Tools for Expression

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making the Lyraei

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Contents

Intro

My quest for the past two years has been to design and create a new musical instrument.
An instrument intended to become the core element of a live performance act —
an extension of my own artistic practice.

An instrument that would attempt to bridge together two worlds:
those of electronic and stringed instruments.

An instrument that, in the absence of a player, should be capable of playing itself as an autonomous object.
In this way, it will claim an ontological space between a tool and an artwork.

In this thesis, I will first discuss some ideas that led to the formation of the concept.
These ideas arise from thoughts around the creative act and, in it, the role of the tool.
These ideas were vital in forming the qualities infused in the final artifact.
The above will make up the first part of this essay, called "T h i n k i n g".

In the second part, I will describe all the stages that took place in going from an array of ideas to a concept,
and from there to a constructed object.
These will involve my thoughts, sketches, designs, experiments, decisions, my failures and successes.
And last, my attempts in learning how to tame the instrument.
This second part will be called "M a k i n g".

Part I

Thinking

Tools for Expression

The luxury to contemplate and generate discourse on matters other than those of sheer survival could be deemed as the greatest achievement of our species.

For only when the daily anxieties of eating and sleeping, escaping the beast and reproducing,
staying warm — but not too warm —
become a waterproof reality; only then we start to think of what we are and how we should be.

How easily this daydream could fall to pieces.

Yet as long as it does not,
we strive at seeking the unnecessary and shaping it into meaning.

On the ground of safety we look for that which comes to life through stories, art, and magic.

We even make tools for its creation.

These tools, made for the sole purpose of bringing that unnecessary into being, will be called in this essay:

Tools for Expression

Our theories are our inventions; but they may be merely ill-reasoned guesses, bold conjectures, *hypotheses*.

Out of these we create a world: not the real world, but our own nets in which we try to catch the real world.[1]

To offer a definition for *expression* might be needless here; the search for sharp definitions escapes the purposes of this discussion. Nevertheless, an attempt at it could be fruitful.

Karl Popper named his autobiography *Unended Quest* and chose to devote its pages to subjects that in a way would transcend his own life, such as politics, physics, and music. The chapter "Two kinds of music" introduces the ideas of *objectivist* and *subjectivist* kinds of music, which he exemplifies through the music of Bach and Beethoven respectively. Popper invented these terms rather hastily, as he says, in order to describe a duality he had observed in music. In the *subjectivist* kind, he explains, music is seen as a manifestation of the creator's inner world, an instance of his personality and his emotions pouring outwards. A furious outburst of the soul, as in Beethoven's case, who "had made music an instrument of self-expression"[2]. Here, the work is but a mirror of the creator's soul, revealing its dark paths, its secret lusts, its dreams. The act of composing is opening up the gates, freeing the beast from its cage.

On the other hand, the *objectivist* kind — and this is Bach's difference — views the artist as a channel through which something else, that surpasses their own existence, becomes externalized. The work here is a *being* in itself, coming to life through a composer that is now but a servant to that work. In fact, the creator must push their emotions aside to allow for the work to come through, and later *use* them to test whether the work is actually successful. Here the creation can still be regarded as an emotional form, but less in reference to its own creator and more in relation to an *expected form* of expression in a specific social context. Thus the composer's own personality or feelings remain trivial here. Martin Heidegger illustrates this idea vividly: "…the artist remains something inconsequential in comparison with the work — almost like a passageway which, in the creative process, destroys itself for the sake of the coming forth of the work"[3].

Popper himself opposes the idea that music, or art in general, can be thought of merely as a form of self-expression, as much as that may be the case in most of Beethoven's work. Or rather, he objects to that constituting the general paradigm for the creation of music. Now, whether one of these views is true, and which, will not concern us further here. But drawing from these themes of objectivist and subjectivist kinds of music, we can lay out a parallel distinction between *collective* and *individual* expression. In a similar manner to Popper's idea, this would refer to the source of the thing that is being expressed; the origin of that which the creative act tries to capture, incarnate or represent. Let us then start by looking at collective expression, which is seemingly a thing of the past.

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[1] Karl Popper, *Unended Quest* (Glasgow: Fontana/ Collins, 1980), 65
[2] Popper, *Unended Quest*, 66
[3] Martin Heidegger, *Off the beaten track* (Cambridge: Cambridge University Press, 2002), 19

We can think of collective expression as a representation of ideas that belong within a sphere of socially established meanings. These have traditionally been born in the realms of myth, religion, or schemes of divine order. They have originated from whatever historical societies may have agreed upon as being their central narrative, their metaphysical core of existence. Cornelius Castoriadis calls these structures “social imaginary significations”[4]: the truths and values invented and then collectively agreed upon and lived by. Up to the 18th century these were exclusively narration-based concepts, and because of that nature, they came to be inextricably tied with the arts. This bond had established art as the preeminent tool for the expression of collective beliefs. Any form of individual expression would have no place, let alone any meaning, in such a context. In this sense, the ceiling of the Sistine Chapel may have been painted by one man, but it is an embodiment of centuries of a collective devotion to a specific narrative and the expression of that in the form of a visual spectacle. By extension, the same would apply to folkloric music, religious hymns, and so on.

Yet the contemporary context makes it harder for the idea of a collective expression to exist. That is because the collective values or the “social imaginary significations” of today— at least in the contemporary western understanding of reality — simply do not originate from the narrative realm. As science marks the end of myth, so does a progressive objectivity take the place of the imagination in its central role in instituting social imaginary meanings. With this domination of the scientific paradigm over the narrative[5], the established connection between social imaginary meanings, which are now rooted in rational reasoning, and their potential representation through an art, is lost. In other words, there is less capacity for a poetic dimension in the scientific paradigm: that is, the belief to an ever-growing repository of human knowledge by increasingly dominating over the material world, through a science and a technology that constitute the pillar of such a belief. And even though it might be implausible that an art that is praiseful to rationality and technique could exist, this does not bring about the death of art. As Hannah Arendt writes, “art has survived gloriously its severance from religion, magic and myth”[6], and through that survival, we witness the emergence of manifold forms of *individual* expression.

The integrity of collective expression in art has since unfolded into an array of voices that nourish on ideas such as: the dissolution of objective aesthetics, the rupture with tradition, the artwork as a statement, the radical, the desperate voice, the “interesting”, the questionable; a frenzied search for new forms and new concepts that branches out endlessly on the basis of an individualistic approach. The immense complexity of an organism like this, that is art today, makes the idea of a common purpose unthinkable. An art whose purpose would be the expression of the newly established rationale, that of an endless progress through science and technological advance, could hardly be conceived[7]. At least, not in a *content-defining* way. However, the rationale of objectivity and technique may have found its way into the creative arts in other ways: in terms of influencing the *processes* of its production, and the *tools* for its production.

[4] The term is introduced by Cornelius Castoriadis in *The Imaginary Institution of Society* (Athens: Kedros, 1978)
[5] This shift is a central theme in Jean-Francois Lyotard, *The Postmodern Condition*: *A report on knowledge* (Minneapolis: University of Minnesota Press, 1984)
[6] Hannah Arendt, *The Human Condition* (Chicago: The University of Chicago Press, 1998), 167
[7] Marinetti’s “Manifesto of Futurism” and futurism in general could be a counter example here had it not praised brutality and violence rather than objective technological progress, in a way inventing its own dramaturgy around technology.

In the case of academia, the process-defining and tool-defining influence from the sciences onto the humanities is particularly evident. In arts education, including music, the necessity for an objective evaluation calls for the establishment of a frame of criteria that is rationalized. However, since there can be no expectations as to what the content of a work should be, there appears to be an emphasis shift from *content* to *process*. But the question is, how could a creative process be evaluated? This is where using language from the sciences takes place. We can now assign value to a work by virtue of its process's accordance to a scheme that is predominantly scientific: research, driven by a set of goals and carried out through a specific methodology. Thus, in the case of music, the mere process of its production (now framed by the scientific vocabulary of research, goals and methodology) starts to acquire a significance that may shift the attention away from the value of a work itself, but might also devalue the significance of creative techniques that belong in the sphere of the intuitive, the arbitrary, the ineffable. By the same token, the practice of borrowing ideas or concepts from science may be used to provide a shield of legitimation. "People in the humanities … will isolate an attractive scientific or mathematical concept and add it to the repertoire of their own disciplinary system, like an exotic pet"[8], writes Brian Massumi, and this is not necessarily a problem unless it becomes a technique for validation, a proof of value.

Color shines and only wants to shine.

If we try to make it comprehendible by analyzing it into numbers of oscillations it is gone.[9]

In this context, the idea of *expression* may start to dissolve in the face of a rationalized concept of creativity: rationalized, in the sense that it is driven by an underlying expectation for deconstruction, definition and verification of the steps that led to its becoming. Undoubtedly, this can serve as a useful reflection pool, so long as it doesn't constitute a general paradigm for the creative process.

Preoccupation with process leads to questions about method. Experimentations on new ways of composing music have been developing since the early 20th century, even though they were not always preoccupied with the idea of their own justification. The arbitrary or the unjustifiable did not seem to be a problem. Today, the emphasis shift from content to process creates a new problematic around *tools*. And the pursuit for originality, as necessitated by the individualist era, might appear as a pursuit for the originality of those tools *themselves*; and even the persistence to their technological sophistication as an indication of value. But in reality, there is no argument that could be made as to why sculpting in marble or composing on a harpsichord cannot be considered valuable or relevant anymore. What happened to those tools?

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[8] Brian Massumi, *Parables for the virtual: Movement, Affect, Sensation* (Durham & London: Duke University Press, 2002), 19. More on the relationship between the sciences and the humanities on pages 18-21.

[9] Heidegger, *Off the beaten track*, 25

If I were to reflect upon my own obsessive practice of *tool* making, I could find it rooted in an effort to discover new pathways for musical expression by creating or manipulating physical objects. Upon grasping a "traditional" instrument, my first intuition had always been to create new music on the spot; never to reproduce a written piece. At the age of twelve, I realized that the sound of stroking down-tuned bass strings on the classical guitar somehow resonated with my introversion, somehow mirrored my attraction towards the mysterious and the dark. At the same time, it was the most incredible discharging mechanism, allowing me to release all the anguish of the bullied four-eyed nerd I was. The guitar became my weapon. Contrary to the taught techniques, I wiggled my right thumb in a both downward and upward swift stroking movement to create crunchier rhythmical textures, and always kept my fingernails at twice the recommended size. By the age of nineteen, the focus on correct technique, speed improvement and shape memorization started to feel like an overshadowing vulture that devoured my personal view of the instrument.

The piano had the opposite effect: It allowed me to visit the most abstract and dreamiest of places. Although having never been trained at it, I tried to use my technique impairment as an advantage: my fingers weren't locked in specific shapes as was the case with the guitar. Slowing down revealed new places within time. Of course, writing something took ages. And there was one more problem: I could never get between the semitones. Nevertheless, I've always thought of the piano as the king of instruments, and those who'd been trained at it as having an enormous advantage in their ability to compose music. I expressed this thought in a discussion with my former boss, artist Zimoun, a person as untrained as me but with an uncanny instinct in creating music. He said: "No, I don't think so."

Naturally, synthesizers and computers opened up an entire new world of sounds to me. Such was the extent of my fascination that it took me years to realize I was not playing music anymore, but I was staring at a screen. The distance here was immense. A complete alienation from the creative process I would come to see in the writings of Jean Baudrillard[10]: the *abstractness* of the new energy sources (electricity in this case) was so prevalent that it completely eliminated the intimacy factor between me and the tool. Affection and effort had been replaced by control. And to stop being an observer, to become involved again, that effort had to be reinvented. It became clear to me that the physical dimension, in terms of a profound intimacy with materiality, was a necessary component for the actual *playing* to occur. There would be no need to exclude the "new energy sources" from the equation of the formation of a new tool. However, it would be absolutely crucial to incorporate the element of the physical. What would be the child between a harp and a synthesizer?

[10] "Man's abstract relationship to his (technical) objects, his 'spectacular alienation', is thus less a matter of his gestures having been replaced than of the abstractness of the very way in which functions have been split up, and the impossibility of any analogical apprehension of this splitting-up by reference to earlier gestures".
Jean Baudrillard, *The system of objects* (London/New York: Verso, 2005), 50

Effort is so closely bound to expression in playing traditional instruments;

it is the principle of energy and desire, of attraction and repulsion in the movement of music.[11]

In graduating from architecture, I presented a tall kinetic sculpture with strings, which functioned like a mechanical sequencer, but could also be played as an instrument. It was a very early and very peculiar embodiment of these ideas. During the presentation, a member of the committee, dedicated practitioner of computer aided parametric design, commented that this could had also been made as a digital simulation instead. I thought: "Of course, but why?"

. . .

An instrument created for making music is a tool for expression, if art-making is not entirely delineated by a rationalized concept of creativity. A tool for expression is a technology created to capture *that which cannot be captured*. Whether that is struggling to express the glory of gods or revealing the ways of the cosmos, inventing mechanisms of self-exploring or unleashing emotional fireworks, embracing meaninglessness, creating nothingness, birthing ideas as abstract and subtle as leafs on a pond, the poietic drive is the coal to this fire, and the poetic dimension is so inherently *there*, as much as it is absent in anything that is rationalized.

That is *expression*, the bringing-forth of that unnecessary whose beauty lies in its true purposelessness[12]. But again, to offer a definition for expression might be needless here; the search for sharp definitions escapes the purposes of this discussion.

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[11] Joel Ryan, "Effort and expression" (Proceedings of the International Computer Music Conference, 1992)

[12] A series of references could be made here, beginning from Kant's notion of "purposiveness without a purpose" that characterizes aesthetic judgment but also the aesthetic object itself, and by extension the work of art. Analyzed in the Third Moment of the Analytic of the Beautiful in Immanuel Kant, *Critique of the Power of Judgment,* (Cambridge: Cambridge University Press, 2000), 105-120

Hannah Arendt will remind us of this idea by using the term *uselessness*, to describe art's faculty of being beyond the world of utility, in *The Human Condition* (Chicago: The University of Chicago Press, 1998), 167

John Cage will use the phrase *purposeful purposelessness* and *purposeless play* to refer to the act of writing music.
He continues:

"This play, however, is an affirmation of life—not an attempt to bring order out of chaos nor to suggest improvements in creation, but simply a way of waking up to the very life we're living, which is so excellent once one gets one's mind and one's desires out of its way and lets it act of its own accord."
John Cage, *Silence: Lectures and writings* (Hanover/ London: University Press of New England, 2000), 12

Materiality ≁ Transparency ≁ Movement

> What makes the weight, the thickness, the flesh of each color, of each sound, of each tactile texture, of the present, and of the world is the fact that he who grasps them feels himself emerge from them by a sort of coiling up or redoubling, fundamentally homogeneous with them; he feels that he is the sensible itself coming to itself and that in return the sensible is in his eyes as it were his double or an extension of his own flesh. [13]

A painter can feel and smell the viscous pigments. They can observe the blending of the colors and the infinite worlds therewithin, swirling on the palette. And as the brush bathes into the luscious hills of color and caresses the canvas, it is like fingers touching another body: with affection, with hesitance, with curiosity, with play.

Intimacy with materiality lays a ground for creative energy to blossom. Intimacy, that is, amongst the artist and the tool, as in this exceptional case of a human-tool relationship, the tool is much more than a mere medium. It is a medium, in that it is instrumental in the channeling and externalization of the creative idea. Yet this tool is essential to the formulation of the creative idea itself. It is a play tool: it stirs the mind and feeds the fantasy, it yearns for a transformation. And it does so through the qualities that constitute its physical nature: its form, plasticity, texture, weight, temperature, its ability to bear load and deformation, to withhold and release tension, to participate in the creative dance of the body and the hands and warp with it until a something else is born.

In music, this kind of intimacy seems challenging to capture. It may come naturally with traditional instruments, yet in the instruments of the electronic age it remains distant, neglected in the face of other values. Like all modern technical objects, they too have undergone the transformations of miniaturization and automatisation, our interaction with them shifting from a gestural system of *effort* to a gestural system of *control*[14]. With this shift, the meshing between the body and the tool has weakened. The sense of touch has turned cold. But as the relationship between a musician and an instrument is an exceptional one — one between an artist and a tool — it may be that these transformations bear a cost. So in attempting to create a new instrument, the questions that arise may come in terms of materiality, in terms of scale, weight and texture, even prior to those of musicality. Surely, the two are intertwined; the musical potentialities are deeply innate to the material dimension.

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[13] Maurice Merlau-Ponty, *The visible and the invisible* (Evanston: Northwestern University Press, 1992), 113-114

[14] Baudrillard makes the distinction between these two gestural systems in *The System of Objects*, 48-49

Embracing the importance of materiality in the creation of a tool need not exclude the abstract energy sources like electricity from the recipe; it rather raises questions of how to embody them. The vastness of possibilities opened up by the electronic is unquestionable. Through it, John Cage had envisioned a kind of liberation from the constraints of the physical world[15], in the same way Marshall McLuhan saw in the electronic a freedom expanding in all horizons of human existence. In the electronic age, McLuhan writes, man will return to "a primitive and integral awareness", as "the mechanical begins to yield to organic unity"[16]. An extraordinary concept to inject into the arts, if we can grasp how to contain this new element and project it into the material world, how to fuse the dimensions of the physical and the electronic, to create a technology that distills the essence of the primitive into the modern. Electricity's sheer scale is far too miniscule and far too fast for us to grasp it, to even sense it as belonging in the same physical realm as we do. But combined with the plastic properties of physical matter, a spectacular synthesis can become possible. In "The Metaphysics of Live Electronics", Jonathan Harvey writes: "When electronics are seamlessly connected to the physical, solid instrumental world, an expansion of the admissible takes place, and the 'mad' world is made to belong."[17]

In my understanding, this expansion could not only apply to what can be made possible sonically, in terms of creating new sounds, but to how modern electronic instruments can still address the human scale visually, tangibly and acoustically. This concerns both musicians and audiences. As we saw earlier, from the perspective of an artist, intimacy with the material dimension can be vital to the creative act. This kind of intimacy, in a live act setting, can be *contagious*; it can reach out and magnetize the spectator. It will draw them in and allow them to connect to the musical act that they are witnessing, as the raw visual force of materiality becomes a stepping stone for them to resonate with the work. This connection is key to the visual arts. One is showered with awe when confronted with the intricacy behind Monet's strokes or the sheer impossibility of the Pietà having been carved by hand out of a piece of marble. In the visual arts, matter carries messages of effort, dedication, and extraordinary ability; in the same way, it is capable of radiating magnetizing waves as it resonates before us in the "fleeting", time-based arts. The musical act too can be palpable.

[15] "Tomorrow, with electronic music in our ears, we will hear freedom." Cage, *Silence*, 87

[16] Marshall McLuhan, *Understanding Media: The extensions of man* (London & New York: Routledge, 2001), 165

[17] Jonathan Harvey, "The Metaphysics of Live Electronics", *Contemporary Music Review, Vol. 18 Part 3: Aesthetics of Live Electronic Music* (edited by Peter Nelson & Nigel Osborne, 79-82. OPA1999), 80

Around the tender age of ten, my friends and I had developed an entire range of vandalistic practices. One of them was stealing freshly ripe oranges from the trees around the neighborhood, and waiting on the sidewalk, loaded with fire, until a car passed by. We would then roll the oranges in bowling fashion, trying to intersect the wheels of the passing car. It was down to fine geometry and speed; if the impact was successful, the show was spectacular: an exhilarating splashing sound merging with the raging machine passing by, celebrated by a firework of golden pieces flying in the air and the scent of fresh orange. It was absolutely gorgeous.[18]

[18] From own writings: *Calendar of the after hours*, 20/02/21

In the absence of a material dimension, especially in the context of a real-time, live art, we risk coming across a problematic of *distance*. This distance can occur in two ways. Firstly, between a musician and their tool, as was the case in my own experience with electronics. Secondly, between the musical act and the audience, as an obstacle in communicating what is happening, or how it is happening. Sensor-based instruments often try to address such issues by involving body and movement. But they rarely involve enough matter into the play; depriving the player of any haptic feedback, any resistance, texture, or pain. And from an observer's perspective, the analogies between movement and sound can often feel empty. When writing about such instruments, Richard Colson says that "physical computing creates the possibility of a direct relationship between a stretch (of the arm) and a sound"[19], comparing this action with prehistoric cave painting, and suggesting that with the same directness the cave dwellers used their arms to transfer the experience of the hunt onto the cave walls. But there is little directness in predetermining a causal relation between a set of numbers and a sound in no meaningful analogy, inside a black box that is housing decisions both arbitrary and hidden. And in respect to the artist-tool organism, as it is, "the *poetic* relation between the two too often tends either to the banal or the meaningless"[20].

There is no intention to undermine these practices but to understand their weaknesses. The goal of this search is to use the plasticity and the liveliness of the material dimension as a *resource*, and discover how it can manifest the vast potentialities of the electronic dimension. Through such interplay, we can expand the world of possible tools and possible sounds; we can materialize the instrumental and the performative capacities of the electronic. And if we are at risk of our tools and actions not being communicative enough, if we risk the disconnection of an audience that is alienated from the live act, we must invent the opposite of the black box. Such an approach would be a deconstructive one:

I should seek for t r a n s p a r e n c y.

[19] Richard Colson, *The Fundamentals of Digital Art (*Lausanne: AVA Publishing SA, 2007), 44

[20] John Croft, "Theses on Liveliness", *Organised Sound* 12/1 (Cambridge: Cambridge University Press, 2007). 59

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> We expect the sound to have a more or less transparent relation to the properties of the sounding body we see in front of us.[21]

In architecture, there were two individuals who advocated passionately in favor of exposure and honesty in the appearance of buildings. Their view urged for the abolishment of every decorative or concealing element that did not play a functional role as a part of the whole, and therefore could only obstruct the reading of the structure. These individuals were Viollet-le-Duc in the 19th century, and Adolf Loos who carried this idea into the 20th century. Their view that appearance should clearly reflect the structural principles was labeled *structural rationalism,* and in its most austere form it would strip buildings from anything that does not serve a clear purpose. It was not a popular view until modernism embraced it; Loos' architecture had even been characterized by his critics as the "naked body of a woman"[22].

To these people structural clarity was an aesthetic principle, in the sense that it is essential to the aesthetic experience that the relationship between form and structure is clearly displayed. It can thus be penetrated by the eye of the observer and analyzed into the component parts. And identifying the relationships that make up the totality of structure becomes part of the aesthetic experience. The visual satisfaction of understanding an artifact seems to be present in observing all kinds of material structures, from bicycles to bridges to the inside of pianos, to any object that generously exposes the ingenuity and delicacy of its workings. In instruments and installation art, these workings extend to the correlations between form and sound: how the physical properties of an object result in the characteristics of the sound, while the exposed details of its structure can communicate how the totality of the organism functions.

This idea of transparency is a reversal of the modern paradigm of an invisible technology, in favor of an open-machine aesthetic. In Jean Tinguely's works it was present as violent display of mechanics; which seems to have been inherited, even abstractly, in the works of sound artists like Pe Lang and Zimoun. Much more subtly, these expose material movement and the processes behind it to stimulate our engagement and immerse us in acoustic-visual amalgams. Transparency is a major factor even in the inventions of composers Ellen Fullman and Alvin Lucier, perhaps in its simplest form, where the relations between object, observation and sound are minimal yet extremely powerful. In its most exuberant, transparency takes a central role in the sculptures of Reuben Margolin, the strandbeests of Theo Jansen, or the incredible mechanical illustrations of Tony Wolf in the fairy tales of the Woodland Folk.

[21] Croft, "Theses on Liveliness", 61.
[22] Paul Carter, *Material Thinking* (Melbourne: Melbourne University Press, 2004), 36.

Technology has become noiseless and masks itself behind design, shiny surfaces and streamlined forms . . . .

As a sculptor I have to strive for a form with a clear *gestalt*, while technology, as I just said, is moving away

from such clarity into an ever more impenetrable anonymity. [23]

With each new thought, the conceptual assembly of this instrument gains a new building block. So far, I can assume that I am seeking for a morphology founded on the human scale, its form emerging from its function and, through this, acting as a communicative mechanism. It is a material assemblage yet its architecture is *transparent*; an exposed structure that can be visually deconstructed into its component parts, analyzed and comprehended. It is an artifact that has a physical substance and a bold presence in space; that can physically blend with a performer and be communicated visually and emotionally to an audience, while at the same time bypassing the limitations imposed by its own materiality.

And in attempting to approach this "bypassing", it is time to think about m o v e m e n t.

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[23] From an interview with Jean Tinguely quoted in Andreas Broeckmann, *Machine art in the twentieth century* (Cambridge, Massachusetts: The MIT Press, 2016), 76-77

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Drones impose a kind of sensory deprivation through effacing the variation we take for granted,

the ebb and flow of acoustic data that occur not only in music but in daily life as well.[24]

In July of 2018, I had the pleasure of working with my brother on a project that began from the simple idea of having animated objects, inside a space, engaging with some kind of a fluid material. We would then amplify the sounds of this material's movements and expose its microstructures at an overwhelmingly loud volume. The material of choice was sand, and the installation was called *Ebb & Flow*. Three mechanical objects engaged in an orchestrated interaction with the sand, each one in their own periodicity, each one with its own inconsistencies and fluctuations. The result was a dense sound landscape of inhaling and exhaling movements of sand. In the next two years, I had the opportunity to create another two mechanical sound installations in a similar direction. One of these was created in May of 2019 at Steim, Amsterdam, by the name of *The Way things Come Around*. The second one was made in July of 2019, again in collaboration with my brother, by the name of *The Two-Body problem*[25].

What is common amongst these works is something that encapsulates my absolute main interest, which is exploring the intricacies of movement and sound in animating materials. Every material seems to contain an inner life of its own, which can be vibrantly displayed when it is animated under certain conditions. These can be set by framing it in a setting where forces are imposed on it, but the material is never completely constrained, rather it is given as many degrees of freedom as possible. By doing this, one can induce states of movement that are seemingly periodical or repetitive, but in fact contain an infinite amount of detail and variation. Through these organized structures, I strive to approach a somewhat organic behavior: a motion full of intricacy, richness and unpredictability. The spontaneity of the materials together with the imperfections of the mechanical structures form a condition of unstable vibrancy; a movement that seems to pulsate around itself, living on a fragile balance between following a pattern and constantly almost escaping it.

Such are the movements that I see everywhere around me: in the dances of the elements under the wind and gravity; in the trees, the water, in the clouds. I find these absolutely fascinating. Seeking for them by manipulating materials may not be about conveying some form of meaning, in terms of human cognition, but rather about allowing the mind to wander as it does when observing the wonders of the natural world.

[24] Joanna Demmers, *Listening through the noise: The aesthetics of experimental electronic music* (New York: Oxford University Press, 2010), 93

[25] All of the above are documented at https://mihalisshammas.com/work

In the latter, taste seems to fasten not so much on what the imagination **apprehends** in this field as on what gives it occasion to **invent**, i.e., on what are strictly speaking the fantasies with which the mind entertains itself while it is being continuously aroused by the manifold which strikes the eye, as for instance in looking at the changing shapes of a fire in a hearth or of a rippling brook, neither of which are beauties, but both of which carry with them a charm for the imagination, because they sustain its free play.

Immanuel Kant, *Critique of the Power of Judgment* (Cambridge: Cambridge University Press, 2000) 126-127

Presumably, every material is in itself already an animated entity, with its own growth and decay, in its own scale and time, regardless of human observation. And usually in rhythms that are immensely slow for the human perception. As Jane Bennett writes, “the stones, tables, technologies, words, and edibles that confront us as fixed are mobile, internally heterogeneous materials whose rate of speed and pace of change are slow compared to the duration and velocity of the human bodies participating in and perceiving them. ‘Objects’ appear as such because their becoming proceeds at a speed or a level below the threshold of human discernment”[26]. My idea is to transpose this life into the human perception time realm, by forcing the materials to exhibit a dance that, regardless of this time shift, still derives from their unique physical properties.

This approach on movement is irrelevant to any concept of directionality or velocity but is much better comparable to the phenomenon of an aura. A movement state similar to a nebulous stasis, veiling an infinite amount of detail within it. Such a state treats time as a static infinite moment, beyond any kind of linearity, as it embraces a different understanding of it: a notion much closer to Jonathan Kramer’s “vertical time”[27]. This is a notion of time, or rather of non-time, that is infused in the movies of Andrei Tarkovsky, the paintings of Mark Rothko, in the music of Eliane Radique and Sarah Davachi, the installations of Olafur Eliasson, in the light atmospheres of James Turrell. It is much more akin to creating an eternal space, a magnetizing density, a pausing of time, being and desire, which to me is the essence of *drone*, and is what I try to capture by creating my own tools.

Music attempts to suspend or abolish time by accomplishing it.[28]

[26] Jane Bennett, *Vibrant Matter: A political ecology of things* (Durham/ London: Duke University Press, 2010), 57-58

[27] Jonathan Kramer, *The Time of Music* (New York: Schirmer books, 1988), 7. “In one kind of music, however, there are no proportions, because time does seem to be suspended. This most radical species of musical time is vertical time: the static, unchanging, frozen eternity of certain contemporary music.”

[28] Jean-Claude Risset, “Composing in Real-Time?”, in *Contemporary Music Review, Vol. 18 Part 3: Aesthetics of Live Electronic Music* (OPA, 1999), 37

Part II

M a k i n g

Concept

The core idea behind this project was formed by two converging forces. The first one was the array of ideas discussed in the previous chapters, seeking to find their expression in a material form. The second one was my experience in performing live music with self-made instruments in the past, and in particular the qualities that these appeared to lack, illustrated through their some occasional glimpses of potential.

The instruments I am referring to are called Kyklophonon I and Kyklophonon II. These are upright, self-standing stringed instruments that utilize simple mechanical principles to allow control over their tuning and their built-in sequencers. Their strings stretch downwards to the floor, kept under a steady tension by weights suspended on both their ends. Even though tensed, the strings are still free to travel vertically in the same way an elevator does. They rest on sliding mechanisms on which they can effortlessly glide when the knobs are turned; their movement smooth but heavily saturated with the inertia of the two opposing weights. Following this rotational motion, wheels attached on these mechanisms will indicate the frequencies of the two string segments at any given position.

Picture 1: Kyklophonon II (2018)

Giving these instruments the degree of height that I did and placing the controls at the top, made it only possible to interact with them in a standing position. It took some time until I realized how uncomfortable and unmusical this position felt to me. During the live performances, it was not possible to physically come to an ease, and to rid of the feeling that I am some kind of an actor. The instruments themselves, apart from being to some degree structurally and visually interesting, lacked the musical potential I had imagined, and eventually served better as autonomous kinetic sound sculptures. Their mechanical sequencers could function for a considerable amount of time before parts started to collapse or everything went out of tune.

But there was a certain poetic dimension to this behavior, something that I repeatedly tried to explore through both sound sculptures and sound installations. In the spontaneity and the errors, in the slowly disintegrating choreographies and the inevitable endings of animated material structures, I saw something that deeply captured my interest. The materials seemed to speak a kind of language. And in each of these cases, as described in the previous chapter, I tried to induce a state of movement unique and innate to the specific material used, exposing its inner life. For this to occur, the systems were given many degrees of freedom. Surely, an instrument might call for a higher degree of rigidity, stability and precision. But it could still benefit from the insights I had in working with the liveliness, unpredictability and finitude of animated material structures.

The only possibly valuable musical potential of the Kyklophonon instruments was revealed when two players would perform at the same time using electronic bows. Each player had to occupy one of their hands just by holding the E-bow in a steady or a varying position, while the other one was free to control the frequency by rotating the pitch mechanism, which allows for very small shifts. This is where all the rich microtonal drones began to emerge. Apart from the ear-tingling dissonances, the motion of the strings, which were simultaneously vibrating and oscillating as pendulums, gave the resulting sound that organic quality I was so keen to induce. Presumably, adding in more performers could even make things better.

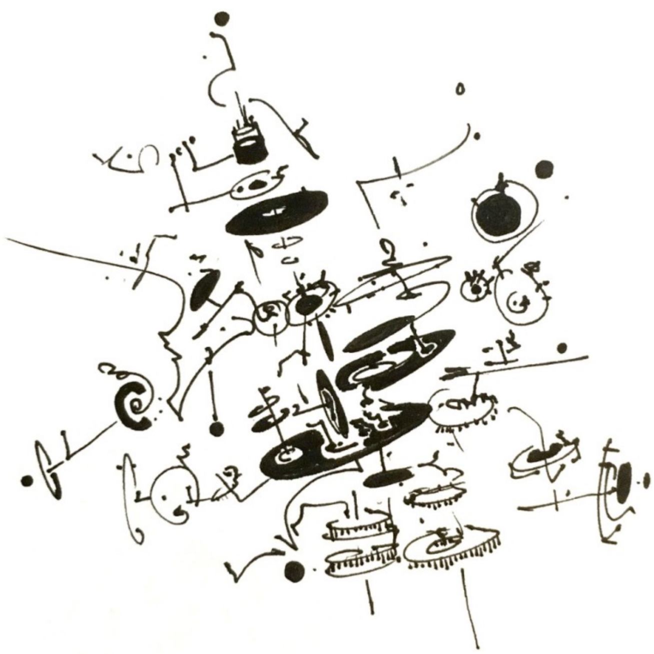
These drones planted the seed for the idea of a completely new instrument. The object envisioned was that of an *electromagnetic drone stringed instrument,* capable of producing many different voices simultaneously by exciting the strings with electromagnetic forces. To eliminate the need for more and more hands, this new structure could incorporate its own built-in electromagnetic excitors. Using strings as the source of sound once again would grant me with a creative limitation, but also with the challenge to discover in these simple linear objects that organic richness that, to my experience, beautifully emerged when animating materials with external forces. The instrument's design could be somewhat more precise and rigid than the previous ones, but still allow for some degree of relative motion between the protagonist parts, that being the strings and the excitors. And instead of only utilizing "primitive" mechanical principles and kinetic mechanisms for adjustments of pitches, dynamics etc., I could incorporate electric and/or electronic controls to manipulate the behavior of the electromagnetic fields. This should allow the instrument to be paired with digital tools and even be programmed. In this way, this instrument would attempt to stretch out its tentacles into both the physical and the electronic dimension and try to take the most out of both.

To begin walking down this path, the first steps to take were straight forward:

1) Laying out a basic architecture for this imaginary structure. This could begin with a diagrammatic sketch on paper which abstractly suggests a form and a scale, and at a later stage acquires more detail to define how the relationships between its component parts can function. This is a practice inherited from my background in architecture.

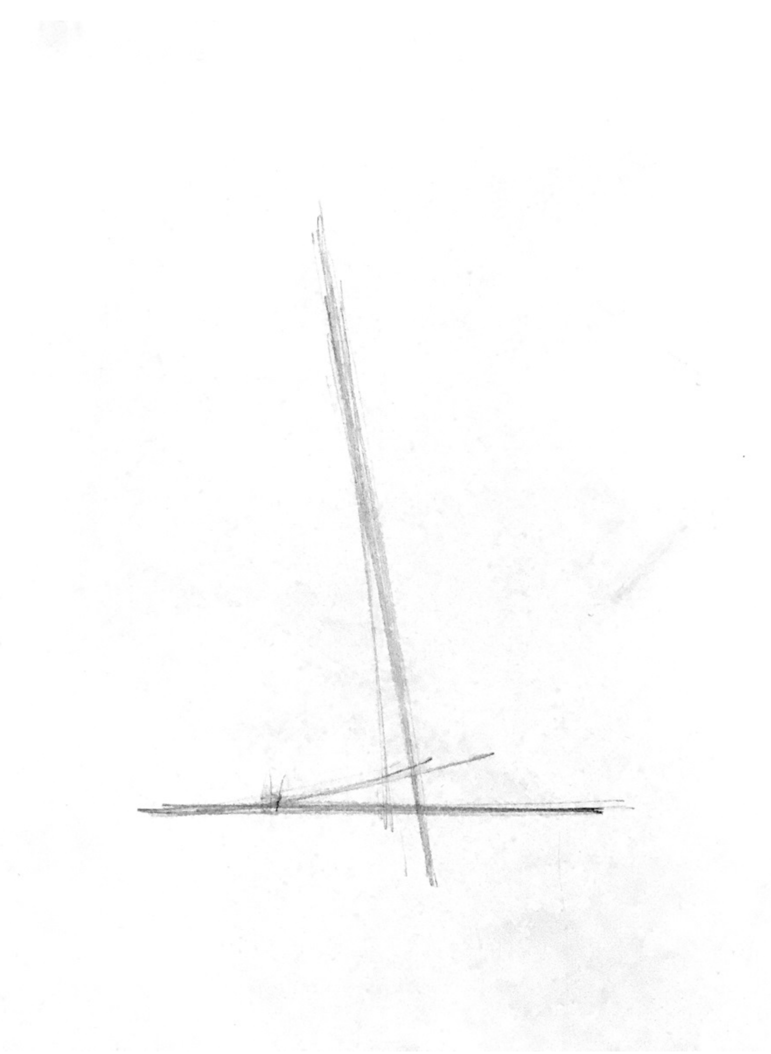
2) Researching how electromagnetic sustainers can actually be made, and to what degree these can be controlled through an electronic interface. Should this research be successful, there would follow an experimentation on different kinds of strings, as well as different lengths and different tensions. By altering parameters in both the mechanical characteristics of the string system and the properties of the electromagnetic pulses, I could identify what variables would be valuable enough to be established as controls in the final instrument.

While the first step was well within my area of comfort, the second one began effectively from square one.



Picture 2: Brainstorming doodle

The lines matter.[29]



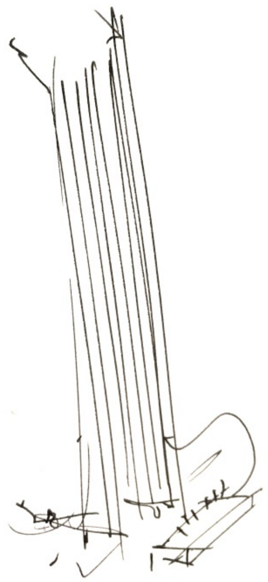
Picture 3: One of the first sketches made for the instrument, September 2019

[29] From own writings: *Calendar of the after hours*, 11/10/19

Research & Design

Draft outline

The first sketches, made in September of 2019, merely indicate an idea of how this object could exist in three-dimensional space. The posture envisioned would fulfill practical, conceptual, as well as aesthetic needs. Accommodating large lengths of strings, as was expected to be needed, would necessitate a longitudinal main body which should also be able to stand vertically on its own. This way it could have a strong presence in space, calmly displaying its form and structure whilst freeing the player from the burden of having to support its weight. The performer should be able to comfortably seat on the floor, cross legged, in front of the instrument. When playing music, I've found that this position had always given me the most grounding and balance, in the sense that I could comfortably forget about my own body and become absorbed into the play. This had been the case with all kinds of different instruments: from guitars to electronics, to percussion objects. A chair or a standing pose had always kept me too close to normality. To the eyes of someone else, the instrument and the performer should be perceived as two distinct and equal entities that come into a gentle dialogue and merge through the act. The balance between the two should never gravitate towards one or the other; but if one were to visually stand out, that should be the instrument. In some abstract way, in its posture, this artifact obtains the characteristics of a ritualistic object, radiating the essence of the sounds that I expect it to create. In their posture, the human is ready to be absorbed, consumed by the object.



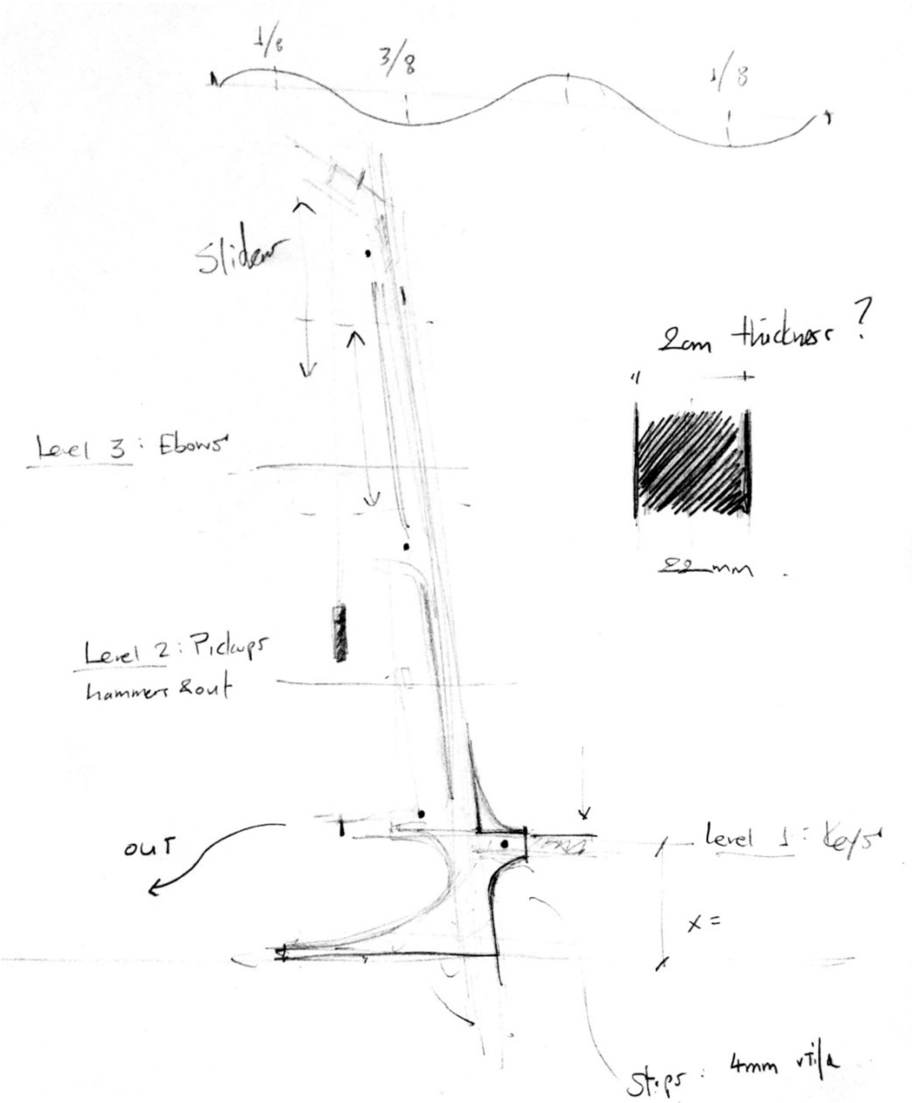
Pictures 4, 5: First sketches

The inclination of the instrument serves both static purposes and allows a seated player to have a more comfortable interplay with the interaction surface, which would be the entire front side of the instrument. At this point, there was still no plan for the methods of playing with this object; only a vague idea that the hands will be used at different heights along its structure, mostly between its lowest part and middle, to control either mechanical or electronic parameters. There was an impression that fingers may be used in a similar arrangement to how they rest on a piano keyboard, exerting forces on some kind of mechanisms or controls. This was an arbitrary but a very strong intuition. Using paint, I made several fingerprint presses on paper to find the average distance between my fingers when my hands rested in a comfortable position. When all the prints were processed, the mean value measured was a distance of 36mm. This distance was decisive in setting the spaces between the strings and eventually became the basic structural unit of the entire instrument.

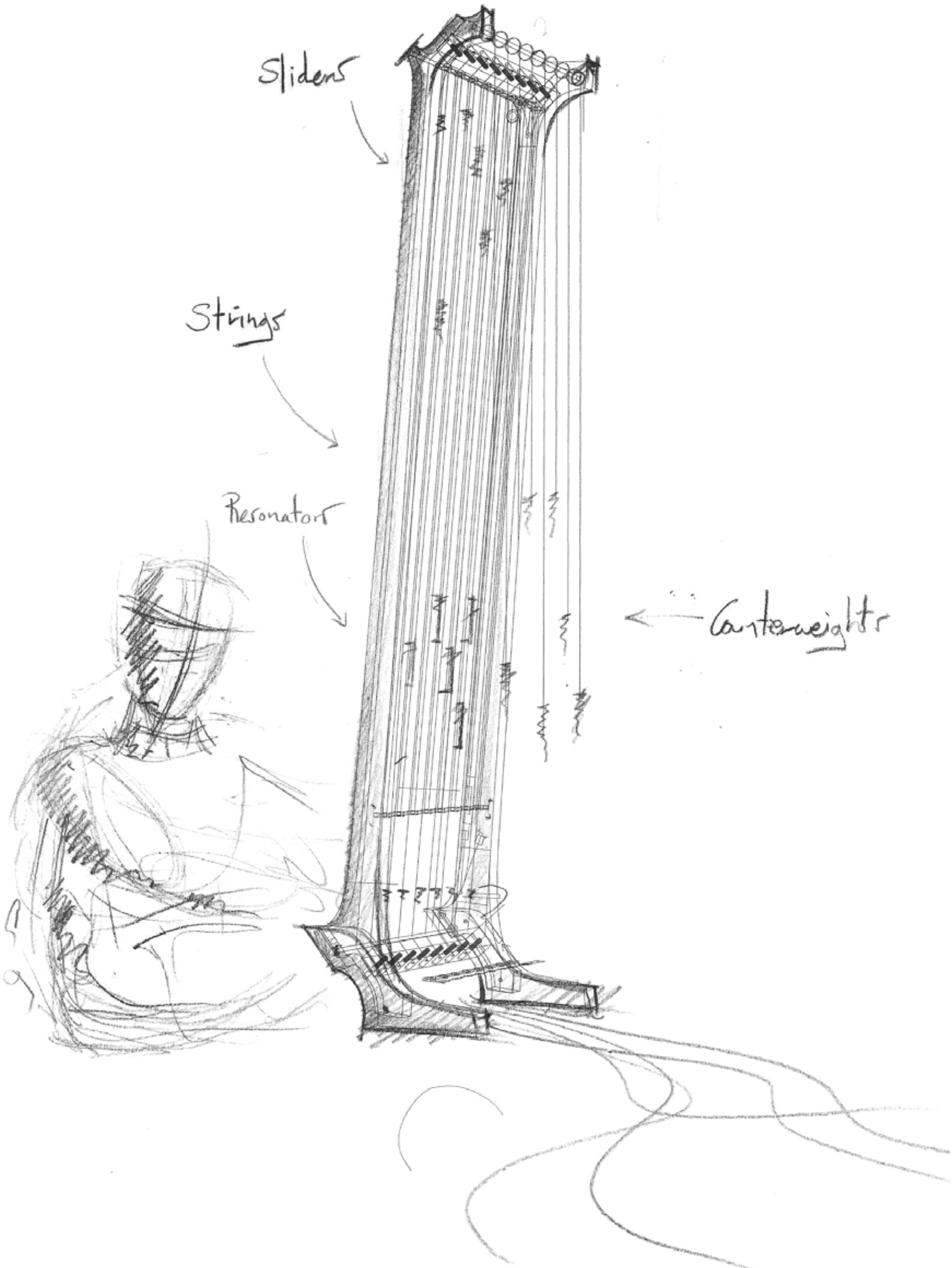
Picture 6: Example of a fingerprint press (1 out of 8)

The layout sketches started to acquire more and more detail as ideas for various functions began to emerge, and these needed to be distributed along the height of the instrument. Firstly, there would need to be a structure on the instrument for mounting the electromagnetic excitors. The mounting method should allow them to maintain a degree of freedom in their movement — this could be for example their linear positioning along the length of the string, their rotation angle, their perpendicular distance from the string, or all of the above. Such movements could be achieved by using steel shafts and linear or radial ball bearings; these allow for fluid motions to occur within an otherwise rigid structure.

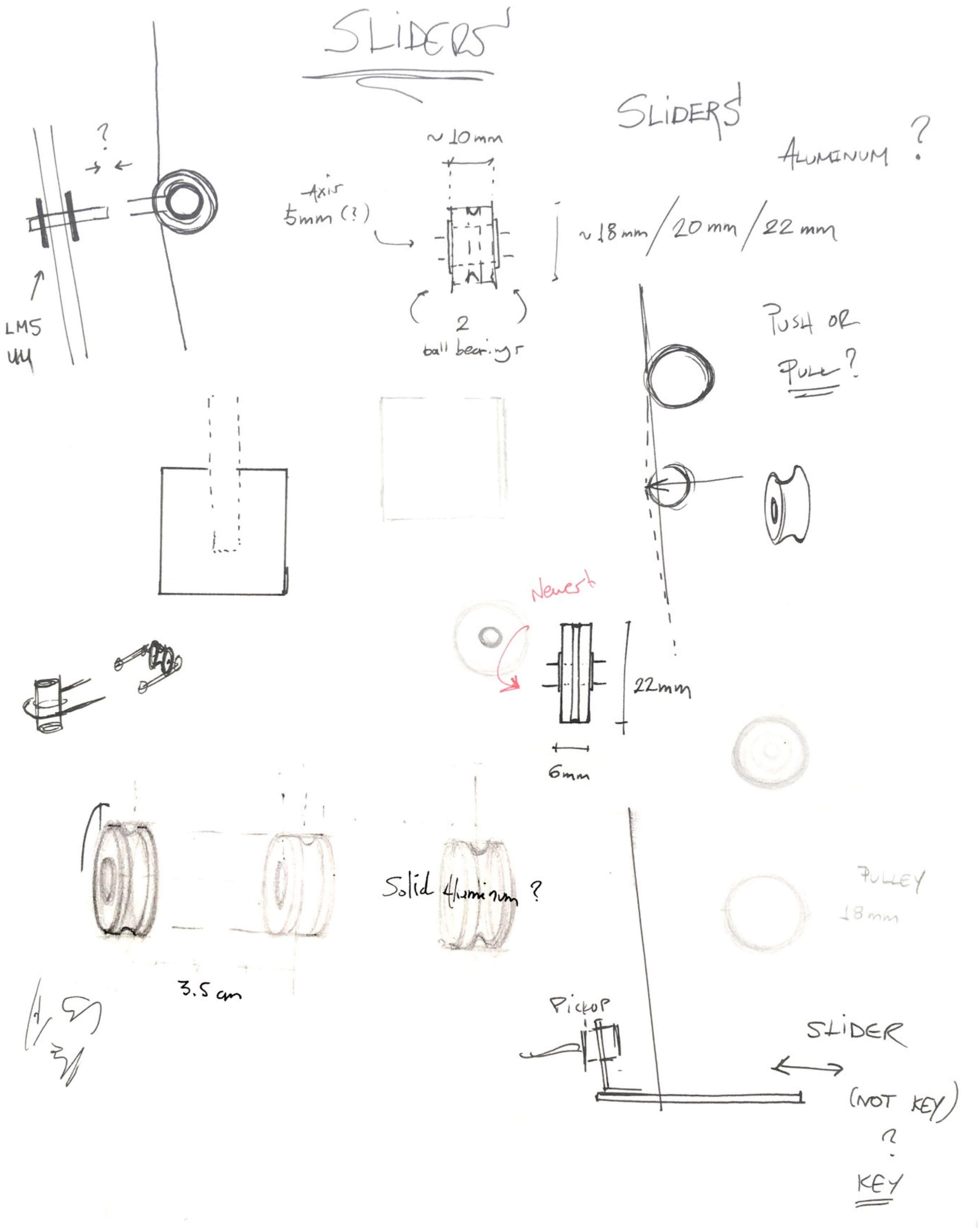
The pitch of each string could be adjusted mechanically, by means of a set of mechanical sliders pressing against the strings. These would change the active length of each string and thereby its fundamental frequency. For an active volume control of each string, there was an idea of piano-like keys being used to bring the electromagnetic pickups (the instrument's microphones) closer or further away from the strings. All of these ideas had to go through a prototype stage and then tested to determine if they can possibly work; if not, undoubtedly more of them would come along the way.



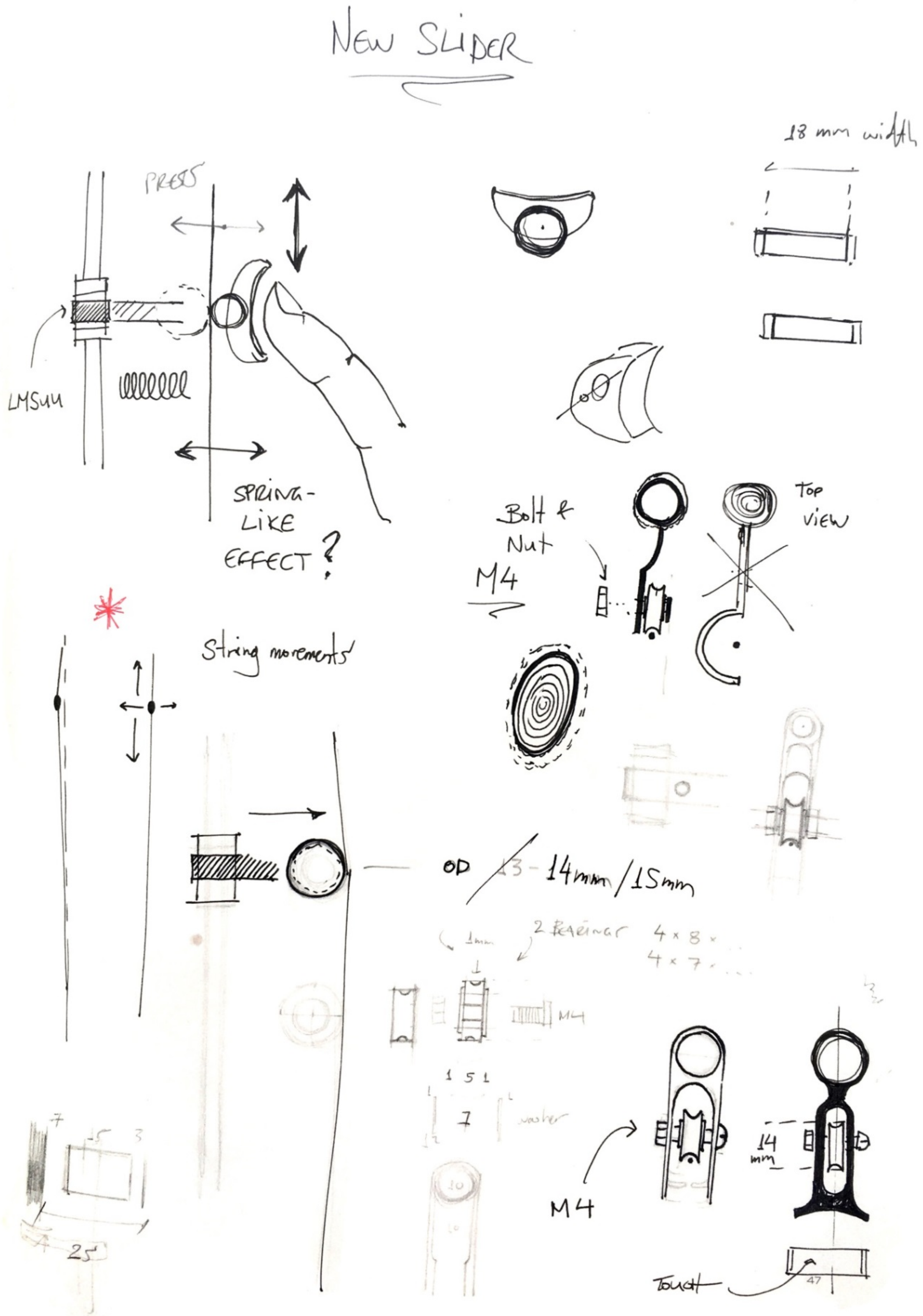
Picture 7: Sketch with functions



Picture 8: Sketch, January 2020



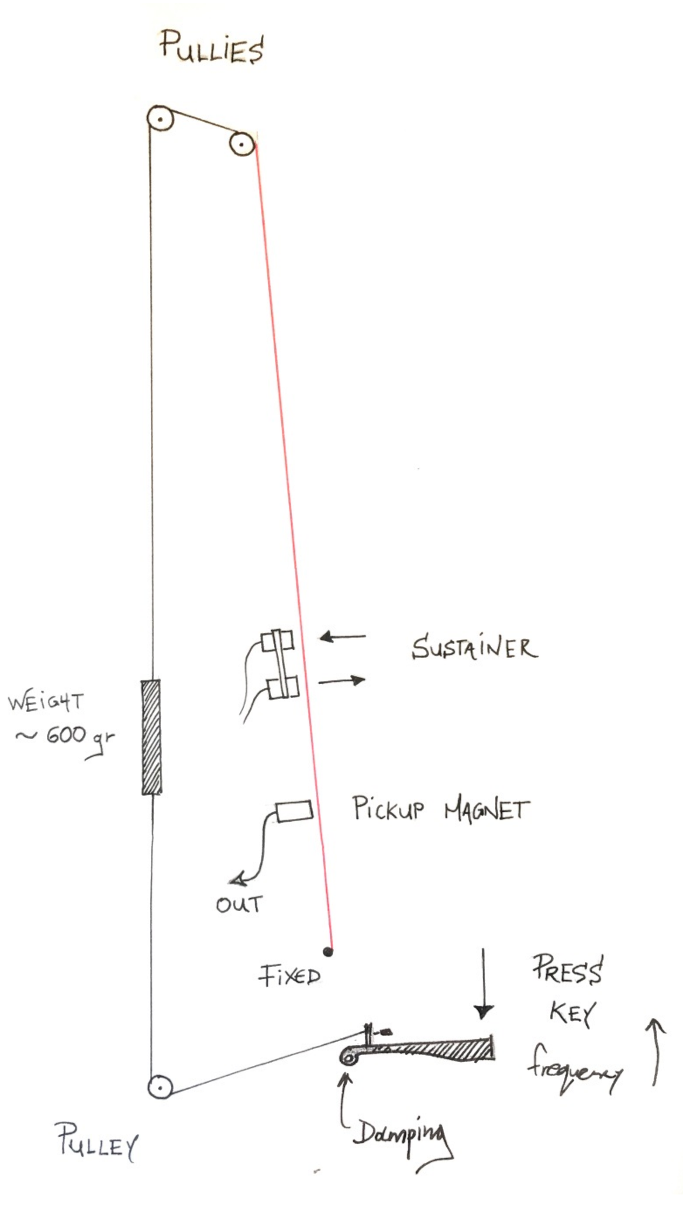
Picture 9: Sketches for the pitch sliders



Picture 10: More sketches for the pitch sliders

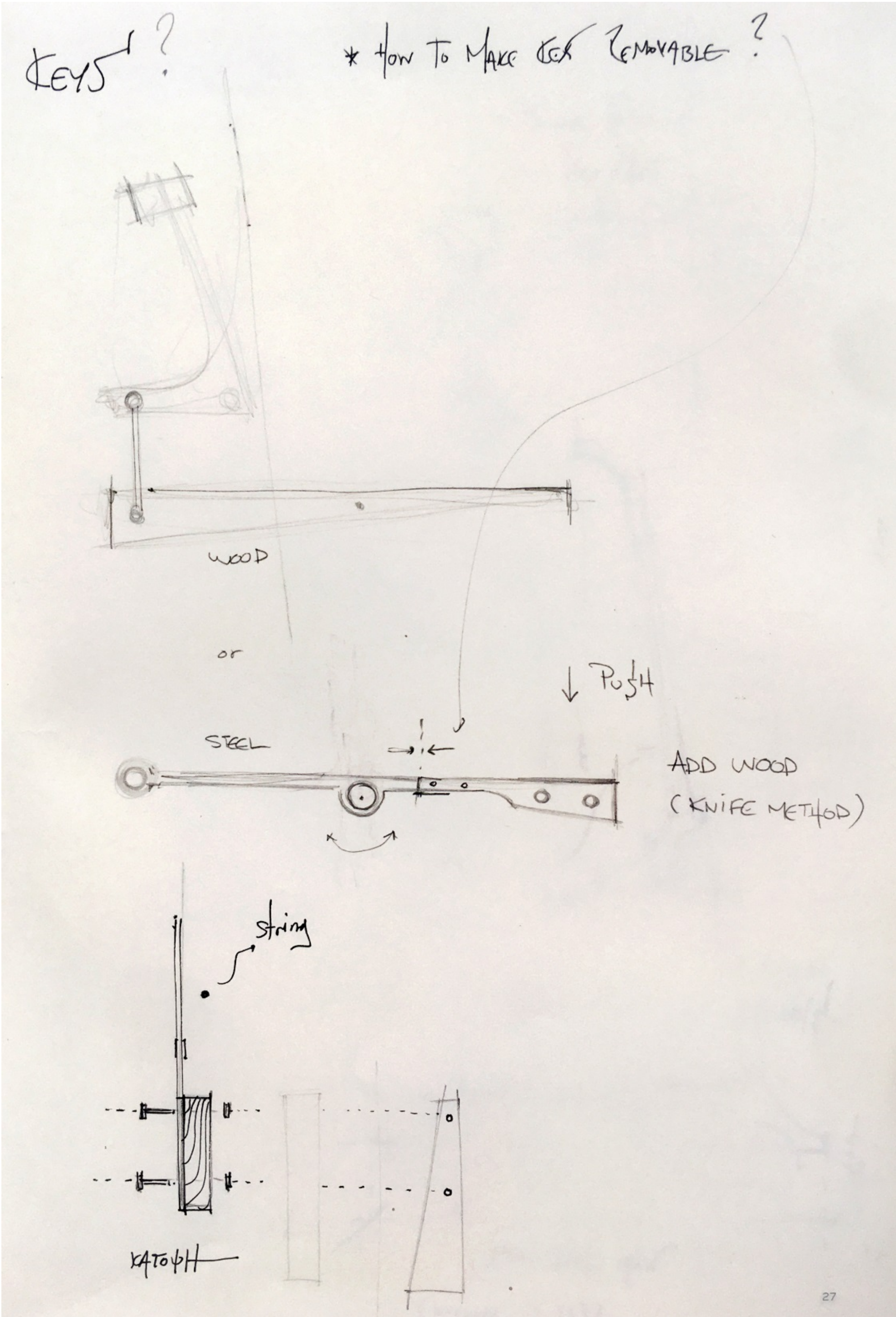
Picture 11: 3D printed prototype for the pitch slider.

The pitch slider idea was one of the first to be tested. My testing lab at this point in time consisted of a long (110cm) piece of pine wood, two piano tuning pins and a 0.5mm saz string. After many experiments it became clear that the slider method was not ideal for pitch control, as it did not produce the desirable effect on the string. Even when the contact wheel was replaced by a metallic one, the pressure needed to be applied on the string was such that it significantly altered the geometrical alignments between the strings and the rest of the elements, compromising their smooth function to a degree that was not acceptable. With lower pressure, the slider only produced an undesirable "muting" effect. Evidently this was probably not the appropriate way for pitch control, so I started to investigate ways in which instead of changing the active length of the string, I could alter its tension. In a discussion with Joel Ryan I explained how I was only interested in micro-changes, and the idea of violin fine tuners came up — an item whose existence I was not even aware of. I quickly purchased a few and tried them on the monochord; the result was so satisfying, that even if my prehistoric mechanical ideas did not work out I knew I could always use that solution.



Picture 12: Weight-and-key idea for pitch change

Key ideas had come up twice so far, once as a volume pedals and once as pitch pedals. I knew that either of these would be extremely challenging to engineer if they had to produce the desirable effect but also have a pleasant feel. Studying the piano mechanism was helpful to some degree, even though its extraordinary complexity — arising from the need for the hammer to be released immediately after it hits the string — was not something needed in my case. I decided to proceed with the overall design of the instrument as well as the research on the electronics and settle on these decisions later on, once I had a first 1:1 prototype.

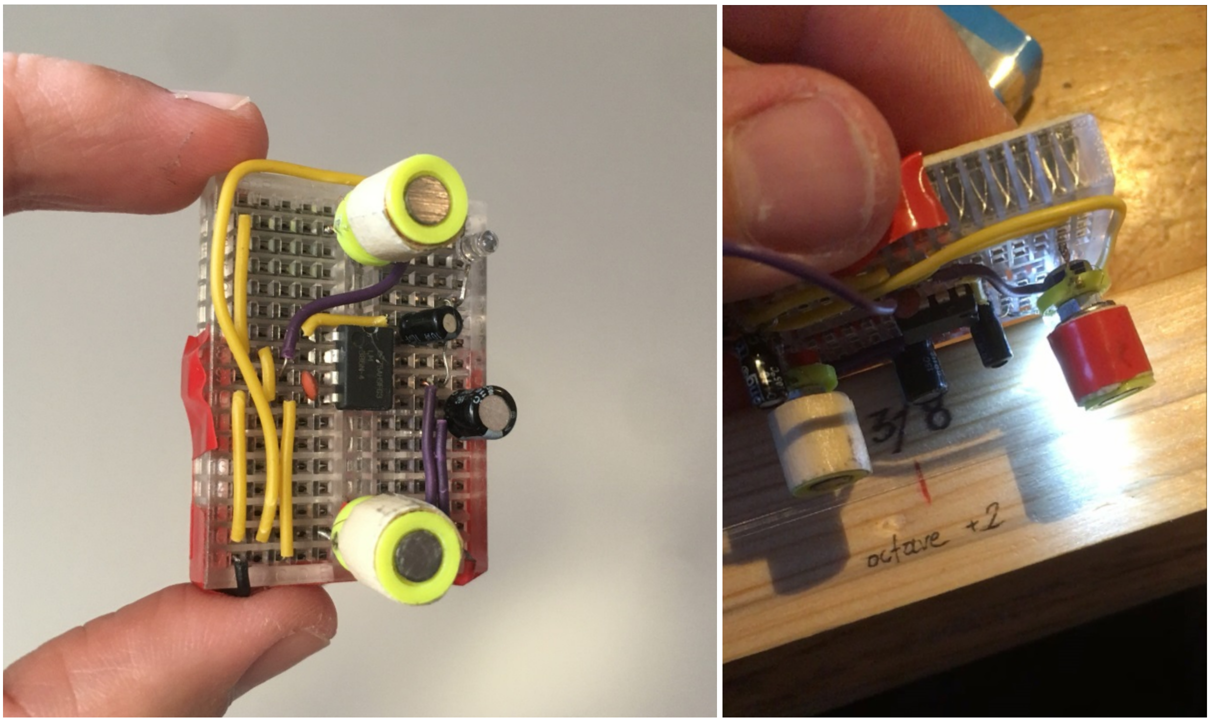


Picture 13: Key sketches

Electromagnetic sustainers: Research

To gain an initial understanding of how electromagnetic sustainers can be made, I began by dissecting and trying to replicate the circuitry of a commercial E-bow device, which is designed to be a string sustainer for electric guitars. Its circuit is based on an input coil (listener) running through an LM386 amplifier to an output coil (driver). The listener coil is passive, and can convert the movements of ferromagnetic material like steel strings into current. The driver coil is active, converting the current running through it into an alternating magnetic force projected outwards. When powered, the battery voltage will induce a default white noise-like current at the driver coil, which is enough to push the string to an initial vibration. Once the string is oscillating strongly enough, the listener coil will pick up on these vibrations and convert them into an electric current which is amplified and sent straight into the driver coil. This is a simple feedback system designed to force the string to oscillate in its own natural frequency. Varying the position of the device along the length of the string can result in oscillations that correspond to a harmonic, usually one or two octaves up (1/4 or 1/8 of the length accordingly) or a fifth (1/6 of the length).

The first experiments were done on the simple monochord mentioned before. A significant amount of time was spent trying to get this system to work. Most of the time went into trying to perfect the coils — which were hand made — in terms of physical size, impedance and their relative ratio in ohmage. And even though after months of work the circuit was working well, the string movements and thereby the resulting sounds were completely *static*. What I was able to achieve were steady, monotonous vibrations that were simply not what I was interested in. It was clear that this circuit needed to be expanded.

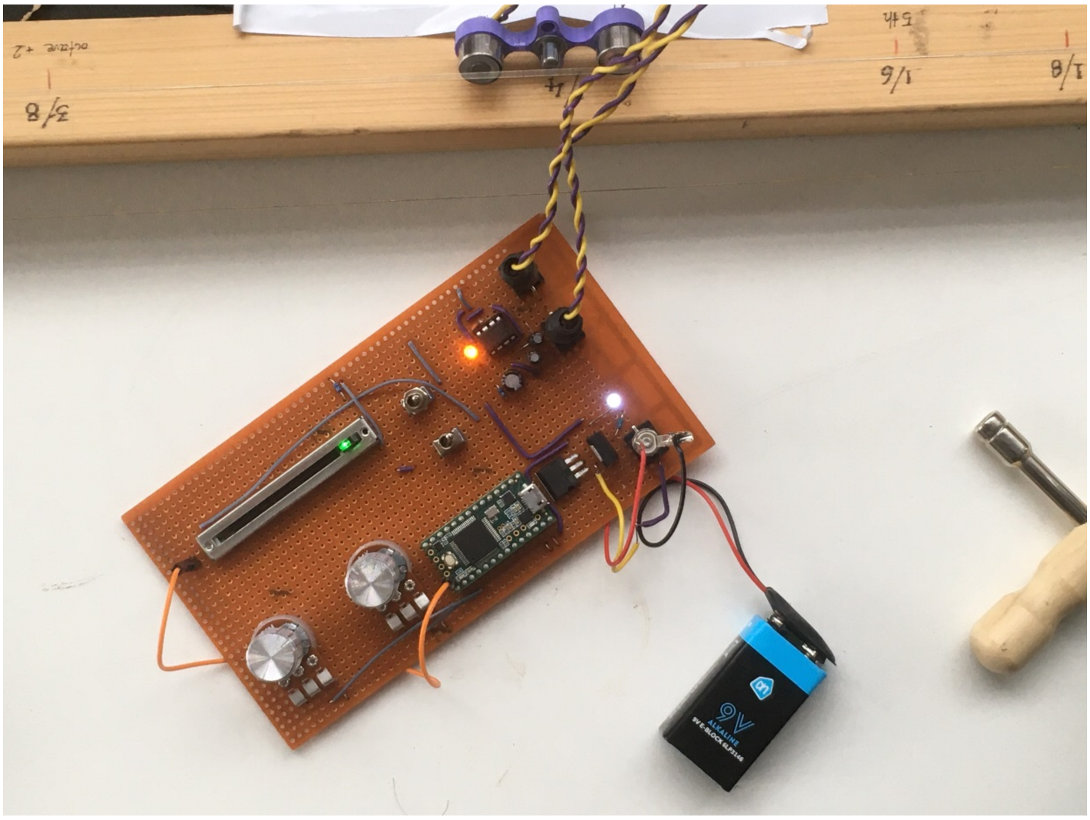


Pictures 14, 15: One of the first working prototypes of an E-bow replica

In the weeks that followed I started to tweak the electronics in completely arbitrary ways: changing the values of the capacitors and adding in new components where they did not belong. This was done in a complete blindfold; my utterly elementary knowledge of electronics did not allow me to comprehend the impact of these modifications. It was a time gamble, waiting for serendipity to occur.

And so it did. One of the modifications caused the driver coil to start pulsating at a low frequency (50-60Hz) and then slowly climb upwards. This had a tremendous effect on the string's vibration: it would oscillate in such a way, that it produced not only its natural frequency with the occasional harmonics, but several other dissonant frequencies, especially at the very high end, associated with the "irrelevant" frequency projected by the driver coil. At any moment, the string was producing at least 3 to 4 tones at the same time which also appeared to be modulating each other. The movement was too complicated to understand; the string was constantly struggling to maintain its natural resonance whilst coping with the magnetic forces imposed on it, the different waves across its length fighting over which one will dominate. It was finally coming alive.

It immediately became a top priority to understand this serendipity and be able to recreate it at will, as well as to attain some degree of control over it. The first component to be recruited for this diagnosis was the Teensy 3.2 microcontroller, which was used to produce simple square waves at an adjustable amplitude and frequency and feed them into the driver coil. In addition, I used a fader to mix between this mode of operation and the simple feedback mode of the initial "monotonous" circuit. The results were promising: I was able to induce similar states of oscillation to those of the broken circuit, but this time in a "designed" manner (for example the amplitude and frequency of the forced magnetic pulses could be adjusted with two knobs).



Picture 16: The Teensy prototype. Mixing between forced magnetic pulses and normal feedback mode.

What is important to note here, is that recreating the serendipity and gaining control over this circuit did not grant me with the power of understanding precisely what result to expect with each parameter change. The string was like a bird in a cage: its movements could somewhat be expected to occur within a specific space, yet the micro-events within that space were erratic, much like the behavior I was looking for.

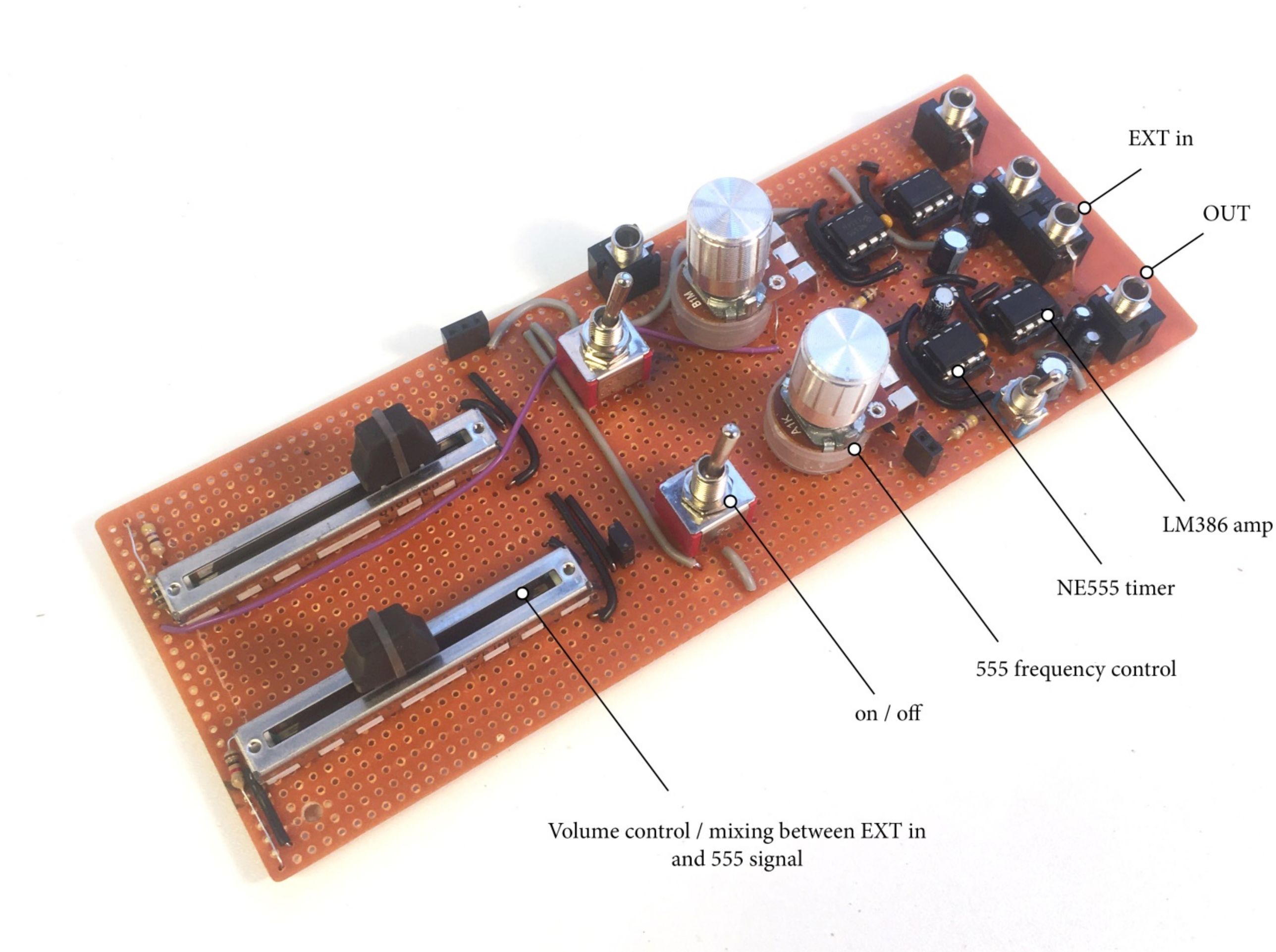
Throughout the course of these experiments, I found that the most successful outcomes occurred when working with relatively large segments of string, approximately 95-105 cm, that were under a very low amount of tension (usually less than 1 kilogram). Being this long and this loose gave them the freedom to reach complex, multi-layered modes of oscillation. The thicknesses of the strings found to work best under these conditions and with this electromagnetic system ranged from 0.25 to 0.5mm. Below this size, the strings were too thin to be significantly affected by the electromagnetic forces. Above this size, the strings were too thick for an instrument of this scale; they seemed to require greater tension and even more length. Lengthwise, I concluded that at most a span of 110cm should be sufficient for this project. And last, the consistency of the strings should be as high as possible in iron, which has the highest ferromagnetic properties amongst all the common metals. Carbon steel strings, which are used in several instruments, were ideal. A combination of tanpura, saz strings and piano wire was sufficient to cover the desired frequency spectrum at this stage.

From Digital to Analog

The Teensy prototype gave me a good idea of what parameters were important to be variable in the electrical signal sent to the electromagnets. At this early stage, simply altering the frequency and amplitude of the signal, thus modulating the exerted magnetic force accordingly, was already giving me satisfactory results. The rate of these changes needn't be fast; in fact, the most majestic shifts happened over immensely slow changes of frequency or when a specific sweet spot was found (usually just a few Hz off the resonant or a harmonic). Micro-scoping between modes of oscillation was opening up spaces where one could "zoom in" endlessly. Nevertheless, I would need to find a way to apply these changes independently to each string, each one with its own dedicated electromagnetic signal. The Teensy microcontroller wasn't ideal for this job; firstly, because it only has one DAC port for generating these signals. So I could never have many lines of different waveforms coming out. Secondly, the overall current needed to run a total of 8 driver coils would be an estimated 800-1000mA which would be too much for this microcontroller to deliver.

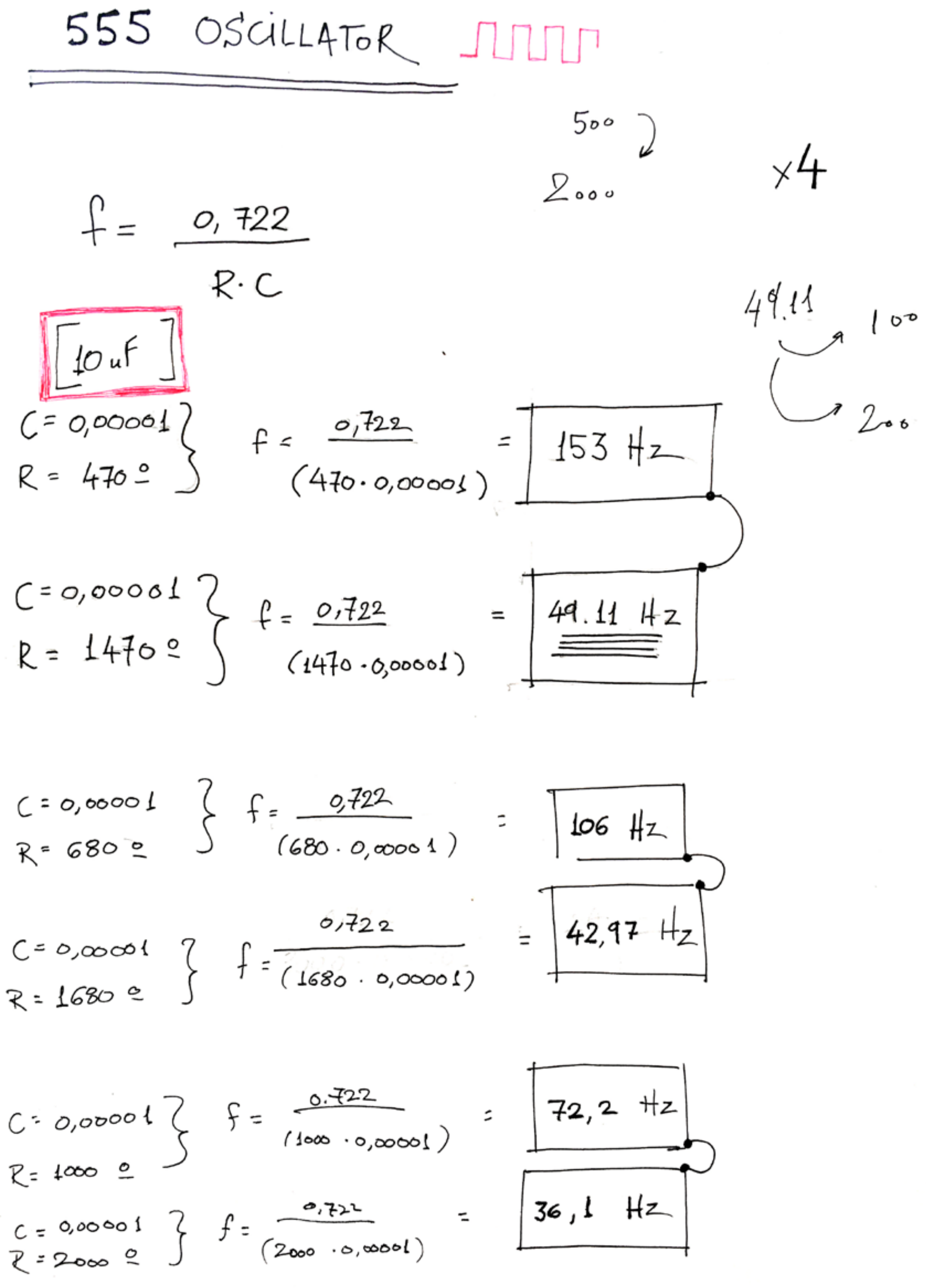
Around this time the book "Handmade Electronic Music" by Nicolas Collins fell into my hands. Going through this book I discovered that creating simple analog oscillators is not a difficult thing, as long as one doesn't need more than square waveforms. Through my experiments with the Teensy, I had found that changing the shape of the waveform sent to the magnets (square/ saw/ sine/ triangle) had no noticeable impact on the mechanical behavior of the string, and therefore the sound. So only using square waveforms wouldn't really be a limitation. I thus had the idea to create a circuit with 8 different analog oscillators, each one with controllable frequency and amplitude. Essentially, this would be a mini 8-voice, drone synthesizer.

After some research and the friendly advice of Mike Page, I decided to use the 555 timer chip, which can turn into an oscillator with just a handful of extra components. A combination of a resistor and a capacitor defines the range of frequencies the 555 can produce, and by adding a potentiometer one can sweep through those values. I created the first module with two oscillators going through an amp and out to the electromagnets. And here is the nice part: I left the circuit open so that different inputs, other than the 555, can always by plugged into this system.



Picture 17: New oscillator system (two parallel modules)

So this circuit offers the option to choose if the electromagnet will be activated by the 555 timer or an external source. The external source can be a listener coil close to the string (initial normal feedback mode) or *any other source* of electrical signal. The two can be mixed together by the using the fader. If one of the two sources is grounded, the fader will act as a volume control for the other.



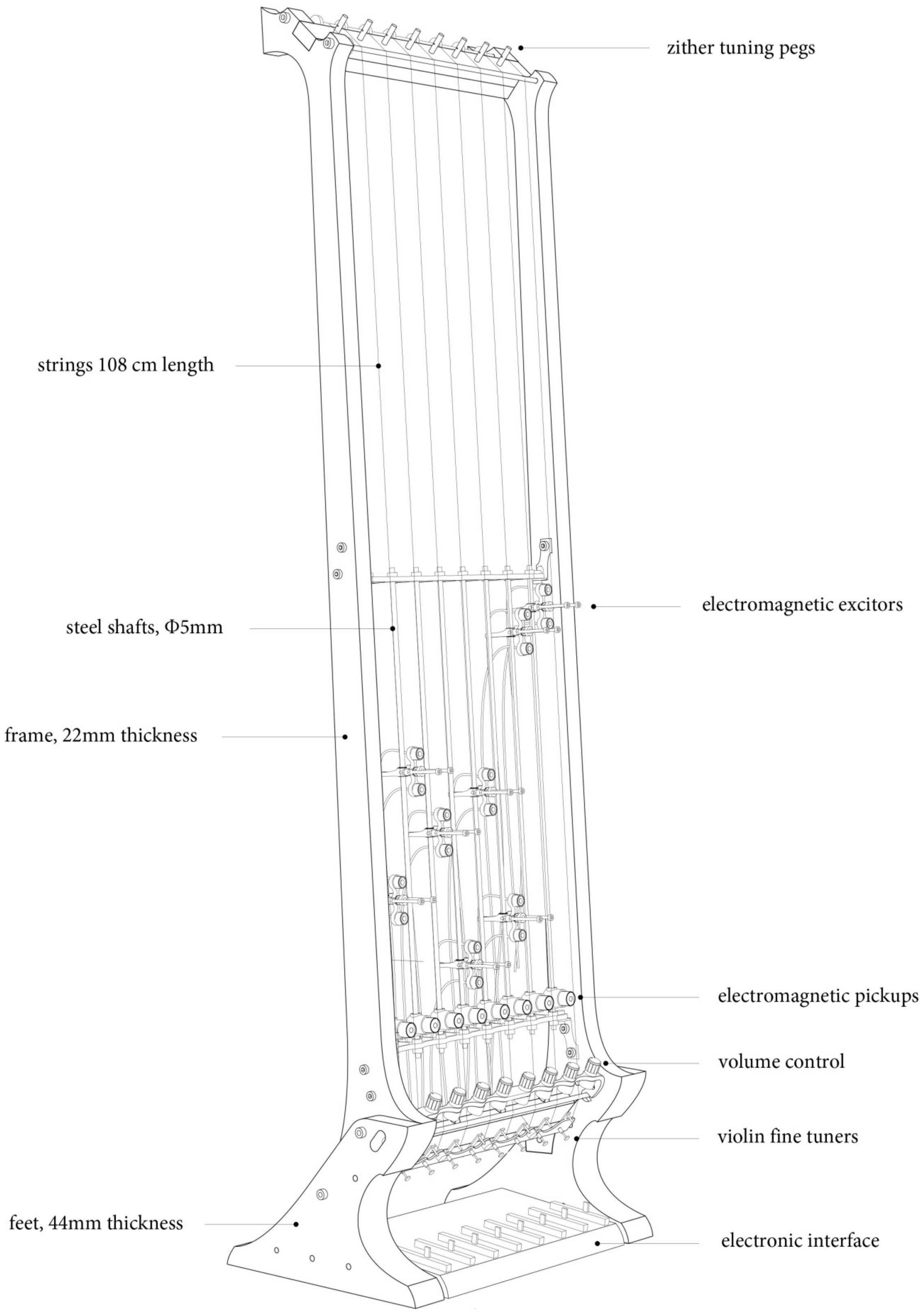
Picture 18: Calculations for the frequency ranges of the 555 oscillators

At this stage there was enough evidence to convince me that the idea of creating this instrument was actually realistic. The initial two steps were now ready to proceed to the next level:

1) Transitioning from sketches on paper to a precise design, and preparing the different parts for fabrication.

2) Finalizing the research on the electronics so that it can be contained in a physical form and incorporated in the body of the instrument, whilst remaining open to further development.

It was time for some serious computer work.



Picture 19: Final design

After countless iterations, the frame of the instrument was set to an inclination of exactly 4 degrees and the string span to a length of 108cm. The mounting structure for the electromagnetic excitors was designed to only occupy half of that length, as that would be enough to cover all of the different oscillation variations that derive from their positioning (extending upwards would just mirror their behaviors). From these three basic premises all of the details followed accordingly. Most of the controls were placed at heights where they would be reachable in a cross-legged sitting position.

It may seem that with this design I am skipping hundreds of hours of work and many important decisions. That is indeed the case. These hours went into finalizing geometries and making decisions about dimensions that go down to the scale of a twentieth of a millimeter. As the next stage from here would be fabrication, this design had to be informed about all the details necessary for the final assembly of the instrument; even the dimensions of the connecting bolts and the exact type of ball bearings, so that all the parts can come together perfectly. During the design process, many ideas were tested and many were rejected, and most of the mechanisms and parts were redesigned tens of times. The two main ideas that never made it through were:

1) The use of metallic sliders for pitch change. The contact of these pieces on the string resulted to a muting effect. As the strings were kept at a very low tension, the pressure needed for an external mechanism to effectively change the pitch was much higher than expected. This would change the geometry and create angles that were not possible to deal with, as it created considerable misalignments between strings, excitor system and pickup magnets.

2) The use of a mechanical key system for volume control. This would incorporate a simple seesaw mechanism to change the distance between pickup magnet and string. It was found that altering this distance was not an ideal way of adjusting volume as it simply sounded like taking the microphone away, which is exactly what it was. Instead, I should opt for being able to control the amplitude of the string's oscillation itself, rather than the volume of the amplified sound.

Picture 20: 1:5 scale model (25cm tall)

A model made to check if the statics were well thought of, especially in the balance between the back and the front side. This model revealed that the frame was inclined to leaning forward, so the “feet” were readjusted by adding 2cm of material towards the front side. Using the least material possible can create a dangerous tension between aesthetics and fragility.

Fabrication

Wood

To evaluate whether the design of a structure is solid, it's a common practice for a prototype to be fabricated in a 1:1 scale (real size), in a cheap material. This model is used for checking the geometry, the statics, detecting weaknesses and readjusting the design for the second version to be produced in the final materials. An ideal choice for prototyping this instrument's frame would be MDF wood, which is extremely cheap and easy to work with. This stage was scheduled to take place in March of 2020. Unfortunately, due to the circumstances, it was not possible to gain access to a manufacturing facility and this stage was delayed by a total of 6 months. By September of 2020, there was no time to prototype a trial version and make improvements upon it. There was only enough time for everything to be produced once.

Some common types of wood used in musical instruments are maple and mahogany — typically in guitars — and spruce used in harps, where large volume and low density are required. In my case, the priorities were high density and strength, particularly against compressive forces. This compression, caused accumulatively by all eight strings, would stress the two elongated wooden sides of the frame. For these reasons I chose walnut, which has a high density (approximately 700kg/m^3) but is still easy to process by hand. Its density makes it highly durable and resistant to deformation over time and tension. The walnut was planed to a 22mm thickness and milled by a CNC router into the different parts. These parts were processed by hand for a total of two weeks, to be finished with a 400-grit sandpaper and coated over 6 times with boiled linseed oil.

Pictures 21, 22: Filing, sanding, drilling & gluing walnut parts

The frame of the instrument was designed in such a way, so that when the feet are not attached it can be placed horizontally on a surface, occupying only 12cm of height. This way it can be packaged neatly in a case — which also needs to be made in the future — or can be placed on a working table for making adjustments and fixes. Last, but not least, the instrument is still playable like this. This position could be useful for studio recordings.

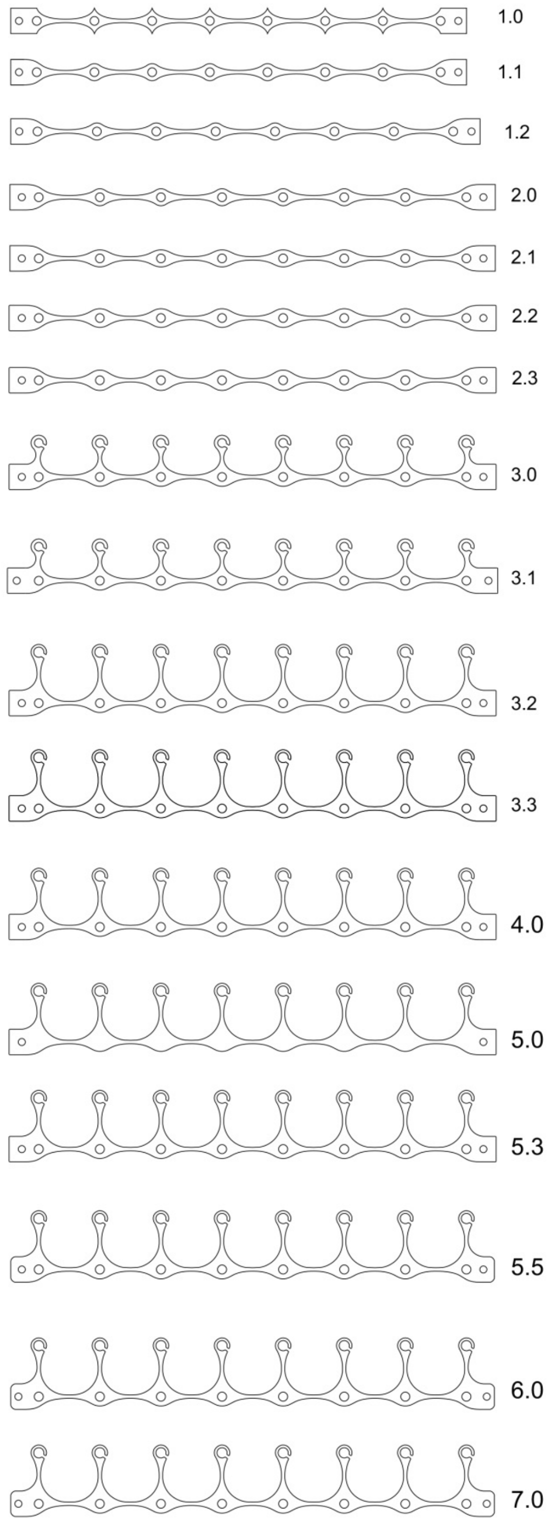
Picture 23: Horizontal placement

Metal

For all the intermediate structural components the material of choice was stainless steel, which is also an extremely strong and durable material, but most importantly it is not ferromagnetic. This means that it will not have any interference with either the permanent magnets or the variable electromagnets of the instrument, but it can still be used for grounding (GND) all the electronics to reduce noise, as it is of course conductive. All the metallic parts were designed in a 3D software, cut with a laser machine, and if necessary bent to the desired shape.

Picture 24: The bridge of the instrument is one of its most crucial parts. It will hold the load of 8 tensed strings, to be attached to the violin fine tuners seen in the picture. It must also house the female jack sockets for the instrument's line outs.

Each different part was redesigned and refined tens of times, with an average spanning between 20-30 times. In approaching the final shape, the adjustments made were usually at the scale of 1/20 of a millimeter.



picture 25: “Shaft holder” iterations

picture 26: “Shaft holders”

These two pieces are attached on the wooden frame, and serve as the mounting sockets for eight chrome plated, steel precision shafts (see next picture).

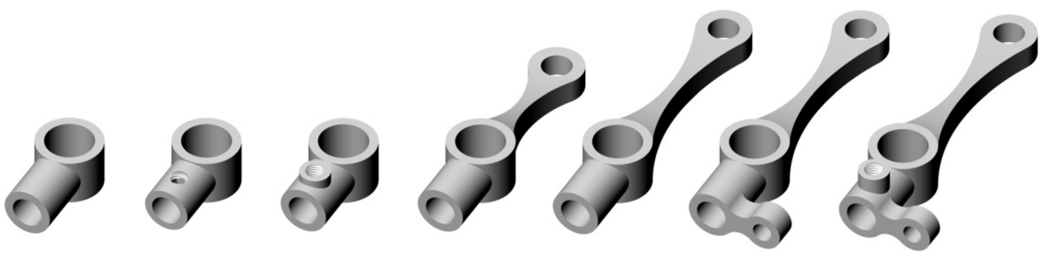
With all the parts prepared properly, assembling is only a matter of a couple of hours.

picture 27: Assembling wood and metal parts together

3D printing

At this point the basic structure was completed and strong enough to take on a string set and host all the functional components of the instrument. These components include the electromagnetic excitors, the electromagnetic pickups, mechanical parts and all the electronic circuitry. Almost all the above are mounted on the instrument by getting a hold on its metallic parts. To achieve this coupling, intermediate parts need to be made. As the scale is now becoming smaller, the ideal method for producing these is 3d printing.

The prototypes were made in FDM printers (filament fusing), and after some testing, the final parts where produced in transparent resin in an SLA printer (stereolithography), which offers a final result of significantly higher precision but also of higher fragility.



Picture 28: Iterations for the “sustainer holder”

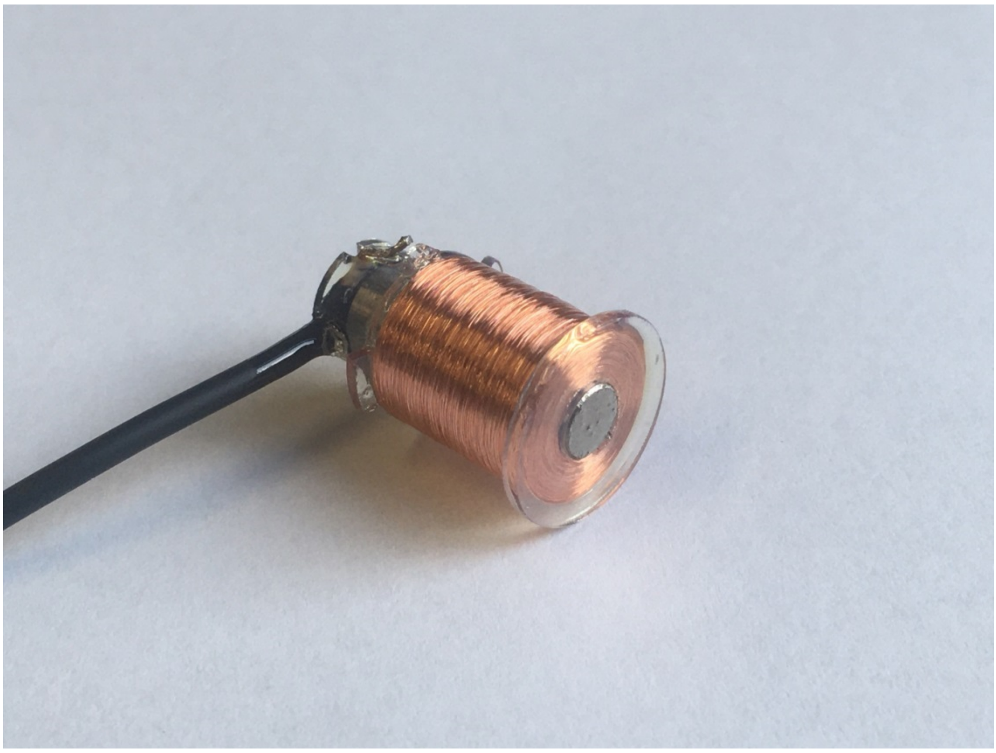
Picture 29: SLA print, “sustainer holder”.

This piece goes through a precision shaft and holds one electromagnetic excitor. It gives the excitor the freedom to travel along the length of the vertical shaft, rotate around it and change its perpendicular distance from it.

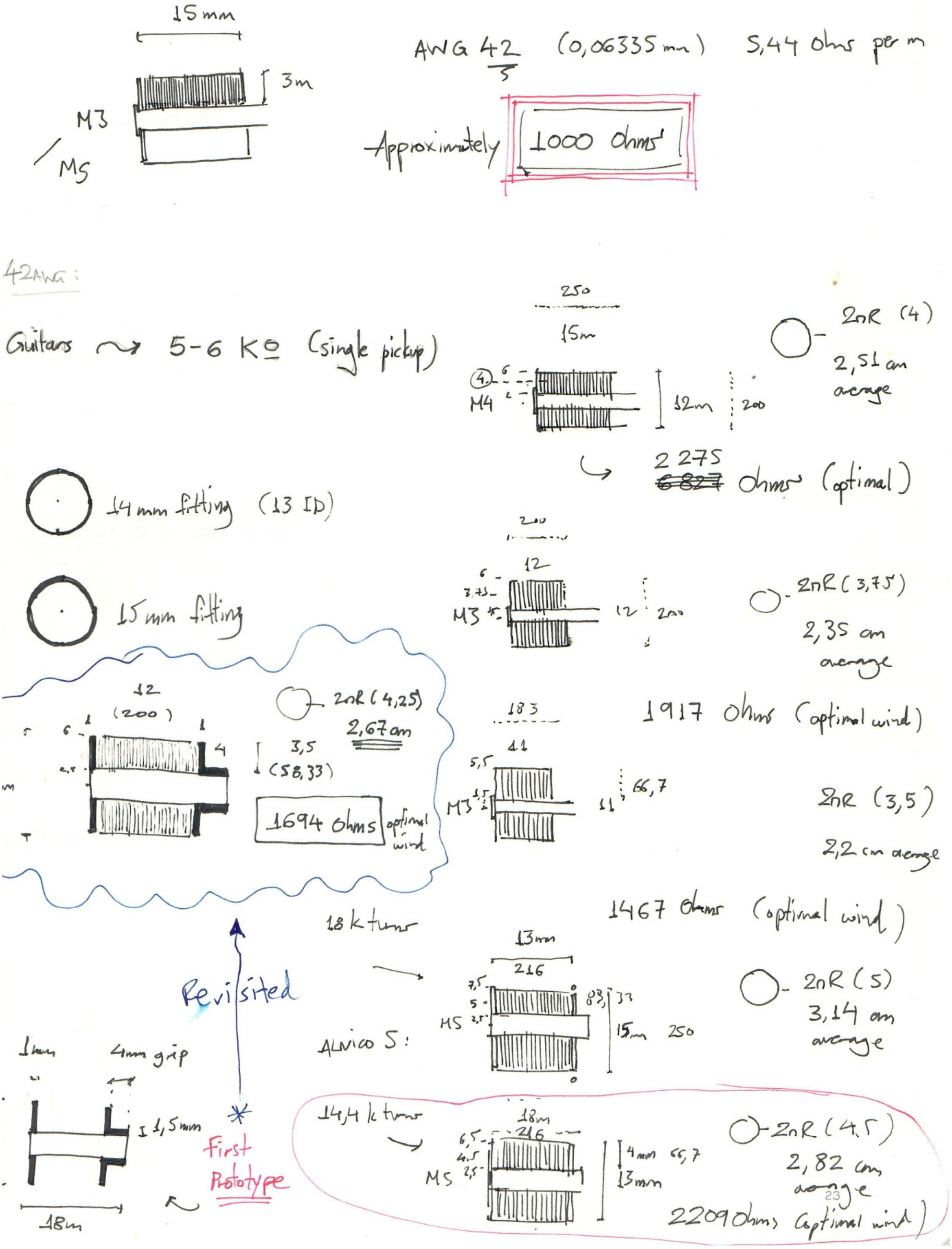
Coils

The instrument uses a total of 24 electromagnetic coils: 16 for the electromagnetic excitors and 8 for the pickups. All of these coils were handmade, as they had to be specifically tailored to meet the needs of this instrument in terms of size and impedance. Commercially available transducers (usually laptop speakers) never worked for use in the electromagnetic sustainers, as their physical size–to-impedance ratio was not appropriate. For the pickups the decision was easier: there is simply no such product available on the market. Guitar and bass coils are always wound around 6 cores. After spending 50 euros on a handmade single-core pickup (made by Paul Rubenstein) which flew over the Atlantic to reach me, I decided I would be better off learning how to make my own.

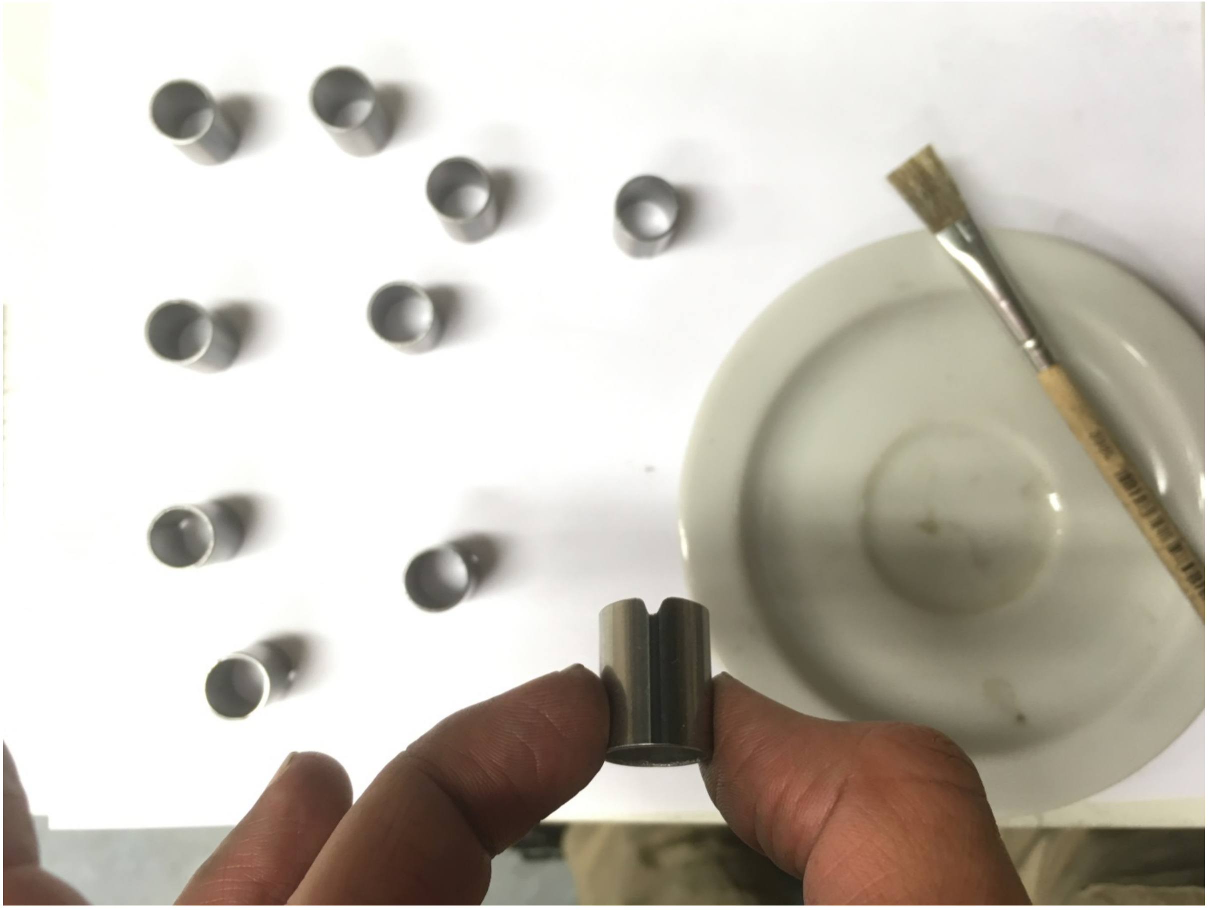
The pickup coils are responsible for converting the strings' movement into electricity to be sent for amplification. For these, I used an Alnico-5 core and two 3d printed parts to create the "bobbins". After consulting various guitar & bass forums I settled on a 42 AWG wire (0.06mm diameter) for creating the windings and estimated that I needed an average of 1000 Ohms to have an adequate output voltage and a decent frequency response. These estimations determined the geometry of the overall unit (picture 31). After winding the wire with the help of a cordless screwdriver and attaching the lead cables, the coils were dipped in lacquer and left to dry for at least 48 hours.



Picture 30: Electromagnetic pickup (made by me)

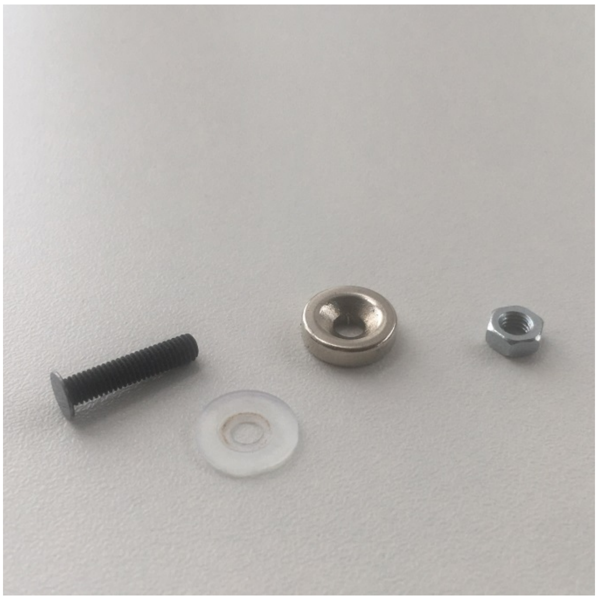


Picture 31: Calculations for the electromagnetic pickups

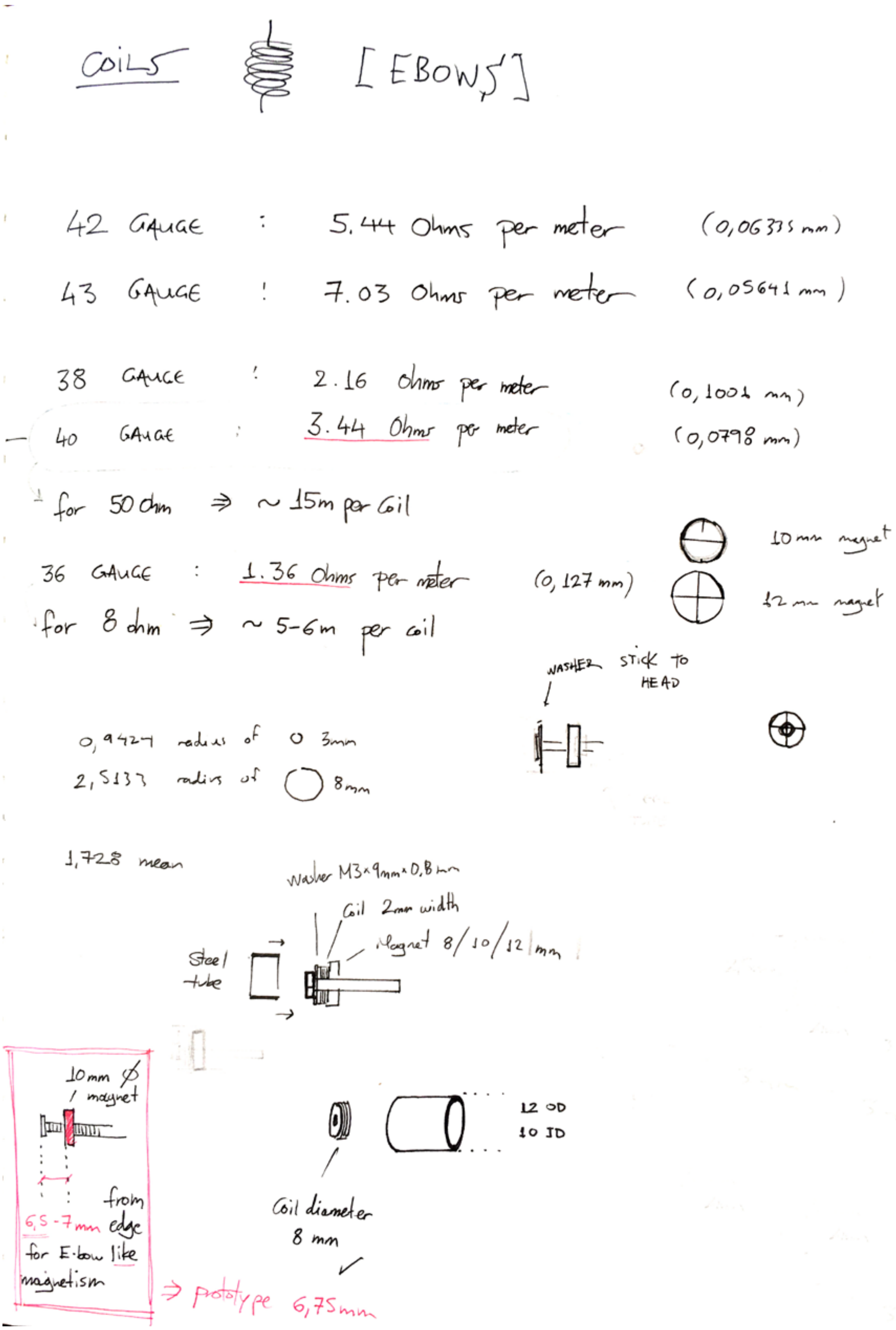


Picture 32: Steel housing units made for the electromagnetic pickups. These provide some degree of protection against external electromagnetic waves such as fluorescent lights, cellphone signals, radiation from antennas etc. But mainly, they protect them from picking up the signals emitted by the electromagnetic excitors.

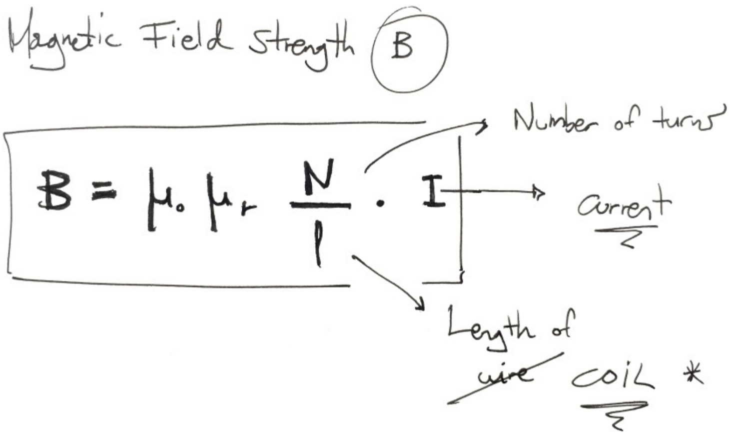
The coils used for the electromagnetic excitors were the smallest and most challenging part to fabricate, probably in the entire instrument. To create their main body, I used carbon steel bolts of size M3x12, and with the help of a belt sander I shaved their heads down to a thickness of 0.5mm. To complete the core a 3D printed cap was placed at the head of the bolt, and a neodymium magnet with a galvanized steel nut at the back. Once this assembly is done, this tiny piece is placed on the cordless screwdriver to make the copper windings. For the driver coils I used either 36, 38 or 40 AWG wire, depending on the final desired impedance. The lower the impedance the more current flows through the coil, inducing a stronger electromagnetic force and therefore a bigger influence on the string. The low impedance coils were used on the thinnest strings.



Pictures 33, 34: Putting together a core for winding an excitor coil

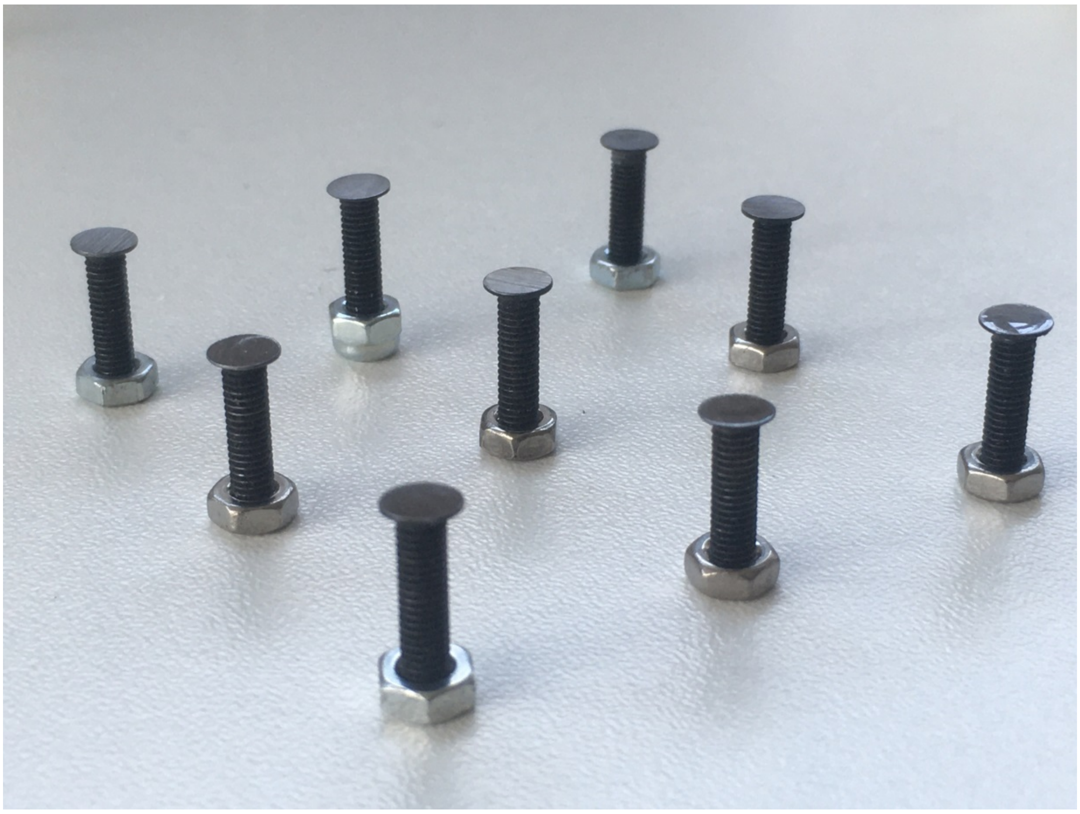


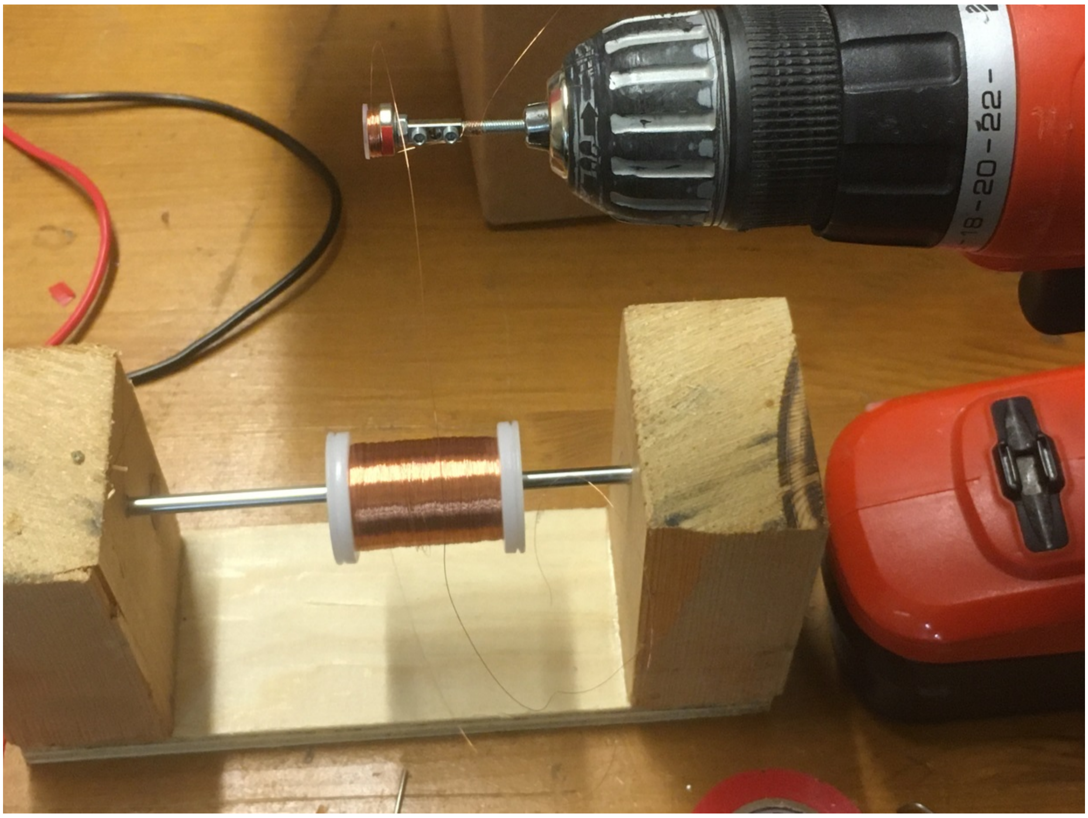
Picture 35: Designing the excitor coils



Picture 36: Magnetic field strength equation for a coil:

Trying to grasp how the thickness of wire, number of overall turns and current flowing through the coil affect the strength of the magnetic field produced. This is a kind of coil "black magic", as changing one of these factors affects the values of everything else. For example, increasing the number of turns (N) increases the overall length of wire and therefore the coil's resistance, which decreases the current (I). But with each turn, the diameter of the coil increases so the length of wire used *per turn* increases. This leads to the counter-intuitive conclusion that by adding more turns we get a less and less stronger magnetic field, all of the above considering a fixed overall length of coil (l).





Pictures 37, 38: Finishing the sanded bolts with droplets of acrylic lacquer to prevent rust (above)

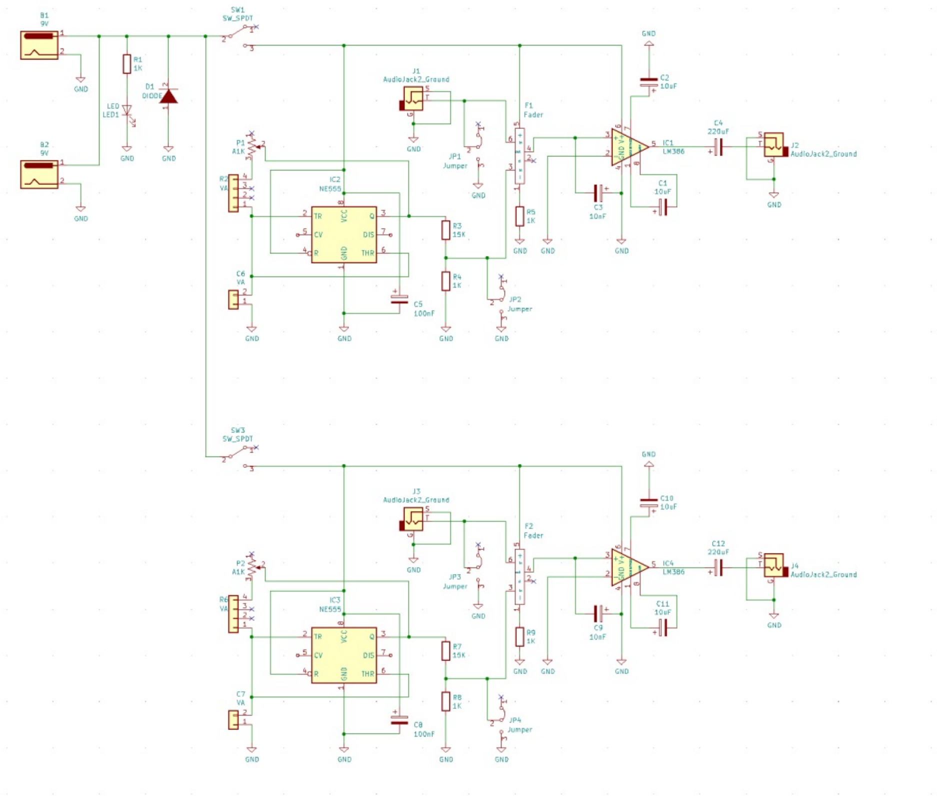
Winding the copper wire (below)

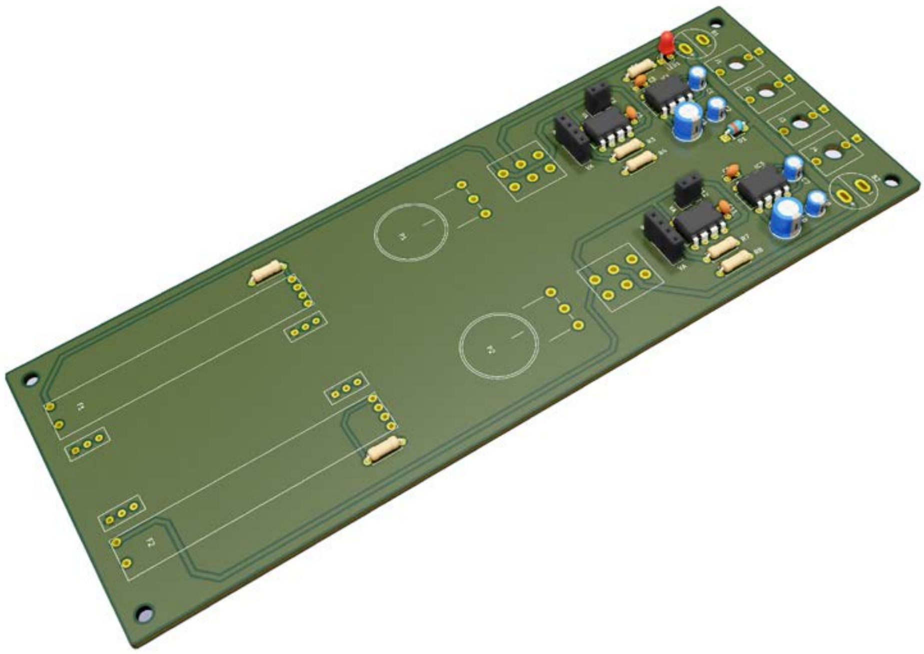
Picture 39: Mounting the excitor coils (left) and the pickup coils (right)

Electronics

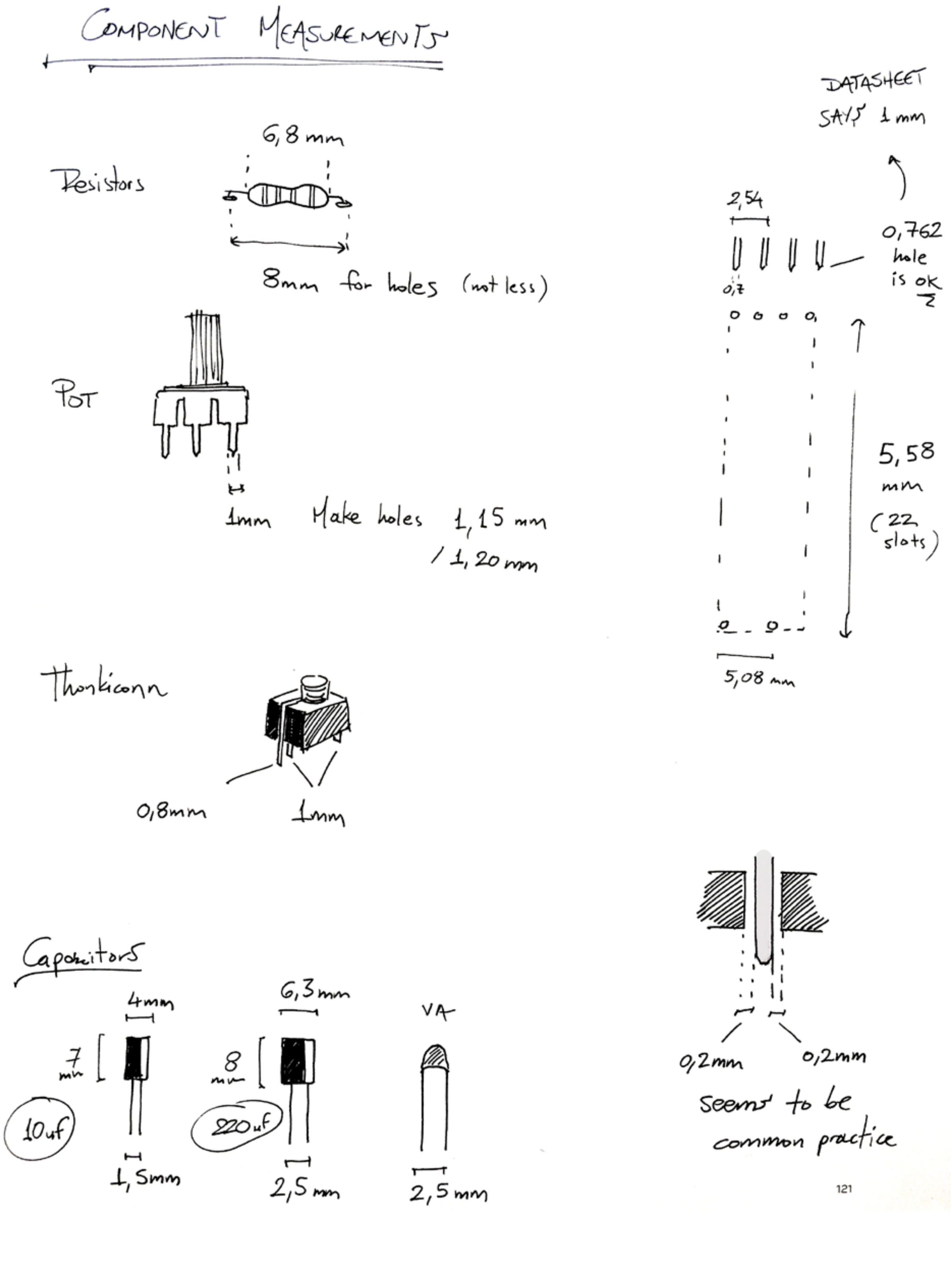
Up to this point, all of my electronic circuits were developed and tested on solderless breadboards and, when finalized, soldered on perfboards. Creating handmade circuits on perfboards can be quite annoying and immensely time consuming after a while. But the actual reason I eventually decided to leave this technique behind was because I realized that 1) mistakes and short-circuits are very easy to make and extremely difficult to detect and 2) due to their overall flimsiness they can never be reliable on the long run. So contrary to what I anticipated at the beginning of this project, I managed to find some time to learn the KiCAD software, which is a tool for designing circuits and printing out factory made PCB boards. I created an array of four double-barreled electromagnetic excitor controllers to communicate to a total of 8 strings. This object was designed to fit exactly into the lower part of the instrument.

Picture 40: The electronic brain of the instrument





Pictures 41, 42: KiCAD software. Designing the schematic of the circuit (above), and the PCB (below) for a double-barreled electromagnetic excitor controller



Picture 43: Preparing a PCB layout requires precise measurements of the components

Voltage measurements

By November of 2020, the instrument was functional by a 25%. That means I had completed the technical infrastructure for the excitation and amplification of 2 strings out of the total 8, which was already enough to start creating some sounds. Over the course of the winter, I started to make some recording sessions and inviting people at the iii workspace to see the instrument in real life. In this way I hoped to get some genuine reactions and feedback from pairs of eyes and ears that were fresh. A few people accepted my invitation and most notably Justin Bennett, Riccardo Marogna and Raviv Ganchrow (the meeting with the latter turned into an online one but was nevertheless productive). These people sat and listened to the sounds and observed the object. Then we talked about it. These three meetings were extremely important.

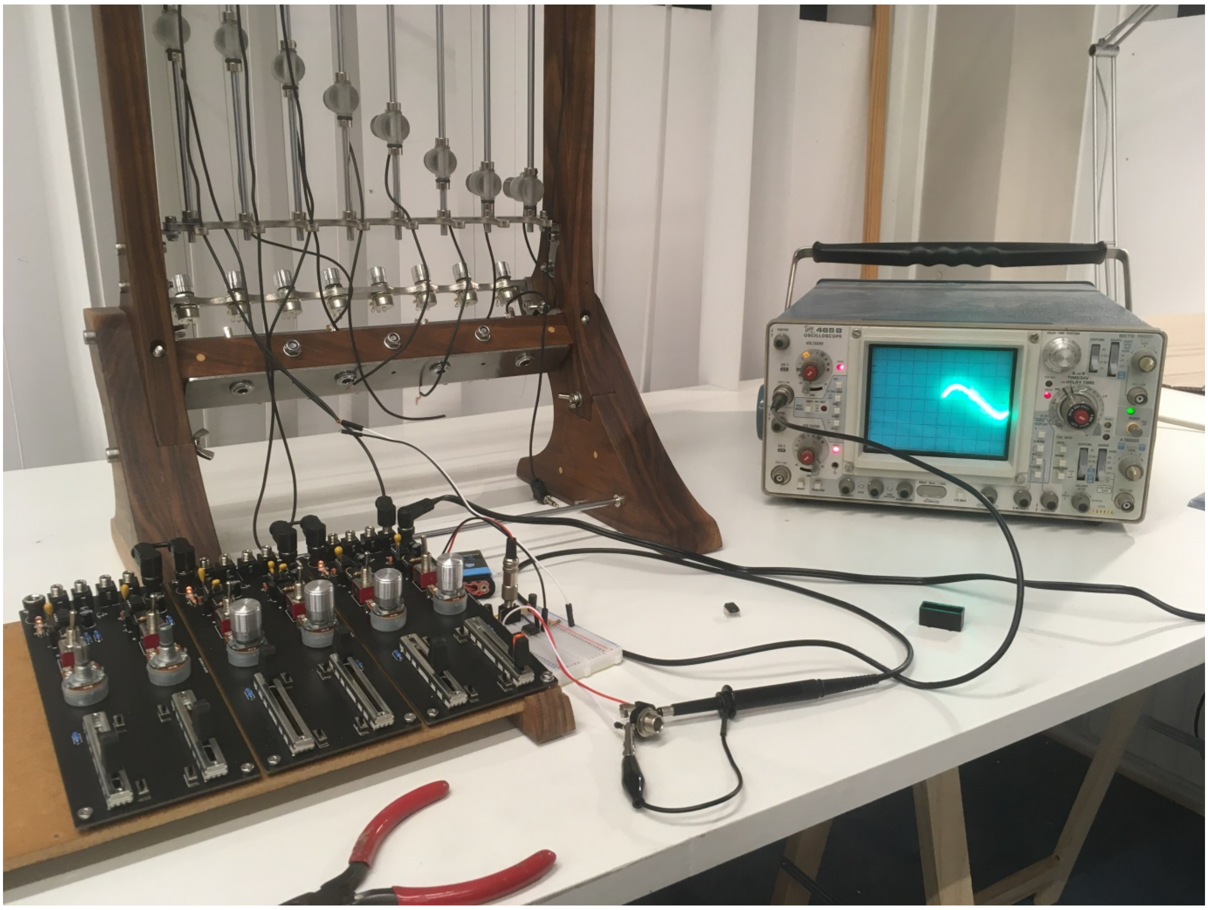
With Justin, I first made an introduction and then simply let him sit and play for some time. I saw that he was becoming absorbed in the play in a very peaceful way, with a subtle smile forming on his face. This was a very important moment for me. He then noted how he enjoyed that the tiny changes in the electronic controls could produce incredible changes in the movement of the strings.

Riccardo was very excited by the complexity and the eeriness of the sounds I was able to get from these two strings. He then went closer to the mixing console where I had my two jack cables plugged in. To his horror, he realized I had cranked up the gain up to a 40-60dB. He immediately took all the faders down. He was clearly extremely upset, as the mixing console belonged to him. He said: “You need to use op-amps.” I had no idea what he meant.

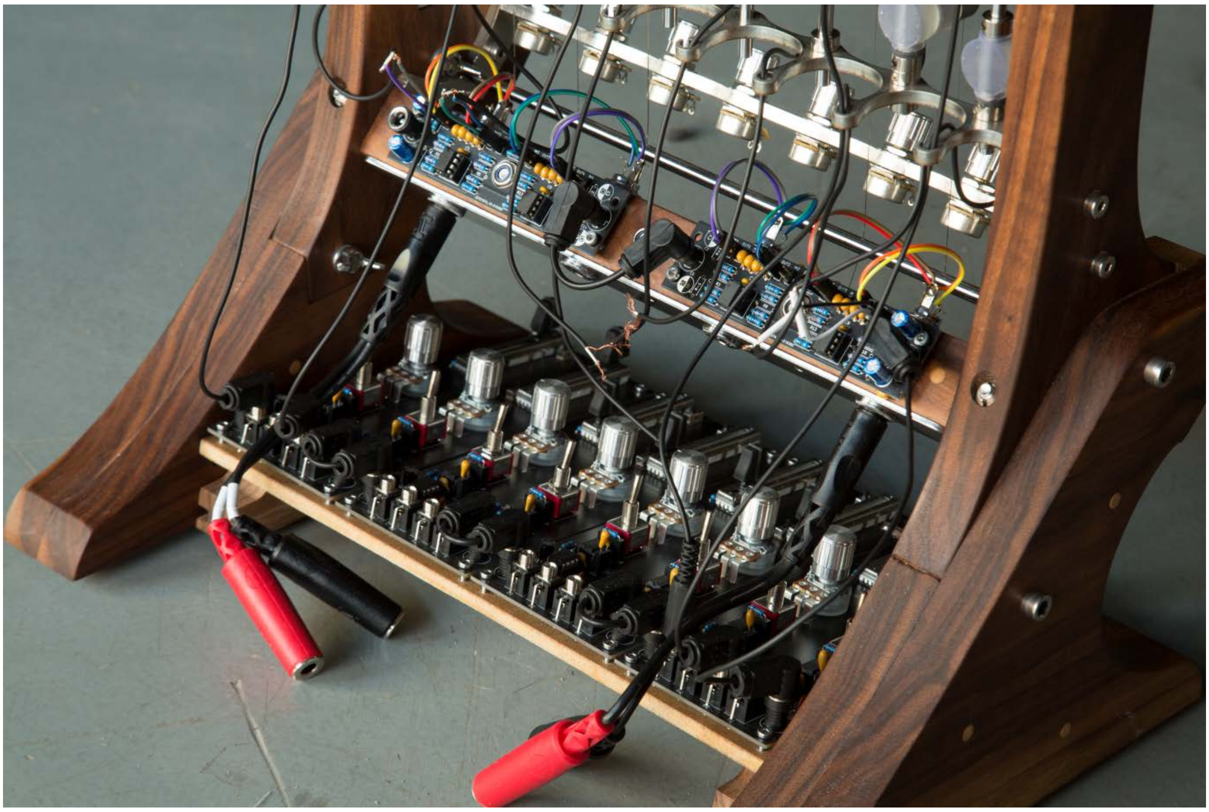
This was the start of yet another 2-month journey. Apparently the output signal of my instrument was too low in voltage, and I needed to compensate for this by maxing out the console. Riccardo explained that I needed to boost this signal with yet another DIY circuit embedded in the instrument before sending it out. I thought that there was no way I would have time for this.

When meeting Raviv, instead of discussing the overall artistic direction of the project as I expected, we ended up focusing on this technical problem more than anything else. It was very helpful, as he already pointed me to 3 options for the main IC of this circuit: the LM386, the LM385 and, his personal favorite, the NE5532. He also suggested that I use an oscilloscope to measure the exact output of the instrument, so that I know by what factor it would need to be multiplied to reach line level (around 1.25V).

To my good fortune, a fine oscilloscope happened to be lying around at the iii workspace. Using this machine I measured each one of my individual signals to range between 10-50 milivolts. If I were to lift this to about line level (1.25V) I should opt for an amplification of x30 times in voltage (+33 in dB). I designed a circuit based on schematics found on the internet and had numerous failed attempts. After a month of trials and errors, with the assistance of Lex Van den Broek and an absolutely decisive meeting with the incredible Archelaos Vasileiou, I was able to finalize an op-amp circuit that suited my needs. The biggest challenge was to have the op-amp working properly by powering it from the same power source (+9V) I was already using for the rest of my electronics. An op-amp normally requires a dual power supply, so the trick in powering it from a single supply of 9V is creating a virtual ground at 4.5V, to which the input signal must be lifted.

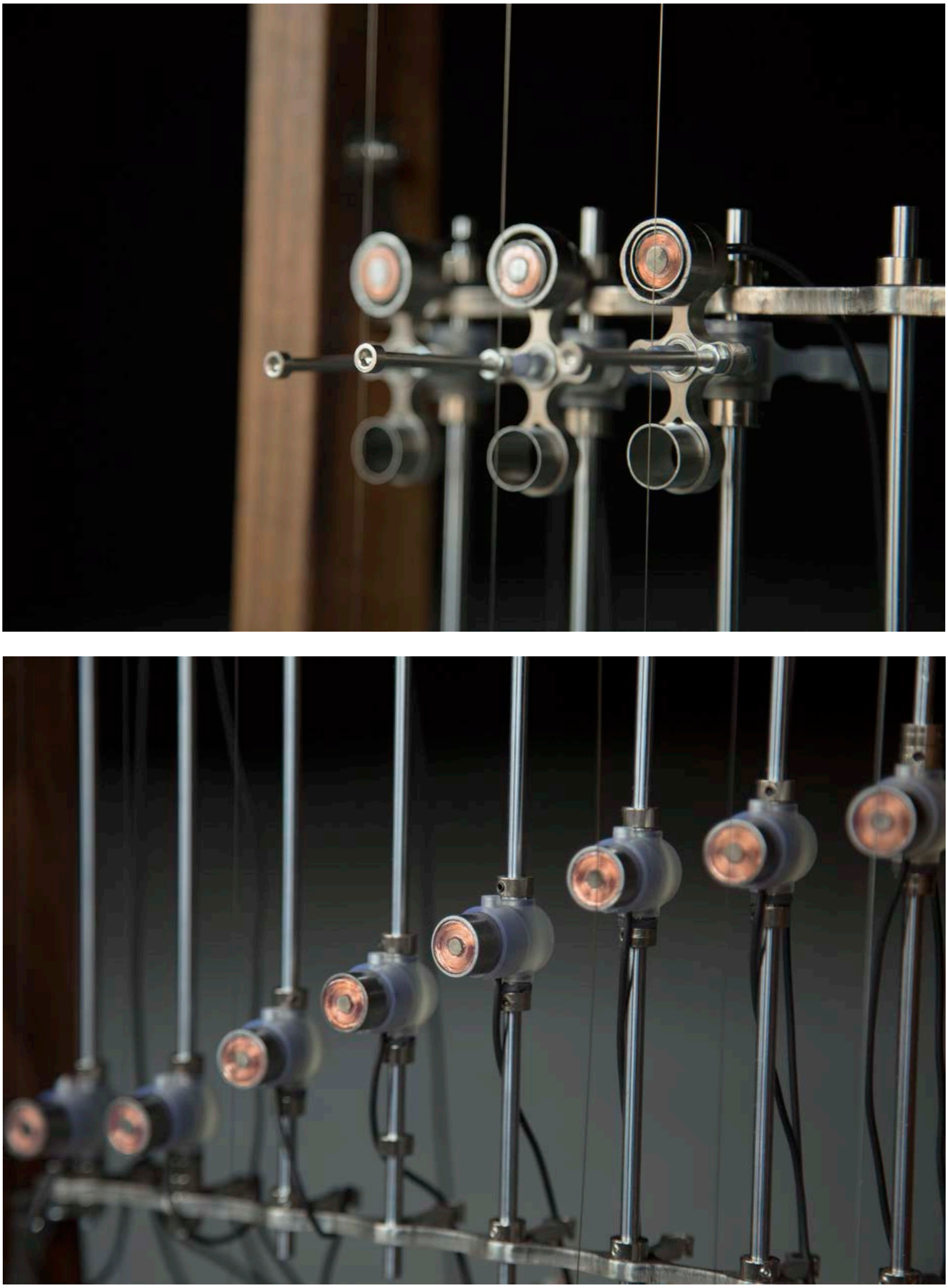


Picture 44: Oscilloscope measurements



Picture 45: Two months after the first measurements, the finished op-amp are mounted on the horizontal piece of the frame.

Picture 46: The LYRAEI



Picture 47,48: Details. Electromagnetic excitors (above), electromagnetic pickups (below)

Learning

By mid-April of 2021, all of the technical issues had been addressed and resolved. After an incredible journey of engineering, it was now time to sit down and play. I discovered that from all the things that could be done with the instrument, the parameters that attracted me the most were the following: on the mechanical side, changing the string tensions by using the violin fine tuners, or momentarily by applying pressure on the bridge. In a more brute-force manner, bending the two wooden sides of the frame with both arms; this would alter all string tensions simultaneously. All of the above are effective considering the strings are continuously aroused by the electromagnets, and they cause shifts to the harmonic clusters created on each string as well as the amplitude of the oscillations[30]. On the electronics side, I was drawn to making very slow shifts to the frequencies of the projected electromagnetic fields, and the degrees to which those modulate each other. Leaving the electronic interface open for cross patching was now giving me room for these decisions. Eventually, the most intriguing events seem to occur when mechanical and electronic parameters are altered simultaneously. And when the instrument reaches a condition where it's trying to say something, the best is to do nothing; at least for a while.

In the month of May, I had the opportunity to participate in the Intimate Open Studios at the iii workspace, as well as the final Sonology discussion concert. Within four days, I made eight very short performances in front of small audiences. Even though I had already been playing the instrument for roughly a month, in these four days I gained a significant amount of experience in very little time. In all of these performances, I set the instrument to an initial tuning as my starting point and then improvised my way out of it. It was completely unknown what would occur in each playing session. Manipulating the mechanical setup of the instrument and the parameters of the electronic interface at the same time always opened doors to completely mysterious events. The harmonic combinations and the modulations that occurred could never be expected, as there were two kinds of interferences taking place: the strings resonating each other mechanically through the body of the instrument, and the electromagnetic pulses modulating each other through the patching and the inconsistencies of the electronic interface. In addition to that, there are always discrepancies between the projected electromagnetic frequencies and the actual string tuning of the instrument. These conflicts between its electronic and mechanical condition determine the instrument's signature timbre. The perplexity also means that there is a long way to go in learning how to play it. It will take months or years to develop techniques, or to plan out specific outcomes and be able to create them. Of course, having absolute control was never my purpose. At this point, it feels like trying to tame a wild horse, and I hope that this feeling never goes away.

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[30] The shifts that occur in the harmonic clusters are not directly proportional to the changes in the tensions. The clusters are determined by the combination of the string's tuning (for example 100Hz) and the projected electromagnetic pulse (for example 85Hz). Bending down the string to a 98Hz will create new mathematical relationship with the number 85Hz, which is a more complex transition than simply downscaling the previous cluster.

Some of the people in the audiences described the listening experience as ritualistic or meditative, or like flowing in a liquid, some even said they were ready to go in a state of trance. Others commented on the details of the sound; the micro-modulations, the glimmering dissonances at the high end and the beatings. Naturally, I was very pleased with these comments. It also seemed to be quite clear to everyone that this was a stringed instrument, but I still had to explain several times how it actually works. So I believe that in giving a significant weight to its electronic functions, I sacrificed a portion of transparency — in terms of how it works — in favor of being able to sculpt the sound with more detail, by having extensive controls over the parameters of each electromagnetic pulse.

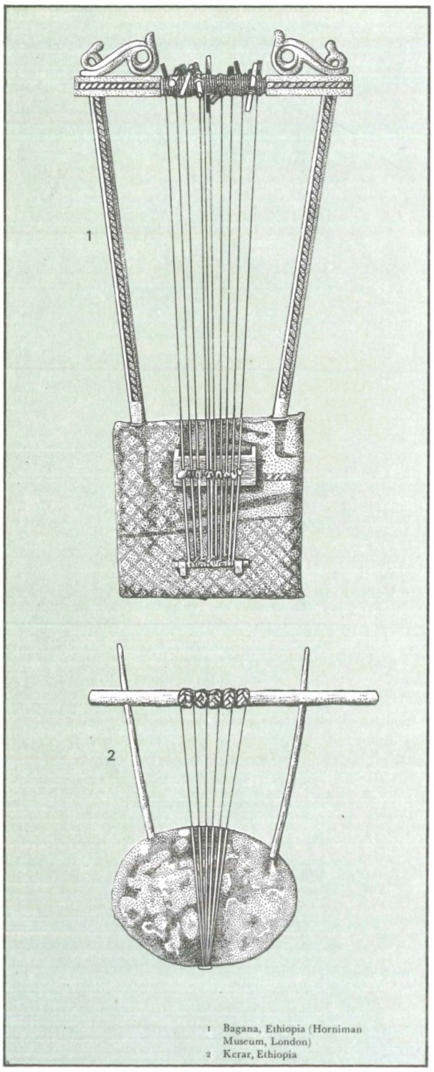
Picture 49: Intimate Open Studios, 16th May 2021, iii workspace

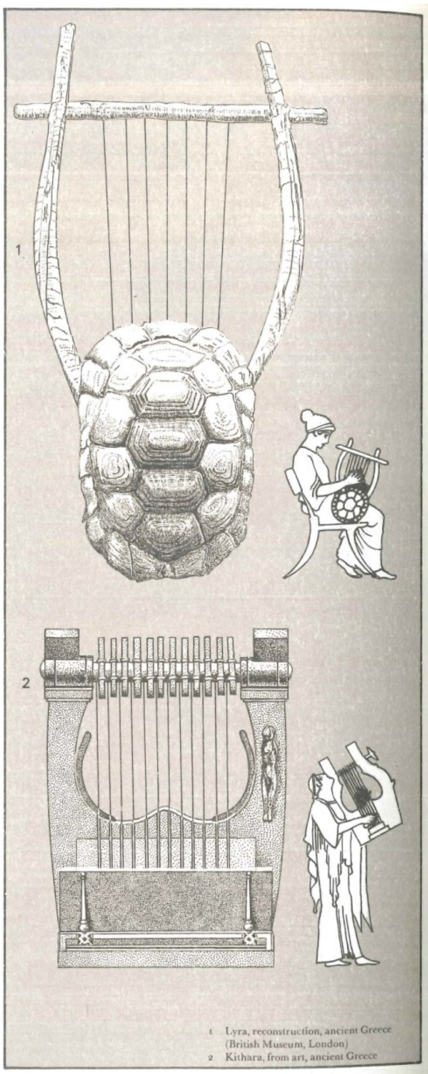
photo by Pieter Kers | Beeld.nu

Another recurring comment was that a session should last at least 25-30 minutes, to allow the audience, but also me, to become absorbed into the performance. That is of course the case. In the future, by learning the instrument further and building up my endurance, I want to work on performances that can stretch up to one or two hours. For such sessions, I would also like to try out duos with different instrumentalists, even vocalists. My first impulse was to play alongside a wind instrument, and on May 21st of 2021 we met with Riccardo Marogna to try this out. He brought a bass clarinet, a trumpet, and his DIY electronics through which he processes his sound. We played continuously for a total of one hour, and the session was recorded in video and audio. After we finished, I told him that towards the end of that hour, the first signs of fatigue had started to show: some back pain, a tired ear, and the feeling that maybe we should wrap it up. He said: “We need to do three hours.”

Picture 50: Drone session with Riccardo Marogna, 21st May 2021, iii workspace

The name of the instrument is an extension of the *lyra* (or *lyre*) instrument, which has ancient origins but still exists today in many different variations. Even though the Lyraei may appear to belong in the harp family, the only resemblance it bears with them is the fact that it is upright and self-supporting. Structurally, the instrument is much closer to the lyre, as it features an orthogonal body frame and strings of equal lengths. Of course, its scale is much bigger. The extension of "aei" (in Greek «αεί») signifies something that is beyond time, endless, everlasting; something that may not be true for the artifact itself, but to the essence of the sounds that it tries to capture.





Pictures 51, 52: Representations of Ethiopian lyras (left), Greek lyras (right).

Illustrations taken from The Diagram Group. *Musical Instruments of the World.*
(London: Paddington Press Ltd, 1976) 168, 170

Snakes do not react to music because of the mental ideas it produces in them, but because they are long, they lie coiled on the ground and their bodies are in contact with the ground along almost their entire length. And the musical vibrations communicated to the ground affect them as a very subtle, very long massage. Well I propose to treat the audience just like these charmed snakes, and to bring them back to the subtlest ideas through their anatomies.

Antonin Artaud, *The Theater and its Double* (London: Calder, 1995), 65

Outro

My quest for the past two years has been to design and create a new musical instrument.

A tool that would attempt to bridge together the worlds of electronic and stringed instruments.

I saw materiality as a ground for intimacy and a source of intricacy,

And I saw the sound as a movement that occurs from the interplay between the physical and the electronic.

I tried to create a transparent artifact that communicates its architecture generously,

And a performance that would be inviting and captivating.

But most importantly, I tried to create an instrument that I would want to play,

And that people would want to listen to.

I believe I have only scratched the surface of what this instrument is capable of.

The truly creative journey only begins now —

For the time being, I have completed my quest.

This work is dedicated to the people who made it possible

My father, Giorgos Shammas

Archelaos Vasileiou

Mike Page

Matteo Marangoni

Riccardo Marogna

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