Smart Knitted Surfaces

Designing and prototyping an indoor air filtration architectural system

POLITECNICO MILANO 1863

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Content

Abstract

The average person spends eighty percent and more of their life within indoor spaces. Yet, the pollution rates in places of commercial and residential use are mostly overlooked, even in the rare situations in which it is taken into consideration. Additionally, many devices that are purchased for the purpose of air purification either fail to accomplish a multiplicity of tasks or are aesthetically compromised for the sake of technological advancements. Although UV-C light has proven to be the most effective [26], there are numerous ways already in use or further studied to decontaminate air, such as HEPA filters and negative ions generation.

Negative ions are natural phenomena occurring in plant-based energy sources, shearing forces of water(waterfalls), and corona discharge of thunders and lightnings [5]. Despite having vague, physical representations of these natural sources in daily life objects, we fail to make use of one of their most astonishing qualities, that is negative ions. Considering the importance they have on the well-being of humans.

This work aims to explore the possibility of using this phenomenon in an architectural context through the modification of PolRe, a resilient textile material as a material, by infusing its components with copper and carbon fiber to achieve negative ion generation. Through an analysis of P.M.2.5,also identified as fine dust particles while the carbon fiber produces negative ions, the air filtration rate of the material that is woven to a surface is assessed. The prototype offers mobility, and stability, given self-standing frame the material is applied onto. Optimistic results depict that by improving the two-component PolRe material with copper and carbon fiber, using negative ion generators, the panel performs air filtration from particle matter with sizes from PM10 to PM2.

1.1

1.1 Introduction

Human life in the twenty-first century spends eighty to ninety percent of the day indoors. Some occupations give an advantage to a dynamic lifestyle. Most state bureaucratic jobs are located in historical buildings or others built more than thirty years ago. Even though most of those buildings contain national memories, a modern building could achieve the comfort level that a modern building could reach.

Those changes usually do not often occur in state buildings because of the inconvenience of the financial support from the state.
Ensuing those details, another option could be relocation, revealing an even more problematic and time-consuming situation.
Following up on those facts, a solution with both eco-friendly and economical could be the answer to enhance the working environment quality of a workspace located in an older building/space.
PolRe is an Italian start-up in Mantova that produces recycled and recyclable fiber well-thought, allowing new products to be realized using it.

1.2 Establishment of the problem

Most economically developed cities give many opportunities to the inhabitants; however, most lack one of the most important things we need: clean air.

That problem does not concern merely the outdoor air but correspondingly the indoor air quality.

People suffer various subjective sorts of discomfort such as headache, insomnia, fatigue, nervousness, joint aches, high blood pressure, which decrease work productivity. It has been recognised that these discomforts appear when there is a higher number of positive ions in the air where the person is[19].

The positive ions prevail in industrial areas and densely populated places (housing estates, busy downtown sections, etc.) and enclosed rooms, which means in the places where we spend most of our lives. One of the causes is presented especially by artificial materials which surround us (PVC flooring, synthetic carpets, and plastic windows), modern appliances (printers, copy machines, fluorescent lamps, TV sets, LD monitors, mobile phones), chemical cleaning agents, polluted air and cigarette smoke. The worst "enemy" of ionization is air conditioning which creates un-natural, artificial environment destroying natural microclimate by destroying all negative ions [20].

1.2

Negative ions can enter the interior from the exterior or can be produced by an ionizing appliance in the interior. Ion generators, or ionizers, have been constructed for this purpose [21].
Ionization has been used to clean the air in an internal environment by reducing dust particles and aerosols from volatile organic substances [22], [23]. Ions also have antibacterial effects and may decrease the amount of microorganisms and allergens in the air [24].

Evaluating the positive and negative sides of those statements, realizing a product with multiple functions, one of which is cleaning the indoor air by negative ionization, is a solution that is worth realizing.
Creating a interior separation wall using PolRe, in order for it to be placed in commercial and residantial spaces by modifying the two components of PolRe. Carbon fiber is one of the best materials that by recieveing an electrical charge can create negative ions. As a result it has been knitted in the synthetic, rope covering the Pet core, that in his order is modified by sticking copper band for the carbon to recieve electrical charge from the negative ion generators.

1.3

1.3 Research questions and objectives

The main research question addressed in this design thesis is whether a connection between function and design can be established when it refers to the air filtration systems and interior separation panels.

Function, as a definition in architecture, is the form-defining objective. It is the mechanism of understanding the primal need and nature of the user, proving the task it was designed to serve. We, as logical creatures, require each space or object we use to be defined by a function for us to see the reasoning behind its existence. The same logic can be followed in nature. Every organism, element, and phenomenon in nature serves a specific objective that defines its existence.

That is what architecture serves for. The function of architecture is to favor the life of people, to make the tasks we have to do easier and smoother, and even to give us pleasure in every step.

Function, most of the time, defines the form of the space or object. Even though this is not necessarily the task in the past or even today, the creators of objects or spaces start their form-finding firstly by defining the function and later, taking into consideration the user and its definite form.

This design thesis aims to produce an architectural object that serves more than one function - not only separating one space into two but also filtering the air and accommodating the feeling of enjoyment when used.

In this case, the combination of design and function is necessary for the project to be seen as acceptable or even craved by the end user.

1.4

1.4 Overview

This thesis consists of eight parts, each one describing in detail each step of the process of designing and prototyping an indoor air filtration architectural system. The introduction elaborates on the need and importance of the final project. The aim explains the idea behind the design, and the tasks elaborate on the principle that the design objective is managed. The case studies are listed with details for the reader to understand their uniqueness and complexity in putting function and design as the same priority.

The project chapter has four sub-chapters, explaining in detail step by step the realization of the concept and later the design itself following the same objective: Form and function to be equally respected.

Finally, in the results, experiments have been made, testing the feasibility of the project and its application in reality. The conclusion gives a closing argument of all the chapters listed above if the architectural system can be produced and sold on the market.

2.1

2.1 Aim

This project aims to prove using PolRe knitted surface with carbon fiber negatively ionized how it affects a space of 12/20sqm. As the PolRe is made of two components, it allows for slight modifications in the structure of each component, so the general use has one more quality: cleaning the air.[2]

Negative ionization is achieved by connecting a sheaf of carbon fibers via a wire with electricity running through it, PEF/pulsed electric field/ treatment. As a result, from the tops of each individual fiber, negative ions start converting and spreading around.[2]

Many factors can cause indoor air pollution, and the solution to it is ventilation. Since the presence of radon, which can be found in tap water in areas with not so evolved economic state, formaldehyde, which is used in plywood, particle board, carpet backing, and some fabrics, asbestos, that is in insulation and numerous decorative materials, correct ventilation can resolve the health issues that may follow after long time inhalation of those materials [2].

2.1

Today there are a variety of ventilation strategies in various European countries. In some countries, uncontrolled air infiltration and window opening is often the only ventilation, while passive stack ventilation systems are more or less used in others. In countries with colder climates, mechanical systems have been installed, which are either exhaust only or balanced, with or without heat recovery units [3,4].
Each system has its advantages, disadvantages, and applications.
Negative ionization of carbon fibers can be found in some air purifiers as the last filter that passing air goes through. However, it is not a famous way. As a result, the general audience does not know of its existence and its significant impact on health it has.
It improves metabolism and has effects on the cardiovascular and respiratory systems. In addition, some research has shown that NAI can also be used to treat chronic depression and sleeping disorders. [5]

2.1

An interesting fact about negative air ions is that they usually can be found around waterfalls and seashores generated by the Lenard Effect. The study showed that NAIs were generated from the surrounding air molecules by charging themselves negatively when water droplets collided with each other or with a wetted solid to form a fine spray of drops. The study also showed that several factors might affect the degree of charge separation in spray processes and, therefore, may affect the generation and concentration of NAIs. These factors include water drop temperature, dissolved impurities, speed of the impinging air blast, and impinging foreign surfaces of droplets. Based on the "Lenard effect", a water shearing appliance has been designed to generate NAIs [6].

Moreover, plants can release considerable amounts of NAI when being put under electric pulse-field (PEF) stimulation.

All of those facts point to the idea that placing an object that generates negative air ions can be an excellent solution for improving the quality of life in any indoor space.[6]

2.1.1 Influence of negative air ions on human health

Following a study made that was published online in March 2020, there was an experiment made with forty-eight children from primary school in Beijing, randomly selected, without any respiratory or cardiological health problems.[9]

The study was carried out within five workdays, ten hours per day. There were two classrooms with eight participants, in one there were six ion air purifiers switched on and in the other they were switched off.[9]

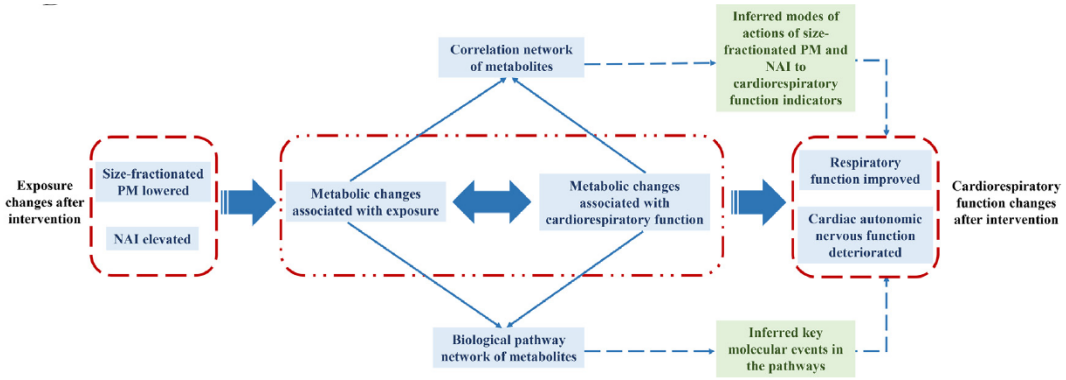


Fig. 1. Flow chat of meet-in-metabolite approach (MIMA) analysis. [9]

2.1.1

At the end of the experiment, the results were conducted by testing the metabolites and urine.

"*This is the first study investigating the molecular linkages between indoor NAI, decreased PM and cardiorespiratory function among children. He increased NAI and decreased PM and improved respiratory function mainly with eight pathways, promoting energy production, anti-inflammation and anti-oxidation capacity. Decreased PM ameliorated HRV with six main pathways, increasing energy production and anti-inflaammation capacity while increased NAI deteriorated HRV with five main pathways, lowering energy generation and anti-oxidation capacity.*"[9]

This experiment illustrates that NAI generation is considered a preferable method for air purification as it proves to improve children's health significantly with a rate of approximately eighty percent success rate.[9]

Another positive health effect of negative ionization is treating seasonal affective disorder SAD in combination with TBL/timed Bright Light/ treatment.[10]

2.1.1

Over the period of six years, over a hundred and fifty participants with clinical depression were separated into six groups, part of which had received only morning and evening light treatment in different sequences, and a minor part also received high and low-density negative ionization. The experiment was separated into two phases, each one ten to twelve days long.

The final result shows that the expected and actual results differ from the actual results. Illustrating that most of the patient's results have been influenced by the placebo effect; however, ionization can be considered part of the light treatment, partially successful.[10]

3.1 Tasks

3.2 Production of the material

"PolRe is a sturdy and resilient textile material, consisting of an inner core which gives structure, and an external jacket that covers, protects and decorates. Load-bearing, containment, shielding, conductive. The virtuous bond of materials, which become structure and architecture, opens PolRe at different applications: roofs, partitions, walls, radiant walls, chairs, decorative items, accessories for fashion and leisure.[8]

The net is the trace underlying inspiration and project connected with this innovative material. Interweaving wise and craft of materials, textile expertise, technology and design. Interlace of ideas, techniques and intelligences that can converge in infinite design applications."[8]

It has a patent:"The patent, deposited in 2013, protects the invention and the technology which allows to coat with a textile tubular the structural core flat section in extruded polymer. The process gives the material a high mechanical resistance: the covering shirt is made with numerical control machines for the production of circular textures in natural and synthetic fibers, in perfect adherence to flat webbing.[8]

The use of recycled and recyclable materials, such as plastic and textile fibers polymers, the reversibility of processes and the absence, in the production cycle, of bonding agents and adhesives make the material completelysustainable and by no means for impacting the environment.[8]

The patent filing also includes the possibility of equipping the PolRe of conduction systems and electrostatic fields, embedding them directly into the plastic webbing. This makes it possible to produce intelligent textures (smart textile), exclusive not only for the value of the used textile fibers, but also for their functionality and efficiency."[8]

4.1 Case Studies

Project name: BioFactory

Architect: ecoLogicStudio (Claudia Pasquero, Marco Poletto)

Project team: Claudia Pasquero, Marco Poletto with Korbinian Erzinger, Claudia Handler, Alessandra Poletto, Emiliano Rando, Eirini Tsomukou

Academic partners: Synthetic Landscape Lab IOUD Innsbruck University, Urban Morphogenesis Lab BPRO The Bartlett UCL

Client: Nestlé Portugal

Structural engineer: YIP London

Biological medium: Algomed

Steel structure: GV Filtri

Sensory system: ecoLogicStudio

Visuals: ecoLogicStudio

Photography: ©André Cepeda[28]

Fig.2.

4.1

Fig.3.

Air Bubble is an eco-machine that purifies the air and was installed in front of the Glasgow Science Centre inside COP26's Green Zone area.
Air Bubble is a biotechnology project that paves the way for new-concept architectures with high ecological performance. The project started from the biotechnological playground with the same name designed and built by ecoLogicStudio in Warsaw, a city chosen for its high pollution rate. It was carried out in collaboration with Otrivin®, company specialised in combating respiratory tract diseases.[28]

4.1

Air Bubble is an eco-machine made up of 99% air, water and cultures of Chlorella, a green algae that purifies the air through the photosynthesis process. A large structure characterised by an organic shape, reminiscent of a jellyfish, welcomed visitors inviting them to directly experience the machine's ability to clean the air thanks to suspended micro-algae cultures. A network of sensors monitored the outer membrane in real time and was able to activate a series of lights to support the photosynthesis process and increase the air purification. Thanks to this responsive approach, the more people interacted with the structure, the more litres of air were cleaned.[28]

4.1

Fig.4.

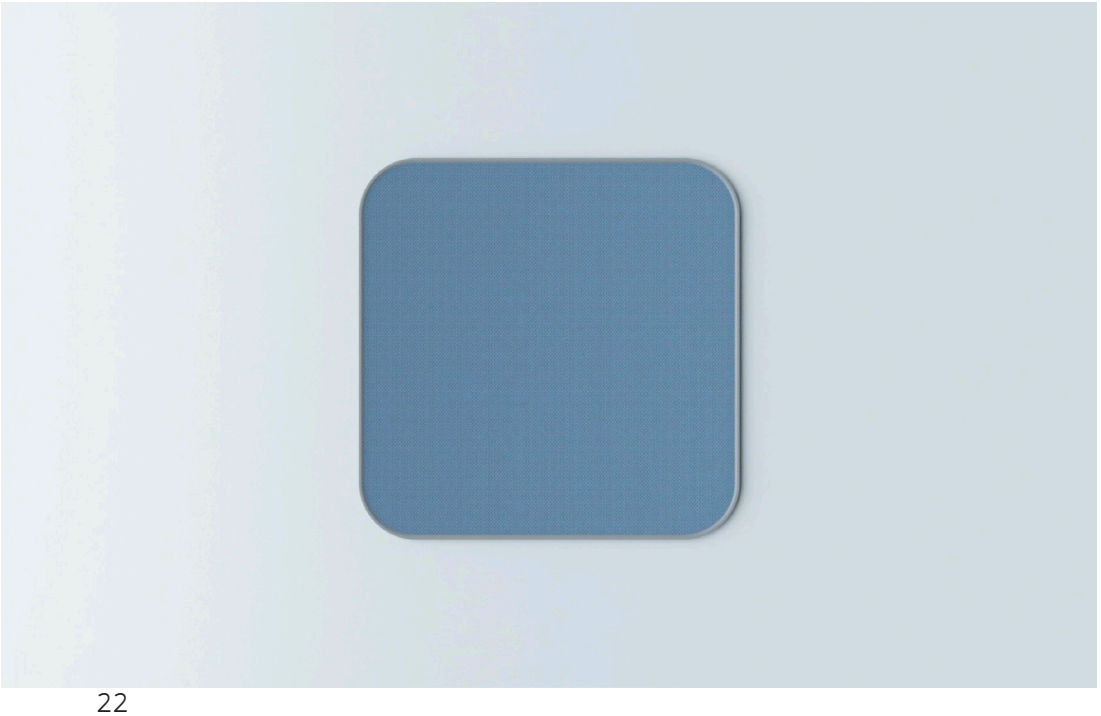
Fig.5.

4.1

Project name: MISSAGLIA HEFLOMI AIR PURIFYING AND DECORATIVE PANELS
Architect: STUDIO VOLPI INC.

The most astonishing thing about Heflomi is that is doesn't need to be powered by batteries nor being connected to the mains: it works by quietly sitting in a room, or better, "hanging" on the wall, as the specially conceived fabric it's made of inexorably captures and destroys most pollutants, bacteria and viruses that might be looming in the ambient air.[14]

Fig.6.



4.1

A new breath to air cleansing

Sometimes, apparently simple solutions find it hard to compete against flashy electronic devices, especially since the current situation has added to the confusion, and suspicion, on the part of consumers. One of Studio Volpi's first objectives was to enhance Heflomi's credibility through scientific evidence, whilst differentiating it from fan-based solutions. On the design front, the Studio concentrated on giving it a smooth and natural looking shape that would blend seamlessly into any interior. [14]

Fig.7.

4.1

Some simple science

The science behind the implacable effectiveness of Heflomi is disarmingly simple, and tends to challenge our common conception of the behaviour of air inside a room. Also, the way tiny particles tend to interact with their environment can be somehow uncanny.[15]

We all know from watching weather forecasts that cold air masses tend to move towards warmer areas. Likewise, air temperature in a room is never perfectly homogeneous, think of radiators and air conditioning units. So air in a room will never be perfectly still. It tends to move around, though its flow is hardy perceivable. Typically, in an average size room, it will completely move around in about 4 hours. There really is no need to force-move it, it is already moving by itself! Hence the absence of an external source of power for Heflomi.[15]

Ok, air in a room is moving, but how does the filter destroy pollutants since the air is not moving "through" it? The answer is that it doesn't really need to move "through" it, but only "near" it, thanks to a scientific phenomenon known as adsorption, with a "d". [15]

4.1

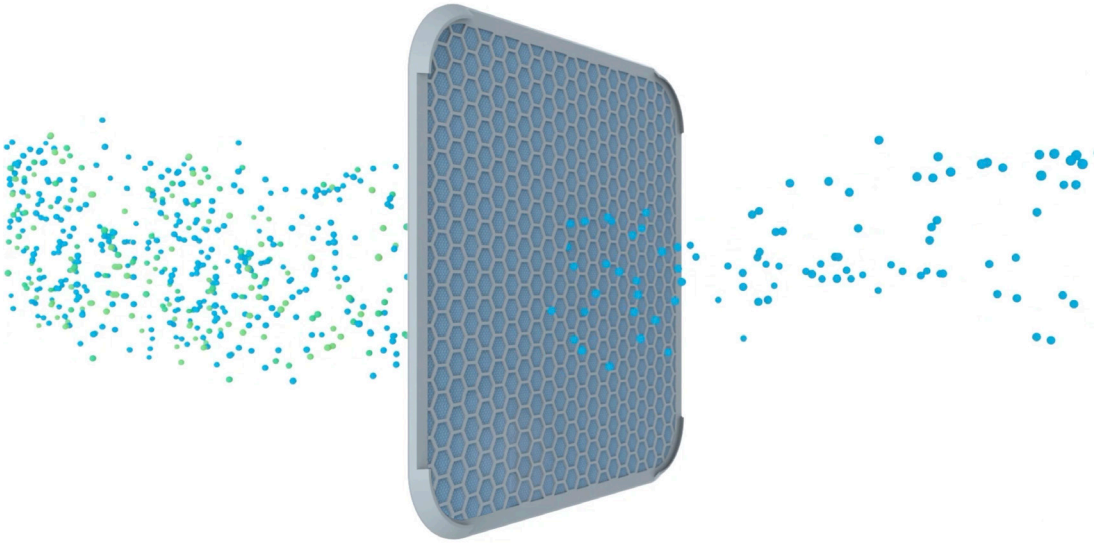


Fig.8.

Fig.9.

4.1

The fabric, called The Breath®, is capable to act on substances such as formaldehyde, allergens, bacteria and viruses. It also absorbs and eliminate odours from food and cleaning agents.[15]

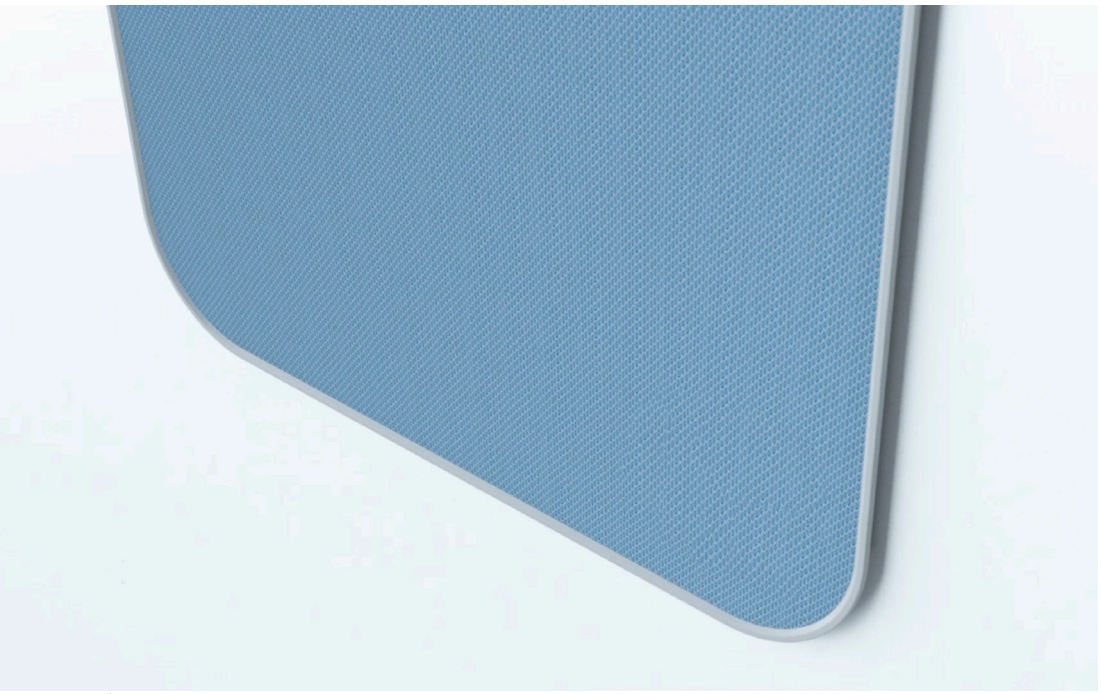


Fig.10.

4.1

Anemotech S.r.l. is the first Italian company founded with the aim of developing technologies to enhance people's well-being, improving their quality of life and promoting a healthier environment.[15]

Based in Milan since 2014, we are part of the Ecoprogram group, which has been operating in the automotive and large-scale corporate hospitality facilities sector for thirty years.[15]

Working with Tiba Tricot , Ecoprogram Group has launched the innovative theBreath® fabric, the first, revolutionary green patent for indoor and outdoor environments.environments. [15]

Fig.12.
Fig.13.
Fig.14.
Fig.15.
https://www.interior.fr/pure-room/

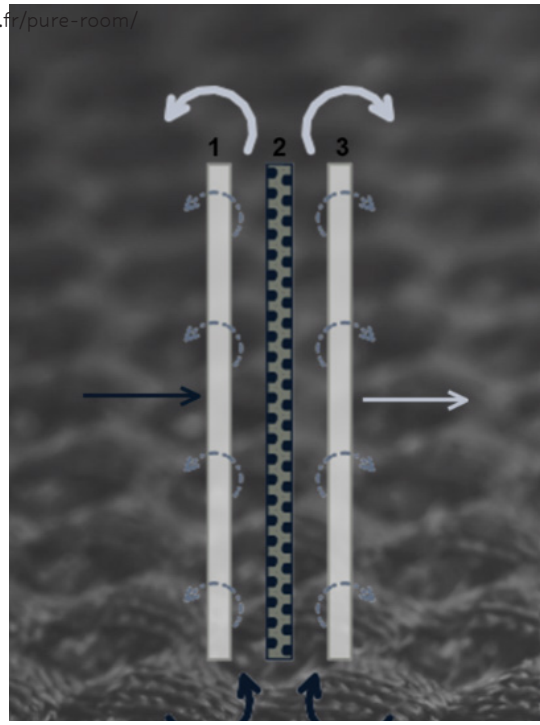


Fig.11.

theBreath® looks like a simple fabric but it is an innovative multilayer fabric that contains cutting-edge technology capable of fighting atmospheric pollution and purifying the air of indoor and outdoor environments. It is completely passive, working with the natural air flow not requiring any additional power source[15].

4.1

Project name: PureRoom

Architect: Marie-Hélène Mercereau, Jean-Paul Lavergne

Project team: Amaury Lavergne

The Pure Room® module is a multi-function technical panel that sucks in ambient air to be cleaned before being expelled. Efficient and silent, the purifier ensures the maximum workplace protection. The indoor air is in fact treated in six successive phases, making it possible to remove PM2.5, VOCs, bacteria, certain viruses, and bad odours, etc.

With Pure Room®, fresh air is no longer just for the great outdoors![14]

Fig.12.

4.1

Fig.13.

4.1

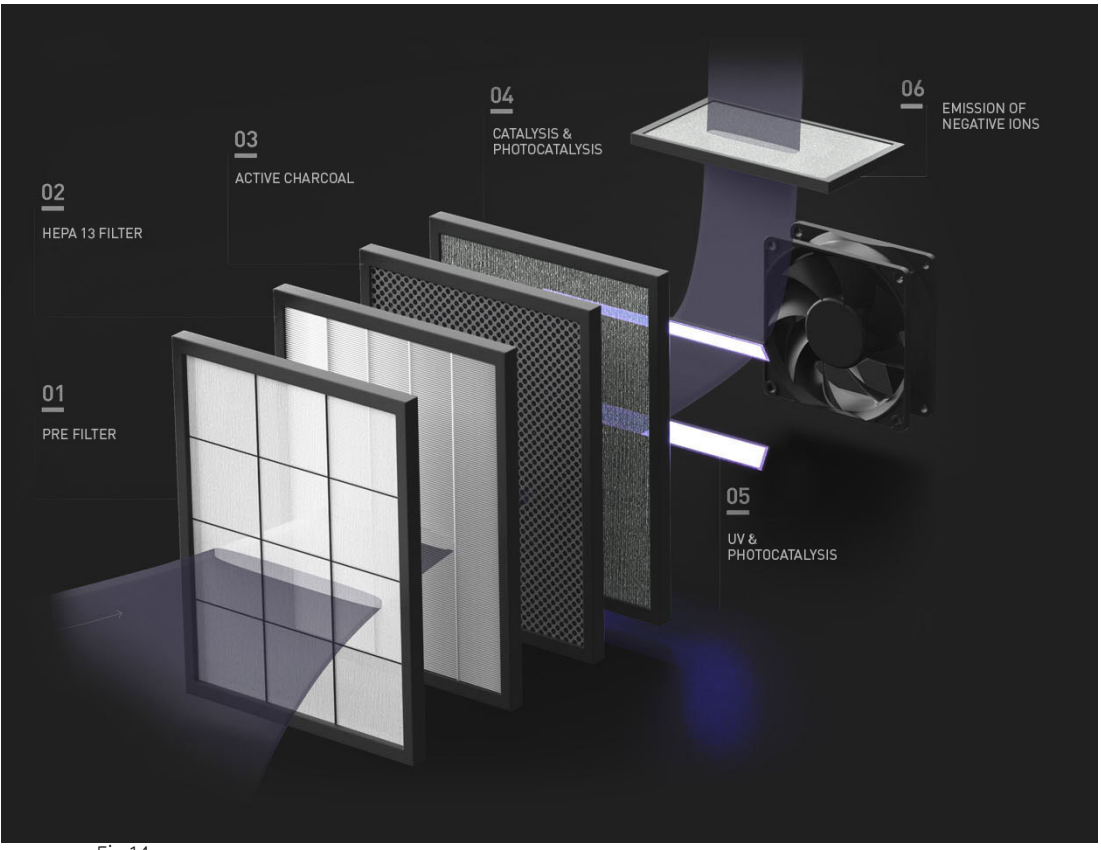

04
CATALYSIS &
PHOTOCATALYSIS
06
EMISSION OF
NEGATIVE IONS
03
ACTIVE CHARCOAL
02
HEPA 13 FILTER
01
PRE FILTER
05
UV &
PHOTOCATALYSIS

Fig.14.

4.1

Pure Room® system: operation

1 – The air is sucked in and passes through an antimicrobial treated pre-filter.

2 – The air passes through the HEPA filter. This filter retains 99.95% of ultra-fine particles down to the size of 0.3 µm.

3 – The air then passes through the activated carbon filter, which eliminates any VOCs present in the air. It also acts on certain odours, such as tobacco and damp.

4 – The air passes through the catalyst, a filter treated with lanthanum.

5 – The air passes through the photocatalysis, activated by UV lamps. The remaining fine particles are transformed into carbon dioxide and water vapour and then eliminated.

6 – Negative ions bond with pollutants and make them fall to the ground. Finally, the treated air is released into the room, cleaned of any pollutants[14].

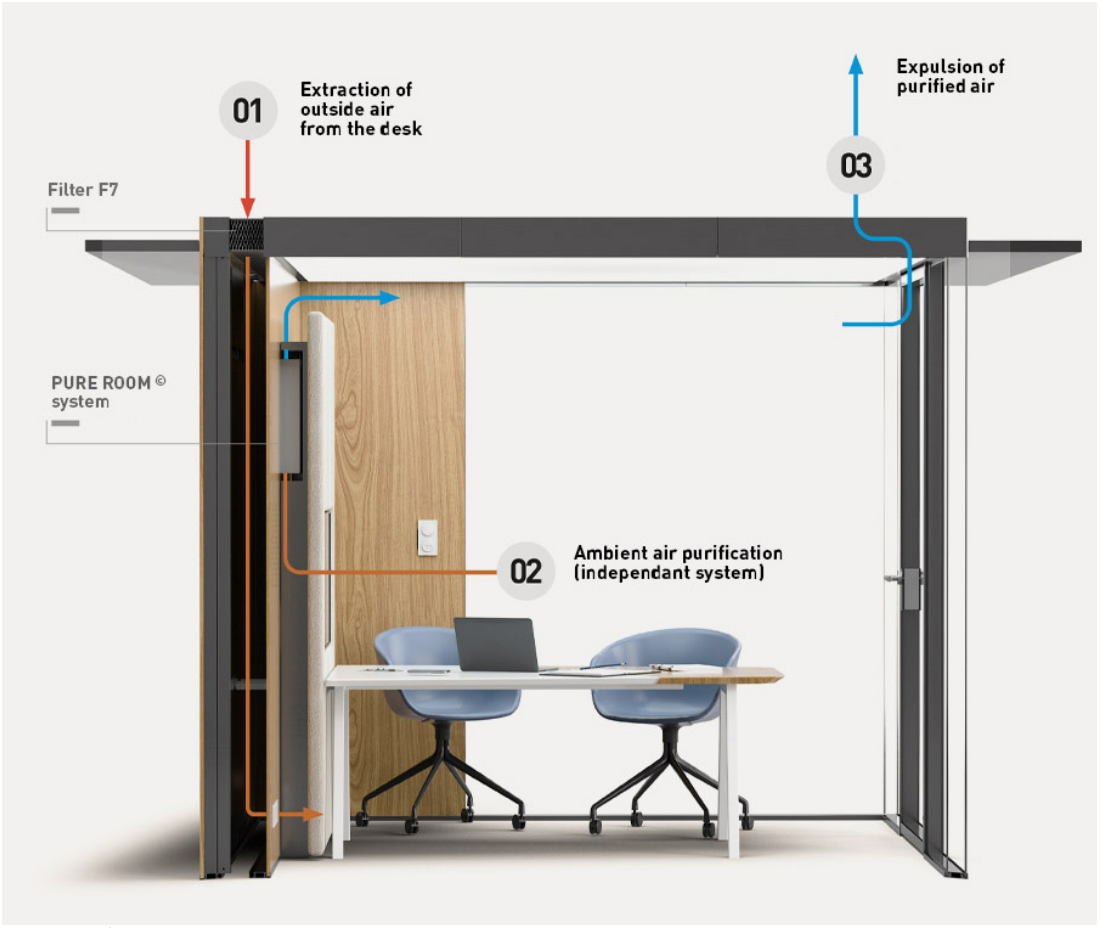

01
Extraction of
outside air
from the desk
Filter F7
PURE ROOM ©
system
02
Ambient air purification
(independant system)
03
Expulsion of
purified air

Fig.15.

4.1

Pure Room® air purification system: air flow in the Oxygen® bubbles

The Oxygen® bubble draws in the outside air from the desk top, with an initial F7 ePM1 55% type filtration stage in order to distribute a cleaner flow of air to users, with some of the suspended particles removed. These particulate filters comply with the new ISO 16890 standard. Independently of the Oxygen® bubble's ventilation system, the air purification system treats the ambient air, the particles not filtered by the F7 filters and, finally, the particles emitted by the occupants of the bubble. In this way, we can ensure the elimination of more than 99.95% of particles inside the bubble. Finally, the Oxygen® bubble expels cleaner air onto the desk top[14].

5.1

5.1 Project

5.1.1 Design Concept

Interior design is part of architecture that most of the time is taken lightly as opposed to other more critical parts such as construction and urban design. However, considering we send most of our days indoors it does have a great influence on the quality of living and working.

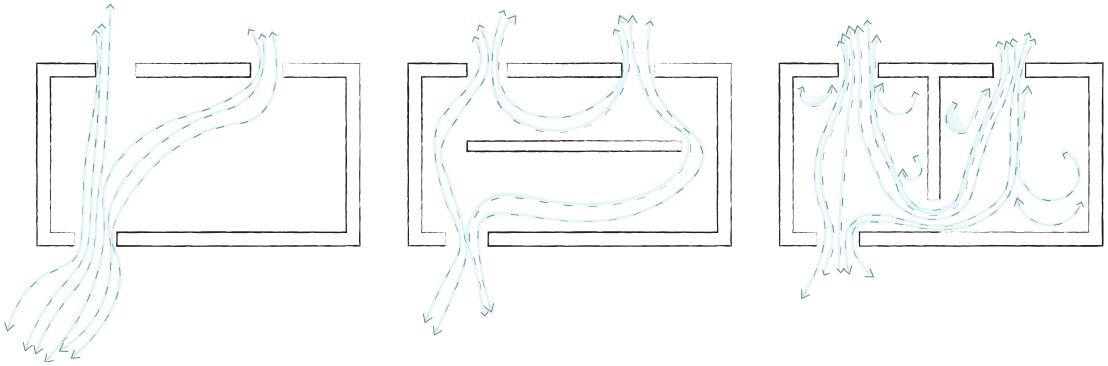
The scale of design is smaller than in any other area so it gives opportunity to observe and take into consideration details that usually are being ignored.One of them is cross- ventilation not only for temperature purpose but also for providing fresh air.

As recent studies have shown [7] that most contemporary air circulation is provided by ventilations systems like air conditioners etc., nonetheless they are not designed to provide enough clean air supply for all the conditions that we face as a post-pandemic period. They were mainly designed to regulate the temperature in the room and collect the largest particles in the air as dust.

That is why innovations are being made and one of them is a self-standing cleaning separation panel that cleans the surrounding by spreading negative ions produced by carbon fiber under pulsed electric field stimulation.

5.1

Plan of cross-ventilation when doors and windows are open



Plan of cross-ventilation when doors are closed and windows are open

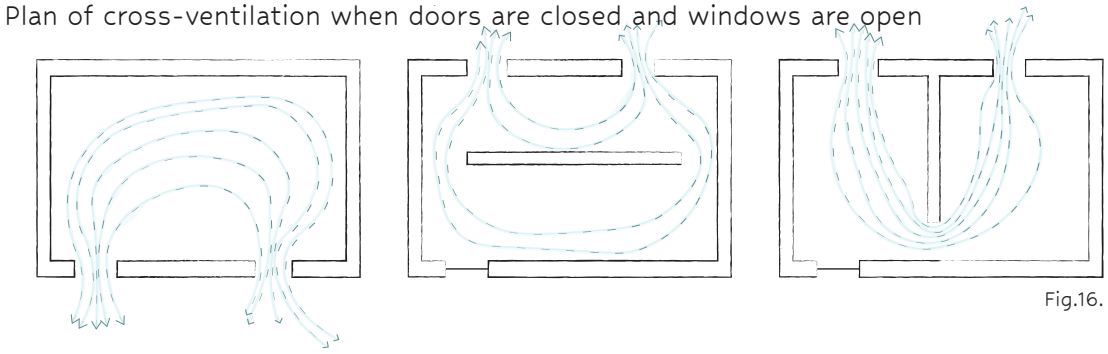


Fig.16.

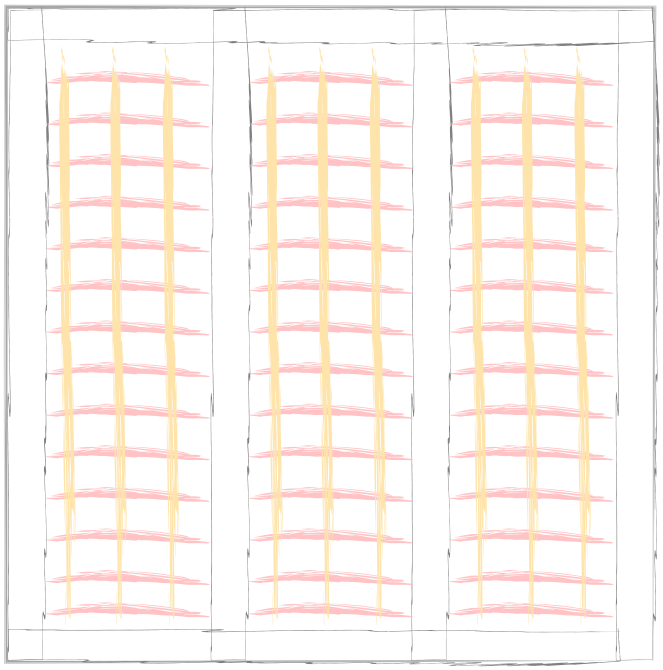
Once there are not many obstacles on the path of air crossing from one opening to the other, the change of the air is successful. That is not the case in many occasions also taking into consideration that the human factor is not included. Once there are two or more people in a room around fifty square meters, the airflow might differ if people are moving around considerably or not.
In most of the cases there is the presence of separation wall or in our case: of furniture that catches the swirling of the air, called vortex. That is the reason the module is design like a quarter of a circle with a diameter of 500mm.

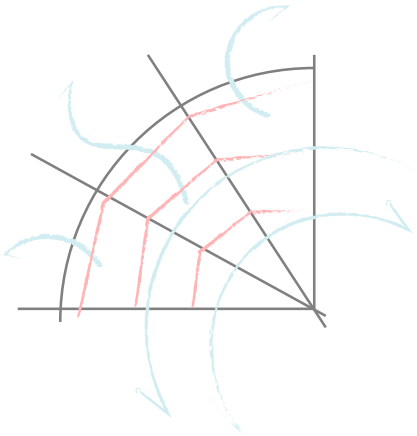
5.1.1

Sketches were necesarry to understand the shape of the design.

The presence of vortex when air can not pass through an object.

Elevation view of the panels





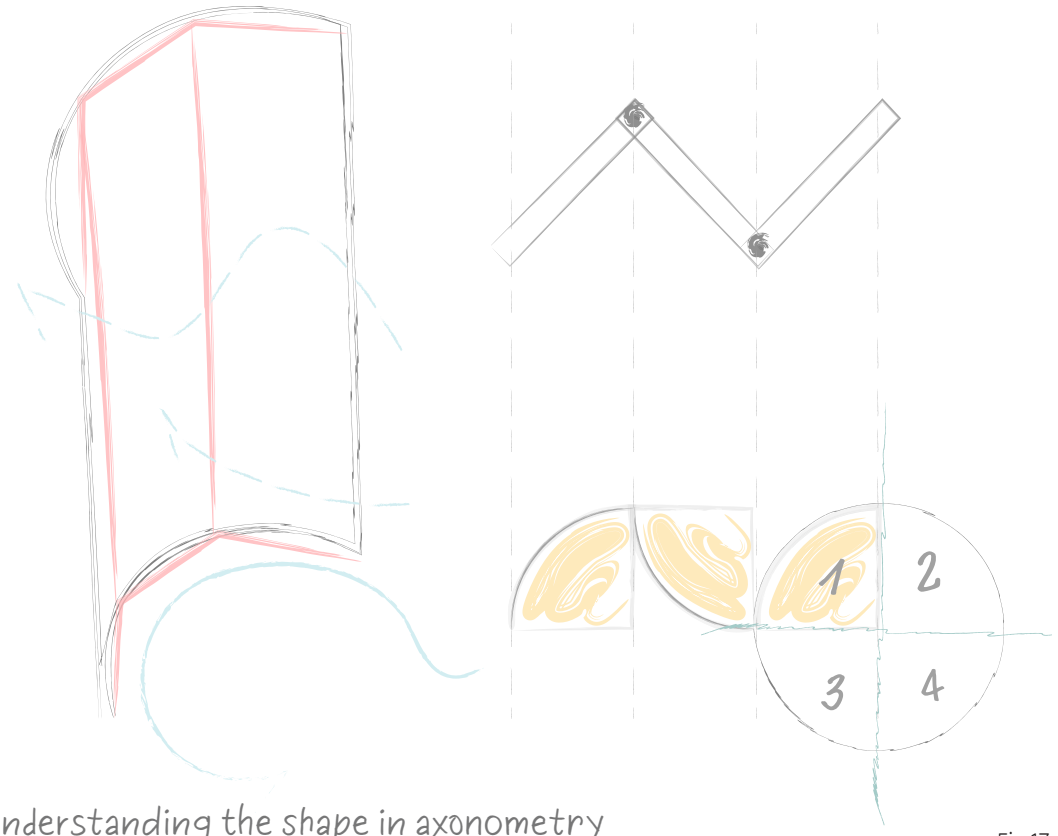
Planview of one panel

Fig.17.

Circular shape can prevent this detail however, the functionality of the self-standing panel will be better realised if the shape is part of a circle, not a whole one.

5.1.1

Moreover, the design is modular and ceparating a circle into four equal parts and then repeating them one after another, gives the oportunity for endless continuity.



Understanding the shape in axonometry

Fig.17.

5.1.2 Weaving Technique

Plaiting is a technique where the elements go over and under each other from two elements up until nine. As the PolRe has three different sizes it gives the opportunity to apply six different patterns. In the case of this project, all of them but one are suitable because the final result is creating a curved plane from one color and finally adding a colored element that combines all of the single panels together into a interior wall or partition system. [8]

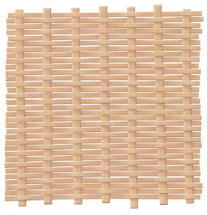
Taking bamboo weaving as an example there are many options to be concidered, a great deal of opportunities, however PolRe has taken only six into concideration taking in mind thr functionality of the final product.

In this case the weaving will be with 2 axis, square or mat plating so the shape of the frame ca be followed at the most efficinet way.

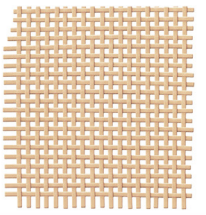
Plaiting Techniques:

'Plaiting is a basketry term used to indicate the interlacing of at least two sets of elements, Orientated in different directions'

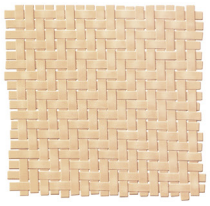
To recreate The work of the Japanese masters, a basic understanding was required of the different plaiting techniques used in the basket construction. The following images look into a variety of different ways that bamboo can be woven to create different aesthetic effects.



Mat Plaiting: Also known as simple plaiting. One of the most common basketry techniques. Differs from square plaiting in that the horizontal elements are more closely spaced than the vertical elements creating a horizontally faced surface. Often used in basic basketry for simple effects.

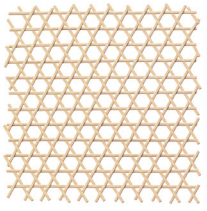


Square Plaiting: Type of simple plaiting whit balanced horizontal and vertical elements. Often results in open work because of the stiffness of the material. Often used for the base or walls of the basket. Variations formed by changing the width of the horizontal or vertical components

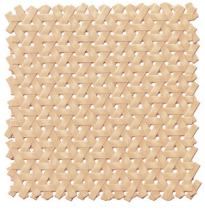


Twill Plaiting: Diagonally orientated technique, where the strips of one direction float over multiple strips of the direction in a regular pattern. Variations are made by changing the orientation or length of the floats, or the width, colour, texture of the strips.

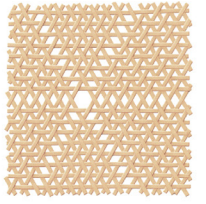
Diamond Twill Plaiting: Variation of the Twill Plaiting. Often used at the centre of the basket base. Called 'Floral Twill Plaiting' when used as a repeated design over a lager area. Same variations to the design apply by changing colour, width, of number of floats.



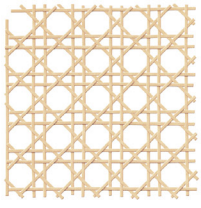
Hexagonal Plaiting: Open-work pattern of hexagonal cells, each individually formed from six strips. Also the foundation for techniques such as hemp leaf plaiting and clematis plaiting. The pattern often forms the decorative walls for the flower baskets with differing pattern variations.



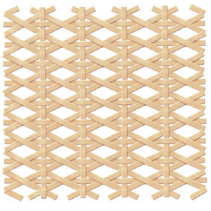
Clematis Plaiting: Variation on hexagonal plaiting, initiated by pressing the six strips of a hexagonal cell together tightly, creating a radiant, almost floral arrangement, hence the name. Relatively opaque surfaces are formed practical for basket bases or trays.



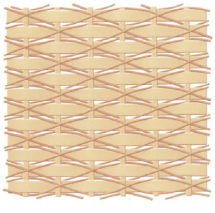
Hemp Leaf Plaiting: Triangular pattern incorporating three extra strips into each cell of the basic hexagonal plaiting. Plaiting in six different directions from a central hexagonal cell results in a hexagonal star design know as a 'hemp leaf' pattern in Japan.



Octagonal Plaiting: Open work pattern of octagonal cells each formed from eight strips - four creating a square pattern and four creating a lozenze pattern. As the plaiting proceeds, each of the strips goes over one strip, and then under the next creating the weaving effect.

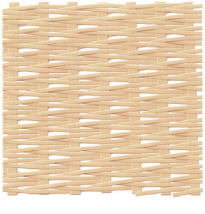


Compound Lozenge Plaiting: Diagonally orientated square plaiting, supplemented with vertical and horizontal elements. Commonly seen in Western Japan, where horizontal strips are often replaced with strips of twining. Employed in the walls of many baskets due to structural rigidity.



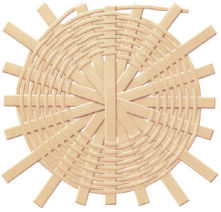
Plover Plaiting: Type of simple plaiting in which each row is supplemented by two fine strips that undulate and cross one another as they zigzag above and below the horizontal strips. Creates delicate crosses resembling tiny bird tracks on the sand, hence the name.

Twining: Literally 'rope plaiting'. Fine strips - often three or four - are alternatively lifted up and around the others and inserted into vertical elements in a staggered twill pattern. Distinctive diagonal rope like effect, The result is a very stable structure, suitable for openwork.

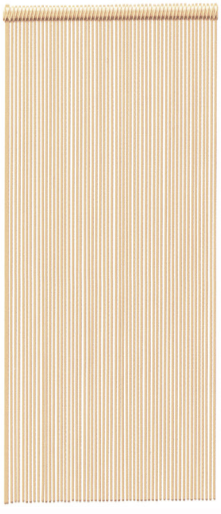


Pine Needle Plaiting: A gentle variation on twining using three horizontal elements in a 2-1 till. Y - like arrangement reminiscent of pine needles created by changing orientation of pattern in alternative rows. Called 'wave plaiting' when the same orientation is used for every row.

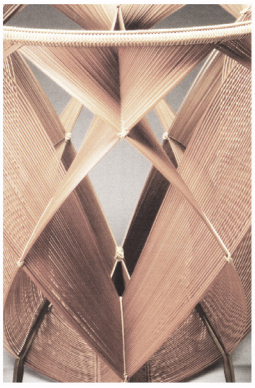
Chrysanthemum Base Plaiting: Base constructed by layering strips in a radial arrangement and plaiting (usually Mat plaiting or Twining) around them in a spiral pattern. Common on baskets dating from the 1800's top the early 1900's, especially from western Japan.



Circular Plaiting: Sometimes translated as 'Bull's eye plaiting' or 'snake eye' plaiting-strips of Bamboo are arranged tangentially to create a circular opening. Most frequently used to form a ring at the baskets base, but can also be used to finish the rim.



Thousand Line Construction:
Technique employed by Shono Shounsai of the *'Shimmering of Heated Air'*. -whilst technically not a plaiting techniques. Involving not the interlacing of various elements, but aligning stiff elements in a parallel direction and securing them using any variety of methods. This is also know as parallel construction.



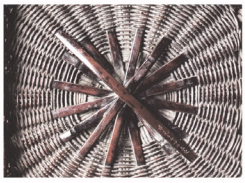


Fig.18.

5.1

Different knitting techniques used by PolRe in the fabrication of furniture and fashion objects.

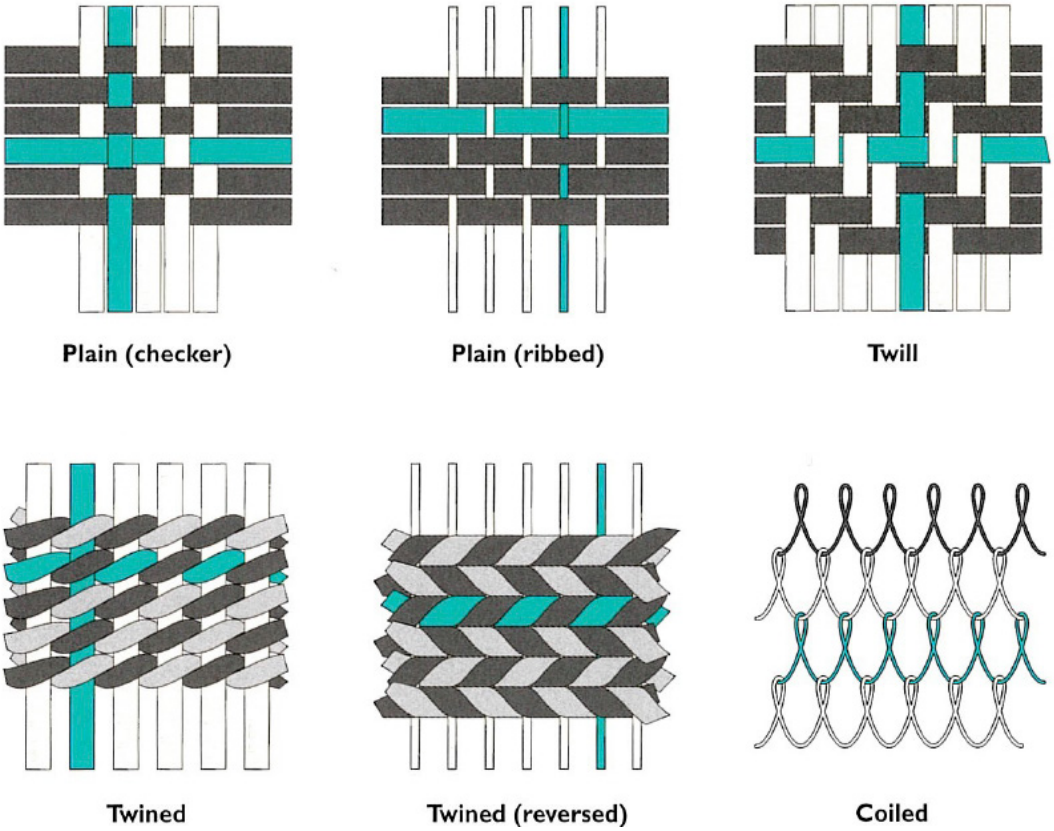


Fig.19.

5.1

Feeling the materiality of PolRe and understanding the best suitable knitting technique for the purpose of the project.

Fig.20.

5.1.3 Design and Dimensions

Plan view of the frame

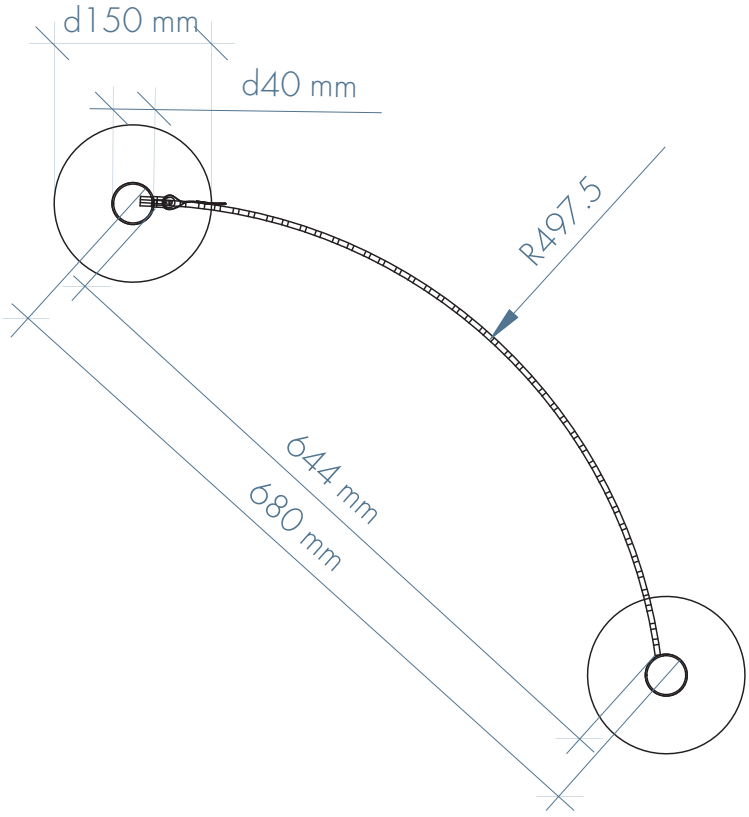


Fig.21.

Elevation of the frame

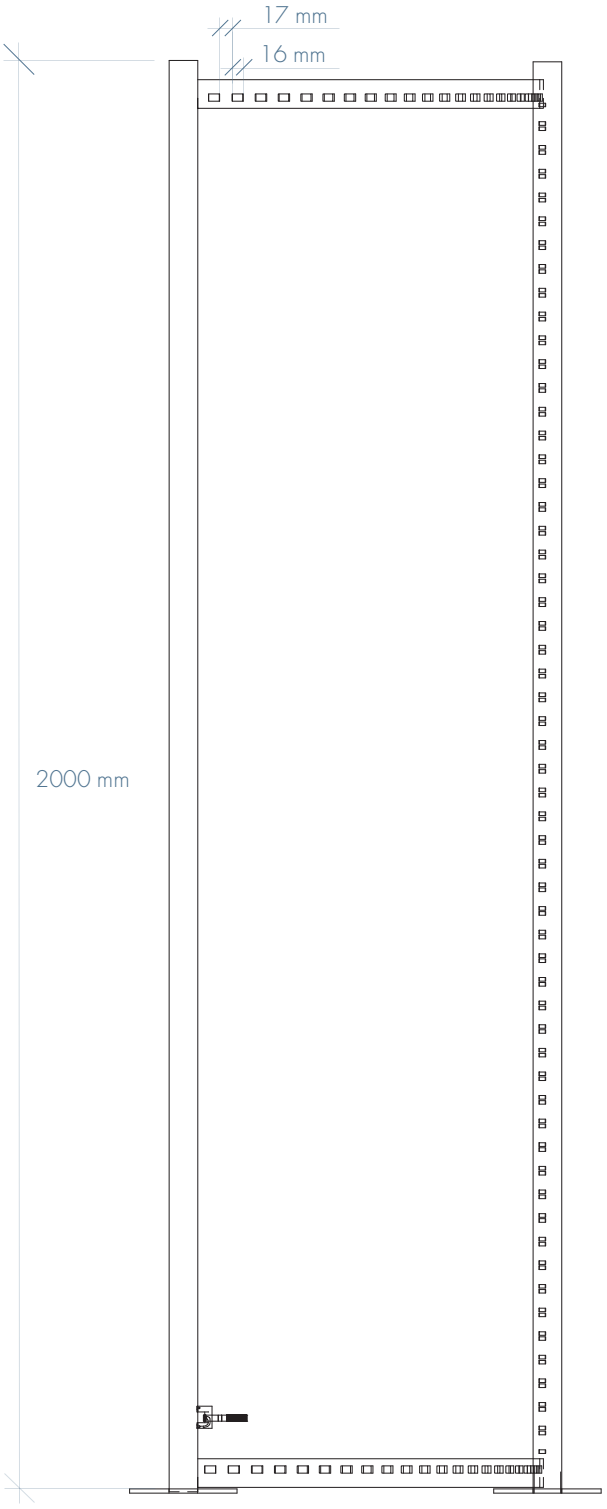


Fig.22.

5.1.3

Detail scale 2:1

Section

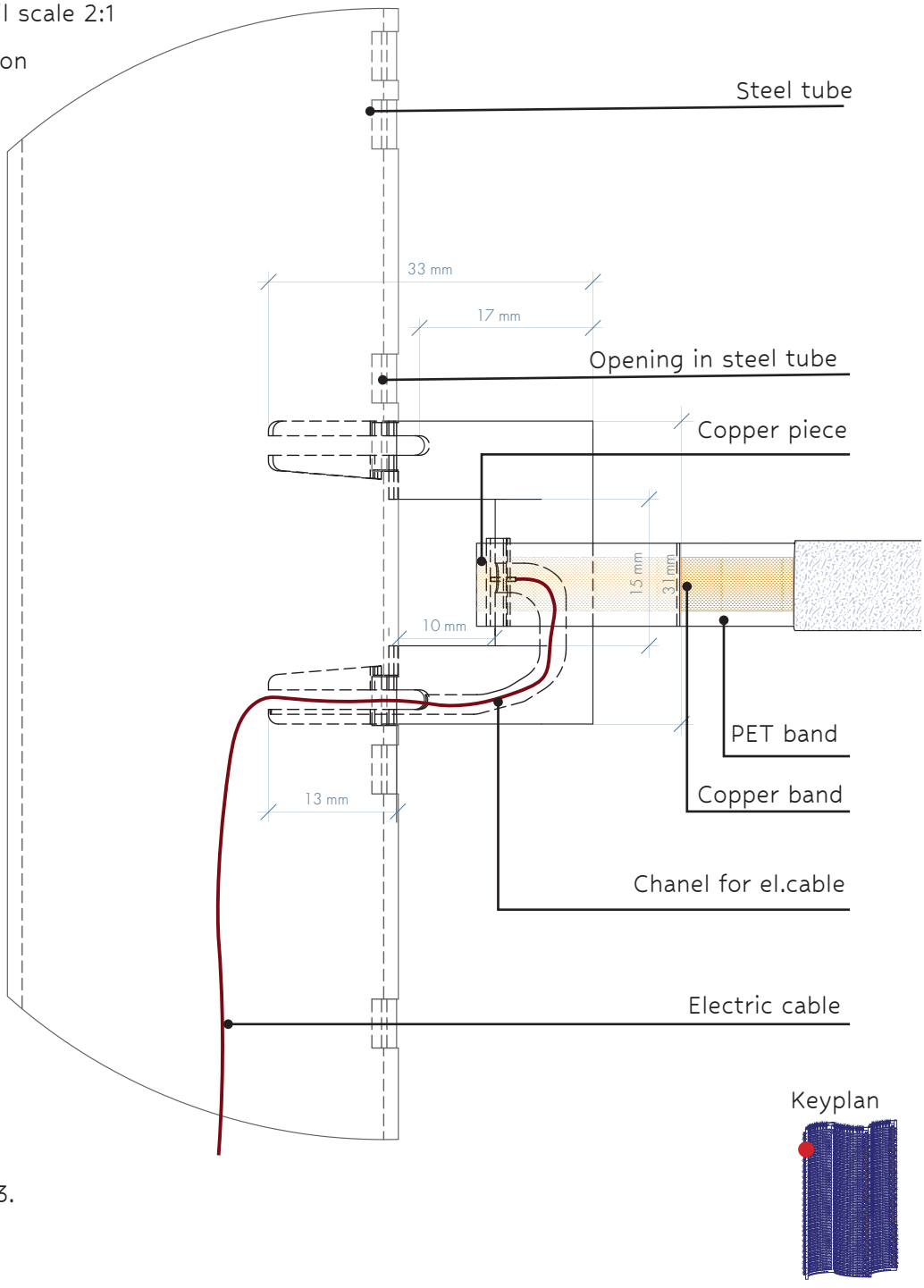
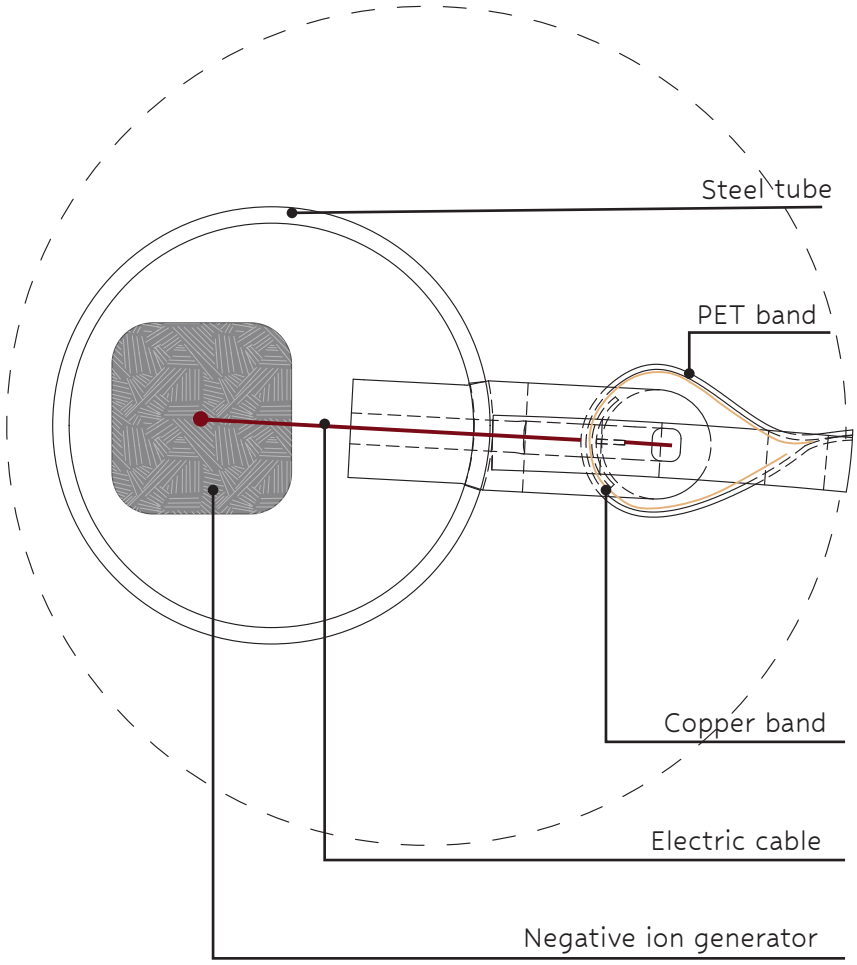


Fig.23.

5.1.3

Detail scale 2:1

Plan



Keyplan

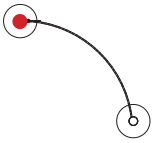


Fig.24.

5.1.3

The selfstanding panel with smart knitted surface is intedned for internal use, mainly for commercial spaces like offices and retail.

Fig.25.

5.1.3

The flexibility of the modular structure gives to oportunity for different lenght of the panel wall.

Fig.26.

5.1.3

Scheme illustrating a home environment

Fig.27.

5.1.3

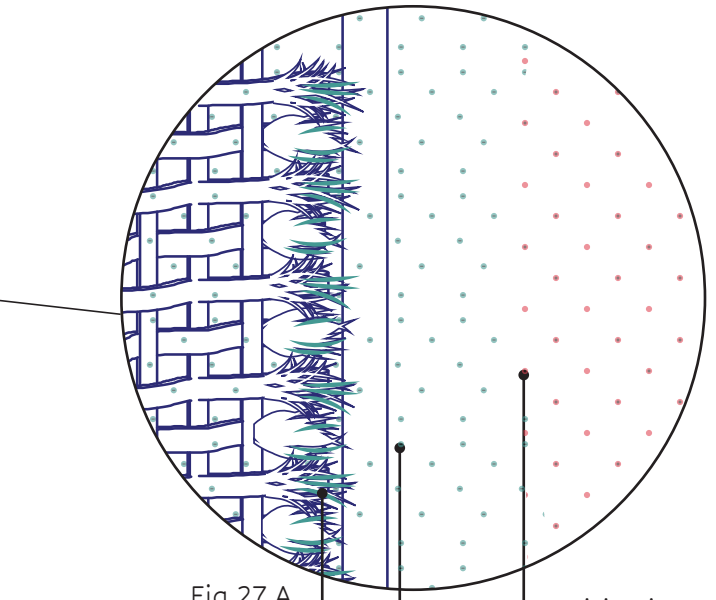


Fig.27.A

Ions are atoms or molecules which are electrically charged. Cations are positively charged and anions carry a negative charge. Ions form when atoms gain or lose electrons. Since electrons are negatively charged, an atom that loses one or more electrons will become positively charged; an atom that gains one or more electrons becomes negatively charged.[27]

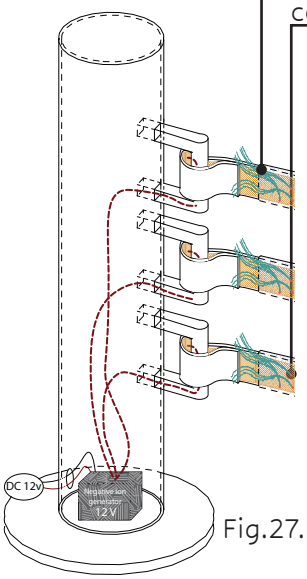


Fig.27.B

The electricity flows from the electrical socketh, through the negative ion generator. From there each generator has four wires that extend and make contact wit the copper band, attachedd to the plastic PET band.

The carbon fibers,intertwined with the polyester of the PET band recieve electrical charge and produce

5.1.4

5.1.4 Details of realisation

The realization took part in several steps, producing three separate elements and then combining them. The first step was producing the steel frame, including laser cut holes.

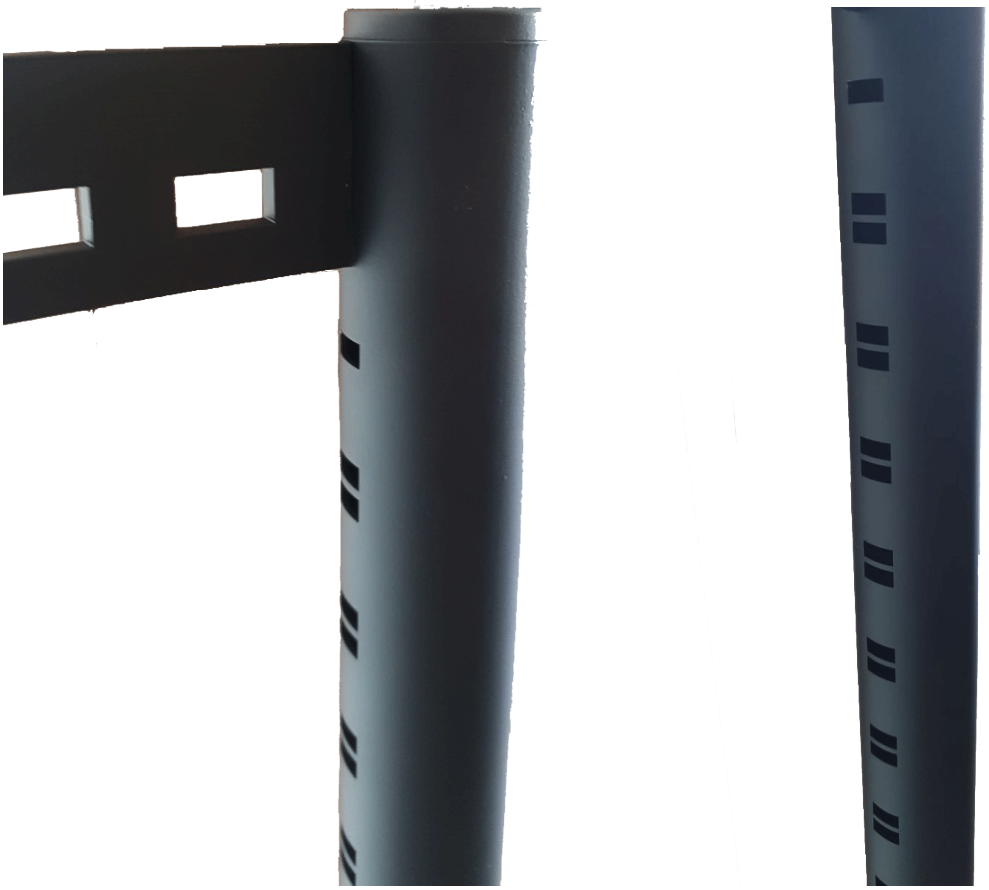


Fig.28.

5.1.4

After comes step two, which is designing elements to hold the PolRe to the frame. Inserting in the electricity is the main goal in order for the carbon fiber to get activated and produce negative ions..

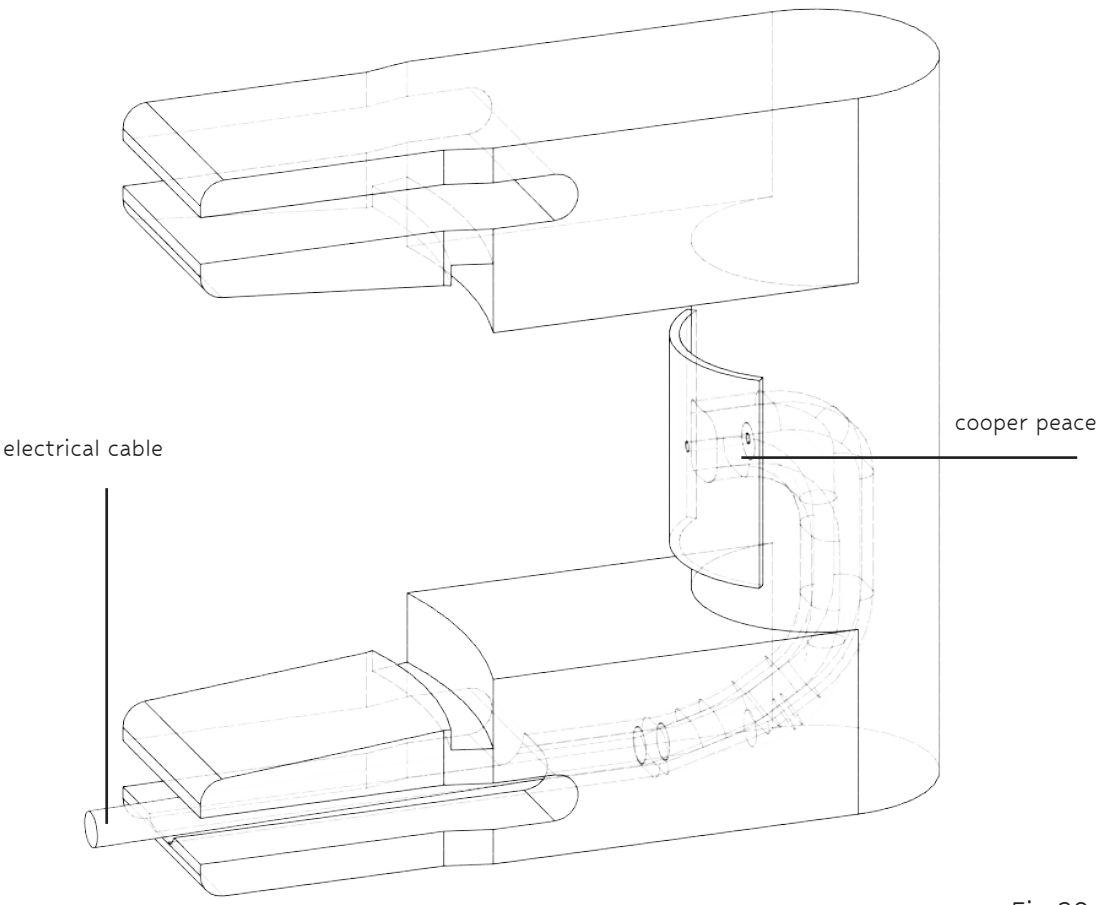


Fig.29.

5.1.4

The piece has been designed on Fusion 360 in order for it to be 3D printed to achieve the most precise results.

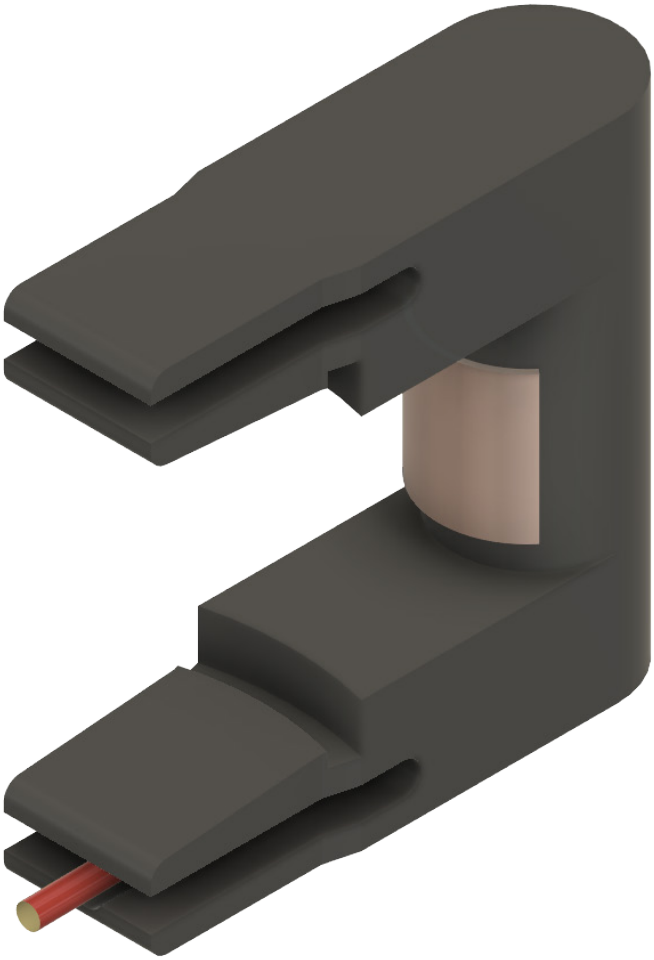


Fig.30.

5.1.4

It has a canal in order for the cable to pass through the interior, considering safety and isolation, and it is being soldered to a copper piece so it can make contact with the PET element in PolRe.

The stages in putting this piece together:

Aquiring a copper sheet in prder for the pieces to be cut out precisely matching the element

Fig.31.

Cutting them with a scissor for steel.

Fig.32.

5.1.4

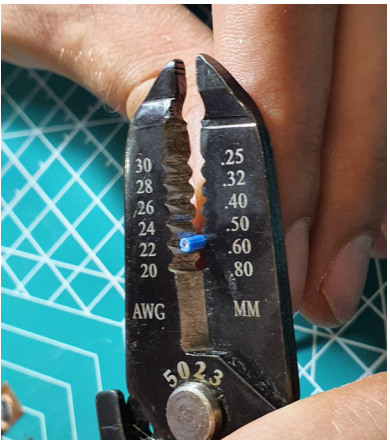
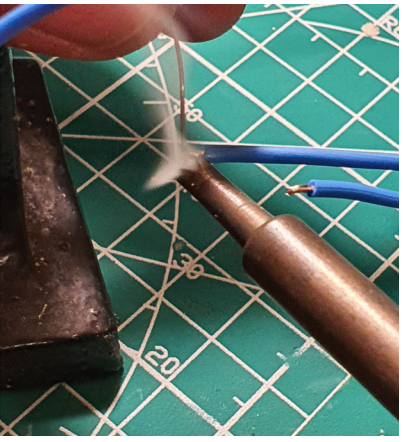


Fig.33.

Adding melted solder to the naked tops of the cable



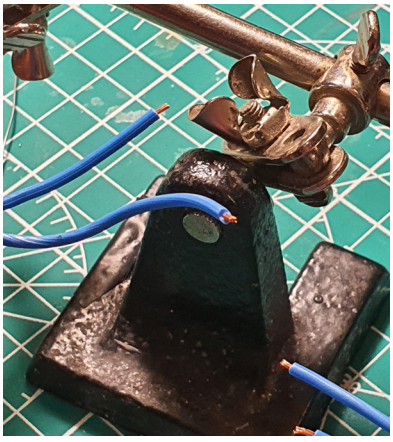


Fig.34.

Preparing the wire by firstly
baring it from the cable

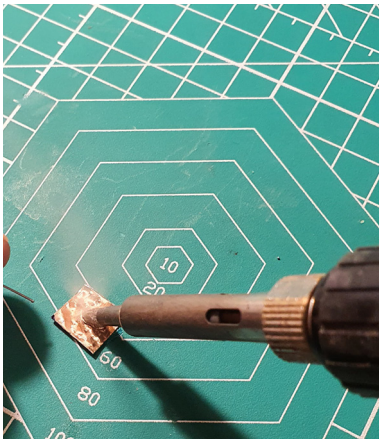
5.1.4

a

b

(a) Adding melted solder to the copper plate

(b) Soldering the wire to the copper plate



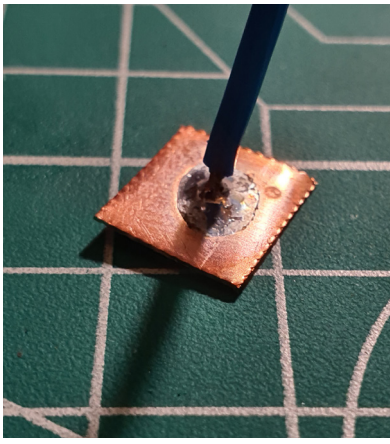


Fig.35.

Lastly the cable is being put manualy through the plastic piece.

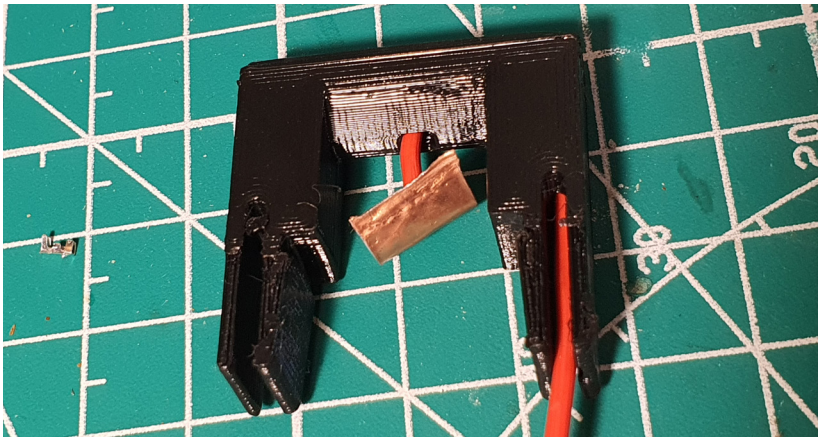
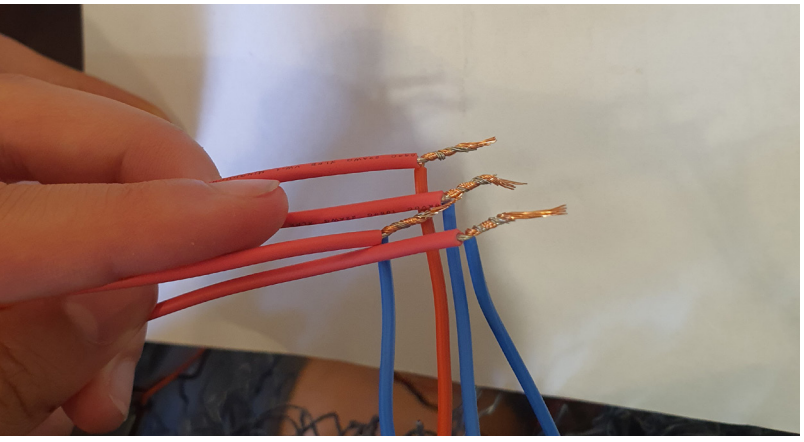


Fig.36.

5.1.4

In order to be sure, electricity will flow through the wire into the copper piece and then make contact with the copper produced on one side of the PolRe.The conductivity of commercial hard-drawn copper can vary. However, the highest conductivity and lowest resistivity are 0.15386 ohms per meter-gram at twenty degrees Celsius, and the percent conductivity is 99.46 percent.[16]

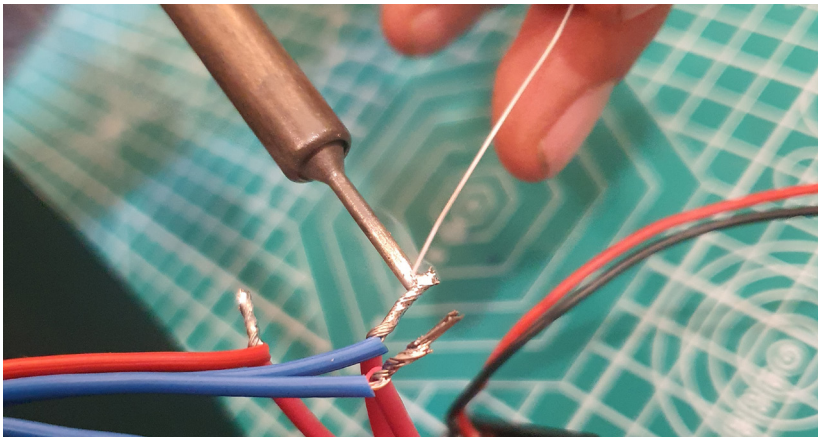
Fig.37.



5.1.4

In order for the whole system to be connected to the generators and after to electricity, the cables comming out from the generator are attached to the ones connected to the PolRe.

Fig.38.



5.1.4

PolRe was modified by the producers. Both components has additional material to them in order for the generation of ions to be realized.

Firstly, carbon roving of 20 000 fibers was knitted with pyester fiber into the covering rope. The rope is made out or 36 dundles of polyester fiber, 10 of which are substituted eith the carbon roving.

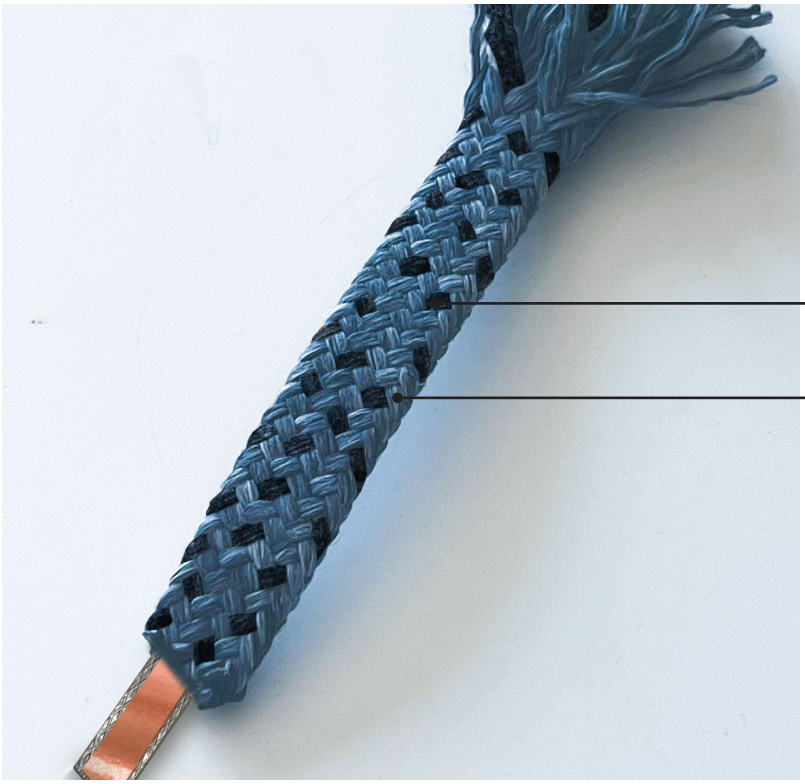


Fig.39.

5.1.4

The Pet band inside the polyester cover was also modified. On one side a copper strip was glued in order for the carbon fibers to recieve electricity from the plastic piece.

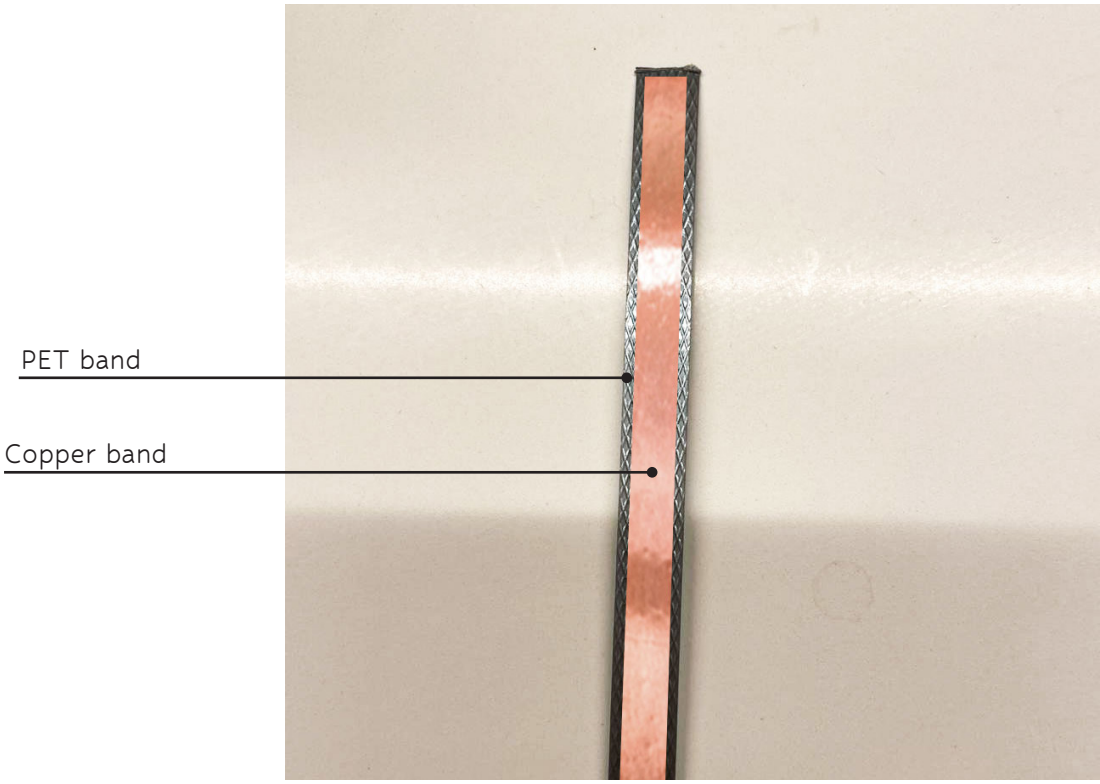


Fig.40.

5.1.3

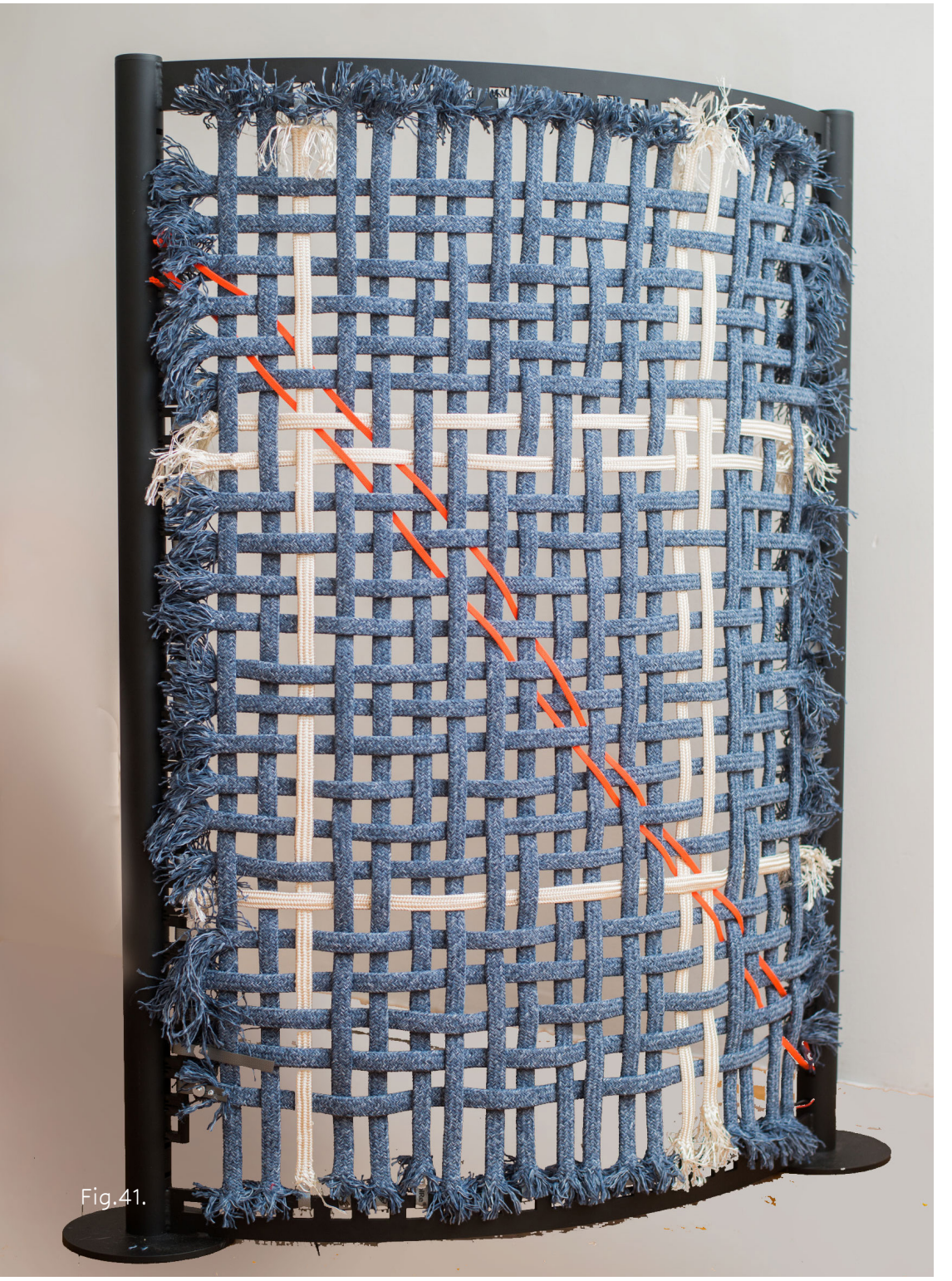


Fig.41.

5.1.3

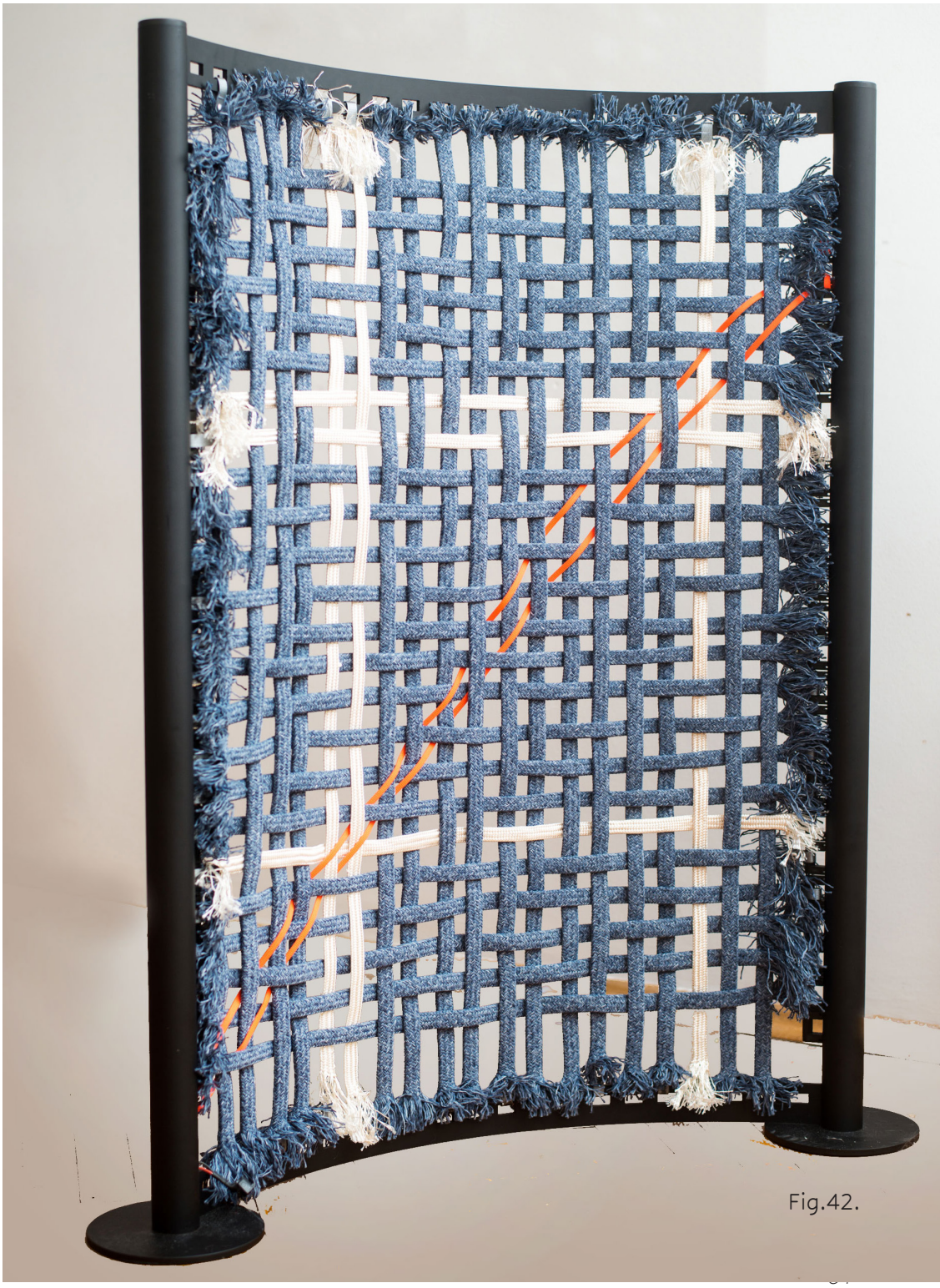


Fig.42.

5.1.3

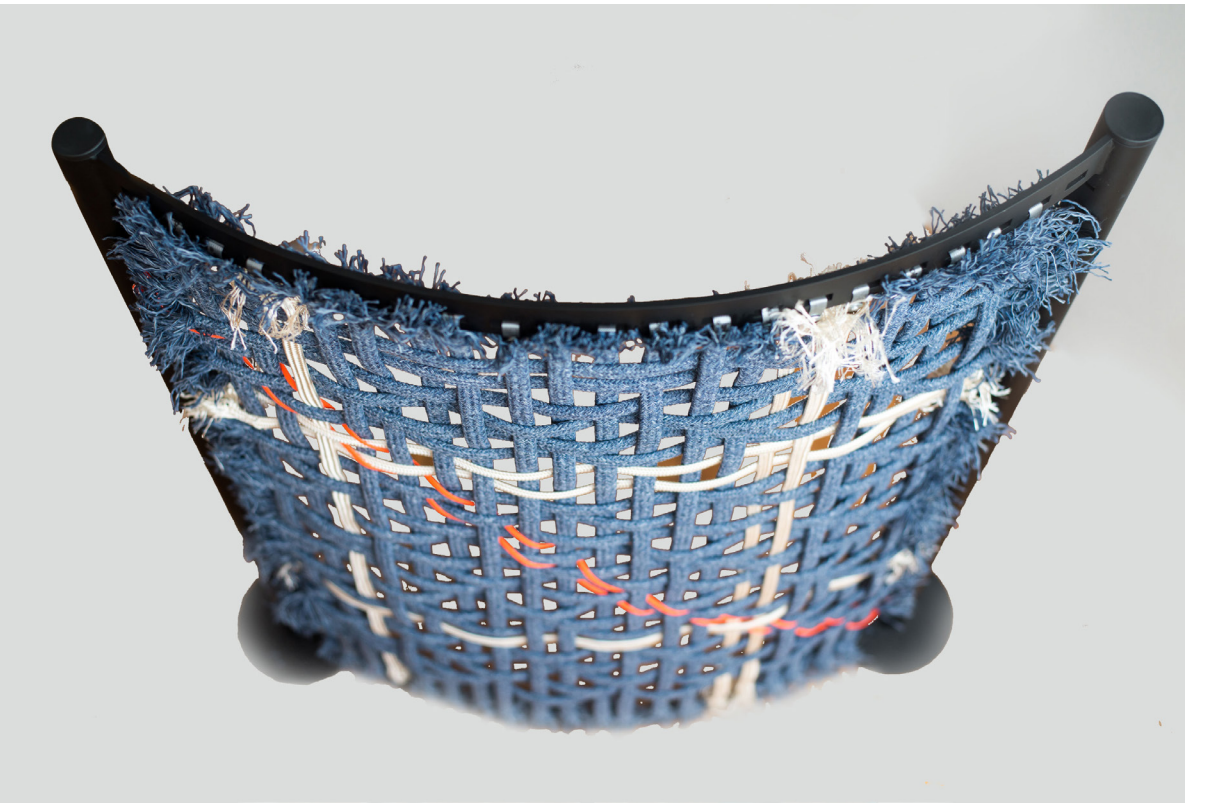


Fig.43.

5.1.3

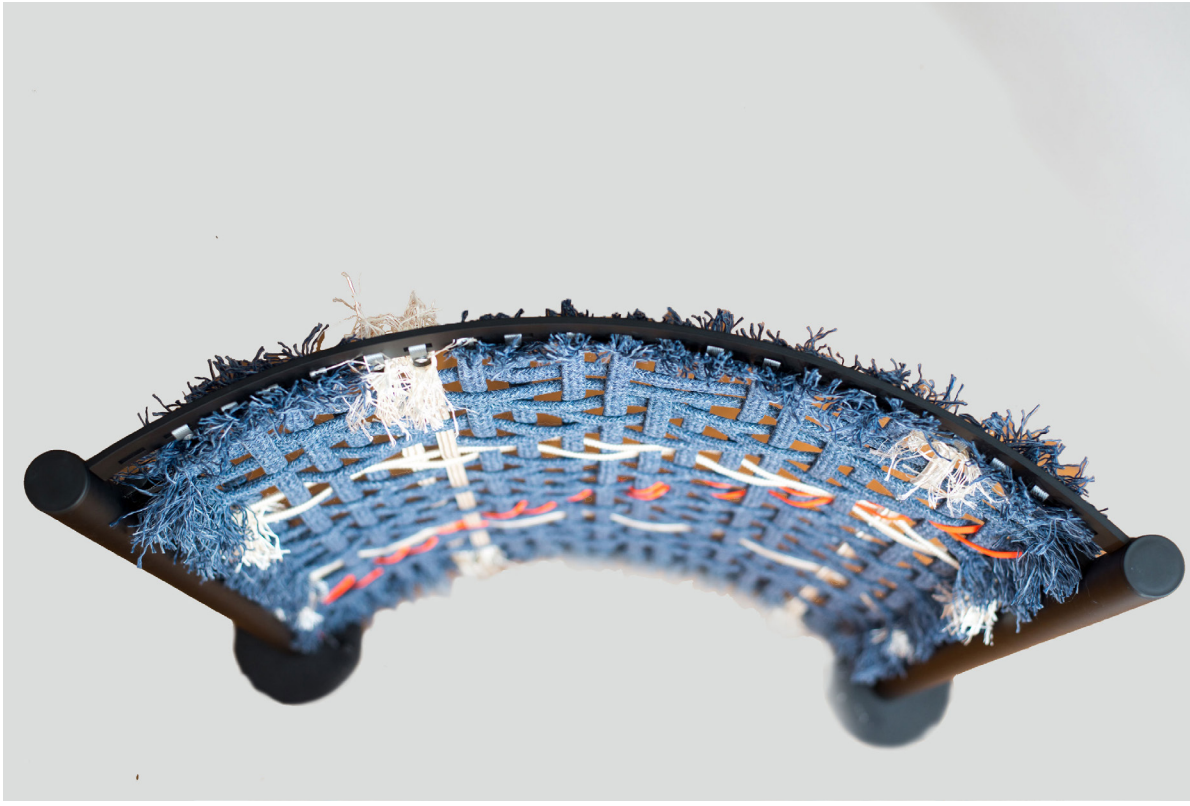


Fig.44.

5.1.3

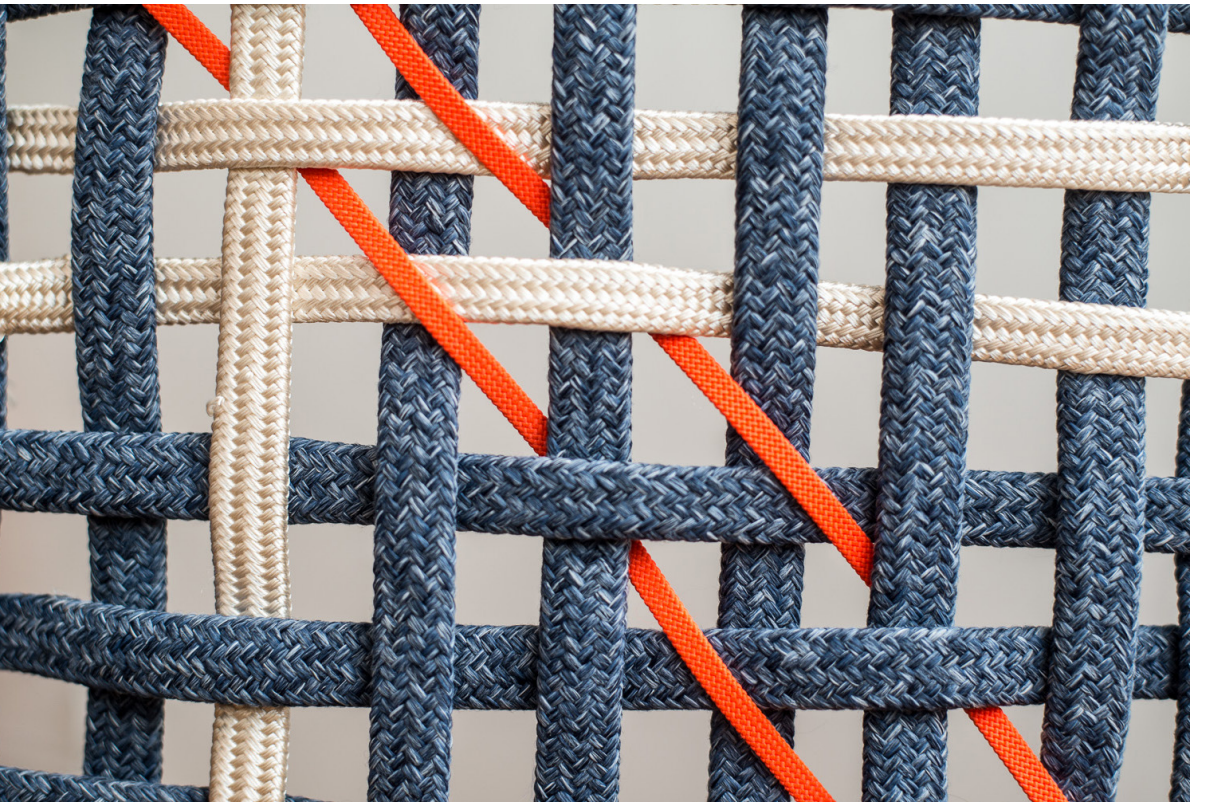
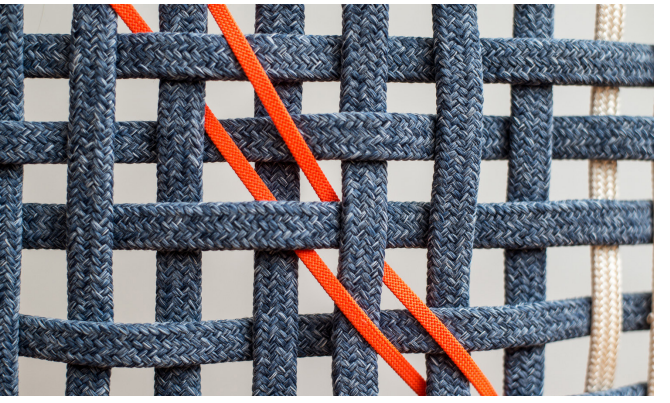


Fig.45.

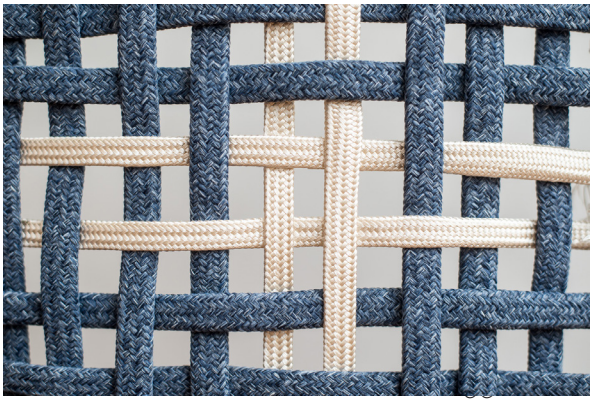


The pattern of the knit is chosen to be the most simplified one. The material has a particular strenght in the pattern and size that the simplicity of the knit underlines

5.1.3

Fig.46.

The color combination consists of three colors. Main one - blue, and two complimentary colours - white and orange. Since all of the polyester covers are with different roughness, the blue contrast with the white and the orange finishes the composition



6.1 Results

In order to evaluate of the project works properly an experiment has been done. It includes a particulate matter sensor for air quality monitoring and control SPS30

Fig.47.

6.1

"Product Summary
The SPS30 Particulate Matter (PM) sensor is a technological breakthrough in optical PM sensors. Its measurement principle is based on laser scattering and makes use of Sensirion's innovative contamination-resistance technology. This technology, together with high-quality and long-lasting components, enables precise measurements from its first operation and throughout its lifetime of more than ten years. In addition, Sensirion's advanced algorithms provide superior precision for different PM types and higher-resolution particle size binning, opening up new possibilities for the detection of different sorts of environmental dust and other particles. With dimensions of only 41 x 41 x 12 mm3, it is also the perfect solution for applications where size is of paramount importance, such as wall-mounted or compact air quality devices." [17]

6.1

Most particulate matter (abbreviated ‘PM’) is microscopic and inhalable. Some examples are:Mold spores, Dust,
Smoke, Pollen, Soot and Dirt[25]
Particulate matter can include organic matter, like dander and spores, and inorganic matter, like dust. While other pollutants are identified through chemical makeup, PM is an umbrella term for all airborne particles, regardless of molecular composition. Scientists and researchers use size to categorize PM, as different sizes of particulate matter prompt different physiological reactions[25].
The difference between PM2.5 and PM10 is size. PM10 and PM2.5 are both forms of particulate matter, but the difference in aerodynamic diameters comes into play when discussing the health effects of particle pollution exposure[25].

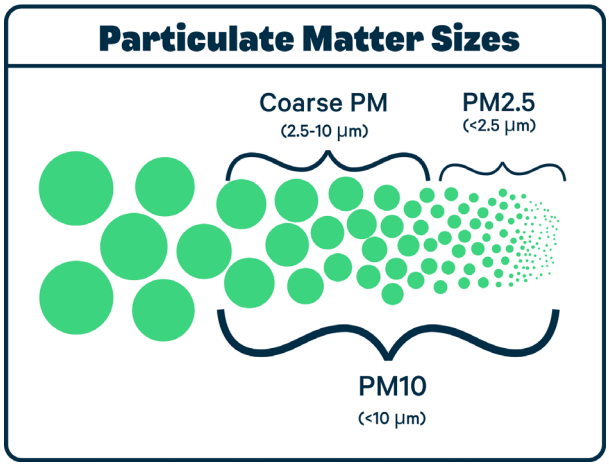


Fig.48. This scheme illustrates the approximate size of the prticle matter and the difference in size[25].

6.1

Folowing the example of an experiment held in much more scientific habitat, this experiment can be identified as a more simplifies version done in home environment.

The professional experiment has been held in Department of Environmental and Forestry Machinery, Faculty of Environmental and Technology Manufacturing, Technical University in Zvolen, Slovak Republic. [18]

Experimental measurements were performed in two rooms – a control room (CR) and a measuring room (MR).
The control room was completely isolated from the measuring room so that no influencing of results in the measuring room can occur while persons move in the control room. The scheme of experimental device placement in the control room (CR) and the measurement room (MR) is shown in Fig.1 [18]
The measuring room, in which the experiments took place, was on the ground floor. The outer walls were constructed from bricks. The room had tiled walls, a tiled floor, and a plastered ceiling. The room temperature was 20 °C (±1 °C) in all of the measuring tests. The room dimensions were 5200×4900×2900 mm (l×w×h). The distances of the air-technical elements from the ceiling and the location of the measuring devices, including the cigarette smoke inlet, are provided in Fig.1. [18].

6.1

The "smoke wire" method was used to visualize the air flow direction from the inlets in the measuring room; its principle has been described in the literature [24].

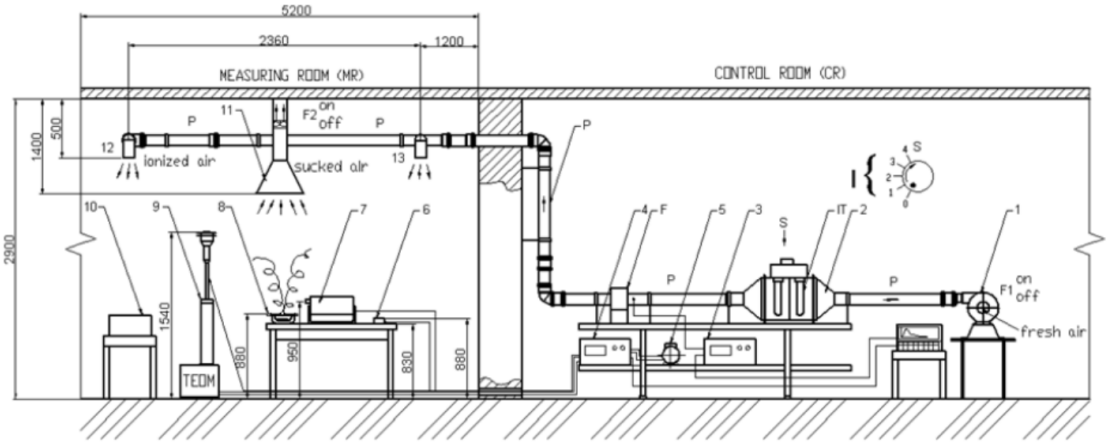


Fig.49. Diagram of the location of the experimental devices in the measuring room (MR) and the control room (CR) 1 – fan F1, 2 – air-technical piping with ionizer DEZOSTER, 3 – Ozone Analyzer, 4 – control unit of the TEOM 1400a dust-measuring apparatus, 5 – pump of the dust-measuring apparatus, 6 – sensor for measuring the humidity, temperature, and O3 concentration in the room, 7 – ion-measuring unit, Ion Counter IC 2000, 8 – cigarette smoke source, 9 –TEOM 1400a dust-measuring apparatus, 10 – humidifier Solac HU 1050, 11 – sucking device, 12, 13 – inlets for ionized air, F – textile filter, P – air-technical piping, IT – ionizing tubes [18]

6.1

Measuring tests were performed with the humidity values of 37 % to determine the PM10 concentration and the amount of negative and positive ions in the measuring room (Fig.47.) resulting from the cigarette smoke. As a cigarette smoke source, four cigarettes (cigarette length was 80 mm) were allowed to passively burn, and their burning period was approximately 15 min.[18]

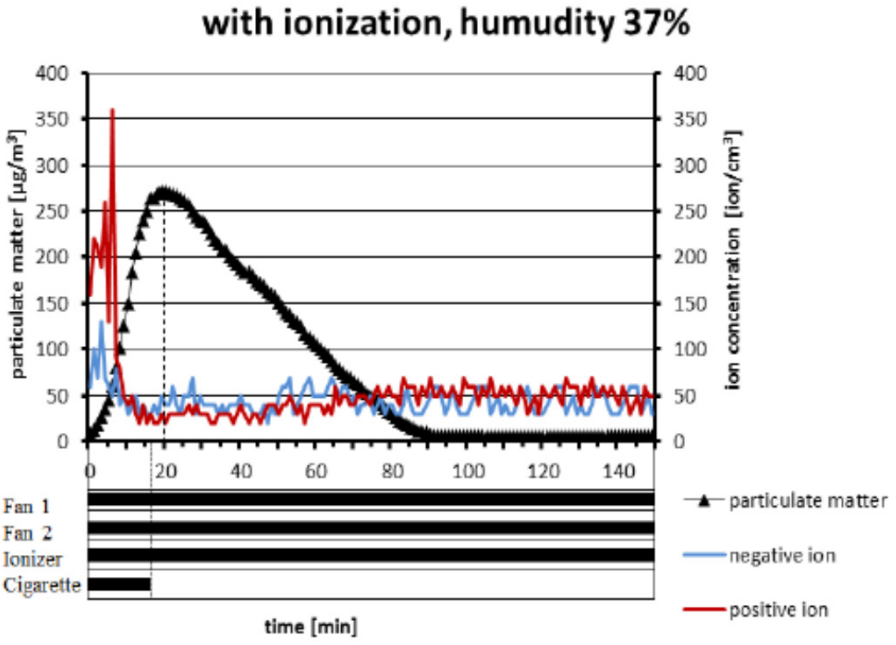


Fig.50. Measurement graph No. 4 for dust particles PM10 and number of negative and positive ions (with ionization, humidity = 37 %, distance of lit cigarettes from ionized air inlet 3 m)[18].

In Fig.4. the cleaning ionization was turned on and the relative humidity was in both Fig.2 and Fig.3. 37%.

Comparing the two graphs with the same confditions the difference is in the nu,ber of negative ions.

In Fig.48. The amount of negative ions increased from 240 to 400 ions/cm3 during the cigarette burning. When the burning process was over, the amount of negative ions decreased to 280 ions/cm3. The amount of positive ions increased from 200 to 250 ions/cm3[18].

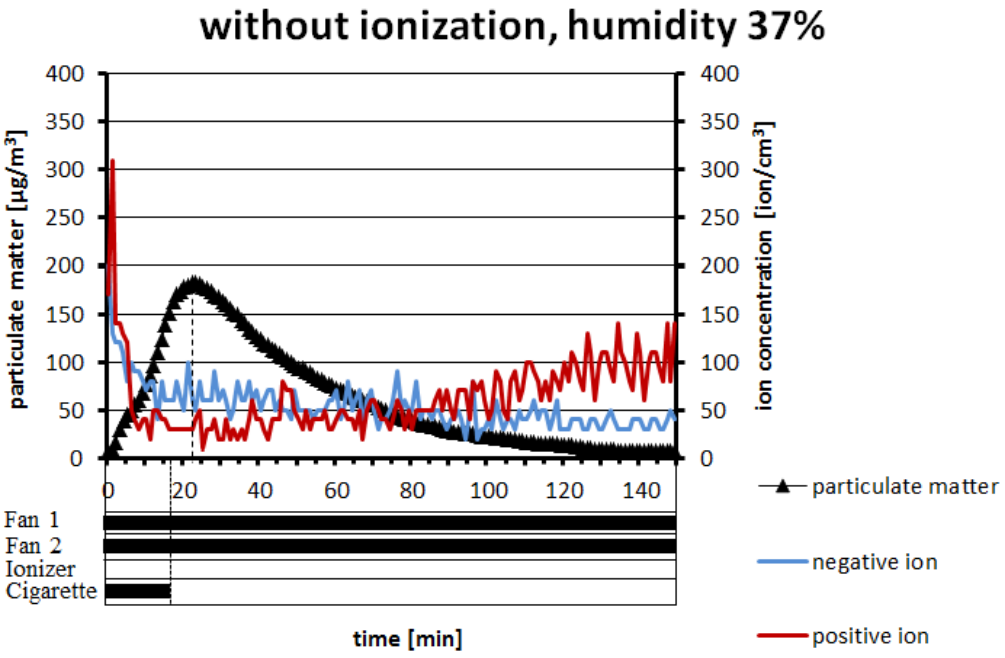


Fig.51. Measurement graph No. 3 for dust particles PM10 and number of negative and positive ions (without ionization, humidity = 37 %, distance of lit cigarettes from ionized air inlet 3 m)[18].

6.1

Whilest in Fig.49. the concentration of negative ion values tended to decrease due to the decreased humidity, reaching the concentration of 50-90 ions/cm3. The concentration of positive ions tended to increase, reaching the final concentration of 50 to 150 ions/cm3[18].

In the experiment in the home environment, the mechanisms were much more simplified. However, an SPS30 particulate matter sensor is used for air quality monitoring and control (as previously explained)in a room of 18.2m3 (260cmx280cmx250). Inside was also the self-standing panel with the smart knitted surface with two persons.
In the first situation, the SPS30 was working while a short, 60mm cigarette was smoked. The door was closed, waiting for the air to get ventilated by itself.
In the second situation, the factors were the same, with the difference that the interior selfstanding panel was switched on(electricity was running through the negative ion generators in the copper band of the Pet element in PolRe and giving electricity to the carbon fibers in the rope covering it).
The results are observed and documentedd using Exel tables.

6.1

Particle matter diagramm

Experiment N1

Number concentration (NC) PM2.5

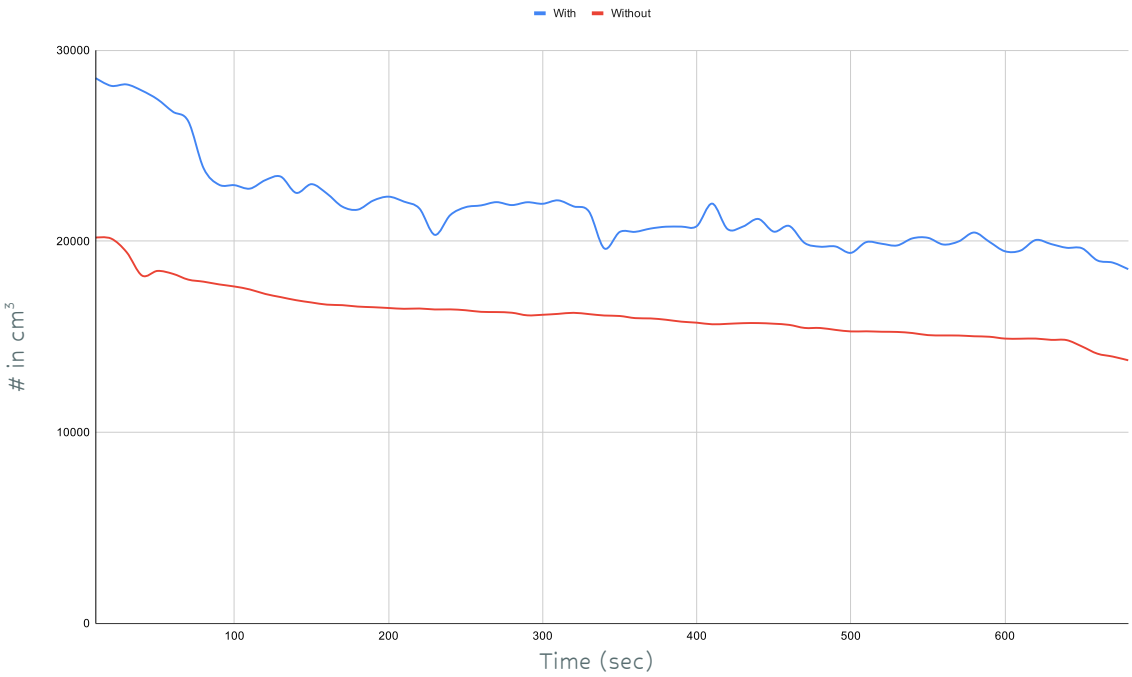


Fig.52. Illustrates the two situations tested in the experiment.

Red line/Without - without the smart knitted surface being switched on

Blue line/With - with the SKS (smart knitted surface switched on).

6.1

Taking into concideration the difference in the start and the end of those two curves it can be colcuded that the efficiancy of this experiment can be improved. However, the red line, without the SKS switched on has a steady curve gradualy decresing, as the blue line, with the SKS switched on, has a fuctuating curve. Since better results can be achieved by altering the circumstances, in the second experiment the area was modified.

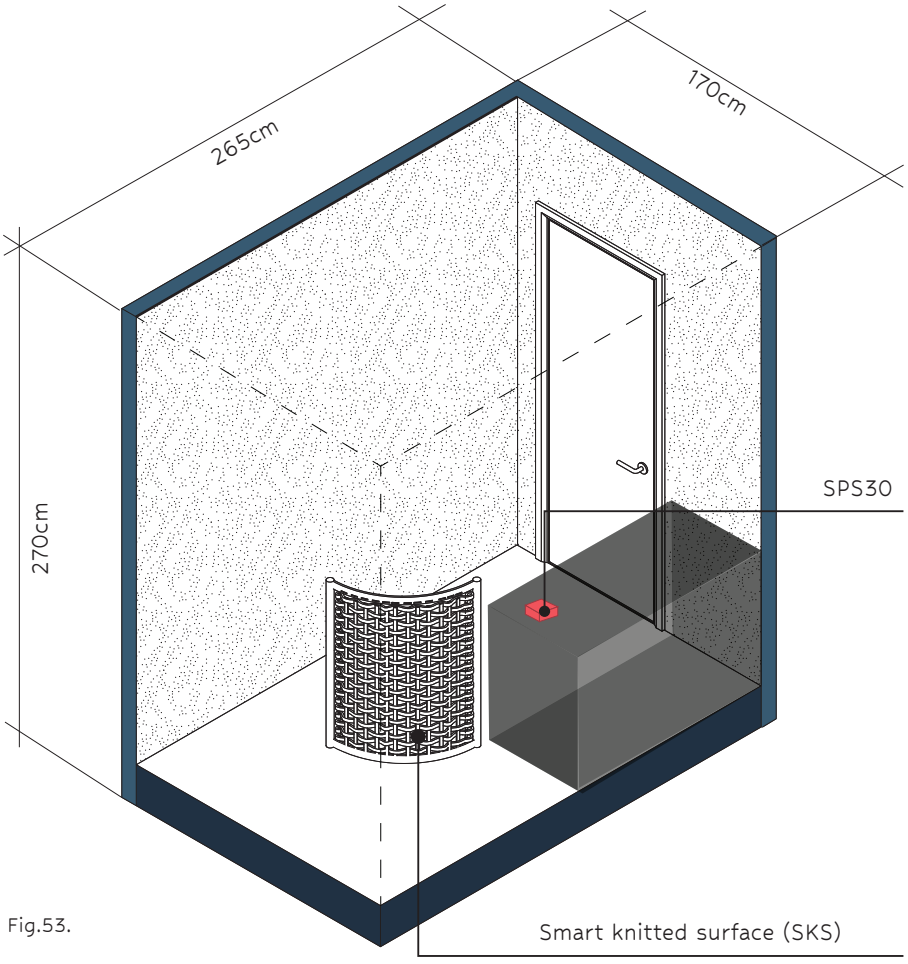
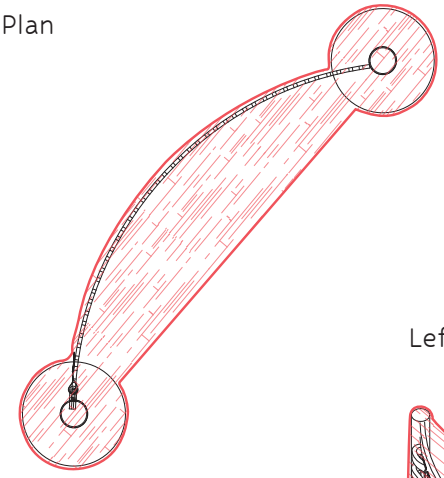


Fig.53.

6.1

Since better results can be achieved by altering the circumstances, in the second experiment the area was modified.
For more cotroled environment, the self-standing panel with smart knitted surface was wrapped with foil. In this way the air circulation is controled without the human factor and the imperfections of the area in the first experiment.

Plan



Foil

Left and right axonometric view

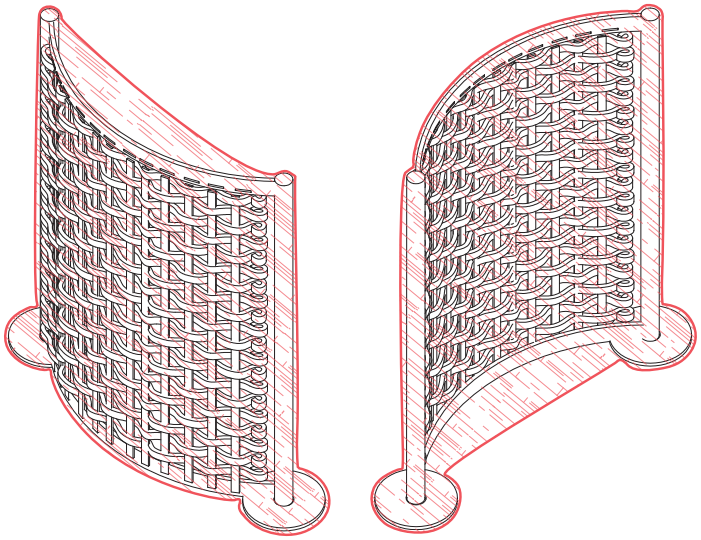


Fig.54.

6.1

Top View Photo

Fig.55.

Front View Photo

Fig.56

Detail View Photo

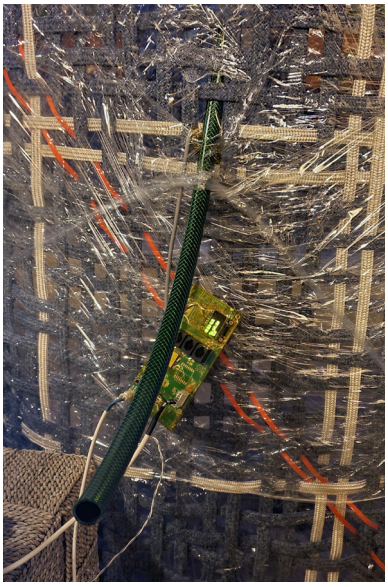


Fig.57.

Back View Photo

Fig.58.

6.1

The area of testing in the second experiment was reduced to minimum and better controled since no air was escaping from the foil.

The first part the SKS was not working and there was pasive smoke from a 60mm cigarette.The test took approximatly eight to ten minutes.

Experiment N2

Number concentration (NC) PM2.5

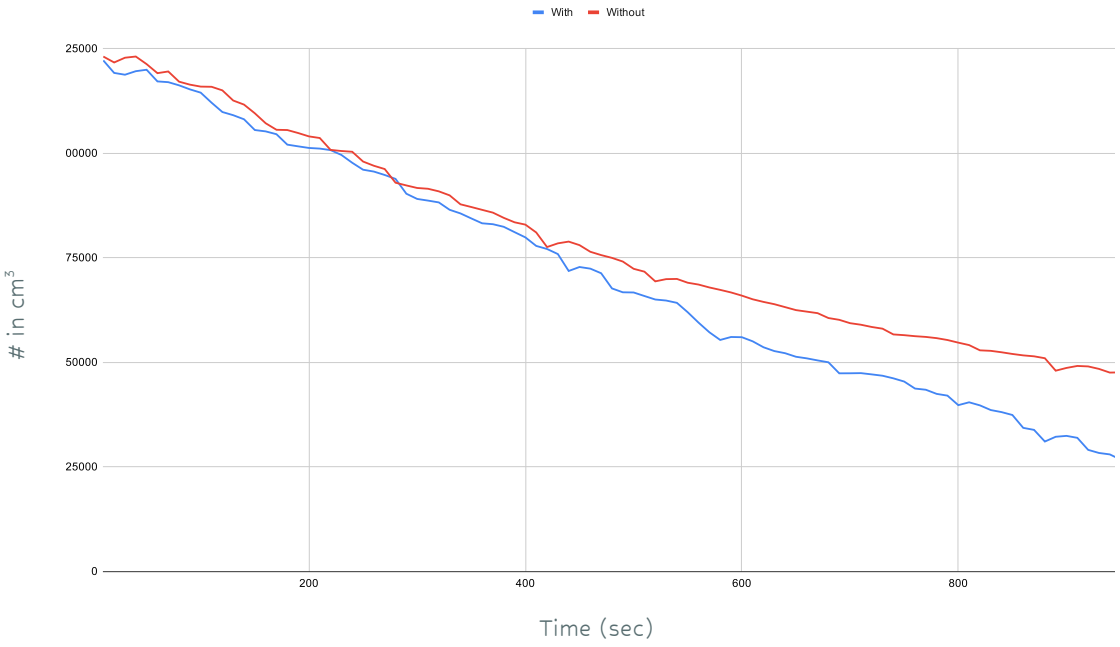


Fig.59.Illustrates the two situations tested in the experiment.

Red line/Without - without the SKS (smart knitted surface) switched on.

Blue line/With - with the SKS (smart knitted surface) switched on.

6.1

As a result the second experiment can be viewed as more
accurate since the impact of external factors was eliminated.
While the SKS was working the purification of the air took less tham in
comparisson when it was not working.
Another difference is the fluctuation of the two curves.
When the SKS was switched off the refinement of the air was steadily increasing,
without any sudden peaks.
Withal the situation when the SKS was working, there
were noticable highs and lows with the difference
approximatly fivehundred number concentration particle matters. They took place
for not more than 0.1/0.6 seconds.

6.1

The area of testing in the second experiment was calculated according to the size of the prototype. A chamber box was created with height of 1500mmx15000x12000mm.

The first part the SKS was not working and there was pasive smoke from a 60mm cigarette.The test took approximatly eight to ten minutes.

The same ciscumstances were applied when the SKS was working.

Experiment N3

Number concentration (NC) PM2.5

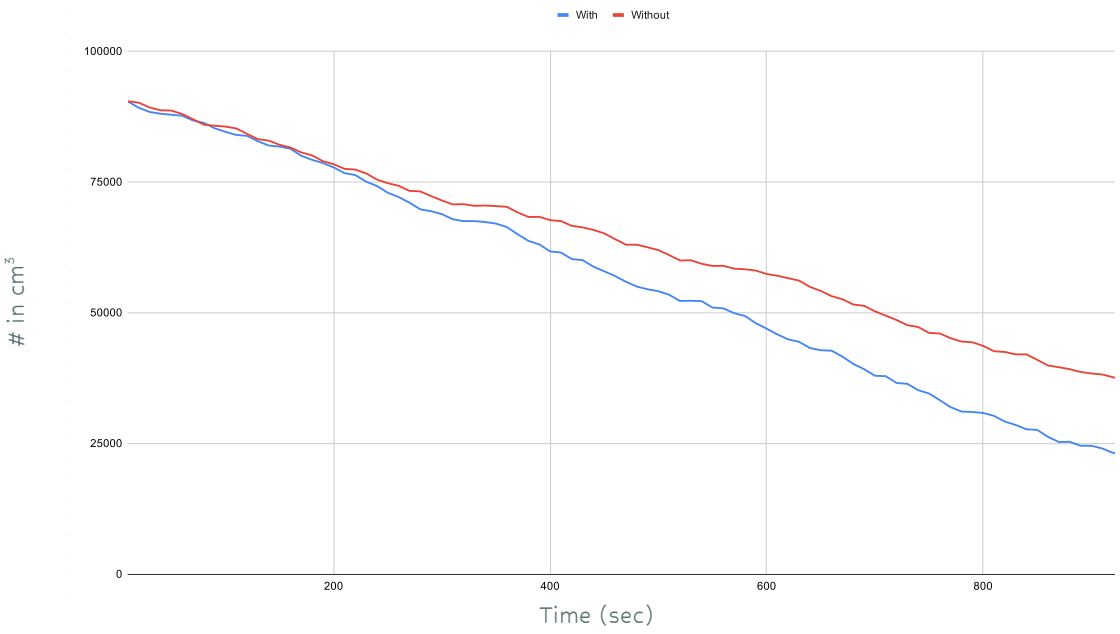


Fig.60.Illustrates the two situations tested in the experiment.

Red line/Without - without the SKS (smart knitted surface) switched on.

Blue line/With - with the SKS (smart knitted surface) switched on.

6.1

Left side with smoke

Fig.61.

Right side without smoke

Fig.62.

Front view without smoke

Fig.63.

Sensor inside the chamber

Fig.64.

6.1

Experiment	Start PM2.5 NC/cm^3	End PM2.5 NC/cm^3	% PM2.5 left (less is better)
N1 with SKS	28541.33	18540.12	**64.96%**
N1 without SKS	20193.46	13771.16	68.20%
N2 with SKS	122150.05	26691.87	**21.85%**
N2 without SKS	123080.84	47559.47	38.64%
N3 with SKS	90378.91	21755.9	**24.07%**
N3 without SKS	90435.59	35701.29	39.48%

Fig.65.

Percents = (PM2.5 End / PM2.5 Start)*100

6.1

A summary of the effectivity of the smart knitted surface can be extracted from Fig.60. The size of the panel highly affects the efficiency of air filtration. IN experiment N1, the room is 12.1m3, and the difference in air filtration with and without the smart knitted surface switched on is 3.24%. This result can not be qualified as a working product yet. However, experiment N2 is held in a much smaller area - 1.9m3, and the difference between SKS switch n and off is 16.79%. This is an exaggerated situation that depicts the highest efficiency of the prototype in those parameters.

Experiment N3 is held in a chamber room, produced by synthetic material styrofoam. Hence air cannot pass through it. Fig.62 and Fig.63 lay out that the SKS has excellent efficiency when placed in a space with the same scale. The difference between SKS being switched on and not is 12.41%.

That means that when the panel is produced in its actual height of 2000mm, one panel will be able to filter 5.4m3 by almost 13% of the air for eight to ten minutes. The efficiency of the product has proven eligible for customer use at this stage.

7.1

7.1 Conclusion

Indoor environment where people spend most of their time does not achieve such parameters of ion presence as it is in the nature environment which is natural for people. Aerosols, such as cigarette smoke, lead to decreasing the amount of negative air ions to almost zero. Therefore, it is necessary to supply the negative ions for healthier and more natural environment. Currently, there are many apparatuses which are able to produce negative ions artificially. A few years ago these apparatuses were designed solely for industrial use, however, now these devices are available also for households[18].

The design of the selfstanding panel with smart knitted surface can be qualified as an appliance suitable for home environment and office.

The idea of the arch comes from air vortexes and it permits flexibility of the panel throughout the space not only for its function, but also for its design.

As far as the results from the experiment can be defined, this project can be refered to as a functional design of an internal separation panel that has the ability to freshen the air. Since the purification of the air by negative ionization is not as reliable as the one with UV-c light or HEPA filters, the results indicate that the function of purification is not an accurate definition of the process. Filtration of coarse and fine dust is more definitive characterization of the function of the panel.

With the color palette choosen it can be said that the panel can be fitted in any interior since the diversity of the colors permits so.

7.1.1

7.1.1 Future work

After understanding the process of air purification by negative ionization and adopting it into the design of self-standing panel with knitted surface,further research is needed to determine the modularity of the panel itslef.
Deeper understanding of the mechanization and application of electricity can be explored in order for the product to be able to compete on the market and be successfully used by the end user.
Refering to the mechanisation of the folding and unfolding movement of a set of panels, more refined method could be considered by reusing the same parts, designed to be detachable without the danger of breaking in the process of assembly. This statement identifies also in the electrification of the carbon fiber. Using thicker cables and more flexible approach could permit the panel to become modular and easier to use.
Indoor air polution is not to be undermined. Different methods of filtration exist and negative ionization can be one of the most comfortable ones since it can be part of the furniture design, silent and invisible, however most efficient in its purpose.

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https://www.researchgate.net/publication/281812112_Ionization_Impact_on_the_Air_Cleaning_Efficiency_in_the_Interior : Fig.47, Fig.48., Fig.49.

Drawing of the autor: Fig16., Fig.17., Fig.21.Fig.22., Fig.23., Fig.24., Fig.25., Fig.26., Fig.27., Fig.27.A., Fig.27.B, Fig.28., Fig.29., Fig.30., Fig.31., Fig.32., Fig.33., Fig.34., Fig.35., Fig.36., Fig.37., Fig.38., Fig.39., Fig.40., Fig.41., Fig.42., Fig.50., Fig.51., Fig.52., Fig.53., Fig.54., Fig.55., Fig.56., Fig.57., Fig.58., Fig.59., Fig.60., Fig.61., Fig.62., Fig.63., Fig.64., Fig.65.,