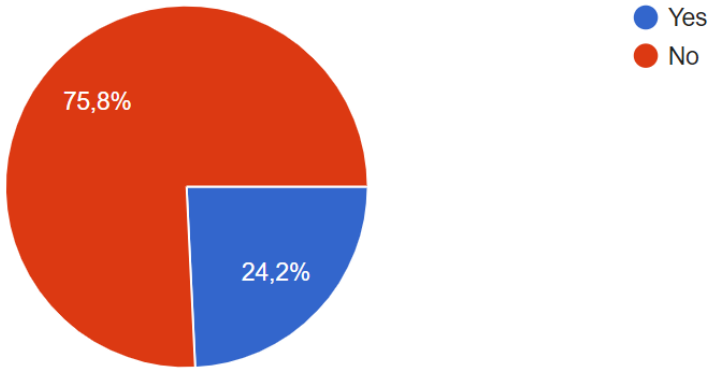

Figure 9.2.18. Poured chemicals in wrong order?

9.2.20 Used exhausted developer?

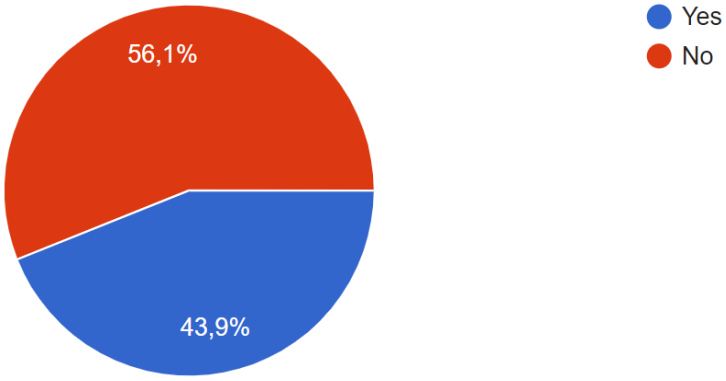

Figure 9.2.19. Used exhausted developer?

9.2.21 Exposed film to light during developing?

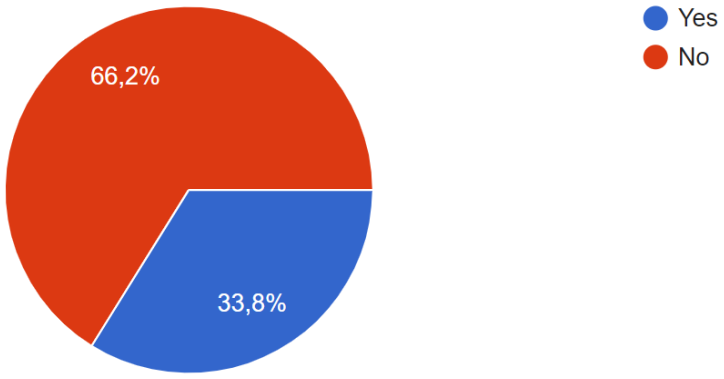

Figure 9.2.20. Exposed film to light during developing?

9.2.22 Have you had problems with quality? (too light/dark or other undesired anomalies)

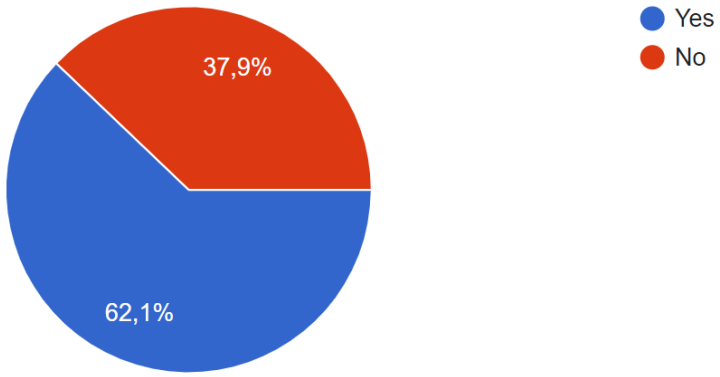

Figure 9.2.21.Have you had problems with quality? (too light/dark or other undesired anomalies?

9.2.23 What were the main reasons for bad quality?

44 answered- most common answers were:

1. knowhow about chemicals (9)
2. exhausted chemicals (7)
3. wrong time/temperature ratio (6)
4. Learning curve (4)

9.2.24 What is the most annoying part of developing?

61 answered- most common answers were:

1. time it takes (22)
2. loading the reels (7)
3. trying the negatives (7)
4. Exposure to chemicals (5)

From here on I asked to answer persons who have done C-41&E6 processing

9.2.25 How do you heat up and control the chemical temperature?

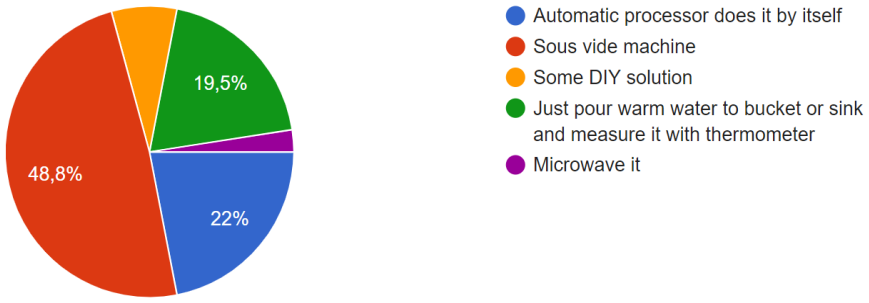

Figure 9.2.22. How do you heat up and control the chemical temperature?

9.2.26 How do you protect yourself against exposure to chemicals?

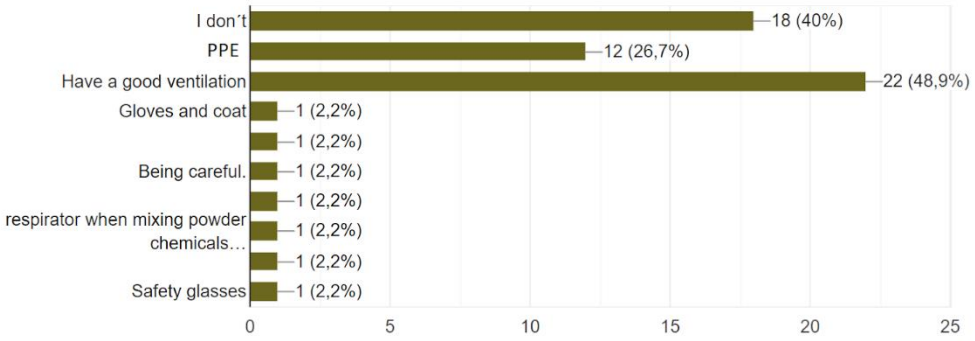

Figure 9.2.23. How do you protect yourself against exposure to chemicals?

9.3 Appendix III- Electric schema

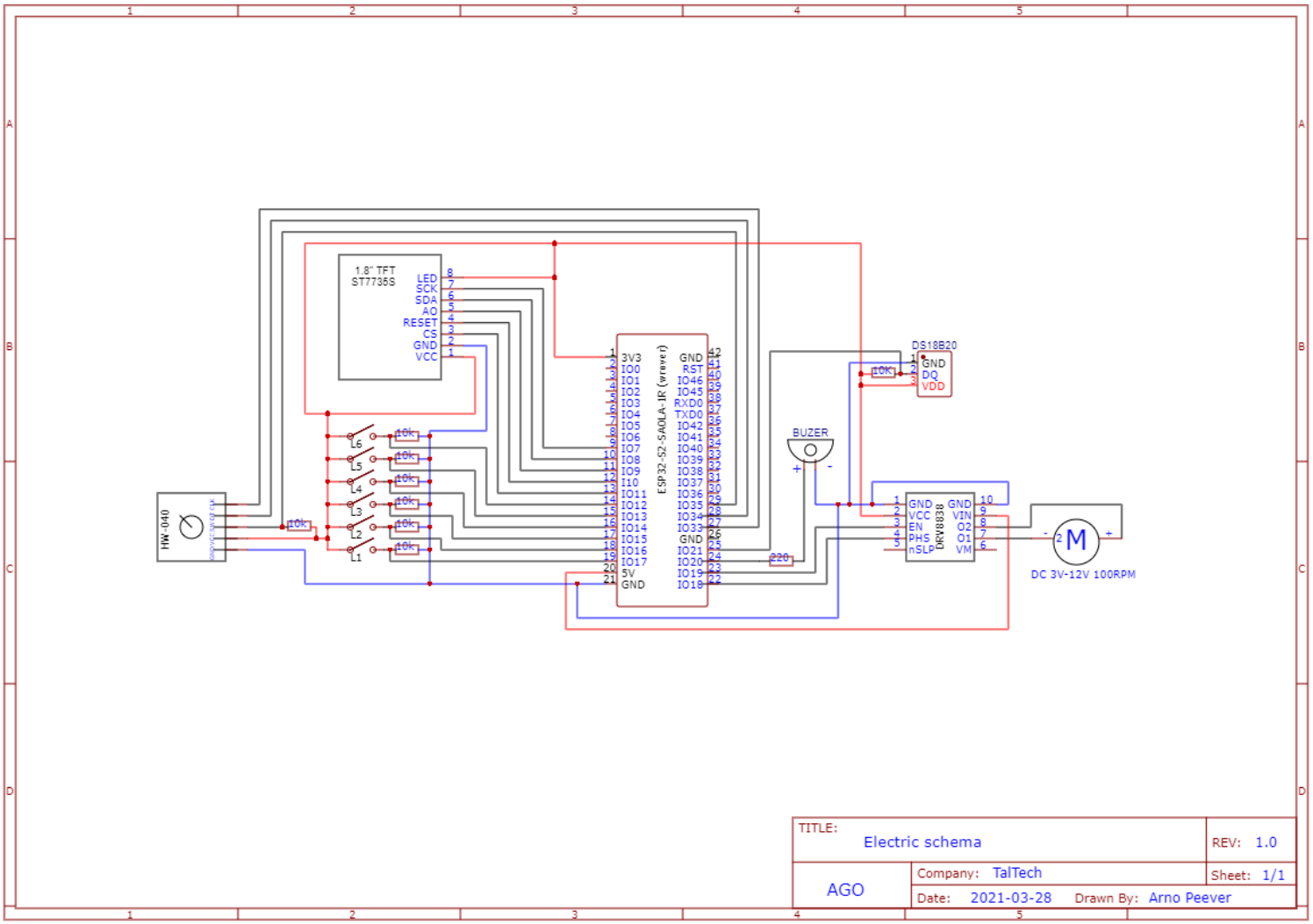

Figure 9.3.1 Electric schema

9.4 Appendix IV- Assembly drawing

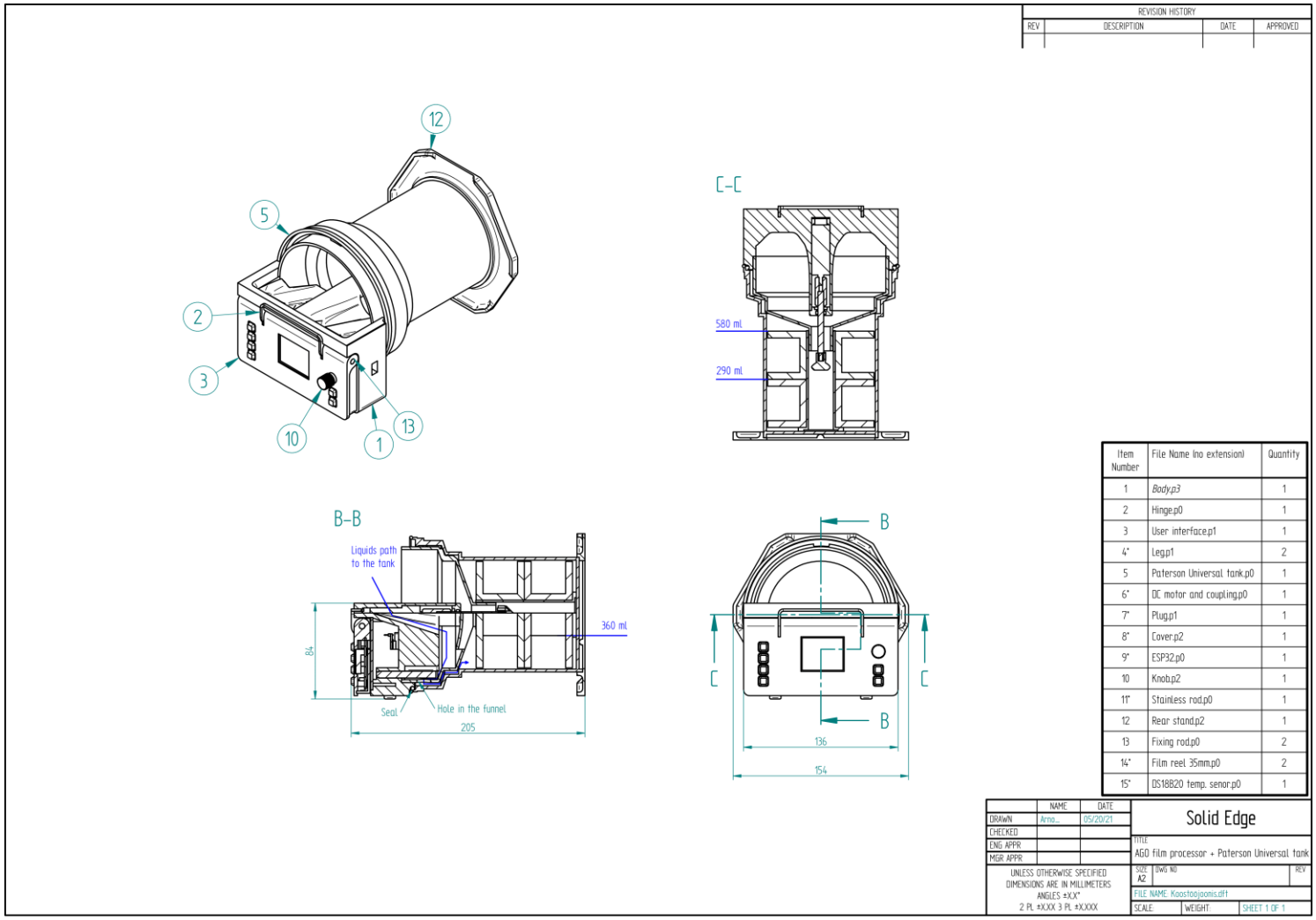

Figure 9.4.1 Assembly drawing

9.5 Appendix V- AGO user interaction

Figure 9.5.1 AGO user interaction

9.6 Appendix VI- Prototype

Figure 9.6.1 Prototype