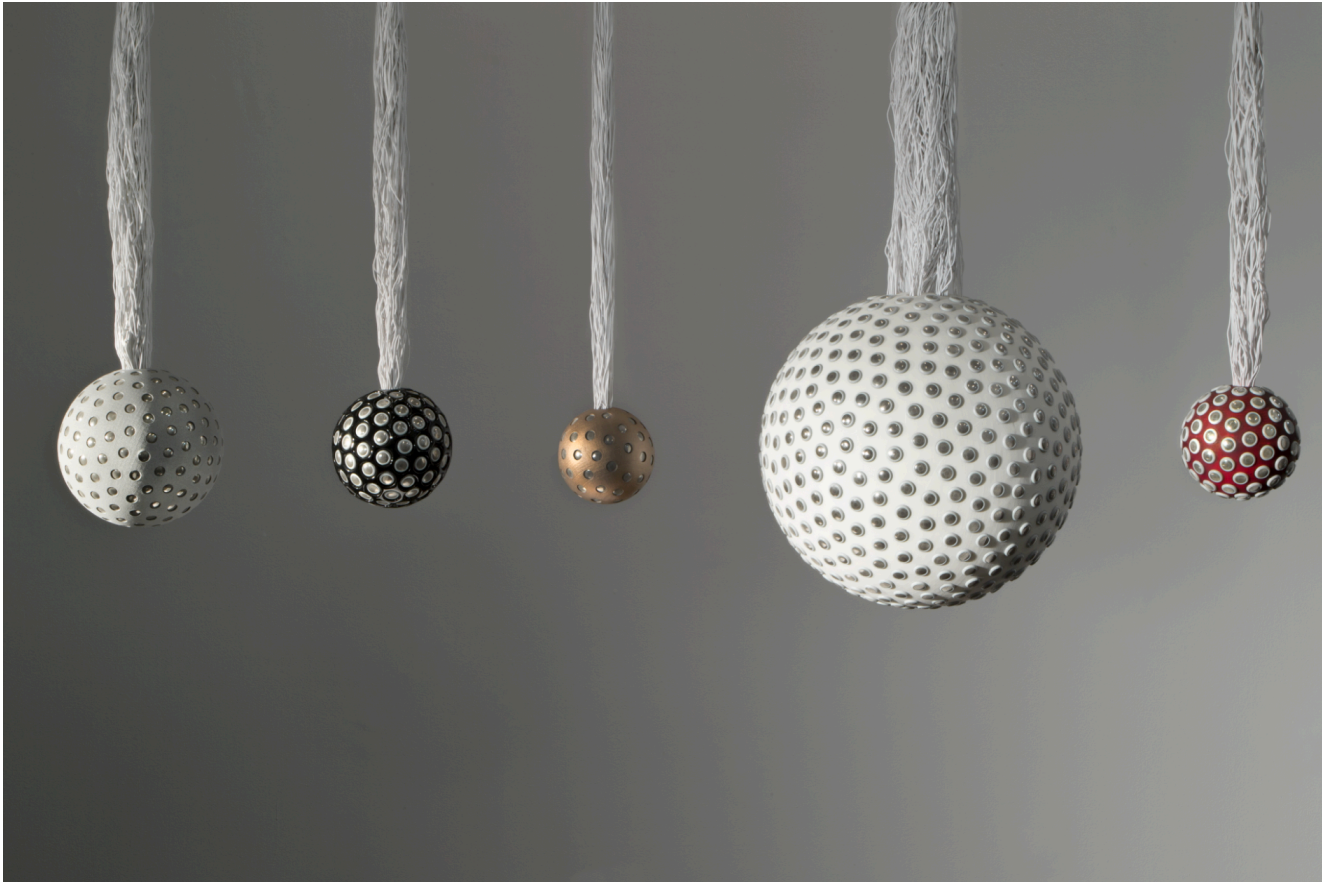


SPHERE PACKING

BY RAFAEL LOZANO-HEMMER



Version: 2024-06-10

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GENERAL IMPORTANT INFORMATION

This short section must be read for proper operation.

SPHERE PACKING, SUBSCULPTURE 15 (2013)

BY RAFAEL LOZANO-HEMMER

Technique

3D printed sphere using different materials depending on the composer, massive multi-channel sound system, custom-made electronics, stainless steel, IR remote control

Description

"Sphere Packing" (Subsculpture 15) is a series of 3D-printed pieces designed to concentrate the entire musical production of a composer in a single dense multi-channel device. The size of each sphere is directly proportional to how prolific the composer was, for example the sphere for Johann Sebastian Bach has 48 cm diameter and holds 1100 loudspeakers playing simultaneously Bach's 1100 different compositions, while the sphere for Hildegard Von Bingen only has 11 cm diameter and 69 loudspeakers. The project presents at a glance the comparative production volume of many composers. As people are a couple metres away from a sphere they hear a quiet murmur of sounds, but as they approach and put their ear up close to individual speakers they can hone in on specific compositions. The series is inspired by American composer Charles Ives' practice of simultaneity as a compositional tool.

A set of custom-made circuit boards allow the simultaneous playback of thousands of separate sound channels. The spheres are modeled algorithmically and then 3D printed in different materials depending on the composer. Each piece is suspended from a small playback box which is hung from the ceiling of the exhibition space. The piece begins playback immediately upon powering the box with 110 or 220V power. A small remote control allows the curator or collector to set an appropriate volume for the piece, although the piece is very quiet by its very design, even at its maximum volume a sphere produces a din that can be heard from about a 3 m radius. To discern individual compositions the public must be right beside a sphere, 5 cm away.

The recordings used are either in the public domain or legally purchased for the piece. Mitigating copyright concerns is that the volume of each track is extremely quiet and that a track can only be heard in the context of the other music being played-back.

Operation

Please refer to [Appendix I - Installation](#) for detailed system information and wiring diagram.

1. Connect the artwork to electrical power with the supplied power cables.
2. Once the sphere receives power for the first time it will turn on at half volume. This is designed so that if the remote fails, the sphere would still work. If the artwork was turned OFF with the remote, simply press on the remote's Play button, to turn it ON (or resume playback, depending on the version).
3. To turn the piece OFF (or pause playback, depending on the version), either press on the remote's Menu Button or unplug the sphere from electrical power.

***** Alternatively, the sphere's power cabling could be connected to an electrical timer. *****

General Artwork Behaviors

When turned on, all the sphere's headphones are playing back their dedicated composition, in a loop. There is no interaction from the visitor that impacts the rendering of the artwork.

Maintenance

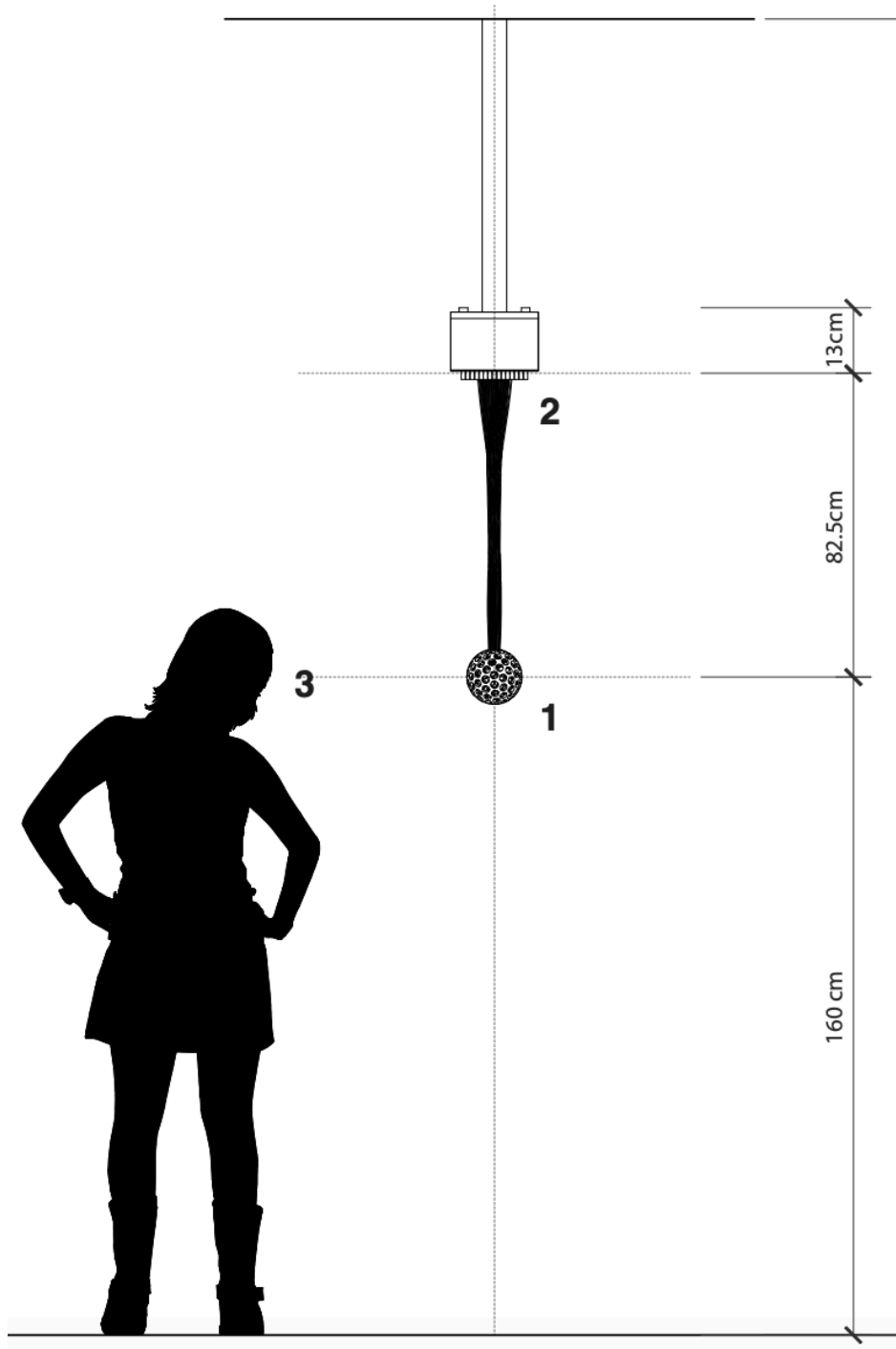
The housing, the mounting bracket and plate are made of stainless steel, it can be cleaned with a soft towel and a small application of lemon oil, or another cleaner designed for stainless steel. Care should be taken to not get any moisture into the inside of the housing, inside the bracket, or into the plugs for the headphones during the cleaning process.

The cables are a mix of rubber and plastic, when they are not in use, care should be taken to protect the connectors on the cables so they are not damaged or dirtied. The cables can be dusted off, or wiped down with a damp cloth.

The nature of the sphere's as experimental objects in new and comparatively untested materials means that they may react strongly or not at all to a variety of cleaners. As a result the spheres should never be cleaned with any cleaning agent. Several of the spheres are dyed transparent polymer 3D prints, this means that if it is cleaned with a wet or damp cloth the dye may run. The spheres should **ONLY be cleaned with a dry microfiber cloth to remove dust** and small smudges. If stained, chipped or dented please call the studio for advice.

Placement Instructions

The final position of the center of the sphere needs to be 160 cm off of the floor, the other dimensions would fluctuate based on the provided sphere, housing and mounting brackets. The diagram below shows an example of the Charles Ives' sphere and a good placement for the artwork. The approximate total weight of the sphere and housing is 35 kilograms (80 pounds), please consider this before anchoring the work to the ceiling.



DETAILED TECHNICAL INFORMATION

Preliminary Troubleshooting Steps

While plugging in the headphones, the sockets go up into the housing.

During transport the bracket that tightens the cards in place may have come loose. The housing can be opened to push the cards back into place, or sometimes the cards can be adjusted through the cable hole if it is a minor adjustment.

There are more extension cables than headphone cables to connect them.

Depending on the sphere, there could be a number of headphone plugs that doesn't match the number of sockets in the housing. Please connect the extra extension cables so that all the sockets on the housing are connected, and tuck them into the area where the extension cables and sphere cables connect.

I see broken headphones cables sticking out of the sphere, or the cable bundle.

Depending on the sphere, there could be a number of headphone plugs that doesn't match the number of sockets in the housing. Please tuck them into the area where the extension cables and sphere cables connect

When I put the artwork into pause mode, there is still one or few headphones playing sound.

This could happen with the MP3 player version (second generation). If a MP3 player isn't well installed in the motherboard, it could get enough power to turn on, while not receiving the different commands (volume modification, play or pause). We've designed the motherboard holder to avoid this, but this could still happen due to shipment or manipulation of the work.

In such a case, you need to inspect every single audio jack, which should be done under the supervision of studio staff. Refer to [APPENDIX VIII - PACKING](#) to wrap the sphere cabling before the following: consider you will need a bit of space around the headphone plugs. Turn on the artwork, put it into pause mode, and unplug every single headphone plug, until you don't hear any track being played back anymore. Plug back the headphones, one by one, to locate which exact jack doesn't respond to the remote signal.

Locate which board (lines of 15 jacks on the housing) and which exact jack isn't responding. You can either totally disconnect the sphere from the housing, or keep it connected and move it around at the same time as the housing: this is a two person's job, to avoid breaking the headphone plugs or the motherboard jacks. Unmount the housing from the ceiling and set yourself on a table.

Now, open the housing and aim for that board: you will have to open the motherboard holder and get the card out. Once done, find the faulty headphone jack number and locate the

MP3 player unit corresponding to that number, then unplug and plug back the MP3 player onto the motherboard.

Once done, reassemble the motherboard into the housing, connect back the wiring as it was and close the enclosure. Give power back to the artwork and test every audio jack from that motherboard while the work is in play mode: ensure you get sound in every single jack. Then put the artwork in pause mode and ensure no channel plays back anything.

If every port works as expected, you can put back the housing to the ceiling, connect back the sphere to it, unpack the wrapping around the headphones cabling and enjoy your artwork.

A headphone or few headphones are generating hissing/static noise.

Due to the nature of the components, some headphones get old over time and their diaphragm might dry out. The dryer the diaphragm is the more prone it is to tears. Once torn, a diaphragm might induce such hissing noise.

When this happens, there are only a few options. The first one is to locate the faulty headphone by unplugging the headphones jacks, one by one, until you don't hear that noise anymore, then leave this headphone plug unplugged and connect back the others.

The second is to reduce the volume of the artwork below the point where it starts emitting that hissing noise: while this is feasible, the artist's studio doesn't encourage such a method as it reduces the presence of the artwork in the space.

The last one, more laborious and complex, consists of replacing the broken headphone by a new one with similar specs and strength. Locating the headphone and getting access to it via the hole atop the sphere can be tricky and we suggest you contact the studio before tackling such a task. Depending on the age of the sphere, it might be more reasonable to get a new sphere built, with newer headphones that could be stronger over time.

Troubleshooting Assistance

Prior to contacting the Antimodular Studio with a problem about your artwork, please ensure that you went through the preliminary troubleshooting steps outlined in the previous section.

The troubleshooting process will vary depending on the problem. In order to make the process easier, it is recommended that you collect and send the following information to the studio:

- Date and time when the problem first happened;
- Description of the problem;
- Actions taken so far and conclusions;
- Detailed photographs (or videos) displaying the problem;
- Detailed photographs (or videos) of the suspected faulty component;
- Detailed photographs (or videos) of the whole artwork and its surroundings;
- Personnel involved.

Support (Contact Us)

If you would like support for the piece, please feel free to call Lozano-Hemmer's studio in Canada:

Antimodular Research
4462 rue Saint-Denis
Montréal, Québec, Canada
H2J 2L1
Tel 1-514-597-0917
info@antimodular.com
www.antimodular.com

APPENDIX I - INSTALLATION

Description of Components

This artwork requires the following components:

Component	Description
Sphere	Sculptural object containing the headphones.
Headphones / earbuds	Used to individually play a unique track from the relevant composer.
Housing Box	A stainless steel box constructed to hold the electronic components of the artwork.
Housing Electronics	Custom electronics that control the headphones within the sphere.
Housing Mounting Bracket	Bracket that allows the housing to be mounted to the ceiling. Can be telescoped with a post.
IR Remote Control	Allows the user to turn the piece on or off and raise or lower the volume.

Wiring Diagrams and Connections

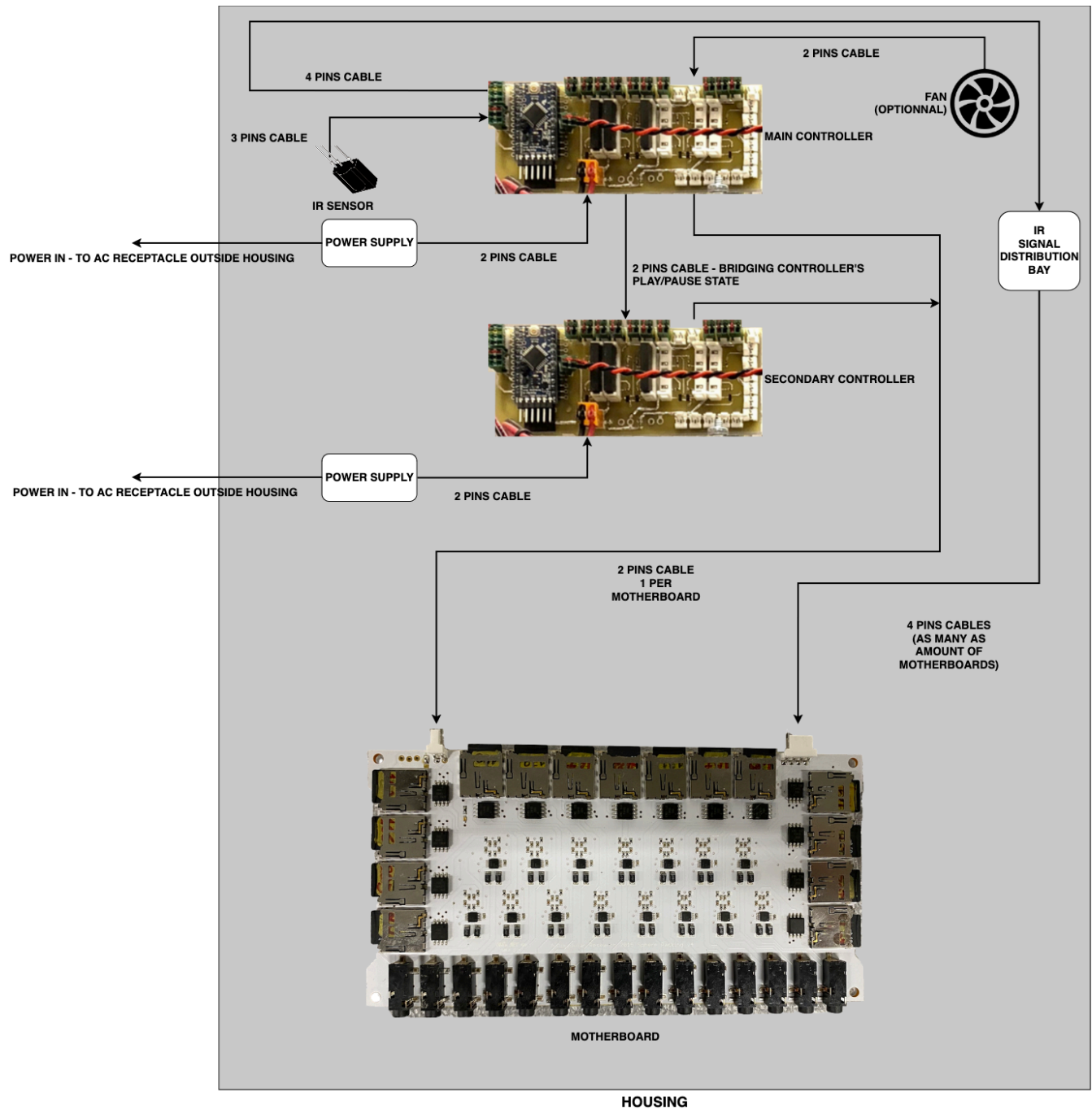
In order for the piece to run properly, the different components should be connected according to the following diagrams.

Sphere

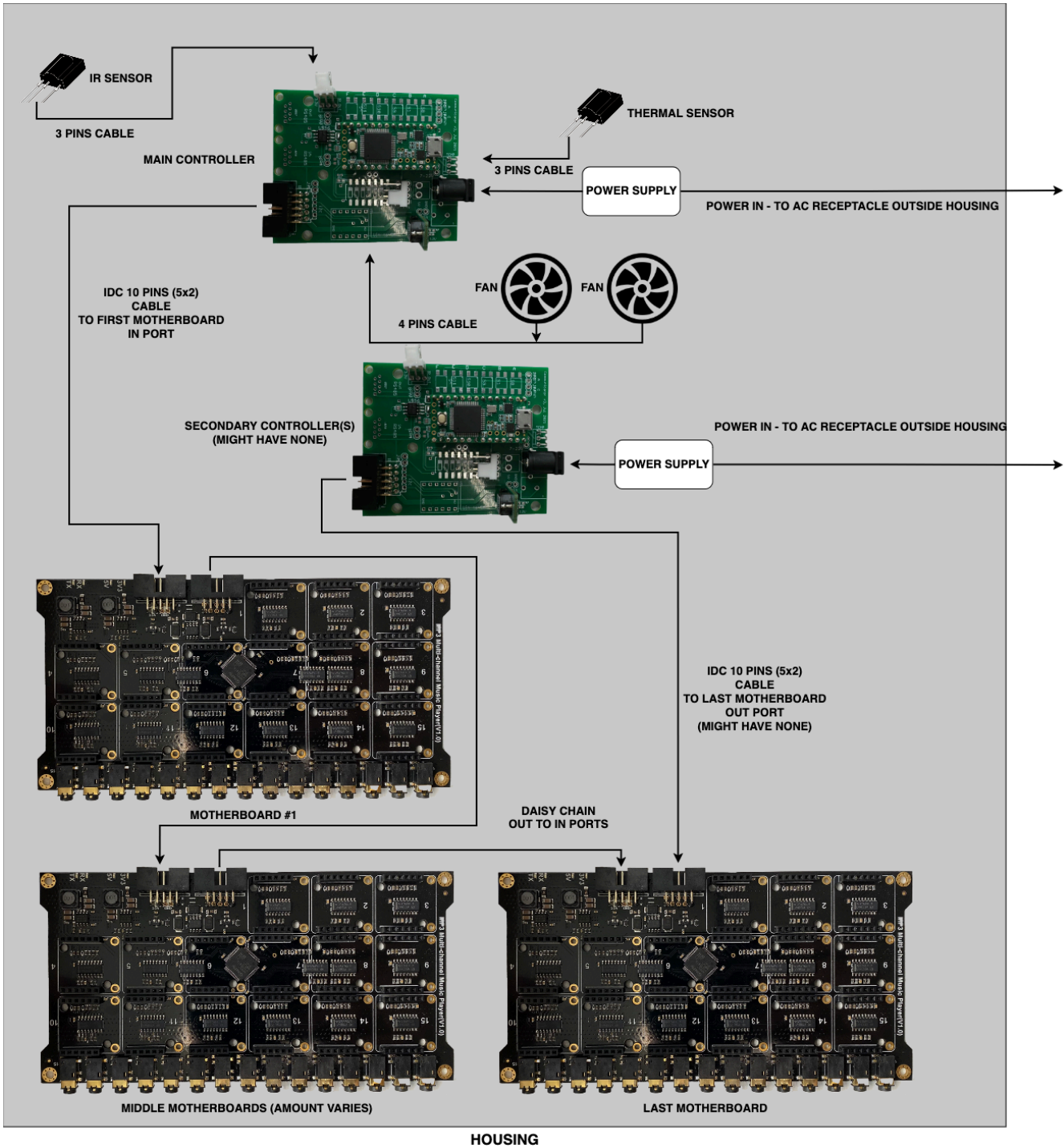
All headphone plugs should be connected to the motherboards audio jacks.



First generation (SD cards)



Second generation (MP3 players)



APPENDIX II - TECHNICAL DATA SHEETS

Sphere



The sphere provided is built with different parameters specific to each composer. These specifications - material, colour, dimensions, number of holes - can be retrieved in the [Appendix III](#).

When the sphere is bigger in size, or when the ratio sphere weight / number of audio jacks is too big, an aircraft cable has been attached to the inside of the sphere and run through the housing to support the sphere's weight as the headphone jacks are not strong enough for it.

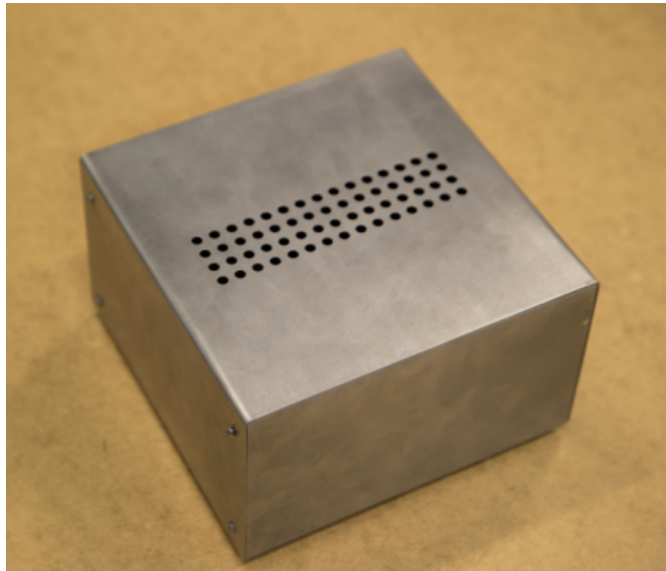
Headphones

Each sphere will have a different number of headphones depending on the composer in use. Each headphone carries a single channel of a composition. These headphones are similar to the first generation of Apple iPod headphones and have similar properties.



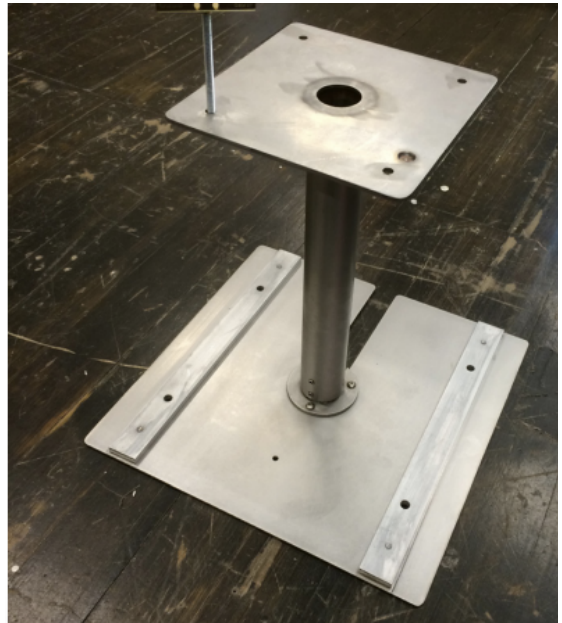
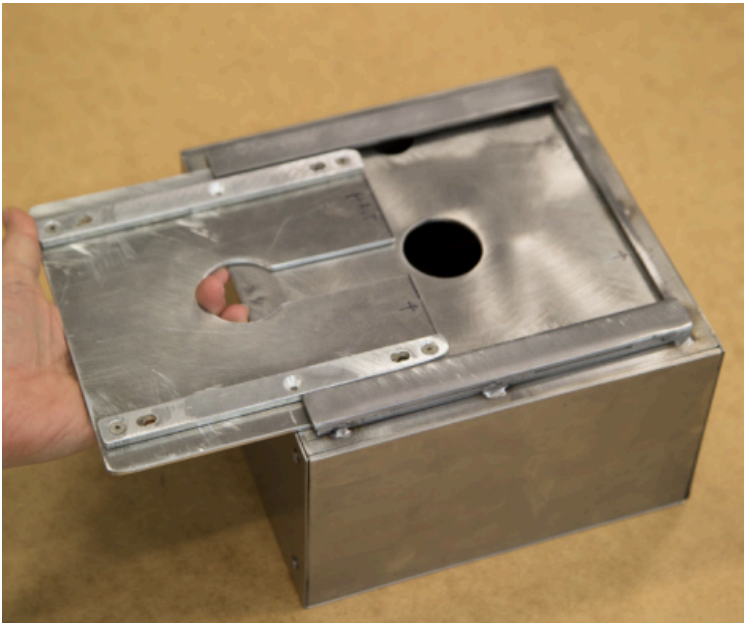
Specification	Description
Jacket material	Rubberized plastic
Number of earbuds	2 buds per stereo jack
Size of headphone jack	3.5mm
Colour	Cable, connector and earbud are white, the earbud has a light gray rubberized rim.

Housing - Box



Built from stainless steel, the housing box contains the electronics playing the audio tracks. The housing box dimensions fluctuate depending on the composer. The dimensions can be retrieved in the [Appendix III](#) section.

Housing - Sliding Mounting Bracket



Built from stainless steel, the mounting bracket anchors the housing box that contains the electronics playing the audio tracks to the ceiling. The mounting bracket can be mounted onto an extension post, to reach longer distances. The post can be of a fixed length, or be telescopic, depending on the version. The mounting bracket dimensions differ depending on the composer, as it is related to the housing dimensions.

Housing - Electronics (SD cards / first generation)

Two different generations of electronics exist for this work. While both generations are quite similar, the two diverge in regard to their playback system: the first generation runs with motherboard cards reading audio files out of SD cards **(described in this section)**, while the second generation runs with motherboard cards controlling MP3 player chips flashed with the audio files (described in the next section).

Please refer to **APPENDIX III** for refined information about your version (composer).

Fans

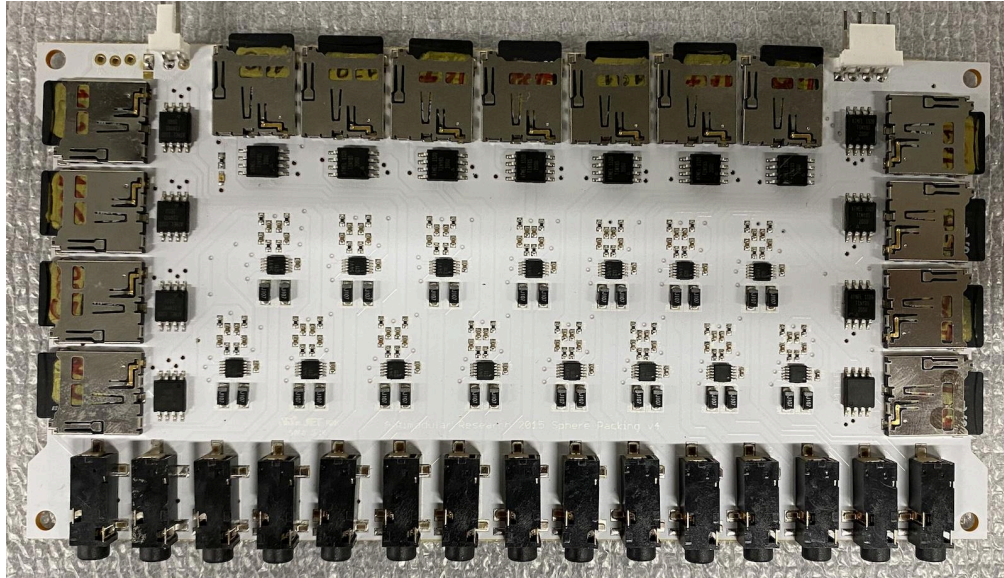
Present or not depending on the composer, a single or few fan(s) is(are) used to extract the warm air out of the housing, to prevent damages to the electronics.

Power Supply



Power supply(ies) used in the housing may vary in amount and power, size and shape. They feed the motherboards and the IR Remote receiving boards. The total wattage of a single sphere would vary from 60W to 300W,

Motherboards - Music Playback Cards

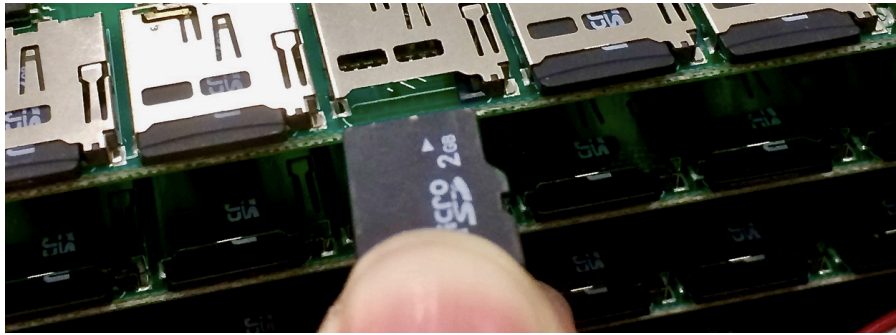


Playback is achieved through ATTiny85s which are Atmel 8-bit AVR RISC-based microcontrollers. They communicate with microSD cards over SPI with custom firmware designed to read a FAT file system and playback stereo WAV files. The power connector plugged to the motherboard is in parallel via the IR receiver board (2 pins connectors). The play, stop, volume up and volume down signals are fed via another cable plugged to the motherboard and to a distribution bay (4 pins connectors).

The following table lists most of the components used in the PCB assembly.

Component	Model	Source	Amount in use
PCB	Custom Design	Antimodular	1
Analog input amplifier	LM4811	Texas Instrument	15
microSD card slot			15
3.5mm headphone jack			15
Blue LED			1

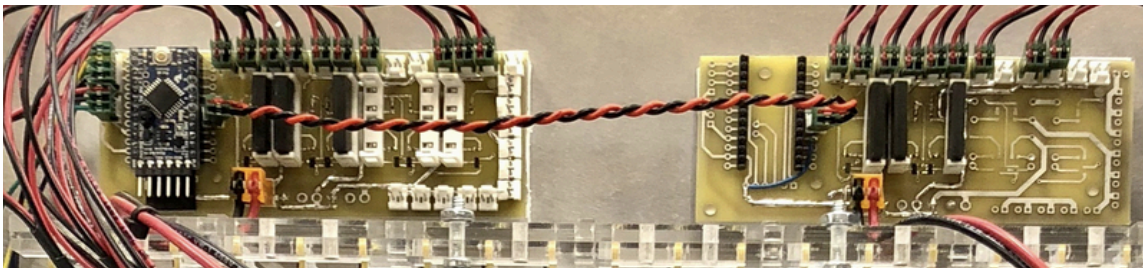
SD Cards



Every single SD card is populated with a unique track, containing two compositions of said composer. The files are 16 bit uncompressed WAV files. They have one composition in the left channel and another in the right channel.

These microSD cards (typically 1GB or 2 GB, SLC flash memory) need to be formatted in FAT16. While formatting with an OSX computer, ensure to keep the card's partition map schemes as Master Boot Record, not GUID or Apple Partition Map.

IR Remote receiver and power controller board



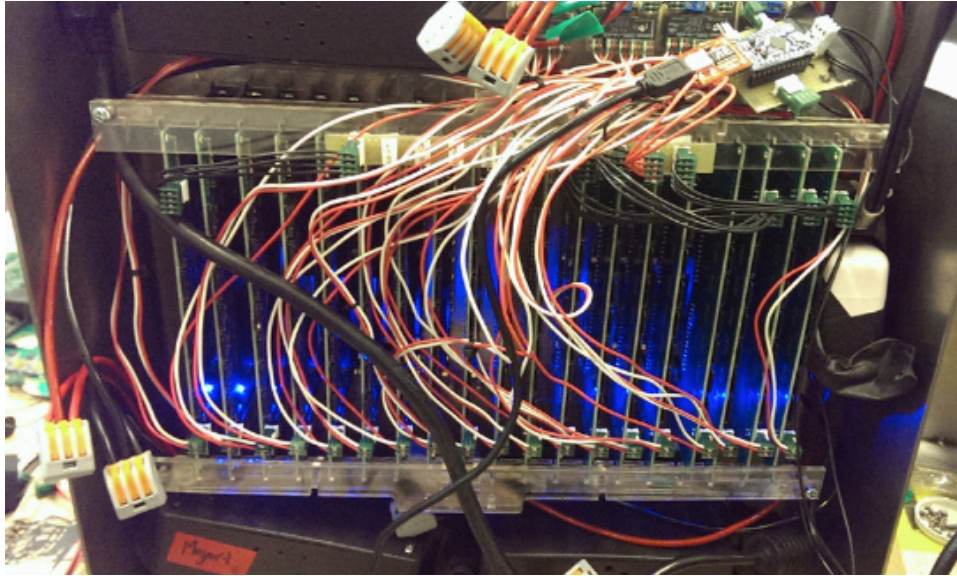
This part could be different in size and layout, based on the iteration on the board design. A custom made board that receives the IR signal from an Apple IR remote control (sensor attached on the 3 pins connector) and drives the motherboards with a signal to either stop, play, reduce or increase the volume (via a distribution board system and the 4 pins connectors). It also acts as a power distribution bay for the power connectors feeding the motherboards (2 pins connectors).

If the sphere is bigger, up to four of these boards could have been installed in, with secondary boards being “less completed” than the main one, while all boards are connected together: bridging the PLAY/PAUSE state from the main board to the secondary ones.

The following table lists all the components used in the PCB assembly.

Component	Model	Source	Amount in use
PCB	Custom Design	Antimodular	1
3 pins TYCO connector for IR sensor	640456-3	Molex	1
2 pins TYCO right angled connector for power input	640457-2	TE Connectivity AMP connectors	Up to 3
Mini Arduino Pro		Arduino	1
4 pins TYCO connector for IR signal to motherboards	640456-4	Molex	1
10K Resistor	RC0603FR-0710KL	Yageo	1
Solid State Relay SPST-NO 4A 0-60V	AQZ102	Panasonic Electric Work	Up to 6
Relay socket 4 pos through hole	PA1A-PS	Panasonic Electric Work	Up to 6
LED	150060VS55040	Würth Elektronik	Up to 6
Bipolar (BJT) Transistor NPN 100 V 4.5 A 150MHz 1.5 W	ZXTN19100CFFTA	Diodes Incorporated	Up to 6
3.3K resistor	RMCF0603FT3K30	Stackpole Electronics	Up to 6
47 Ohm resistor	ERJ-3GEYJ470V	Panasonic Electric Components	Up to 6
2 pins TYCO connector for motherboards power, PLAY/PAUSE state between controllers	640456-2	Molex	Up to 25

Acrylic Motherboard Holder

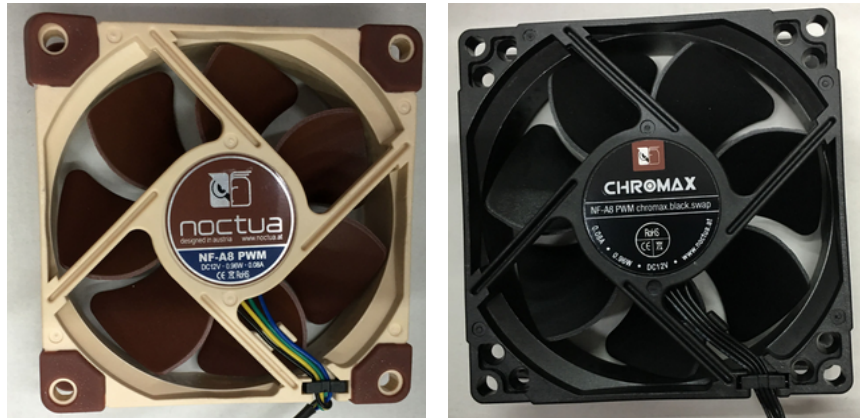


With this generation, the motherboards are held in place with an acrylic holder. Depending on the number of motherboards, the acrylic holder might have a different size, structural strength and anchoring system within the housing.

Housing - Electronics (MP3 players / second generation)

Two different generations of electronics exist for this work. While both generations are quite similar, the two diverge in regard to their playback system: the first generation runs with motherboard cards reading audio files out of SD cards (described in the previous section), while the second generation runs with motherboard cards controlling MP3 player chips flashed with the audio files (**described in this section**).

Fans



Present or not depending on the composer, a single or two fan(s) is(are) used to extract the warm air out of the housing, to prevent damages to the electronics. The fans are mounted to the housing part facing the ceiling, with rubber pegs to prevent vibration noises. To this day, the Noctua NF-A8 PWM has been used and liked. The Chromax NF-A8 PWM could be a good replacement unit, however, do consider the rubber pegs provided with the Noctua are the best to seat the fan onto the housing.

Specification	Details
Dimensions	80x80x25 mm
Mounting hole spacing	71.5x71.5 mm
Connector	4 pins PWM
Rotational speed	Minimum: 450 RPM. Maximum: 2200 RPM
Maximal airflow	55,5 m ³ /h
Rated Current	Maximum: 0.96W - 0.08A @ 12VDC

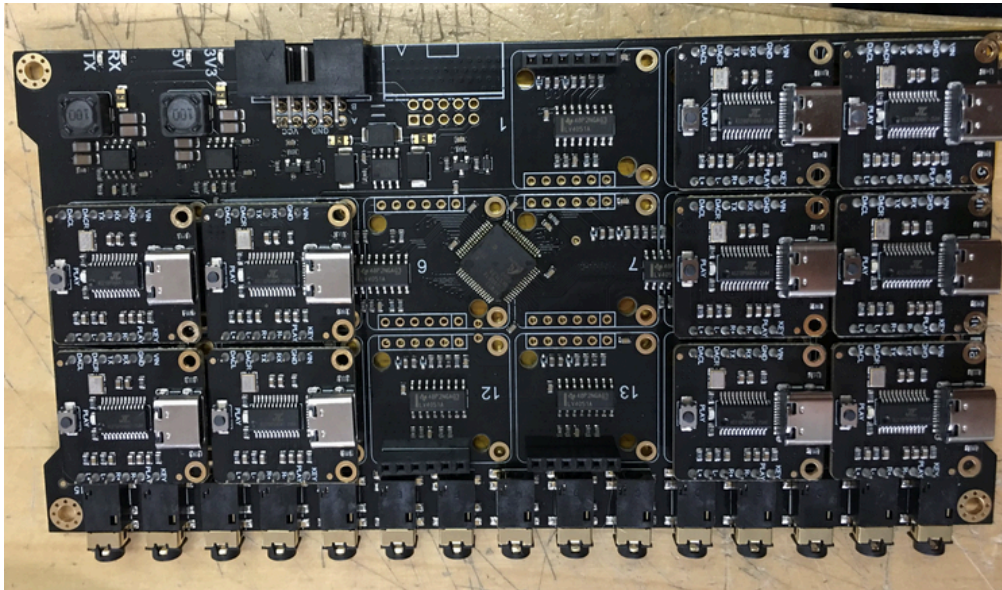
Power supplies



Power supply(ies) used in the housing may vary in amount. They feed the motherboards and the IR Remote receiving boards. The total wattage of a single sphere would vary from 75W to 300W. The used power supply, so far, is the Ideal Power 15DYS902-090750G.

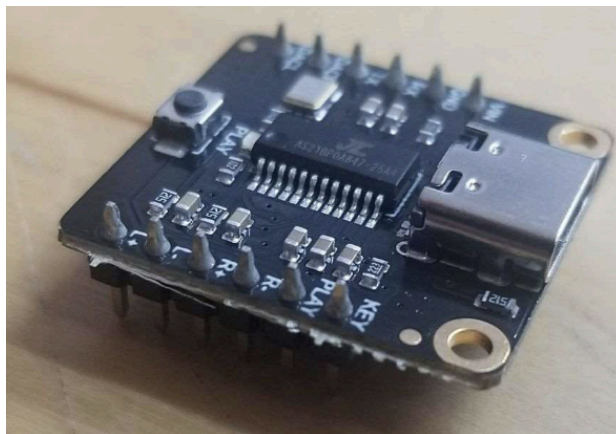
Specification	Details
DC Voltage	9V
Rated Current	7.5A @ 9VDC / Source can fluctuate from 90 to 264VAC
Rate Power	68W
Output plug	Barrel connector Inner diameter: 2.5mm Outer diameter: 5.5mm Barrel length: 11mm Polarization: Positive center, negative sleeve

Motherboards



In the second generation, the custom-made motherboard got replaced by a motherboard designed by DFRobot, customly for Rafael Lozano-Hemmer. The model is DFR0857 and each board is populated with 15 MP3 players and stereo output jacks. All the motherboards in a housing are daisy chained with 10 pins ribbon cable (IDC 5x2 cable, with 0.1" connector pitch) connected on the top part of the board. When more than one power controller board is involved, the motherboards are daisy chained: bridging power and data near mid-way in the motherboards collection.

MP3 players

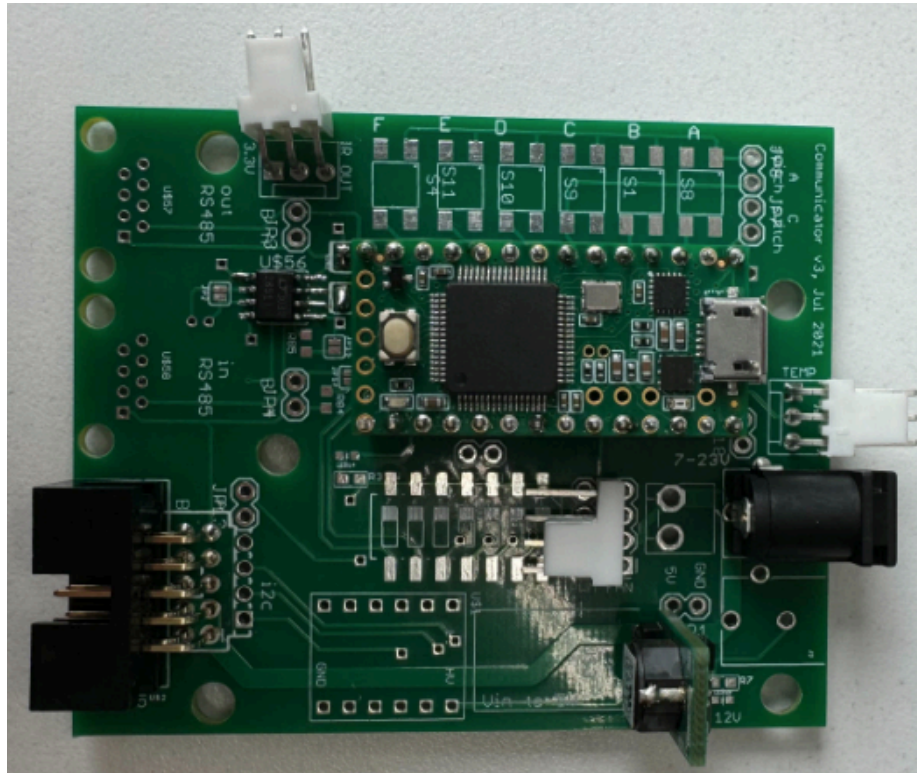


Designed by DFRobot customly for Rafael Lozano-Hemmer, the MP3 player (model DFR0768-RLH), hosts a unique MP3 track, containing two compositions of said composer. The

files are 128Kb bitrate uncompressed MP3 files which shouldn't be bigger than 100 Mb of filesize. They have one composition in the left channel and another in the right channel.

The MP3 player can be repopulated by connecting it to a computer via the micro USB port and dropping the MP3 file onto it, like it was a mini hard drive. This drive should be detected as a MS-DOS (Master Boot Record) drive, formatted with a FAT16 partition.

IR Remote receiver and power controller board



A custom made board that receives the IR signal from an Apple IR remote control (sensor attached on the 3 pins connector on top of the picture above), the signal for the thermal sensor (sensor attached on the 3 pins connector on right of the picture above), power from the power supply (via the barrel connector) and the fans (4 pins connector near center).

The controller board is then connected to a first motherboard (10 pins connector on ribbon cable), carrying both power and data signal to either stop, play, reduce or increase the volume. Finally, a 4 pins connector feeds one or several fans to cool down the housing.

If the sphere is bigger, up to four of these boards could have been installed in, with secondary boards being “less completed” than the main one.

The following table lists all the components used in the PCB assembly.

Component	Model	Source	Amount in use
PCB	Custom Design	Antimodular	1
5V DC/DC converter	OKI-78SR-5/1.5-W36H-C	Murata Power Solutions Inc.	1
Teensy 3.2	1528-2385-ND [2756]	Digikey [Adafruit]	1
RS485 transceiver	LTC2851IS8#PBF	Analog Devices Inc.	1
14 pins female header 8.5mm high	PPTC141LFBN-RC	Sullins Connector Solutions	2
Connector header right angled 10pos (5x2) 0.1" connector pitch	SBH11-PBPC-D05-RA-BK	Sullins Connector Solutions	1
LED			3
Resistor 400 Ohm			2
Resistor 1.8k			1
Circular power connector - barrel on PCB (2.1mm-5.5mm ID/OD)	PJ-102A	CUI Devices	1
4 pins TYCO connector right angled, for fans	640457-4	TE Connectivity AMP Connectors	1
3 pins TYCO connector right angled, for thermal and IR sensor	0022053031	Molex	2

IR sensor

The IR sensor is taped inside the housing, behind a hole in one of the housing's sides. Connected to the main controller board, it allows the control of the artwork in pair with the Apple IR remote. It is a simple assembly, built with the following components:

Component	Model	Source	Amount in use
Infrared sensor	1528-157-ND [157]	Digikey [Adafruit]	1
Cabling	3 leads		1
Connector	TYCO 3 pins - 3-640443-2	TE Connectivity AMP Connectors	1

Thermal sensor

The thermal sensor is tucked between 2 motherboards near the complete center of the housing. Connected to the main controller board, it detects the general temperature of the artwork and allows the controller to adjust the fan speeds accordingly, to keep a decent temperature within the housing. It is a simple assembly, built with the following components:

Component	Model	Source	Amount in use
Thermal sensor	TMP36GT9Z	Analog Devices Inc.	1
Cabling	3 leads		1
Connector	TYCO 3 pins - 3-640443-2	TE Connectivity AMP Connectors	1

PLA Motherboard holder



With this generation, the motherboards are secured by 3D printed PLA or PLA-CF holders, each tailored to fit the right number of boards for said composer. These holders vary in size, strength, shape, and aesthetic, glued to the housing near the audio jacks and assembled to accommodate the motherboards. Once in place, the housing is securely locked to prevent any mishaps during transportation.

Apple IR remote control



The sphere is controlled by an Apple IR remote (A1176). The remote is simple and the button layout is described under. The remote takes a CR2032 3V battery.

Button	Action
+ button	Volume Up
- button	Volume Down
Reverse button	Minimum volume - Not always enabled
Forward button	Maximum volume - Not always enabled
Play / Pause button	- Power On/Off (SD cards version) - Play (MP3 player version)
Menu button	- Power On/Off (sd cards version) - Pause (MP3 Player version)

Audio extension cable

In rare cases, the studio provided audio extension cables to increase the distance between the sphere and the housing. These cables were as close as possible to the headphone cabling, in terms of colour and strength. The tension in the audio socket of these cables need to be firm, in order to hold the weight of the hung sphere.

We stopped proposing that option to ensure a better audio signal to the headphones and a more uniform aesthetic, in general.

APPENDIX III - SPECIFICATIONS OF THE DIFFERENT SPHERES PER COMPOSER

Ludwig van Beethoven



Specification	Description
Number of active headphones	488 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	255 stereo jacks, 22 channels (11 jacks) being duplicated.
Number of motherboards	17 motherboards
Number of power supplies	2 power supplies, therefore 2 power cables getting out of housing
Sphere material	Transparent acrylic
Sphere diameter and weight	27.8 cm (10.95 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	36 x 36 x 12 cm (14.2 x 14.2 x 4.75 inches)
Number of fans	Typically 2 fans
Power consumption	150W on 110 OR 220V

John Cage



Specification	Description
Number of active headphones	269 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	135 stereo jacks, 1 channel (1 jack) being duplicated.
Number of motherboards	9 motherboards
Number of power supplies	2 power supplies, therefore 2 power cables getting out of housing
Sphere material	White Plastic Formiga 3D print, dyed with dark blue tint
Sphere diameter and weight	23.6 cm (9.3 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	23 x 23 x 12 cm (9.1 x 9.1 x 4.75 inches)
Number of fans	Typically 2 fans
Power consumption	150W on 110 OR 220V

Henryk Mikołaj Górecki



Specification	Description
Number of active headphones	105 headphones / tracks
Headphones seating	Outside the sphere
Number of audio jacks / MP3 players (or SD cards)	60 stereo jacks, 15 channels (8 jacks) being duplicated.
Number of motherboards	4 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Frosted Ultra Detail Transparent polymer 3D print, dyed with dark red tint
Sphere diameter and weight	12.4 cm (4.9 inches) diameter - Weighs about 3kg
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

George Frideric Handel

Specification	Description
Number of active headphones	612 headphones / tracks
Headphones seating	Outside the sphere
Number of audio jacks / MP3 players (or SD cards)	315 stereo jacks, 18 channels (9 jacks) being duplicated.
Number of motherboards	21 motherboards
Number of power supplies	3 power supplies, therefore 3 power cables getting out of housing
Sphere material	TBC
Sphere diameter and weight	Diameter TBC - Weight TBC
Housing dimensions (LxWxH)	Dimensions TBC
Number of fans	TBC
Power consumption	225W on 110 OR 220V

Charles Ives



Specification	Description
Number of active headphones	128 headphones / tracks
Headphones seating	Outside the sphere, recessed in the material
Number of audio jacks / MP3 players (or SD cards)	75 stereo jacks, 7 channels (4 jacks) being duplicated.
Number of motherboards	5 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Glazed white ceramic 3D print
Sphere diameter and weight	13 cm (5.15 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

György Ligeti



Specification	Description
Number of active headphones	87 headphones / tracks
Headphones seating	Outside the sphere
Number of audio jacks / MP3 players (or SD cards)	45 stereo jacks, 3 channels (2 jacks) being duplicated.
Number of motherboards	3 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Frosted Detail Transparent polymer 3D print, dyed with dark orange tint
Sphere diameter and weight	11.2 cm (4.45 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Gustav Mahler

Specification	Description
Number of active headphones	39 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	45 stereo jacks, 6 channels (3 jacks) being duplicated.
Number of motherboards	3 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Polished nickel steel 3D print
Sphere diameter and weight	10.8 cm (4.25 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Claudio Monteverdi



Specification	Description
Number of active headphones	17 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	30 stereo jacks, 43 channels (22 jacks) being duplicated.
Number of motherboards	2 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Matte gold steel 3D print
Sphere diameter and weight	6.6 cm (2.6 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Wolfgang Amadeus Mozart



Specification	Description
Number of active headphones	565 headphones / tracks
Headphones seating	Outside the sphere
Number of audio jacks / MP3 players (or SD cards)	285 stereo jacks, 5 channels (3 jacks) being duplicated.
Number of motherboards	19 motherboards
Number of power supplies	2 power supplies, therefore 2 power cables getting out of housing
Sphere material	White polymer 3D print
Sphere diameter and weight	35 cm (13.8 inches) diameter - Weighs about 5 Kg
Housing dimensions (LxWxH)	36 x 36 x 12 cm (14.2 x 14.2 x 4.75 inches)
Number of fans	Typically 2 fans
Power consumption	150W on 110 OR 220V

Conlon Nancarrow

Specification	Description
Number of active headphones	79 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	45 stereo jacks, 11 channels (6 jacks) being duplicated.
Number of motherboards	3 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	TBC
Sphere diameter and weight	Diameter TBC - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Luigi Nono



Specification	Description
Number of active headphones	70 headphones / tracks
Headphones seating	Outside the sphere, recessed in the material
Number of audio jacks / MP3 players (or SD cards)	45 stereo jacks, 20 channels (10 jacks) being duplicated.
Number of motherboards	3 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Stain Black ceramic 3D print
Sphere diameter and weight	13.7 cm (5.4 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Krzysztof Penderecki

Specification	Description
Number of active headphones	151 headphones / tracks
Headphones seating	TBC
Number of audio jacks / MP3 players (or SD cards)	90 stereo jacks, 29 channels (15 jacks) being duplicated.
Number of motherboards	6 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	TBC
Sphere diameter and weight	Diameter TBC - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Franz Schubert



Specification	Description
Number of active headphones	998 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	510 stereo jacks, 22 channels (11 jacks) being duplicated.
Number of motherboards	34 motherboards
Number of power supplies	4 power supplies, therefore 4 power cables getting out of housing
Sphere material	White plastic Formiga 3D print, dyed with green tint
Sphere diameter and weight	45 cm (17.75 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	36 x 36 x 22 cm (14.2 x 14.2 x 8.7 inches)
Number of fans	Typically 4 fans
Power consumption	300W on 110 OR 220V

Karlheinz Stockhausen



Specification	Description
Number of active headphones	203 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	105 stereo jacks, 7 channels (8 jacks) being duplicated.
Number of motherboards	7 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Aluminum composite 3D print
Sphere diameter and weight	17.75 cm (17.75 inches) diameter - Weighs about 3 Kg
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	150W on 110 OR 220V

Igor Stravinsky

Specification	Description
Number of active headphones	129 headphones / tracks
Headphones seating	Outside the sphere, recessed in the material
Number of audio jacks / MP3 players (or SD cards)	75 stereo jacks, 21 channels (11 jacks) being duplicated.
Number of motherboards	5 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	TBC
Sphere diameter and weight	Diameter TBC - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Hildegard Von Bingen



Specification	Description
Number of active headphones	69 headphones / tracks
Headphones seating	Inside the sphere
Number of audio jacks / MP3 players (or SD cards)	45 stereo jacks, 21 channels (11 jacks) being duplicated.
Number of motherboards	3 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Bronzed steel 3D print
Sphere diameter and weight	10.8 cm (4.25 inches) diameter - Weighs 3 Kg
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

Richard Wagner

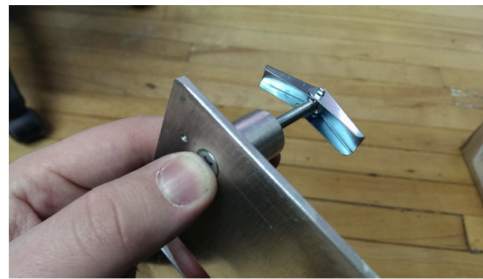
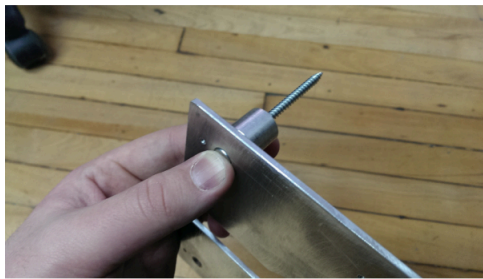
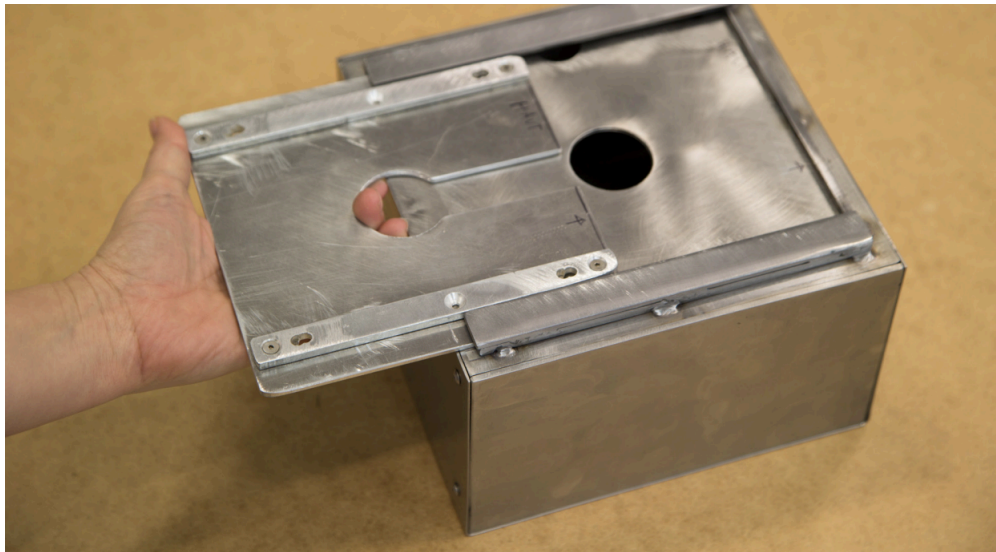


Specification	Description
Number of active headphones	113 headphones / tracks
Headphones seating	Outside the sphere, recessed in the material
Number of audio jacks / MP3 players (or SD cards)	60 stereo jacks, 7 channels (4 jacks) being duplicated.
Number of motherboards	4 motherboards
Number of power supplies	1 power supply, therefore 1 power cable getting out of housing
Sphere material	Black Glazed porcelain 3D print
Sphere diameter and weight	13 cm (5.15 inches) diameter - Weight TBC
Housing dimensions (LxWxH)	20 x 20 x 12 cm (7.9 x 7.9 x 4.75 inches)
Number of fans	Typically 1 fan
Power consumption	75W on 110 OR 220V

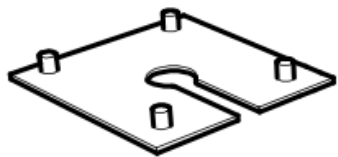
APPENDIX IV - ASSEMBLY OF THE WORK

Mount Mounting Bracket Directly to Ceiling

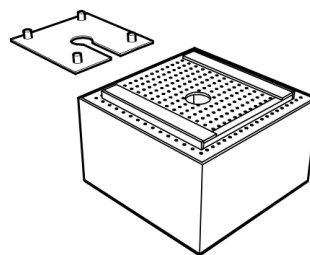
The mounting bracket attaches to the ceiling from 4 mounting points. This plate allows the housing to slide onto and off of the ceiling to provide easy mounting. Use either the included screws, or bolts with mounting toggles to attach the plate to the ceiling. Centering the plate above where the sphere is to be located. Insert the included aluminum standoffs above the mounting plate to provide a cable and air gap above the housing. See the final mounting diagram below for reference.



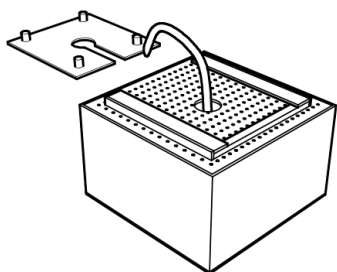
Step 1: Screw the plate to the ceiling.



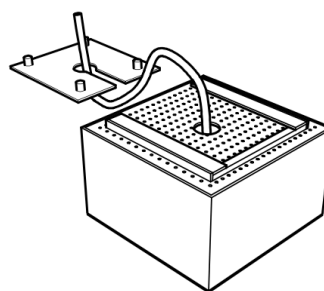
Step 2: Get the housing box near the bracket.



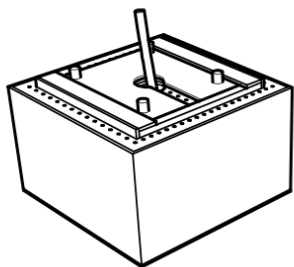
Step 3: Prepare the power cable to be fished.



Step 4: Fish cable through bracket's hole.



Step 5: Slide the housing onto the bracket.



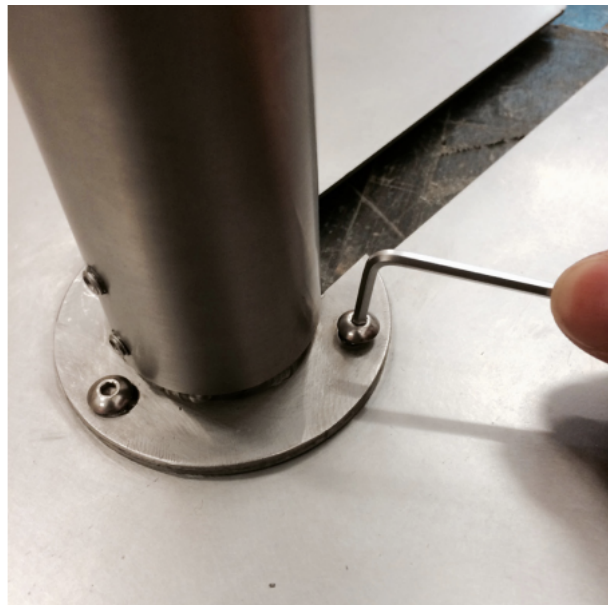
Extension Post

In some cases, you might want to use the extension post to lower the housing in the room. Follow the steps below to properly install the piece when using it. Steps 1 to 3 and 4 to 7 might have been done already.

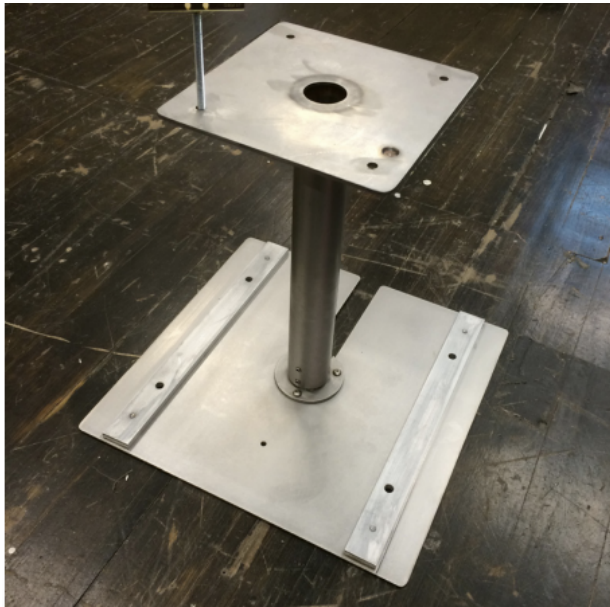
Step 1: Organize all parts on a horizontal surface.



Step 2: Connect the bracket's pole and plate together with the provided screws.



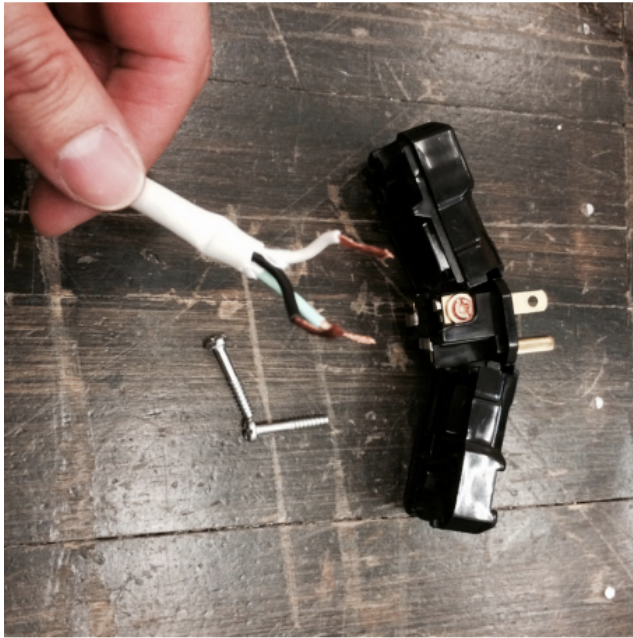
Step 3: Prepare the structure to be placed on the four ceiling anchors.



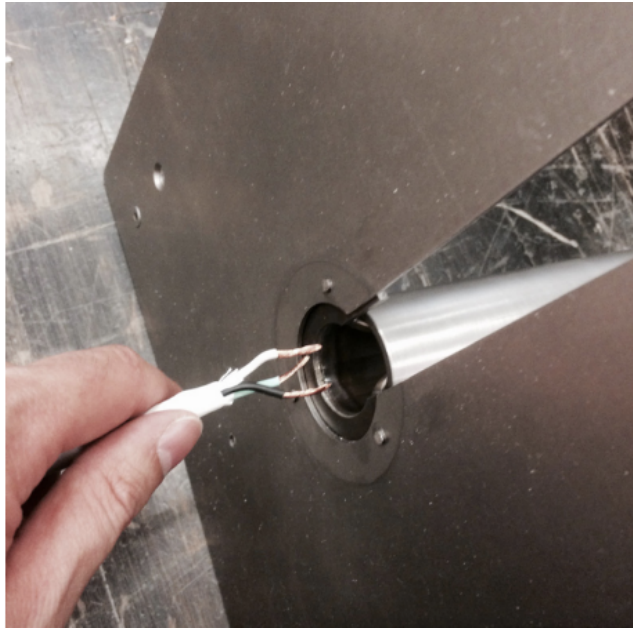
Step 4: Locate the plug(s) of the piece. If it (they) fit(s) through the post, skip to Step 6.



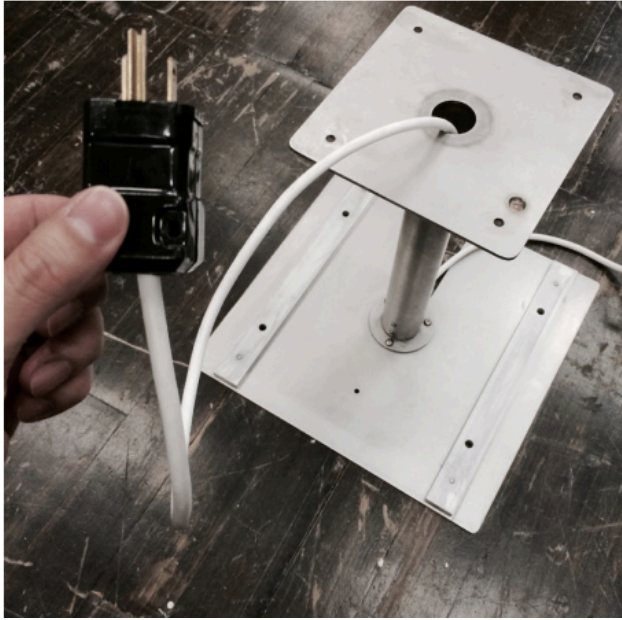
Step 5: Dismantle the plug. Beware of the ground, live and neutral leads.



Step 6: Pass the cable through the pole at the underside of the bracket.



Step 7: Assemble the plug. Beware of the ground, live and neutral leads, flipping them would damage the artwork's electronics.



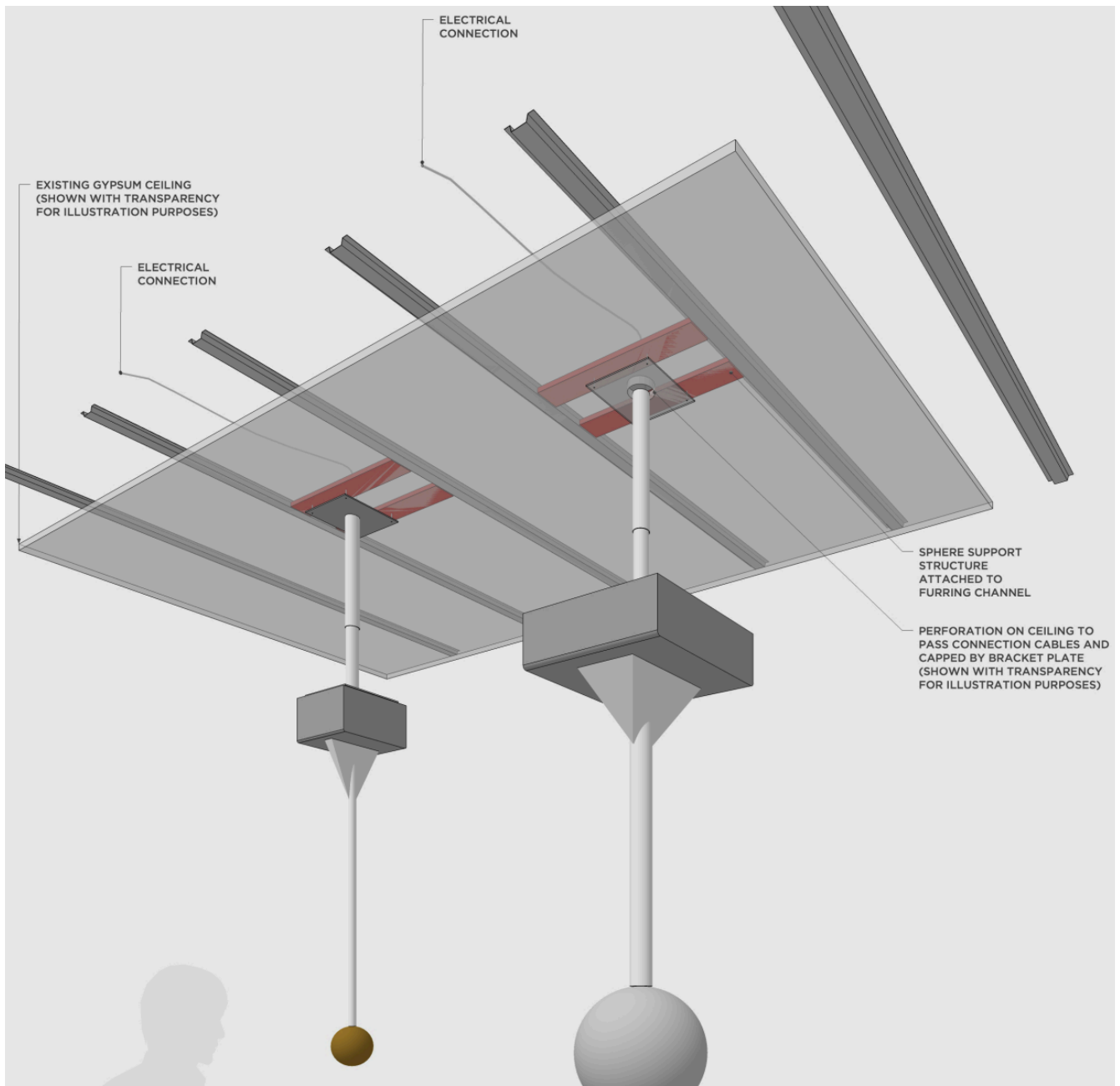
Step 8: Connect the plug to AC power and conceal it in the ceiling.

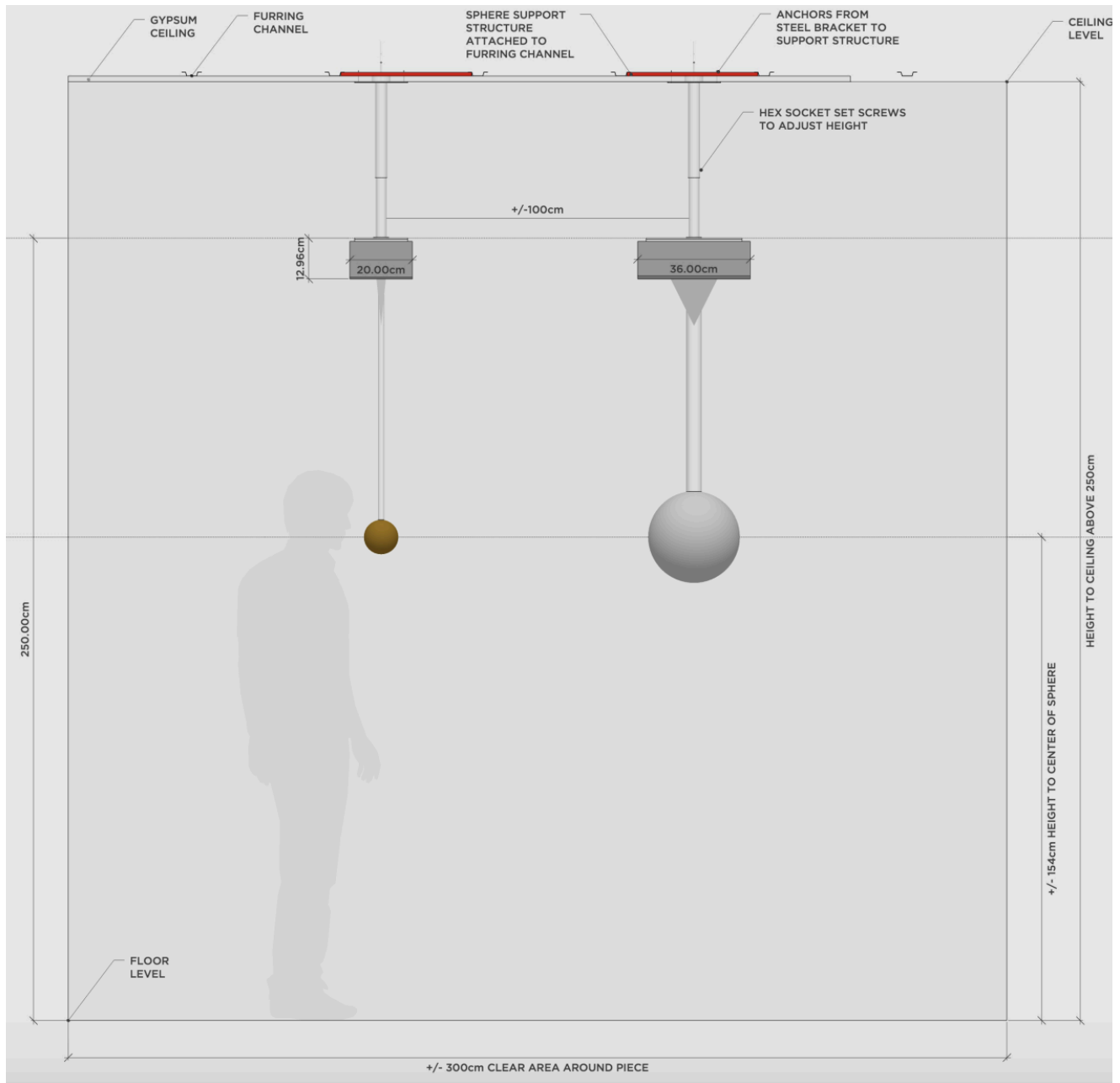
Step 9: Install the bracket against the ceiling with anchors.

Step 10: Slide the piece onto the bracket and gradually push the extra cable inside the pole to fully hide it.

Step 11: Once done, it should look like the image and diagrams below.

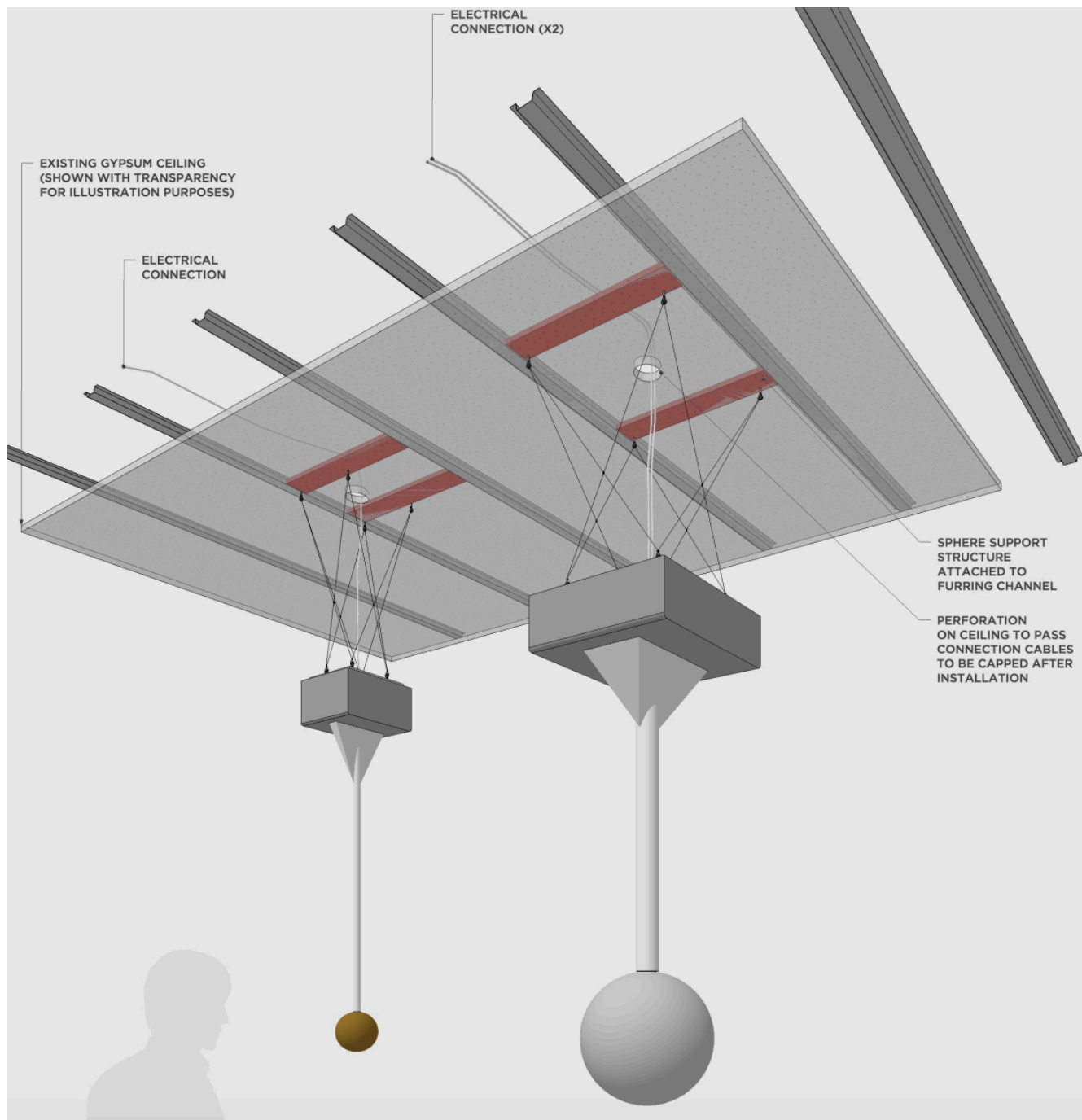


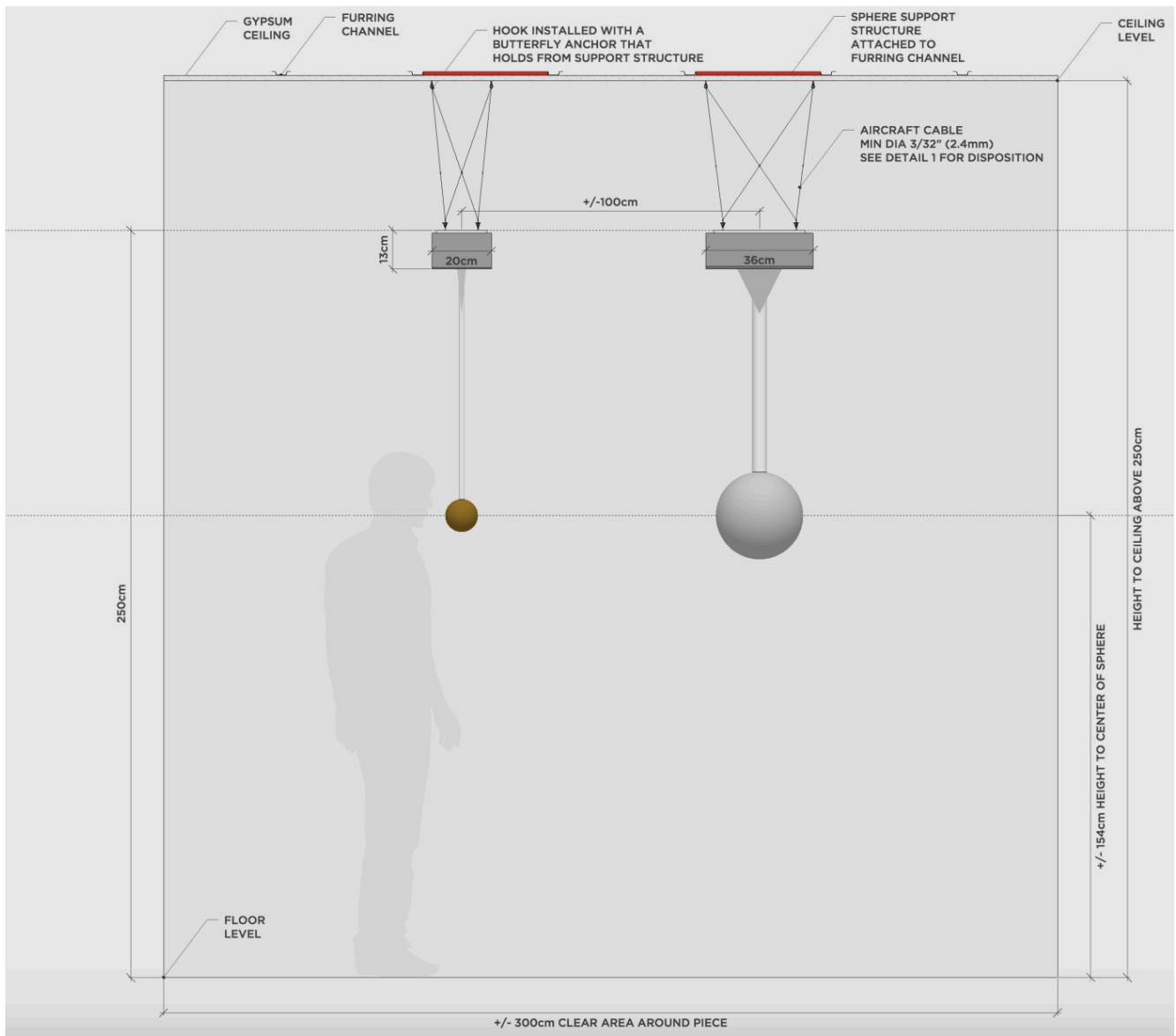




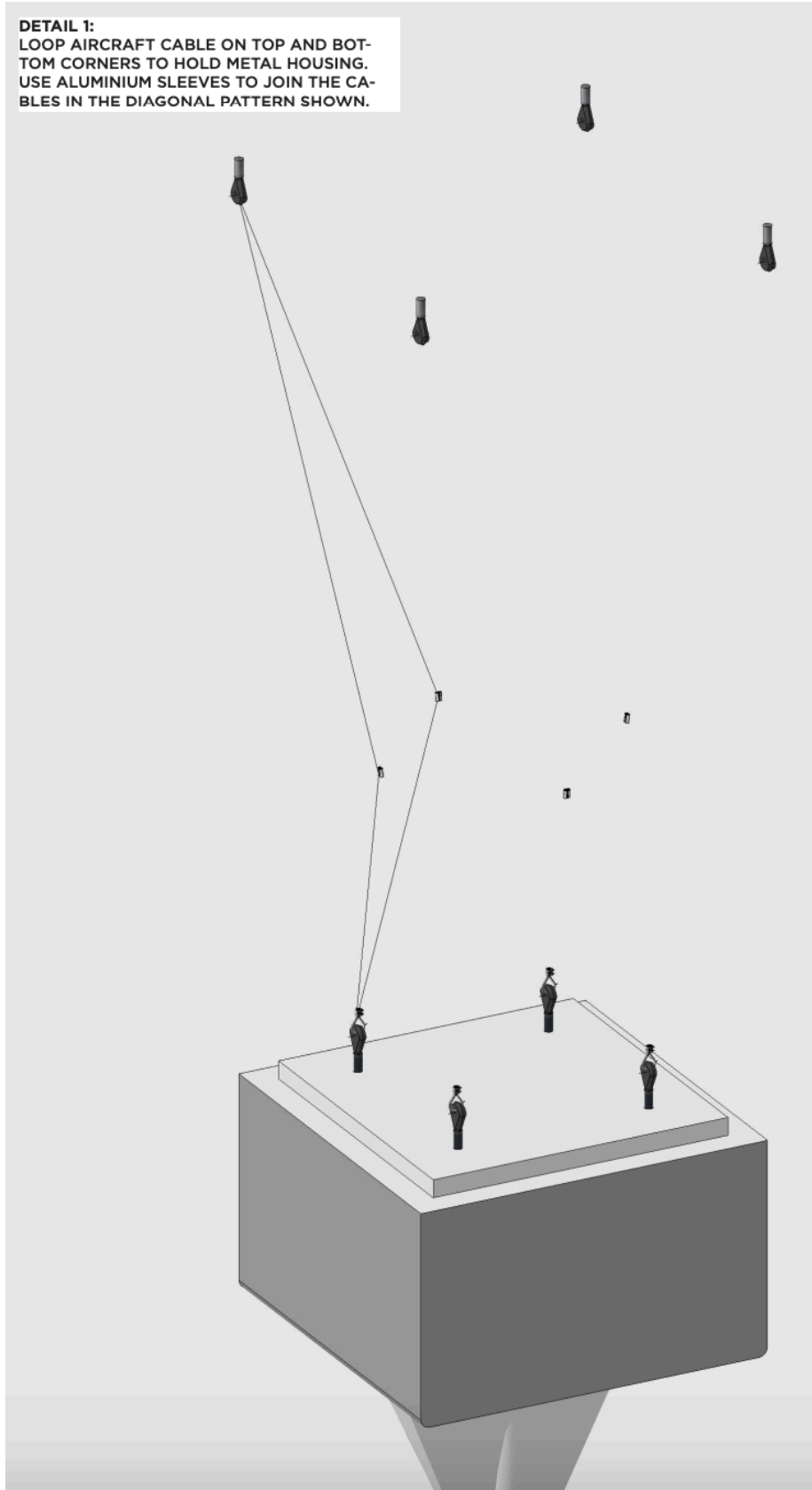
Aircraft Cable Installation

Another option is to hang the housing with aircraft cables. This version is more aerial and a bit less stable, it is also less liked by the artist - the first two options should be given priority. Measurements are dependent on different factors, like housing dimensions, ceiling height, etc., they need to be verified and adjusted specifically on site.

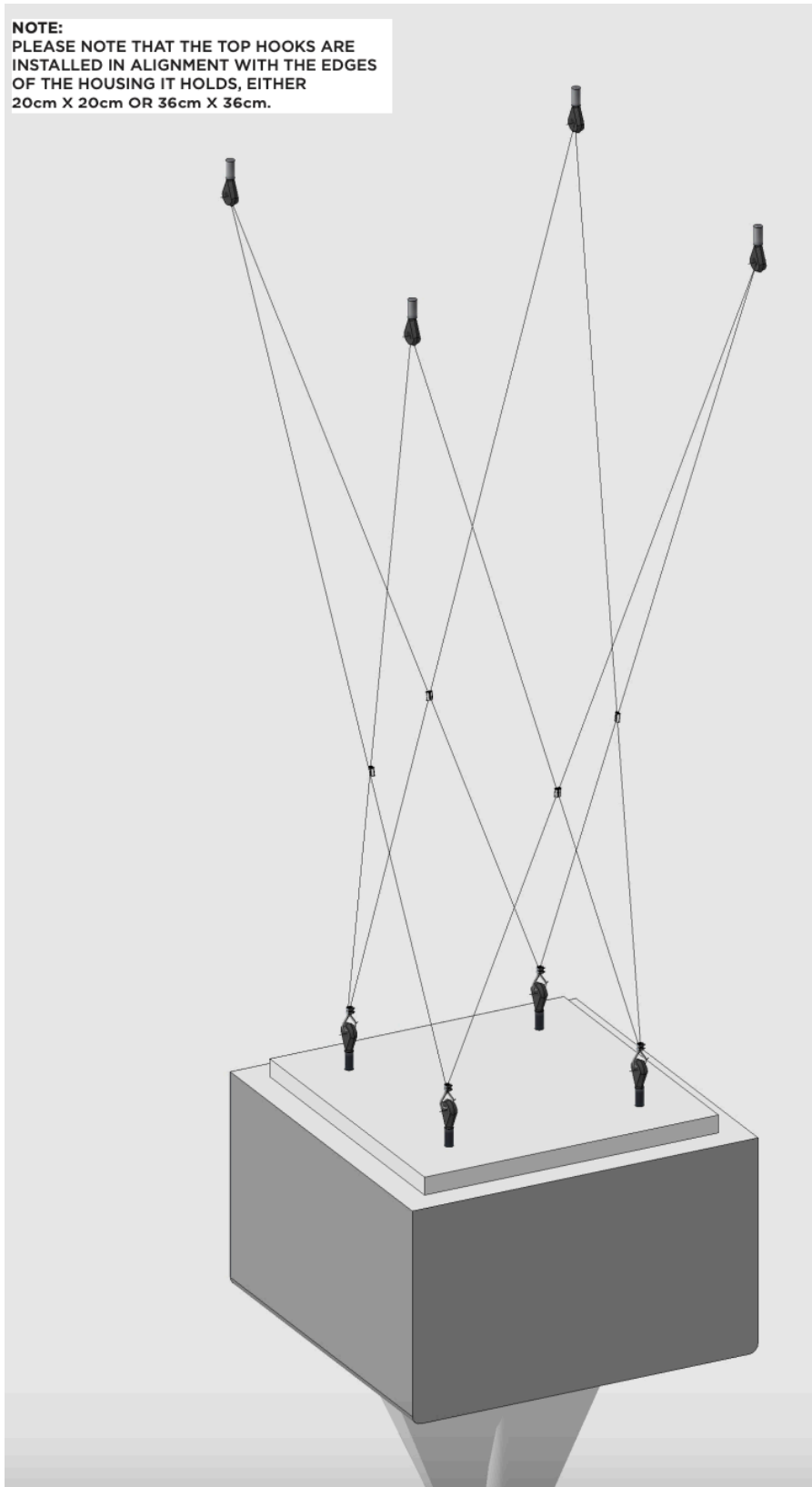




DETAIL 1:
LOOP AIRCRAFT CABLE ON TOP AND BOT-
TOM CORNERS TO HOLD METAL HOUSING.
USE ALUMINIUM SLEEVES TO JOIN THE CA-
BLES IN THE DIAGONAL PATTERN SHOWN.



NOTE:
PLEASE NOTE THAT THE TOP HOOKS ARE
INSTALLED IN ALIGNMENT WITH THE EDGES
OF THE HOUSING IT HOLDS, EITHER
20cm X 20cm OR 36cm X 36cm.



APPENDIX V - REPAIRS (ADVANCED MAINTENANCE)

Tearing down the housing

Accessing the inside of the housing might be needed to debug issues with the artwork. First and foremost, we recommend wearing clean cotton gloves to prevent any damages to the sphere or housing and preparing a large surface protected with soft foam or non-static fabric on which you could lay down the components.

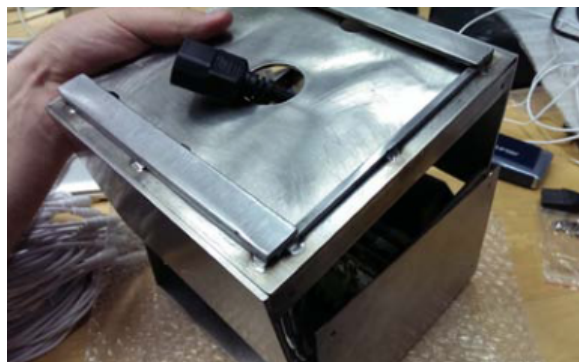
Disconnect the sphere's audio connectors in groups of 15 plugs (per motherboard). Once fully disconnected, place the sphere on the protected surface, surrounded with soft material to prevent it rolling away.

Then slide the housing out of its mounting bracket, disconnect it from power and set it onto the protected surface with the headphone jacks facing down.

Unscrew the 8 or 12 screws on the box (4 on two housing sides and optionally 4 on the bottom - same surface as the audio jacks), using a 2mm hex screwdriver (size may differ).



Lift the top part of the housing. Note that two sides of the box are attached to the back of the box and could grip electronic components in the move, pay attention to any restriction to avoid pulling connections out.



While lifting the top, managing power cabling through the housing hole, this would free the top or give you enough roomspace to rest the housing's top nearby while having a clear access to the inside of the housing.

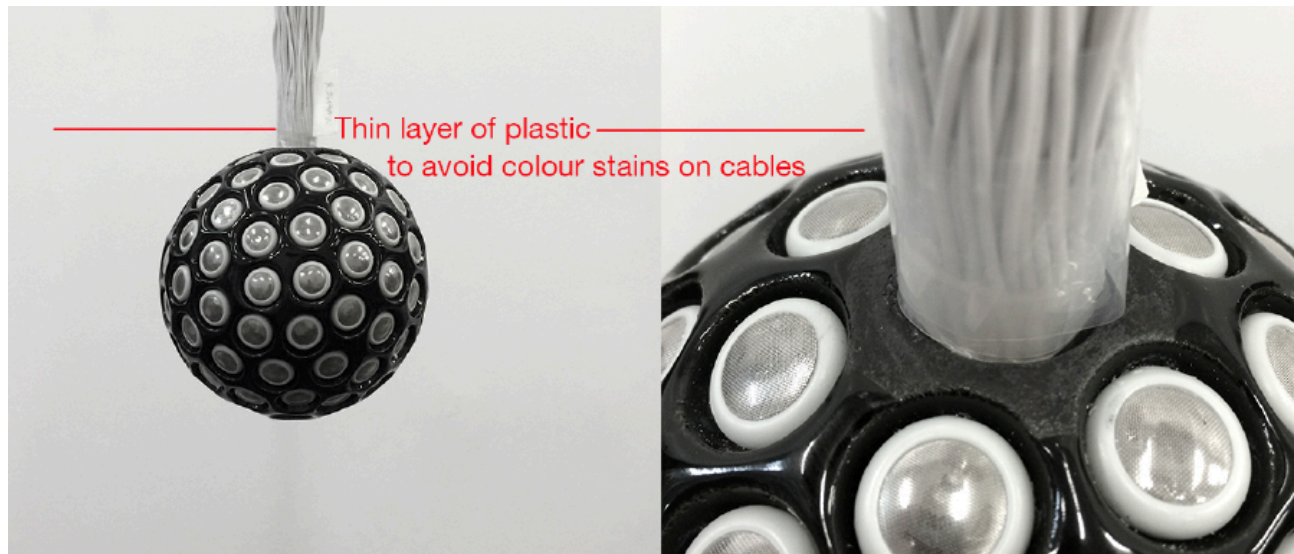


Once inside, you can inspect the connections and adjust components. Once done, you can build back the housing, reverting the steps. You can use regular headphones or some of the sphere headphones to test the electronics before reinstalling the whole sphere.

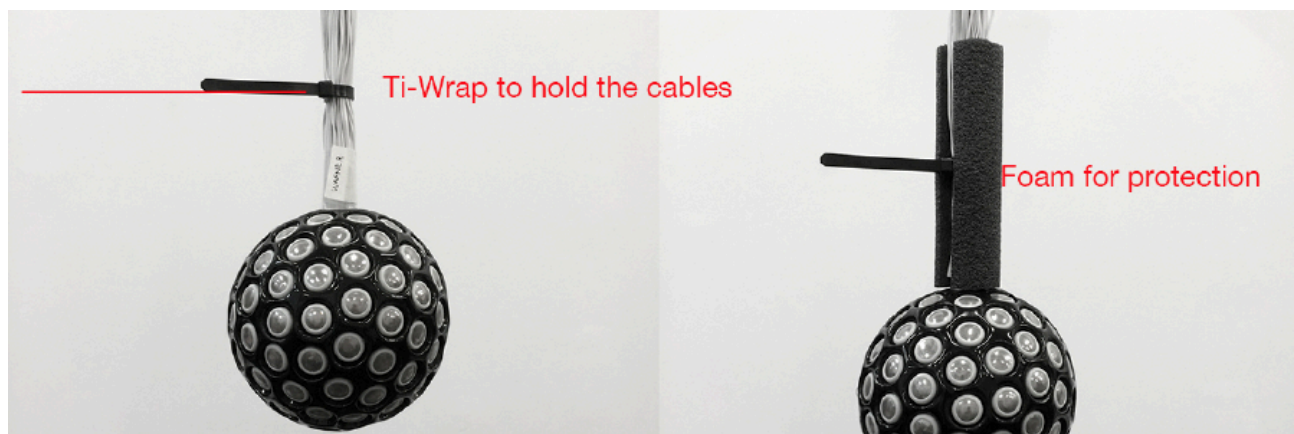
Once ready, bring the housing back onto its bracket, after plugging it back to its regular power source. Turn off the power to that source and plug the sphere back to the audio jacks: we recommend starting with the middle row, then alternate from one side to the other, until complete reconnection. The artwork should be ready to be turned back on.

APPENDIX VI - PACKING / UNPACKING

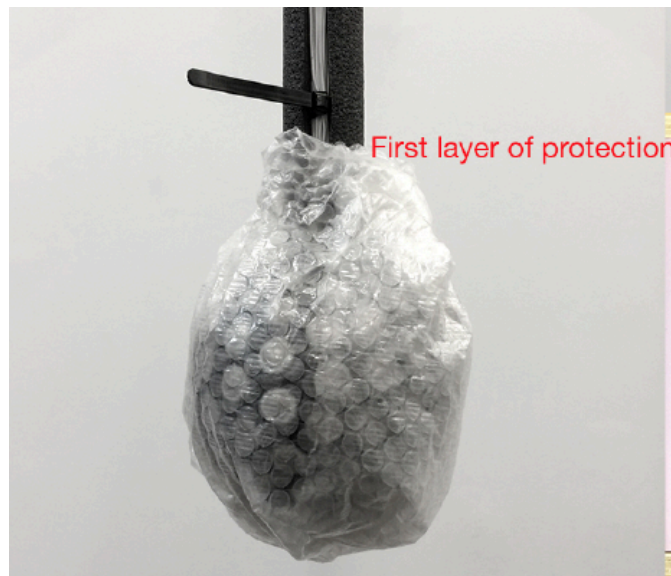
The following is based on the optimal way to pack the artwork. Technique might have varied over time, please adapt considering the equipment you got. The packing of the artwork is fairly simple, yet pretty important to avoid any damages. As shown in the following pictures, we recommend using a thin layer of plastic around the headphone cable bundle, starting at the neck of the sphere going up for about 20 centimeters, to avoid stains and abrasion on the cabling.



Then, the bundle should be tied (with a reusable tie-wrap preferably), about 10 centimeters away from the sphere. After, a pipe insulation sleeve (or any kind of protective foam) should be wrapped around the bundle to protect the cables.



Finally, the sphere should be wrapped in a thin layer of plastic sheet followed by a layer of bubble wrap.

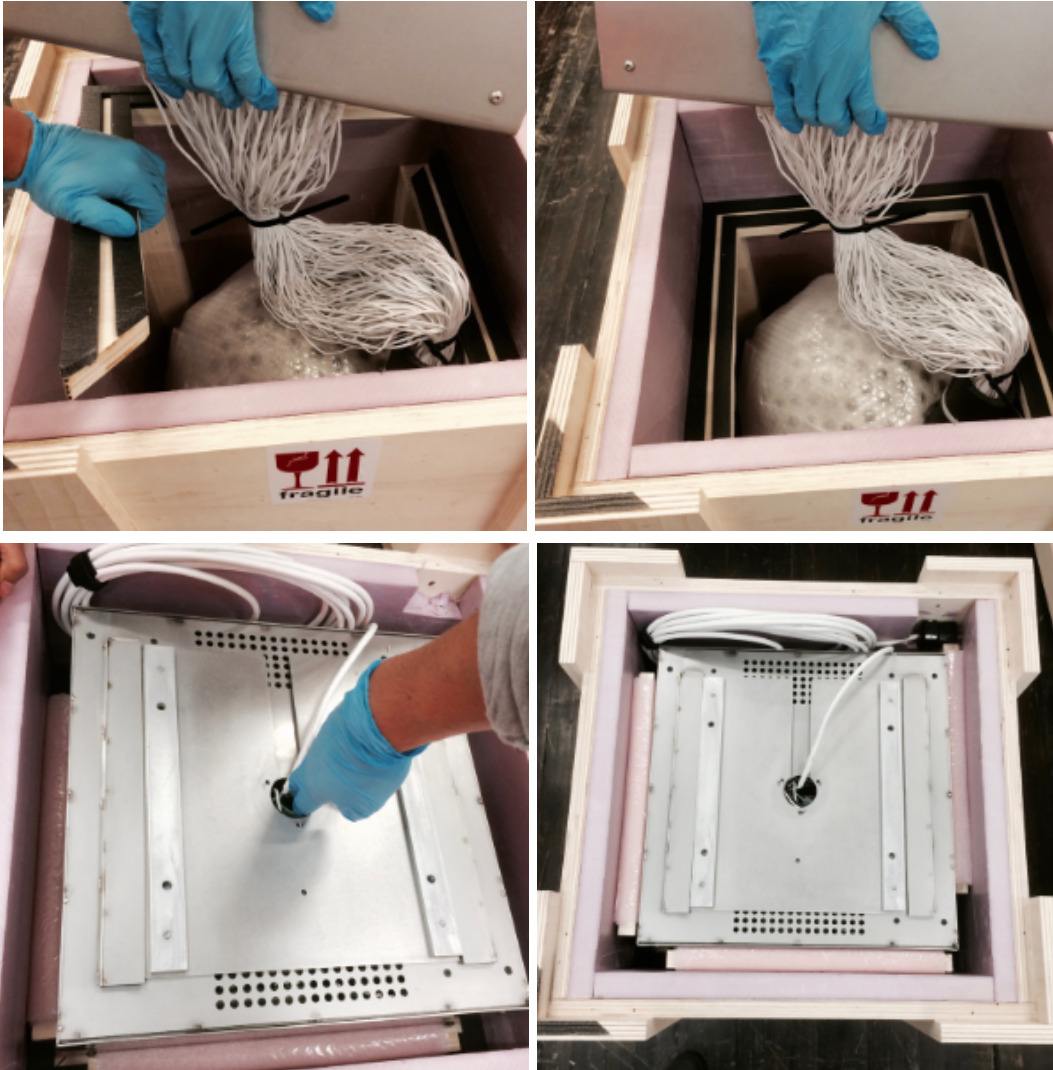


If the original shipping crate has been discarded and needs to be recreated, we recommend proper support for the housing, as seen in the following pictures. It is best practice to assign one person to manipulate the sphere and another to handle the housing. Use of cotton or latex gloves is a must to prevent damages and stains to any surfaces.

First, seat the sphere within a box, or a foam enclosure, at the bottom of the shipping crate.



Then slowly drop the housing above the adding packing material to prevent the sphere bumping into the housing and damage either the sphere or the audio plugs during transport. Ensure any structure supporting the housing is well foamed, to prevent damages to the metal surface of the enclosure. Tuck the power cabling to the side of the housing, while protecting the power plug(s), if the plug(s) and power cords(s) don't fit above the housing.



For unpacking, we suggest being two people to handle the work. Simply go in the opposite order as the packing steps listed above : as one opens the crate another person will be able to pull the piece by manipulating the metal housing box. Then the first one person should assist in removing the crate housing and guiding the sphere out. Layout all the elements that are inside the crate and follow the instructions that fit the specific type of installation (with a bracket (plate), a post or hung from cables).