

wind tunnel bulletin

3	Editorial
4-5	Odyssey
6-7	Wind from Everywhere
8-9	Göttingen Windtunnel
10-17	Our Windtunnel In the Making
18-19	Why a Windtunnel
20	Odyssey

n° 01

Impressum
The Wind Tunnel Bulletin is published by the Transdisciplinary Research Focus at Zürich University of the Arts.

Editors of Issue #1:
Haseeb Ahmed, Florian Dombois, Kaspar König

Contributors:
Mirjam Steiner, Sarine Waltenspül, Reinhard Wendler

Design:
Viola Zimmermann, Corinne Dörig

Translators of Homer's Odyssey:
Johann Heinrich Voss (German)
James Huddleston (English) from The Chicago Homer, online at <http://digital.library.northwestern.edu/homer/>
[Accessed: 30 Oct 2013]

Excerpt from Handbook of Wind Energy by Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi (eds.), Chichester: Wiley, 2001

Images:
Members of the Size Matters research group at the Zürich University of the Arts produced the images in this issue except for those listed below:

Cover: © 2013 Archive Masamichi Abe, Tokyo. This image was taken in the 1930s by the Japanese physicist Masanao Abe (1891–1966) for his long-term research on the clouds and air currents around Mt. Fuji. Abe observed the clouds around Mt. Fuji using photography and film from 1926 to 1941, and completed his studies with wind tunnel experiments, using a model mountain of 1:50000. Abe was a pioneer in simulating the different layers of the atmosphere around a landscape in a wind tunnel. In 2014 a book by Heilmut Völter on Abe's cloud studies will be published by Spector Books.

P. 2: 2013. Odysseus, Bag of Winds. [image online] Available at: http://www.latin.ch/falte_sprachen/odysseus/odysseus.php?item=4
[Accessed: 31 Oct 2013].

P. 6: 2013. Aerial view of the Walter H. Beech Memorial Wind Tunnel at University of Wichita, Kansas, USA, 1951. [image online] Available at: http://webs.wichita.edu/dt/shockermag/show/dept.asp?_s=426&_d=1
[Accessed: 31 Oct 2013].

P. 7: 2013. The Construction of a Model Experimental Station, Göttingen, 1908. [image online] Available at: http://www.dlr.de/100Jahre/en/DesktopDefault.aspx?tabid=3301/5150_read-7838/gallery-1/gallery_read-image.37.3000/
[Accessed: 31 Oct 2013].

We thank all copyright owners for their kind permission to reproduce their material. Should any person entitled to rights have been overlooked, legitimate claims shall be compensated within the usual provisions.

<http://fsp.trans.zhdk.ch>
©2013

Publishing information:
Research Focus Transdisciplinarity
at the Zürich University of the Arts, November, 2013
Zürich, Switzerland

ISBN 978-3-9524260-0-5

wind tunnel bulletin n° 01 / nov 2013

The Wind Tunnel Bulletin is produced by the research group **Size Matters: On the Scale and Size of Models** to share material that we find interesting. Following our concept of a man engine, it is alternately edited by one half of the group with their different backgrounds either in the arts or in the humanities.

What is a wind tunnel? We assume it is Aeolus, our ancestor: when he caged all winds to leave only one, it produced wind-tunnel-like conditions at a large scale (pp. 2–3, 20). However we learn from the Handbook of Wind Energy (pp. 4–5) that this condition is wholly artificial because wind is always highly variable and omnidirectional—whirling on every scale. Looking at our own wind tunnel in Zürich we realized parallels to Göttingen and Ludwig Prandtl, who invented and built the first closed circuit tunnel there in 1908. It is still known today as the Göttingen-type (pp. 6–7). We have dubbed the housing of the wind tunnel the ‘Temple of Winds’. Some early design drawings of Kaspar König show his idea of the modular tunnel, which may be the first in the world of its kind (pp. 8–11). Wind tunnels come in all shapes and sizes with the common task of ‘straightening’ the wind to study effects on scalar models (pp. 12–13). When printing this issue, we are still in the making of our tunnel (pp. 16–19). Finally we ask: Why a wind tunnel (pp. 18–19)?

Haseeb Ahmed, Florian Dombois, Kaspar König,
Mirjam Steiner, Sarine Waltenspül, Reinhard Wendler

Homer: Odyssey X, 17-26

ἀλλ' ὅτε δὴ καὶ ἐγὼν ὁδὸν ἤτεον ἠδ' ἐκέλευον
 πεμπέμεν, οὐδέ τι κείνος ἀνήνατο, τεύχε δὲ πομπήν.
 δῶκε δὲ μοι ἐκδείρας ἄσκον βοὸς ἐννεώροιο,
 ἔνθα δὲ βυκτάων ἀνέμων κατέδησε κέλευθα:
 κείνον γὰρ ταμίην ἀνέμων ποίησε Κρονίων,
 ἡμὲν παυέμεναι ἠδ' ὀρνύμεν, ὃν κ' ἐθέλησι.
 νηὶ δ' ἐνὶ γλαφυρῇ κατέδει μέρμιθι φαεινῇ
 ἀργυρέῃ, ἵνα μὴ τι παραπνεύσῃ ὀλίγον περ:
 αὐτὰρ ἐμοὶ πνοιὴν Ζεφύρου προέηκεν ἀῆναι,
 ὄφρα φέροι νῆάς τε καὶ αὐτούς:



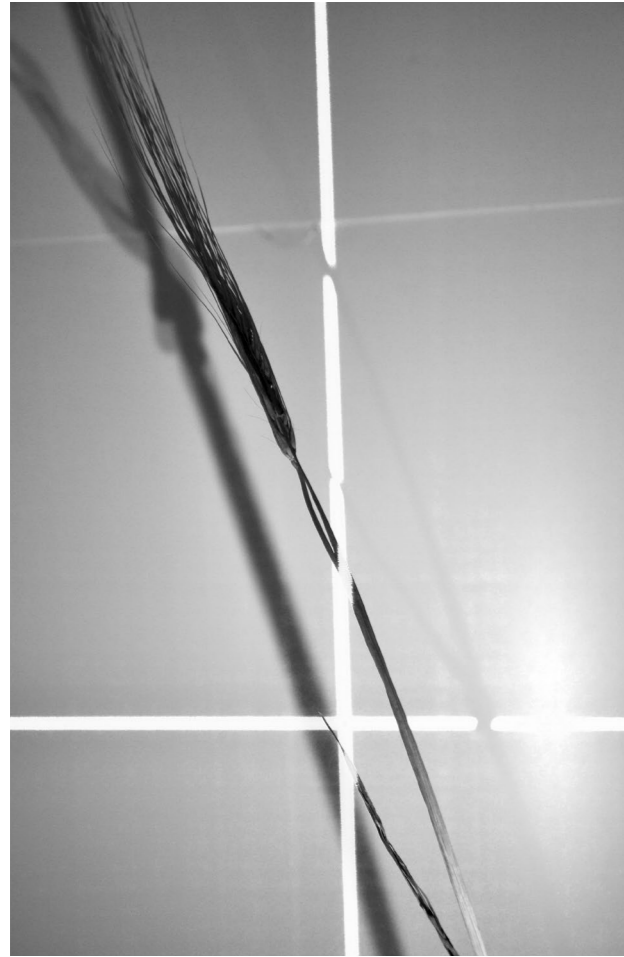
Odysseus with Bag of Winds, Etruscan seal ring. [c. 5th century BC]. Private collection

But when I also asked the way and bid him dispatch me,
 that one refused nothing, and made me a convoy.
 He gave me a leather bag, of a nine year-old ox he'd skinned,
 and bound the ways of the blustering winds in it,
 for Cronion had made him master of the winds,
 both to start and stop the ones he wishes.
 He tied it tight in our hollow ship with a shiny silver cord,
 so nothing would blow out even a little,
 then he sent forth West Wind's breath to blow for me,
 to carry the ships as well as ourselves.

Transl. by James Huddleston

Als ich nun weiter verlangte, und ihn um sichere Geleitung
 bat, versagt' er mir nichts, und rüstete mich zu der Abfahrt.
 Und er gab mir, verschlossen im dichtgenähten Schlauche
 vom neunjährigen Stiere, das Wehn lautbrausender Winde.
 Denn ihn hatte Kronion zum Herrscher der Winde geordnet,
 Sie durch seinen Befehl zu empören oder zu schweigen.
 Und er knüpfte den Schlauch mit glänzendem silbernen Seile
 fest in dem hohlen Schiffe, dass auch kein Lüftchen entwehte.
 Vor mir liess er den Hauch des freundlichen Westes einherwehn,
 Dass sie die Schiff' und uns selbst heimführten.

Transl. by Johann Heinrich Voss



Tony Burton, David Sharp, Nick Jenkins, and Ervin Bossanyi (eds.): Handbook of Wind Energy. Chichester: Wiley, 2001. Extract pp. 11-17

2.1 The Nature of the Wind

From the point of view of wind energy, the most striking characteristic of the wind resource is its variability. The wind is highly variable, both geographically and temporally. Furthermore this variability persists over a very wide range of scales, both in space and time. The importance of this is amplified by the cubic relationship to available energy.

On a large scale, spatial variability describes the fact that there are many different climatic regions in the world so much windier than others. These regions are largely dictated by the latitude, which affects the amount of isolation. Within any one climatic region, there is a great deal of variation on a smaller scale, largely dictated by the physical geography—the proportion of land and sea, the size of land masses and the presence of mountains or plains for example. The type of vegetation may also have a significant influence through its effects on the absorption or reflection of solar radiation, affecting surface temperatures, and on humidity.

2.2 Geographical Variation in the Wind Resource

Ultimately the winds are driven entirely by the sun's energy, causing differential surface heating. The heating is most intense on land masses closer to the equator, and obviously the greatest heating occurs in the daytime, which means that region of greatest heating moves around the earth's surface as it spins on its axis. Warm air rises and circulates in the atmosphere to sink back to the surface in cooler areas. The resulting large-scale motion of the air is strongly influenced by coriolis forces due to the Earth's rotation. The result is a large-scale global circulation pattern.

2.3 Long term wind variation.

There is evidence that the wind speed at any particular location may be subject to very slow long-term variations. Although the availability of accurate historical records is a limitation, careful analysis [...] has demonstrated clear trends. Clearly these may be linked to long-term temperature variations for which there is ample historical evidence. There is also much debate at present

wind tunnel bulletin n° 01, nov 2013

about the likely effects of global warming, caused by human activity, on climate, and this will undoubtedly affect wind climates in coming decades.

2.4 Annual and Seasonal Variations.

$$F(U) = \exp\left\{-\left(\frac{U}{c}\right)^k\right\}$$

Weibull distribution: Hourly mean wind speed over a year at many typical sites.

Where $F(U)$ is the fraction of time for which the hourly mean wind speed exceeds U . It is characterized by two parameters 'scale perimeter and 'shape perimeter'.

2.5 Synoptic and Diurnal Variations

On shorter time-scales than the seasonal changes... wind speed variations are somewhat more random, and less predictable. Nevertheless these variations contain definite patterns. The frequency content of these variations typically peak around 4 days or so. These are the synoptic' variations, which are associated with large-scale weather patterns such as areas of high and low pressure and as-

sociated weather fronts as they move across the Earth's surface.

2.6 Turbulence

Turbulence refers to fluctuations in wind speed on a relatively fast time-scale typically less than about 10 minutes.

Turbulence is generated mainly from two causes: 'friction' with the earth's surface, which can be thought of as extending as far as flow disturbances caused by topographical features such as hills and mountains and thermal effects which can cause air masses to move vertically as a result of variations of temperature, and hence of the density of the air. Often these two effects are interconnected such as when a mass of air flows over a mountain range and is forced up into cooler regions where it is no longer in thermal equilibrium with its surroundings.

Turbulence is clearly a complex process, and one which cannot be represented simply in terms of deterministic equations.



Göttingen-type wind tunnels take their name from Göttingen, Germany where Ludwig Prandtl laid much of the foundations of modern aeronautics. He discovered the boundary layer which separates surfaces from fluid mediums especially in motion. The Göttingen-type wind tunnel was developed in the early 20th century when aeronautics made its initial leaps and bounds.

It consists of a closed loop through which air circulates. This creates a steady or laminar flow of air and keeps it separate from the turbulent flows outside of the tunnel. When placing a model in this uniform airflow in the relatively small test-section, one can see how it interacts with air flow and where vortices appear.

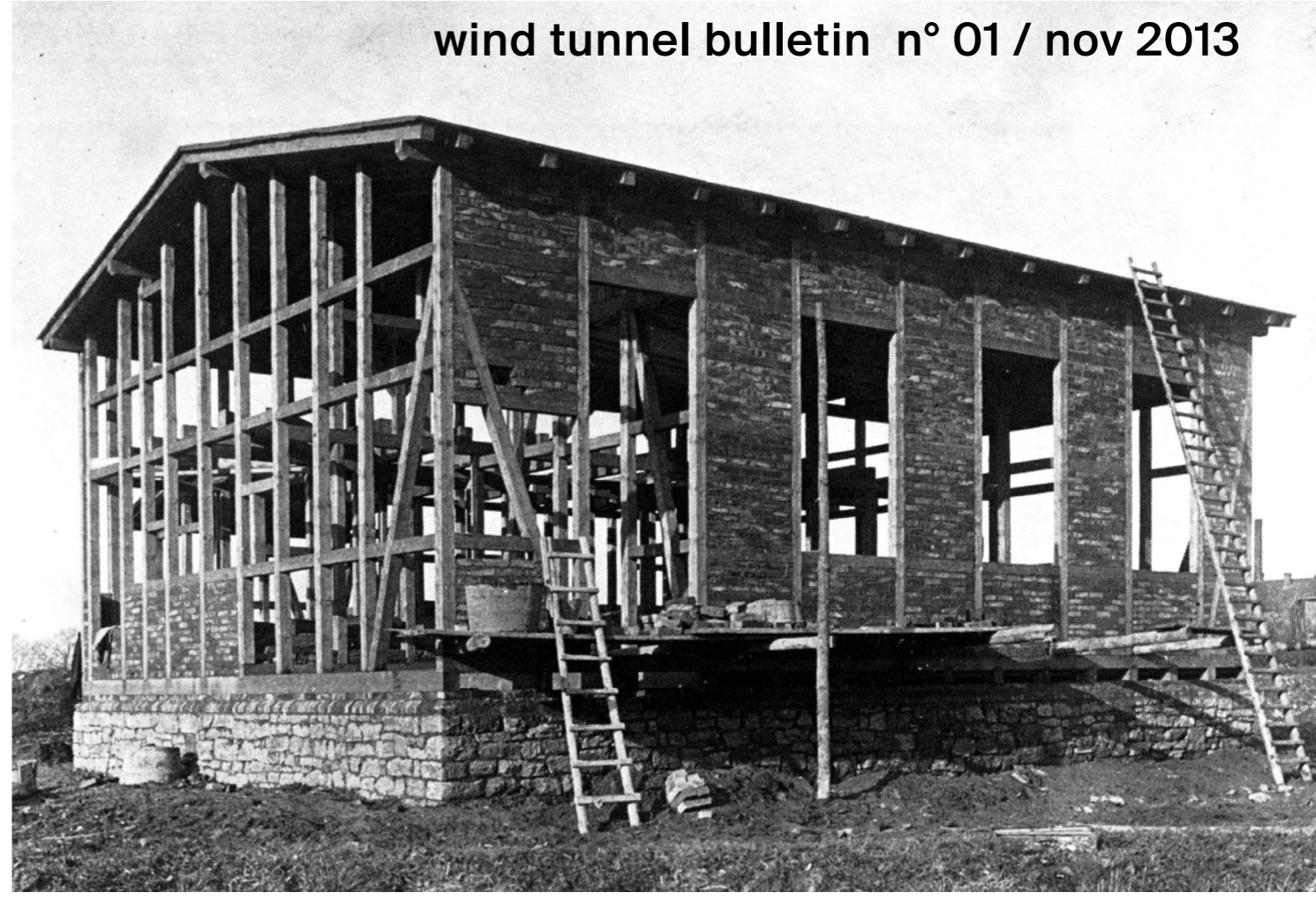
The Size Matters team chose the Göttingen-type wind tunnel for several reasons. One is technical, because it allows for low speed wind tunnel testing. The closed circuit requires much less power and allows for an open test section so artists can interact with the wind beyond the placement of objects. We are especially interested in the small and slow as it interacts with the air and how different this reality can be.



Top: Aerial view of the Walter H. Beech Memorial Wind Tunnel at University of Wichita, Kansas, USA, 1951
Bottom: A 3D printed scale model of the Size Matters Wind Tunnel. Zürich, Switzerland. 2012

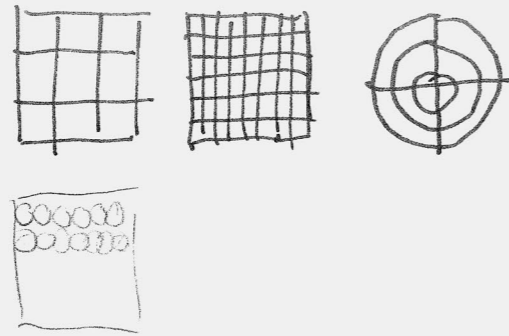


Top: The Construction of a Wind Tunnel Experimental Station for Models, Göttingen, 1908
Bottom: The Construction of the Size Matters Wind Tunnel. Zürich, Switzerland. 2012


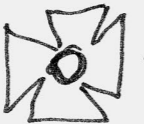

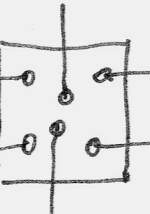

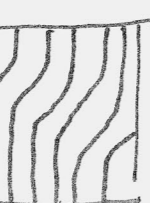


ZÜRICH
4.11.2012

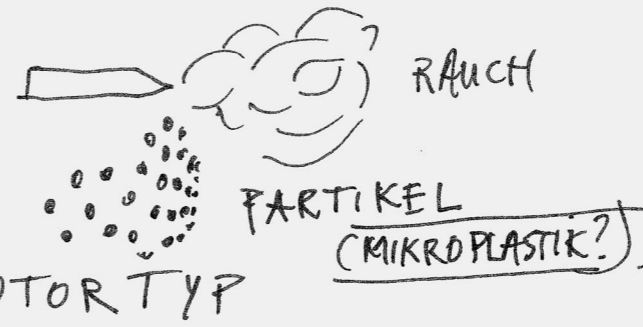
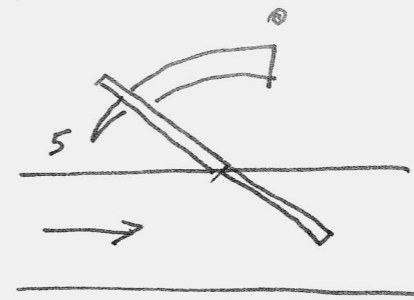
GLEICHRICHTER



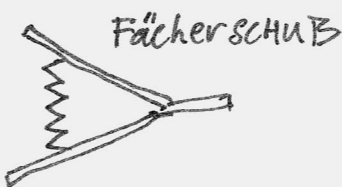
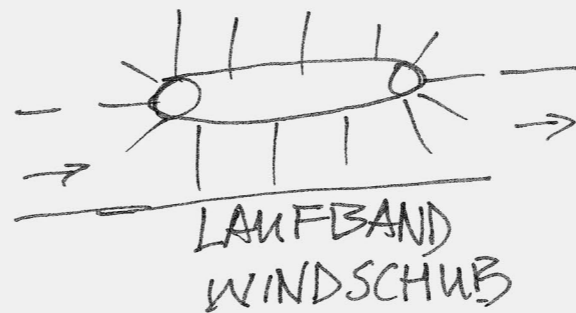
DÜSEN

-  - Turbo Strudel
-  - Spot-WIND
-  - DIAFRAGMA
-  - RAUCH DÜSEN INTEGRIERT
-  - LOW PRESSURE DÜSEN
-  - SPEZIAL DÜSEN

Mess INSTRUMENTE



ROTOR TYP

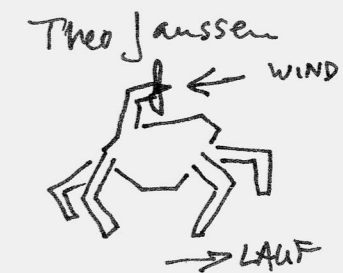


TEMPERATUR / GAS BETRIEBEN

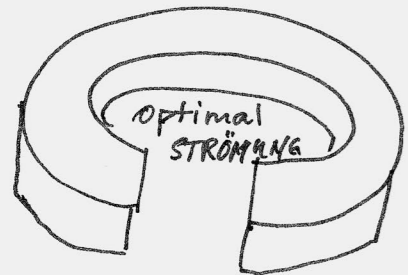
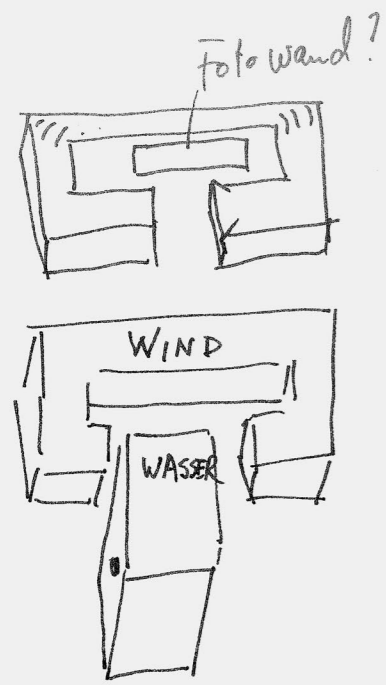
MATERIAL

- Polycarbonat
- FASERSCHICHTHOLZ
- HARDPAPPE
- AIRCO METALL
- RECYCLE?
- VERBINDUNG
- SCHLAUCH
- PVC-SCHRUMPF-SHRINKRAP.

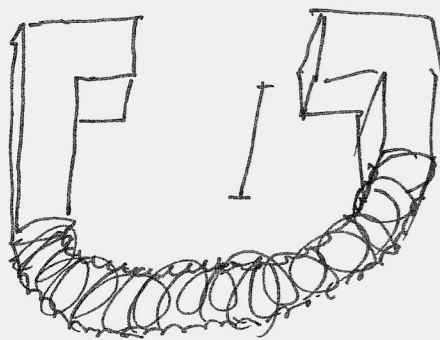
OBJEKTE



- KLANG INSTRUMENTE
- KLANG HERUMSCHICKEN
- RESONANZ / LUNGEN(?)
- Begehbaren Wind AKAPOOR

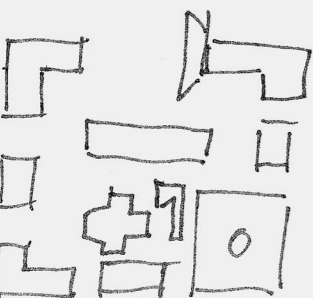


HÖHE | ABSTAND



DAS 100-Teilige Set.

8,9 Our Wind Tunnel



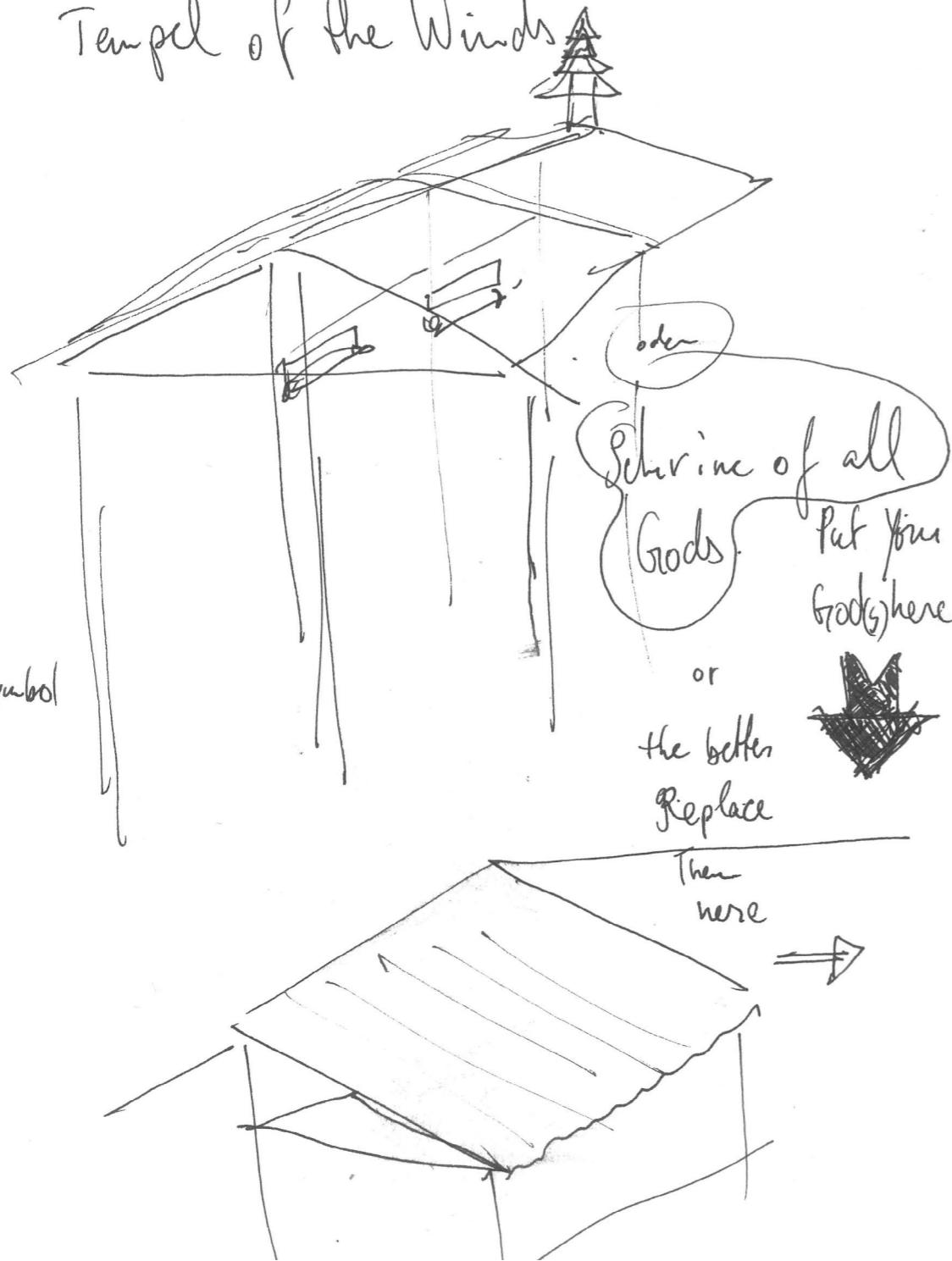
WINDTOOLBOX

- HiAG (Zugesch. + Lieferung)
- gemeinsam runtergehen
- Konstruktion Christoph Baidenb.

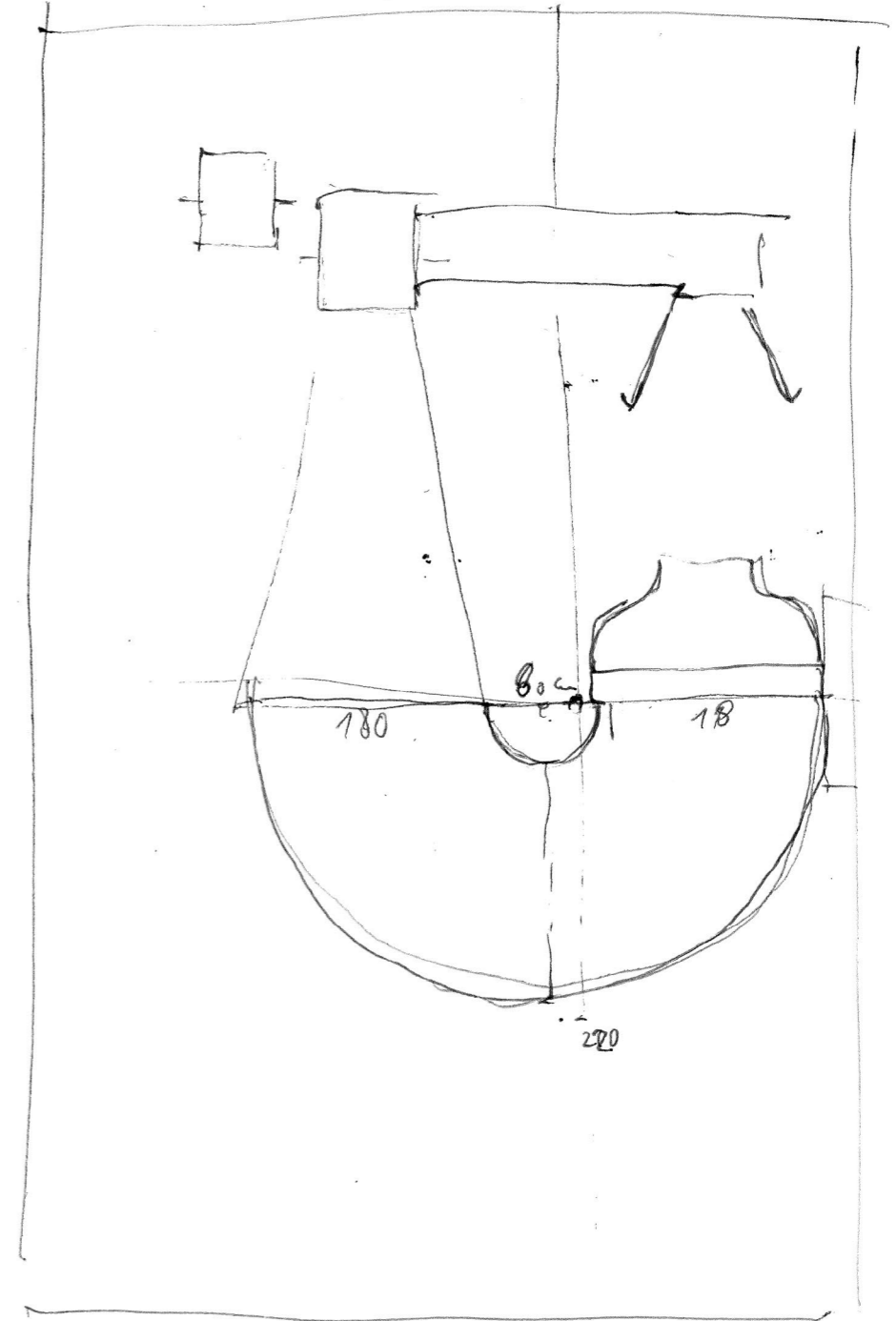
furkapass hotel

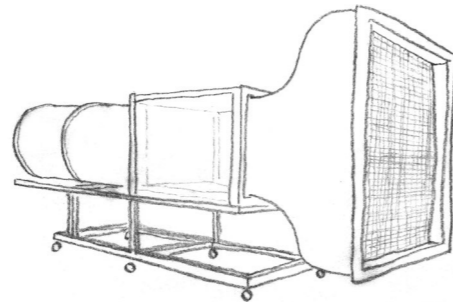
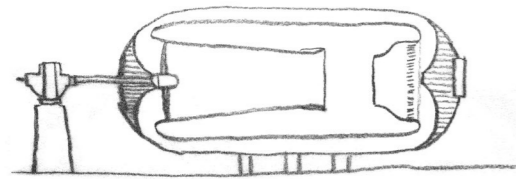
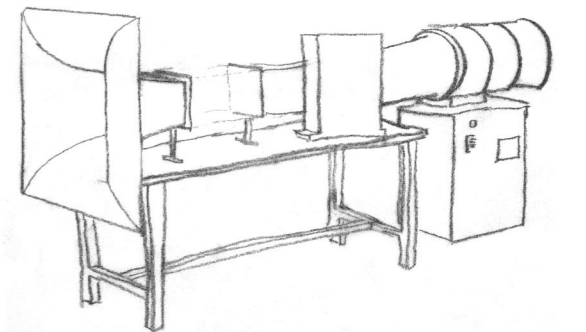
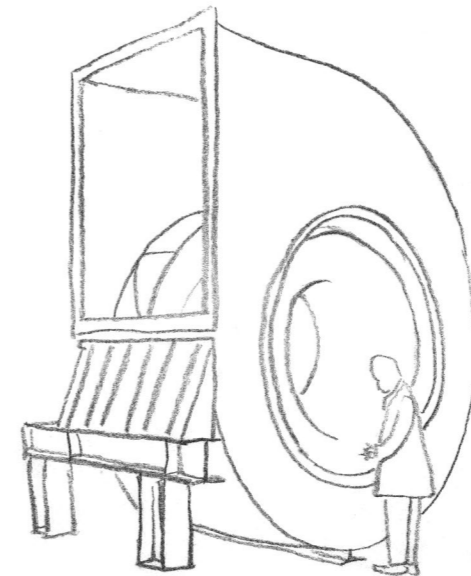
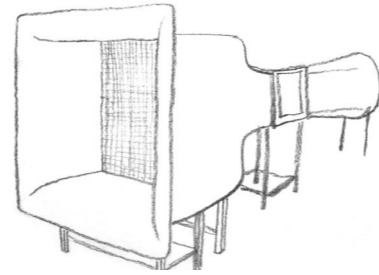
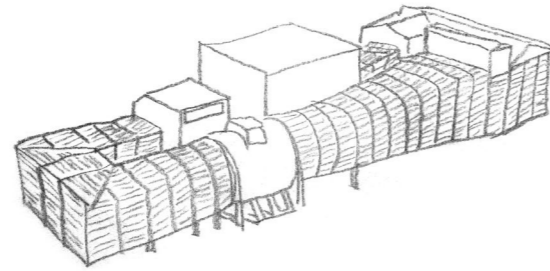
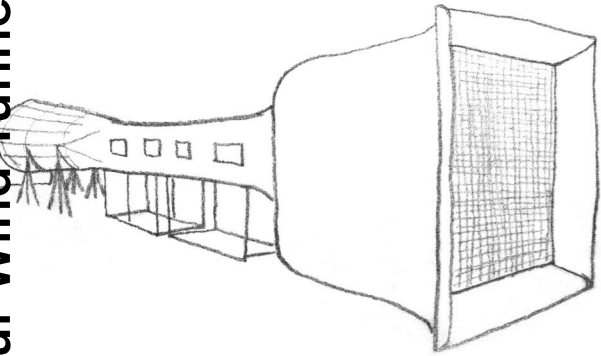
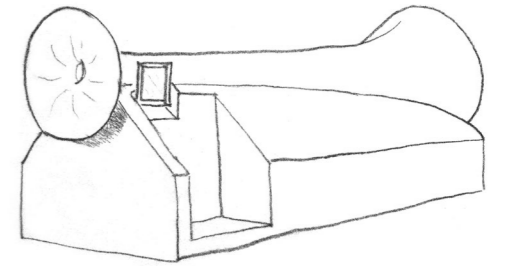
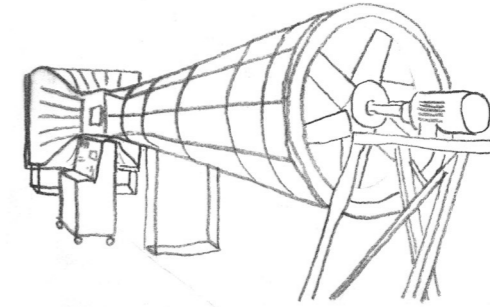
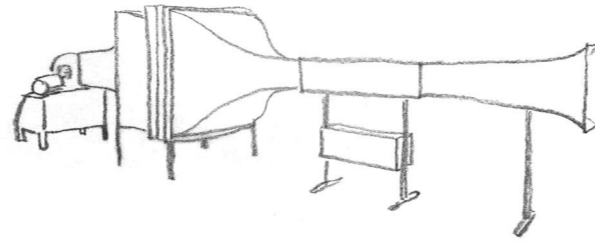
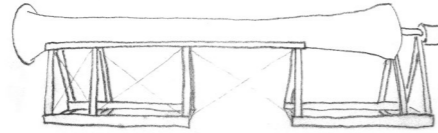
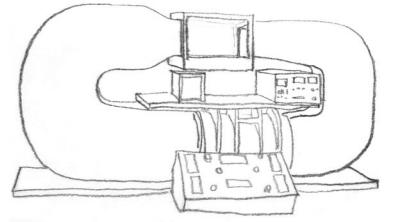
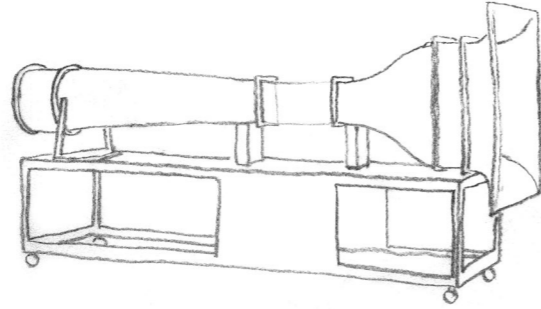
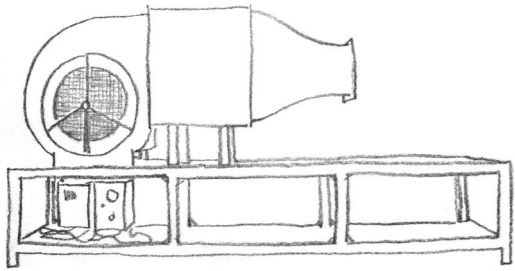
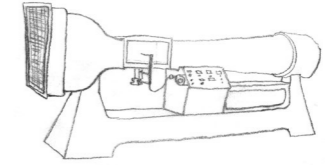
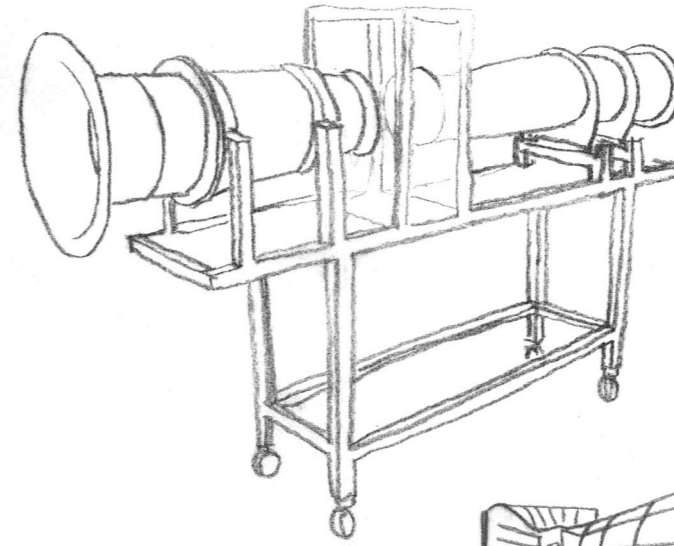
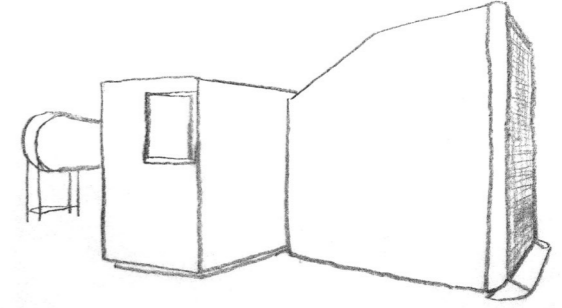
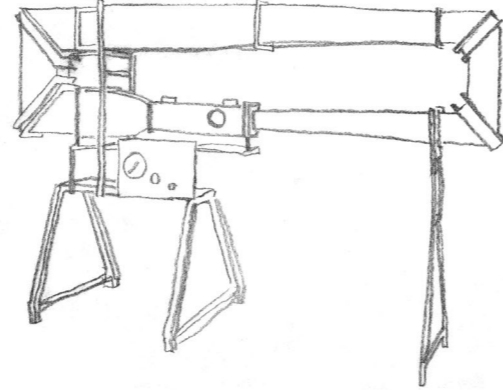
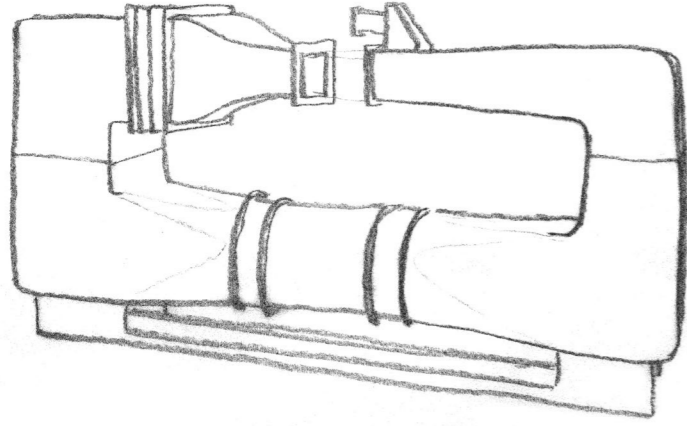
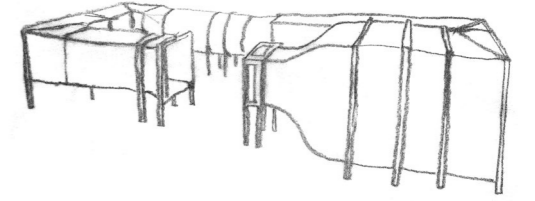
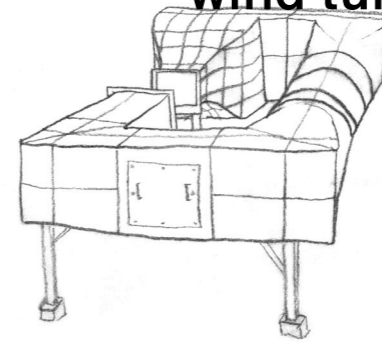
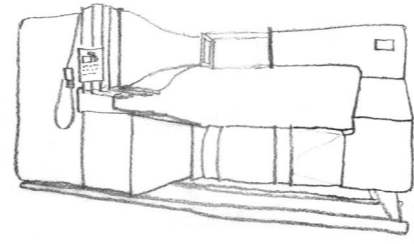
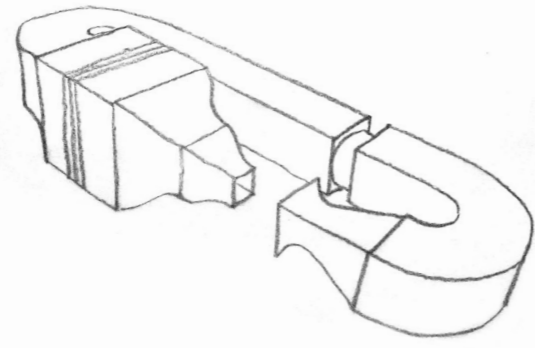
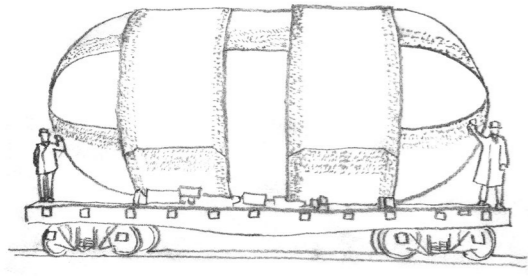
2.11.2012

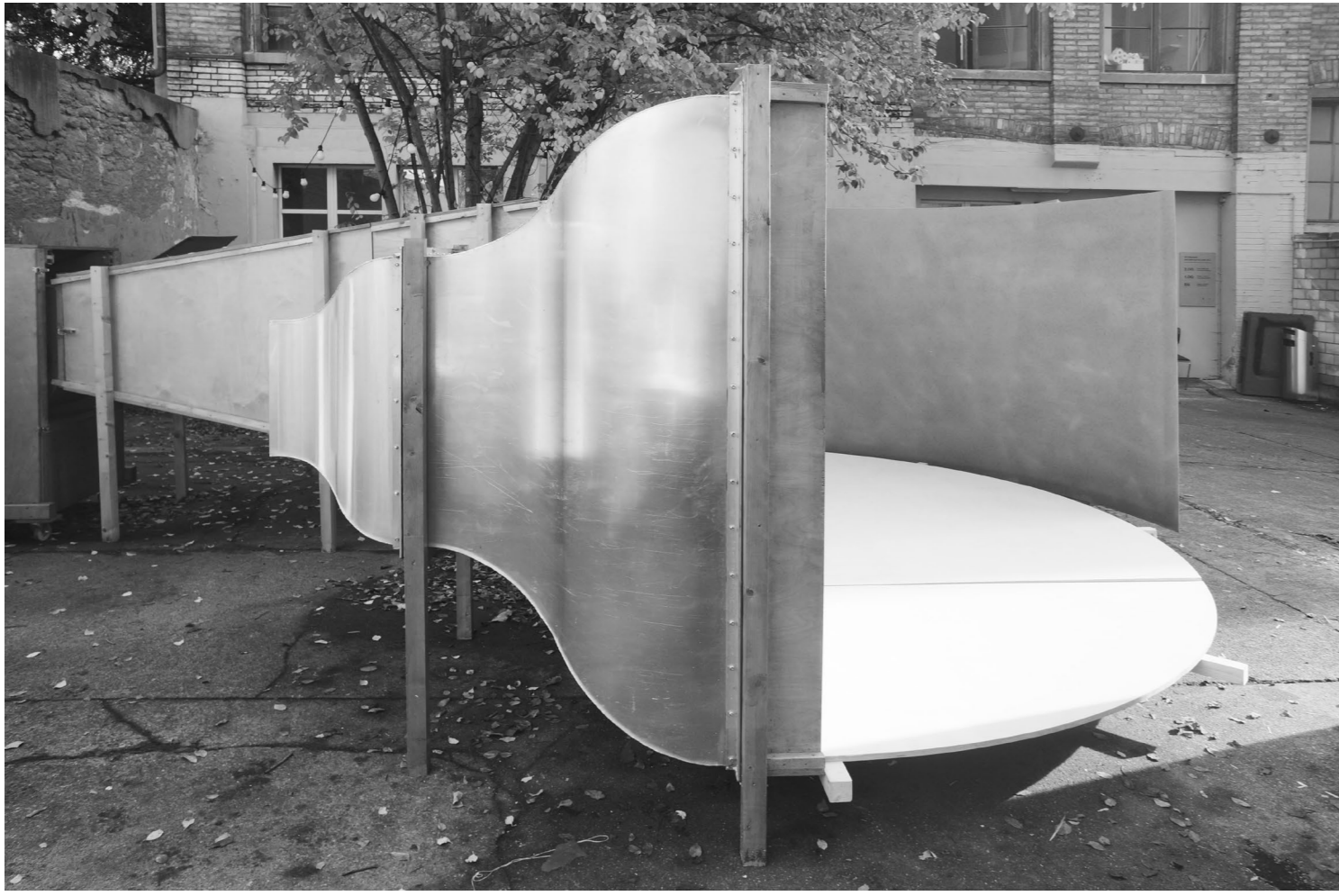
Temple of the Winds



- Kreuz
- Platine
- Allah symbol
- Hindi
- etc









Why a wind tunnel?

An interview with Florian Dombois, head and founder of the Transdisciplinary Research Focus

Why does this wind tunnel exist?

There are various answers to that question. It depends on what you mean.

Okay, to begin with: Why was it built?

Intuition. In 2011 it suddenly dawned on me that I definitely wanted to be build such a device. The trigger was the wind tunnel at MIT in Boston, which I initially saw from the outside and visited only later. I've sailed since I was a child and have long been fascinated by the design of large technical facilities which, due to engineering needs, continually take on fantastic forms in my eyes. You look at these facilities and feel they have to have this form. This form is the only right one ... the engineers can explain it to you in minute detail. They have a certainty we often have to struggle for a long time to achieve in art.

But why does every wind tunnel look different?

(Laughs) Because there are different possibilities in science too. And every team believes it has found the perfect solution. And for a moment, it's often true. But then new questions are found, different parameters. And aerodynamics is a trial and error science. For example, the teardrop shape is not the only possible way to offer little resistance. So the shapes are continually varied.

And what other reasons are there besides artistic intuition?

The wind tunnel is a form-finding machine. It is a facility that is there to give an object an 'ideal' form. So around every wind tunnel there is an infrastructure of workshops and model builders who operate the facility. The facility is like a big animal that has to be continually fed ideas and forms. It creates necessities, asks questions.

Questions related to aerodynamics?

Not only. And now we come to some answers to your first question. We are dealing here with models and especially questions of scaling. This an extremely far-reaching topic that

also has political dimensions, if, for example, we look at the situation in China. There they often make things on a large scale that were developed on a much smaller scale elsewhere. The Chinese fascination for Switzerland and vice versa also has something to do with it in my opinion. However, there are many things you can't simply scale. And that interests me. In a wind tunnel this is called scaling effects. For example, a small aircraft model doesn't fly the same way when it is built bigger. The wind doesn't scale with it...

That's very general. Is there a concrete approach?

I think something has gone wrong in modernity. And we cannot overcome this by simply removing it, forgetting it. Then we would repeat it exactly the same way. So we are proceeding by going back to one of the starting points of modernity and heading out from there again but with a different approach. In concrete terms that means: wind tunnels were invented around 1900. From 1905, Gustave Eiffel set up his first systematic testing facilities (with open wind tunnels, which are also called Eiffel tunnels). In 1907 Ludwig Prandtl built a

model testing facility for aerodynamics in Göttingen and developed the circular wind tunnel (the so-called Göttingen type). It was at this exact time the European avant-gardes set out. For example the Futurists use a lot of aerodynamics in their work. Luigi Russolo used the motif of the mach cone, to cite one example, in the painting *Dinamismo di un'Automobile* (1912–13). But they were all men. They wanted fast cars, loud cannons, and the euphoria of technology. But a wind tunnel can also produce slow wind currents. So what forms arise then? We use the same facility but change the categories. We're interested in the quiet and slow. We look for forms that are not developed from machismo. Perhaps you could say we want to operate the wind tunnel in a more feminine way.

But then why are there more men in the working group?

We have four men and two women in the core team. If just one of the men were a woman, it would be balanced out. That's one answer. The other is: why shouldn't men be able to embrace feminine usage of the wind tunnel?

wind tunnel bulletin n° 01, nov 2013

Is gender an issue?

Gender is always an issue. And the generation conflict is an issue. The political situation is an issue. I'm occupied with all of this. And it is a subject of our discussions in the team, fixed points we return to often. But I'm not a politician. I don't have to call a spade a spade and bandage things with a semantic network. I look for forms of expression that are more under the surface and long-term. Hans-Jörg Rheinberger has called our wind tunnel "a model of a second order" because it is also a metaphor machine. It sparks a discourse, several discourses. Again and again, we have guests with whom we sit around the facility and talk. They bring surprises, and see things we didn't notice before.

Is that transdisciplinarity?

Yes, maybe.

How does the project function within the university?

That's a devious question, which I like. First, the students like to come; they work with us, conduct their own experiments. And many colleagues also stop by often because we practise such concrete research, but that is not all. Such a wind tunnel also triggers institutional dynamics, which I find extremely interesting. There's not only the streamlined form. Why is it in the courtyard and not in the building? What is research at an artschool? How does it work in conjunction with teaching? Is the circular tunnel a symbol of institutional processes? I also like the fact that you don't know where the energy is: in the machine or in the wind? And you can't even see the latter.

Homer: *Odyssey* X, 17–26

ἐννῆμαρ μὲν ὁμῶς πλέομεν νύκτας τε καὶ ἡμαρ,
τῇ δεκάτῃ δ' ἤδη ἀνεφαίνετο πατρίς ἄρουρα,
καὶ δὴ πυρπολέοντας ἐλεύσσομεν ἐγγύς ἐόντας:
ἐνθ' ἐμὲ μὲν γλυκύς ὕπνος ἐπέλλαβε κεκμηῶτα,
[...] οἳ δ' ἔταροι ἐπέεσσι πρὸς ἀλλήλους ἀγόρευον,
καὶ μ' ἔφασαν χρυσόν τε καὶ ἄργυρον οἴκαδ' ἄγεσθαι
δῶρα παρ' Αἰόλου μεγαλήτορος Ἴπποτάδαο.
ᾧδε δὲ τις εἶπεσκεν ἰδὼν ἐς πλησίον ἄλλον:
ᾧ πόποι, ὡς ὅδε πᾶσι φίλος καὶ τίμιός ἐστιν
ἀνθρώποις, ὅτεών τε πόλιν καὶ γαίαν ἴκηται.
πολλὰ μὲν ἐκ Τροίης ἄγεται κειμήλια καλὰ
ληΐδος, ἡμεῖς δ' αὐτε ὁμὴν ὁδὸν ἐκτελέσαντες
οἴκαδε νισόμεθα κενεὰς σὺν χεῖρας ἔχοντες:
καὶ νῦν οἳ τὰ γ' ἔδωκε χαριζόμενος φιλότῃτι
Αἰόλος, ἀλλ' ἄγε θάσσοιν ἰδόμεθα ὅττι τὰδ' ἐστίν,
ὅσσοις τις χρυσός τε καὶ ἄργυρος ἀσκῶ ἔνεστιν.
ὡς ἔφασαν, βουλή δὲ κακὴ νίκησεν ἐταίρων:
ἀσκὸν μὲν λύσαν, ἀνεμοὶ δ' ἐκ πάντες ὄρουσαν.
τοὺς δ' αἴψ' ἀρπάξασα φέρειν πόντονδε θύελλα
κλαίοντας, γαίης ἀπο πατρίδος.

Nine days we sailed, day and night alike,
and on the tenth our fatherland appeared,
and we caught sight of them tending fires, near as they were.
Then sweet sleep came upon me in my weariness, [...]
My comrades talked to one another,
and said I was bringing home gold and silver,
gifts from great-hearted Aeolus Hippotades.
In this way, glancing at another near him, one would say:
Humph! How dear and honored this one is to all mankind,
whoever's land and city he arrives at.
While from Troy he brings many beautiful treasures
from the spoils, we, who made the same journey,
return home holding empty hands together.
Just now Aeolus favored him with friendship and gave him
this. But come, let's quickly see what these things are,
how much of any gold and silver's in the leather bag.'
So said they, and my comrades' evil plan prevailed.
They loosened the leather bag and all the winds rushed out,
and storm at once snatched them and carried them,
crying, out to sea, away from fatherland.

Transl. by James Huddleston

Schon durchsegelten wir neun Tag' und Nächte die Wogen;
Und in der zehnten Nacht erschien uns das heimische Ufer,
Dass wir schon in der Nähe die Feuerwachen erblickten.
Jetzt schlummert' ich ein, ermüdet von langer Arbeit; [...]
Und die Genossen besprachen sich heimlich untereinander,
Während, ich führte mit mir viel Gold und Silber zur Heimat,
Äolos' Ehrengeschenke, des hippotadischen Königs.
Und man wendete sich zu seinem Nachbar, und sagte:
Wunderbar! Dieser Mann gewinnt die Achtung und Liebe
Aller Menschen, wohin er auch kommt, in Städten und Ländern!
Aus der troischen Beute wie manches unschätzbare Kleinod
Bringet er mit! Und wir, die alle Gefahren geteilet,
Kehren am Ende doch mit leeren Händen zur Heimat.
Nun hat Äolos dieses Geschenk aus besonderer Freundschaft
Ihm verehrt! Auf, lasst uns denn eilen und sehen, was dies sei,
Wie viel Silber und Gold in diesem Schlauche doch stecke.
Also sprach man. Es siegte der böse Rat der Genossen;
Und sie lösten den Schlauch, und mit einmal entsausten die Winde
Plötzlich ergriff sie der Sturm, und schleudert' weit in das Weltmeer
Hin die Weinenden, ferne vom Vaterlande.

Transl. by Johann Heinrich Voss

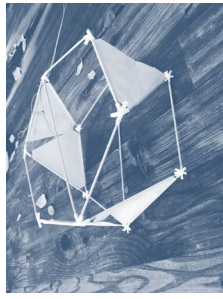
- 001 20.02.13 Yarn Skiing
- 002 12.06.13 Flag Pen
- 003 12.06.13 Feather Tank
- 004 12.06.13 Wind Surface Sound
- 005 12.06.13 Turbine Pen
- 006 12.06.13 Wheat Shaft / Forest Flow
- 007 12.06.13 Erosion Landscape
- 008 12.06.13 Feather Pole
- 009 12.06.13 Yarn Row
- 010 12.06.13 Propeller Mouth
- 011 12.06.13 Florescent Streaming
- 012 12.06.13 Wind Harp
- 013 12.06.13 Fan Flute
- 014 13.06.13 Feather in a Black Light
- 015 14.06.13 Flying by Pant Seat
- 016 15.06.13 World Wheat
- 017 14.10.13 Design Department Tests
- 018 16.10.13 Kites: Tetrahedral
- 019 17.10.13 Kites: Tetrahedral II
- 020 17.10.13 Kites: Delta Wing
- 021 17.10.13 Kites: Classic
- 022 17.10.13 Kites: Two-Man Game Kite
- 023 17.10.13 Kites: Spiral Kite
- 024 16.10.13 Flying Carpet Study



021



022



023



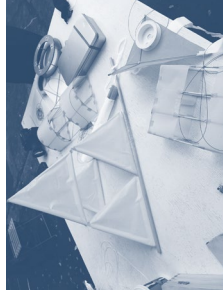
024



016



017



018



019



020



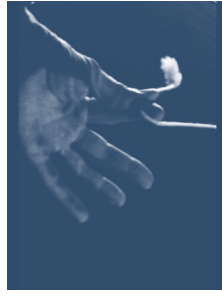
011



012



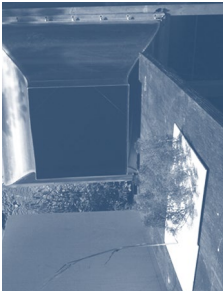
013



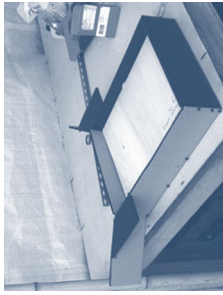
014



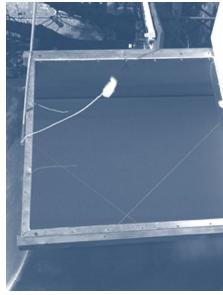
015



006



007



008



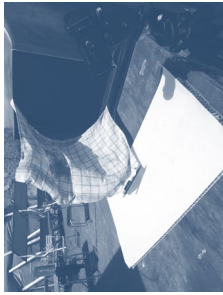
009



010



001



002



003



004

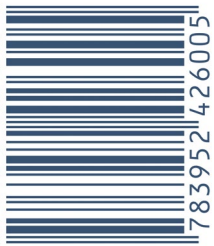


005

Z

hdk

ISBN 978-3-9524260-0-5



9 783952 426005

Zürcher Hochschule der Künste