



# Sphere Packing

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## **Sphere Packing (2014)**

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

### **Dimensions**

Sphere: 13 cm diameter

Housing: 20 cm x 20 cm x 15 cm (LxWxH)

### **Edition**

3+1AP: single spheres, 3+1AP: constellations of 5 composers, 1+1AP: constellations of 17 composers.

### **Description**

“Sphere Packing” 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.

Technically, 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.

### **Composers (Number of Compositions)**

17 Claudio Monteverdi, 39 Gustav Mahler, 69 Hildegard Von Bingen, 70 Luigi Nono, 79 Conlon Nancarrow, 87 György Ligeti, 105 Henryk Mikołaj Górecki, 113 Richard Wagner, 128 Charles Ives, 129 Igor Stravinsky, 203 Karlheinz Stockhausen, 269 John Cage, 487 Ludwig van Beethoven, 565 Wolfgang A. Mozart, 612 George Frideric Handel, 998 Franz Schubert, 1128 Johann Sebastian Bach



## Technical Information

### Power

Auto switching 80W 10A @ 3.3v power supplies run at 110/220v 50/60hz. 1 to 3 depending on the sphere.

### Music Files

All music is stored on the players in MicroSD cards. The files are 16bit uncompressed WAV files. They have one song in the left channel and one song in the right channel.

### Playback Electronics

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 audio from the ATtiny85's are then amplified with a LM4811 stereo amplifier which has volume control integrated in the chip. The playback cards are controlled from one Arduino Pro Micro, which reads the input of an IR remote receiver which controls the playback cards.

### Sphere Packing: Example Parts List

Electronics Housing - Stainless Steel

Housing Ceiling Mount - Stainless Steel

3D Printed Sphere w/ Embedded Headphones

1-3x - Power Cable

4x - Aluminum Unthreaded Spacer, 5/8" OD, 1/2" Length, 1/4" Screw Size

4x - #10 3" Flat Head Screw

4x - 10-24 2-1/2" Flat Head Bolt w/ Toggle

1x - Screw Adapter

1-3x - 80W 10A @ 3.3v power supply

1-3x - Fan

1x - IR Remote

1x - Arduino Based Control Board

3-19x - Music Playback Cards

15x - ATtiny85

15x - LM4811

15x - MicroSD Card

15x - MicroSD Card Slot

15x - 3.5mm Headphone Jack

1x - Blue LED

1x - Custom PCB

Resistors and Capacitors

## Operation

### Apply Power

Once the sphere receives power for the first time it will turn on at half volume. This is designed so that should the remote fail, the sphere still works.

### Using the Remote

The remote controls are listed below, the easiest way to power on and off the sphere is by the remote. Using either the center or menu buttons. The volume buttons allow you to jump between volume settings and to make fine adjustments.

Volume Up

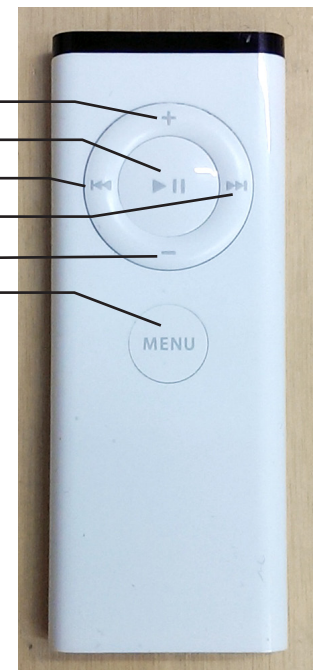
Power On/Off

Min Volume

Max Volume

Volume Down

Power On/Off



### IR Remote

The spheres are controlled by an IR remote. The remote is simple and the button layout is described below. The remotes take a CR2032 3V watch battery. The remote receiver is located on the side of the box, it is a small, round, black hole.

## Components

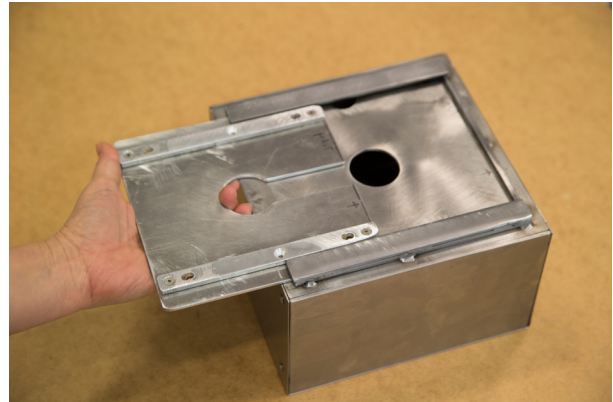
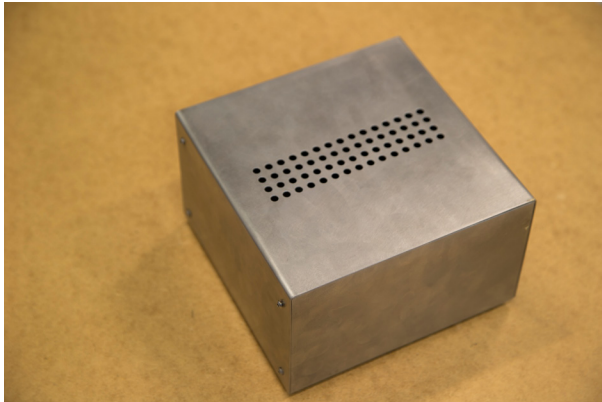
### The Sphere

A dyed transparent polymer 3D print which contains 105 individual headphones coming to 53 headphone cables out of the top of the sphere.



### The Housing

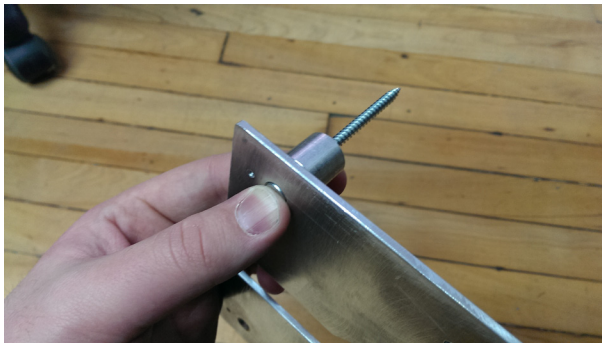
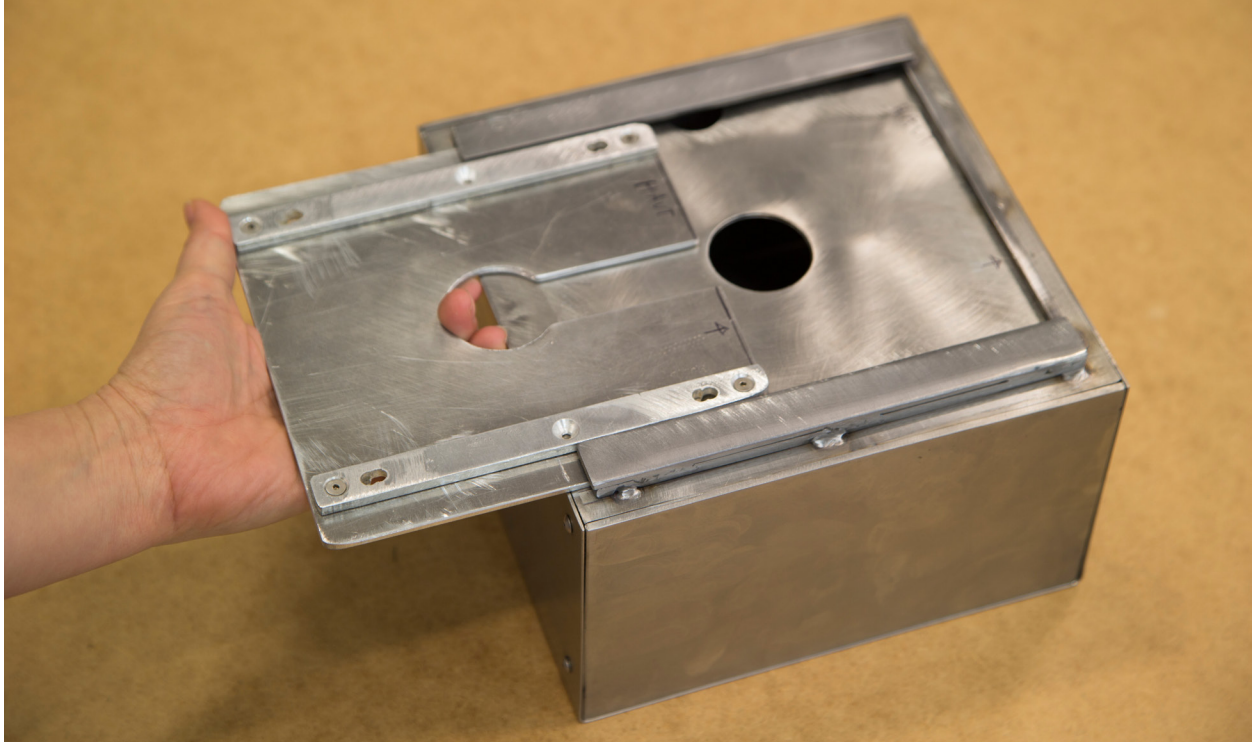
A stainless steel box (20x20x15cm) containing a sliding mounting bracket, 4 custom circuit boards, a power supply and cooling fans.



## Installation

### Step 1

Prepare a cable hole, and mount the included bracket.



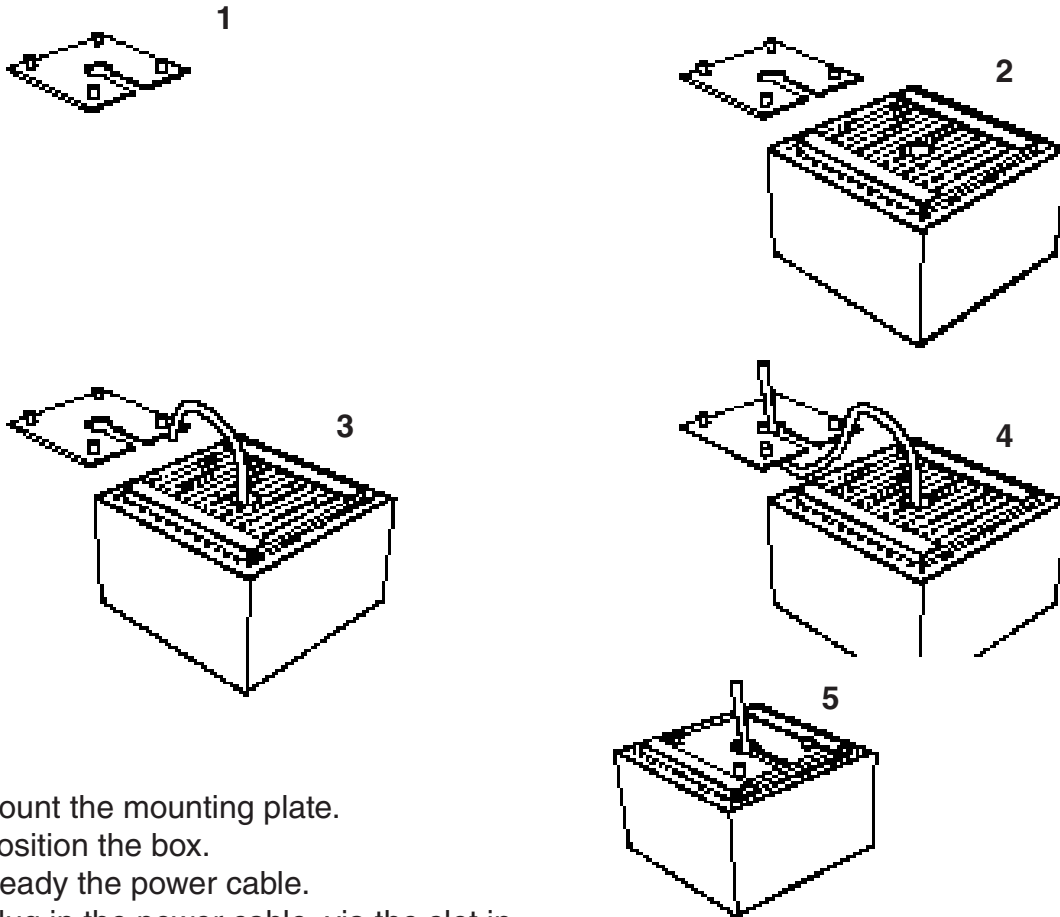
The mounting plate, shown in the first image, attaches to the ceiling from 4 mounting points. This plate allows the housing to slide onto and off of the ceiling to provide easy mounting. Use either the included screws, or bolts with mounting toggles to attach the plate to the ceiling. Centering the plate 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 for reference.



## Installation

### Step 2

Plug in and slide on the housing.



1. Mount the mounting plate.
2. Position the box.
3. Ready the power cable.
4. Plug in the power cable, via the slot in the mounting plate.
5. Slide the box onto the mounting plate.



Once the mounting plate is mounted, pull a length of power cable down, plug it into the back of the housing, and slide the housing with the mounting plate in its groove until it rests against the edge of the mounting plate.

## Installation

### Step 3

Plug in the sphere headphone cables.

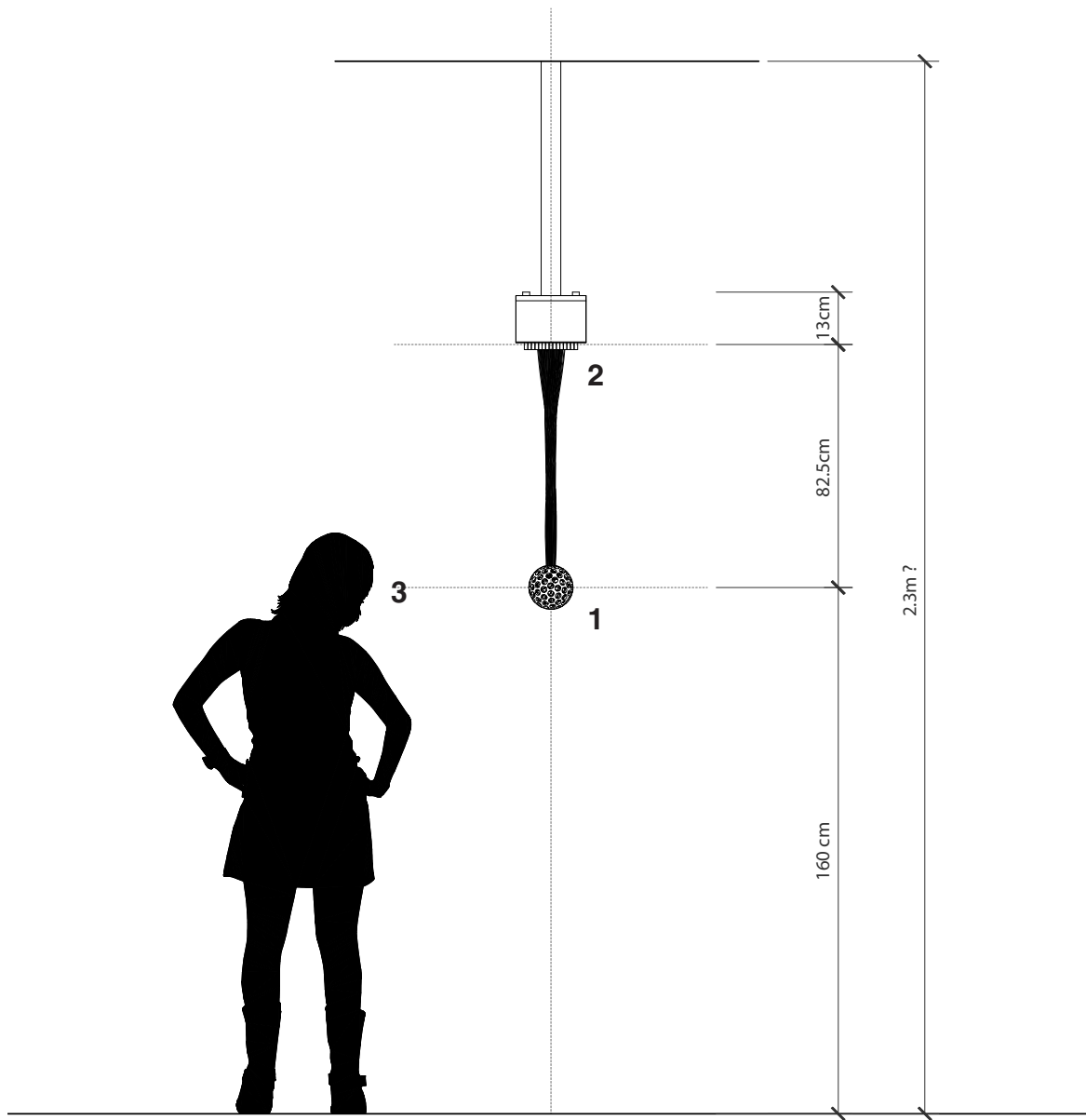


After plugging in the extension cables, the sphere can be plugged in. Take careful note of where the sphere headphone cables are connected. The cables vary in length, it is best to connect the longest cables to the headphone cables from the outside of the housing. This distributes the weight and provides the best way for the cables to hang.

Also note that the sphere comes with tape around the cables near the sphere, and a plastic collar near the connections. The tape is to protect the cables during transit, and the collar is to keep the cables together at the point of connection. The collar should be left on, and the tape removed. Once all the cables are connected, the sphere is ready.



## Installation Diagram



### Notes

1. The final position of the center of the sphere needs to be 160cm from the floor.
2. The weight of the sphere when properly hung is distributed across all the plugs and they provide needed support.
3. To discern individual compositions the public must be right beside a sphere, 5 cm away.



## Teardown



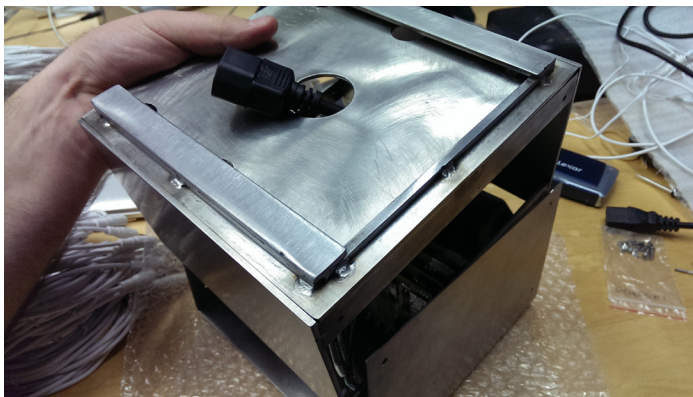
### **Dismount the housing.**

Be sure to place it on a clean, protected surface. Rotate the housing so that the headphone jacks are face down.



### **Unscrew the 8 screws on the box.**

The screws can be removed with approximately a 2mm hex screw driver or key.



### **Begin to lift off the back.**

Note that two sides of the box are attached to the back of the box.

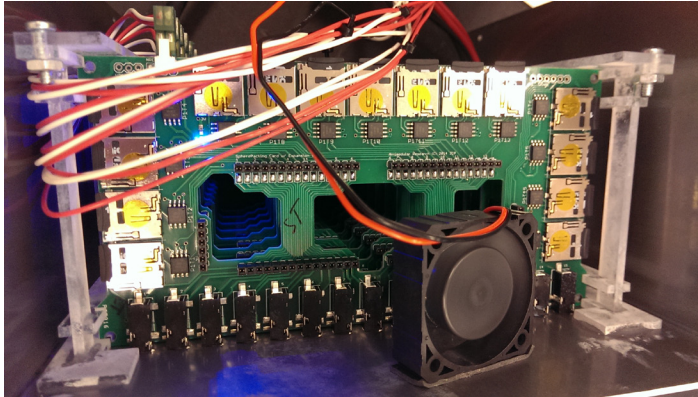


### **Push the plug through.**

While removing the top, push the plug back through the hole. There is around 20cm of cable to work with. Also note some spheres come with wires broken down into three grey terminal blocks.

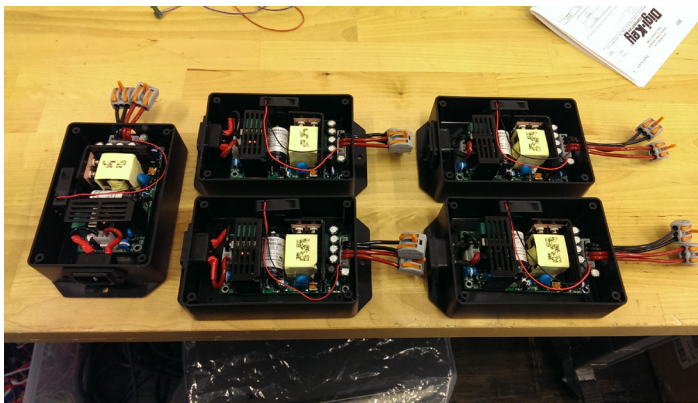


## Interior



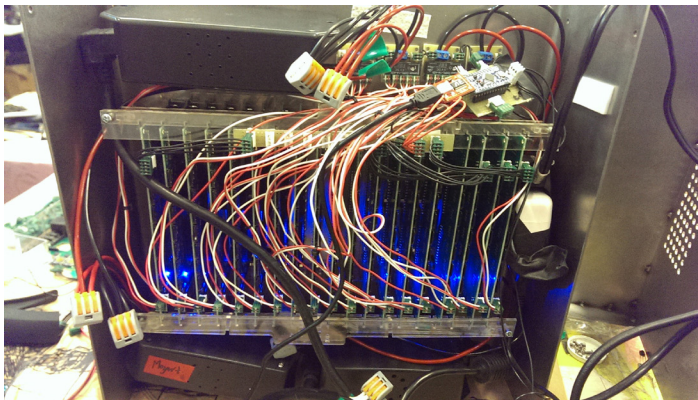
### The Cards

The playback cards are housed in a clear plastic bracket which keeps the cards in place and aligned, the bracket is tightened with two screws on the top.



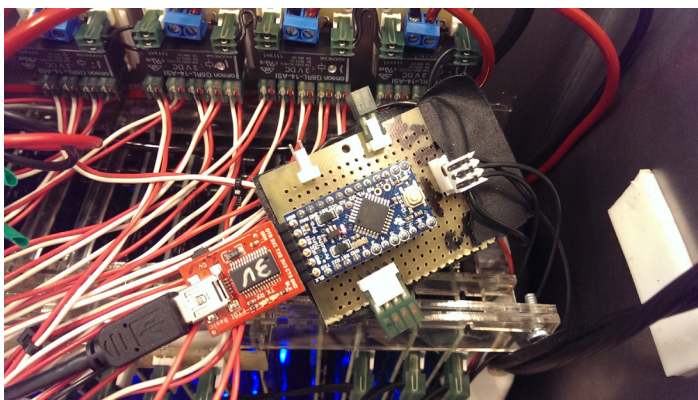
### The Power Supply

All of the AC power conversion is done in the black plastic housing, the cards play the music and the red and white/black cables carry 3v DC. The power supplies have small internal fans, and can switch between 120 and 240V.



### The wiring

The powersupplies run power to a series of small relays, which are controlled by the arduino. The arduino is wired to a IR sensor on the lid, and the arduino is wired to the cards to control volume and power.



### The Controller

A small arduino mini reads the remote signal, and turns the cards on and off while adjusting the volume.

## **Cleaning**

### **Housing**

The housing is 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, or into the plugs for the headphones during the cleaning process.

### **Mount**

The mounting pole and plate is the same material as the housing, and should be cleaned in the same fashion. Take care not to get an excessive amount of moisture inside of the inner post.

### **Cables**

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.

### **Sphere**

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 micro fiber cloth to remove dust and small smudges.* If stained, chipped or dented please call the studio for advice.

## Troubleshooting

### **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. Please see the housing breakdown for instructions on how to tighten the cards.

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

Depending on the sphere, there is an uneven number of plugs, please connect the extra extension cables so that all the plugs on the housing are connected, and tuck them into the area where the extension cables and sphere cables connect.

## **Support**

**If you would like support please call Lozano-Hemmer's studio in Canada.**

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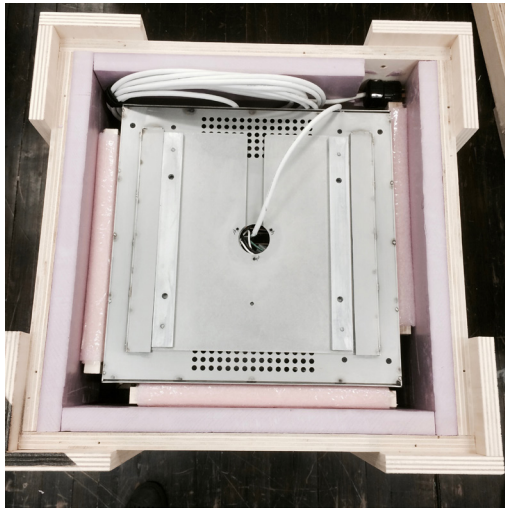


## CRATE AND PIECE HANDLING

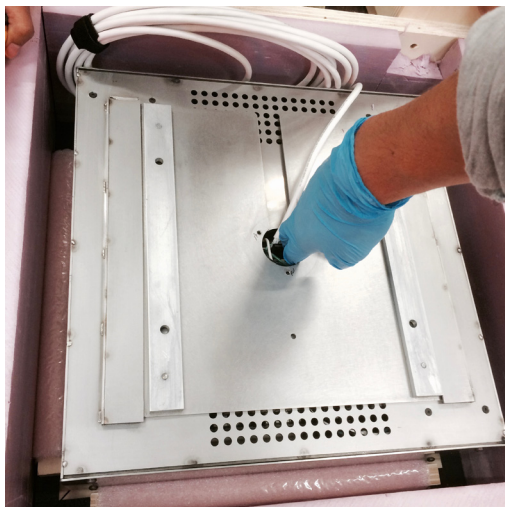
SPHERE PACKING IS SHIPPED SO THAT IT NEEDS ONLY TO BE CONNECTED TO AC POWER AND THEN HUNG IN PLACE. PLEASE PREPARE THE ELECTRICAL CONNECTION AT THE CEILING AREA WHERE THE PIECE WILL BE INSTALLED (THIS CONNECTION IS MEANT TO BE CONCEALED INSIDE THE CEILING CAVITY). PLEASE BEWARE THAT THE STRUCTURE OF THE CEILING SHOULD BE FIT TO HOLD ABOUT 30KG.

AS YOU OPEN THE CRATE ONE PERSON WILL BE ABLE TO PULL THE PIECE BY MANIPULATING THE METAL HOUSING BOX. ANOTHER PERSON SHOULD ASSIST IN REMOVING THE CRATE BRACES (FIG 4) 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 PLATE, A BRACKET OR HUNG FROM CABLES).



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2



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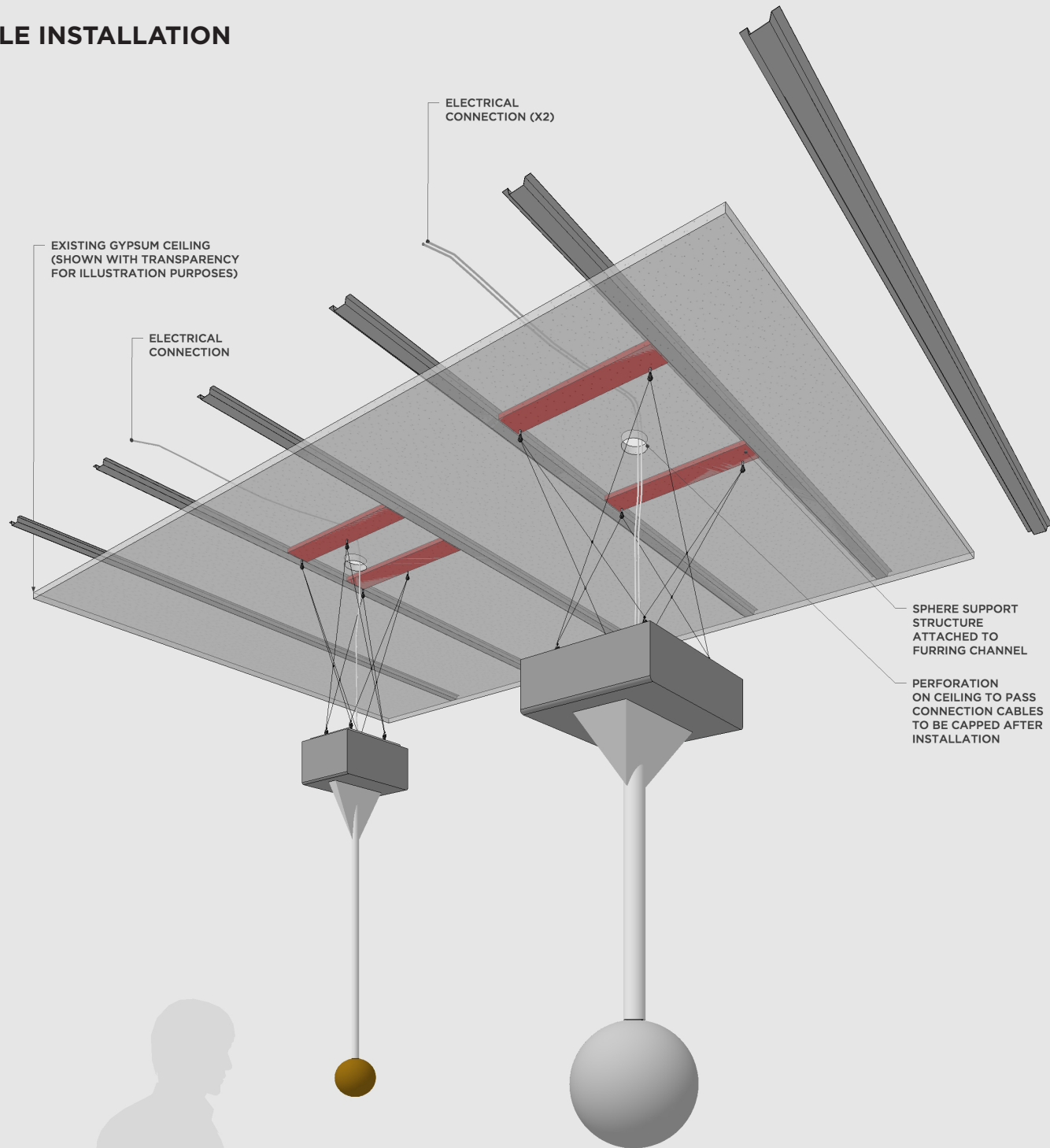


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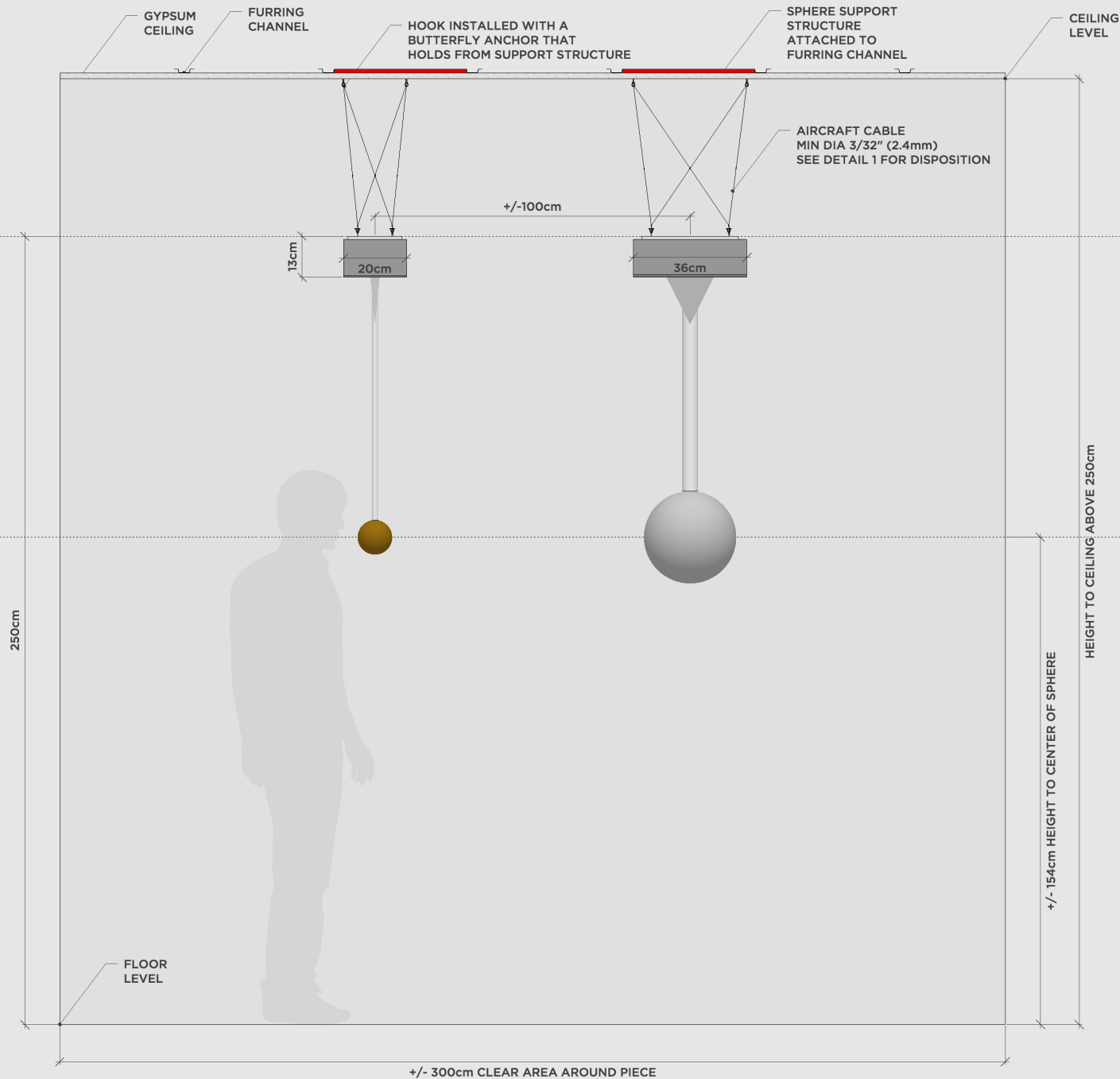


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## APPENDIX I AIRCRAFT CABLE INSTALLATION



**ELECTRICAL NOTES:**  
PLEASE FURNISH PLUGS COMING FROM THE  
CEILING. THE PIECE CONNECTS DIRECTLY TO  
THEM AND THE CABLE IS THEN IMMERSED IN  
THE CEILING CAVITY.



**NOTES:**

IN THE CRATE YOU WILL FIND SAMPLES OF CLEANING PRODUCTS FOR THE METAL HOUSING, APPLY A SMALL AMOUNT ON A DRY CLOTH AND THEN RUB THE METAL AVOIDING CONTACT WITH THE CABLES. FIRST APPLY SURFOX RENEW TO CLEAN THE SURFACE AND THEN USE SURFOX SHINE TO FINISH IT.

SHOULD THERE BE ANY PROBLEMS,  
PLEASE ADVISE ANTIMODULAR BEFORE  
HANDLING ANY OF THE ELECTRONICS OF  
THE SPHERE OR THE HOUSING.

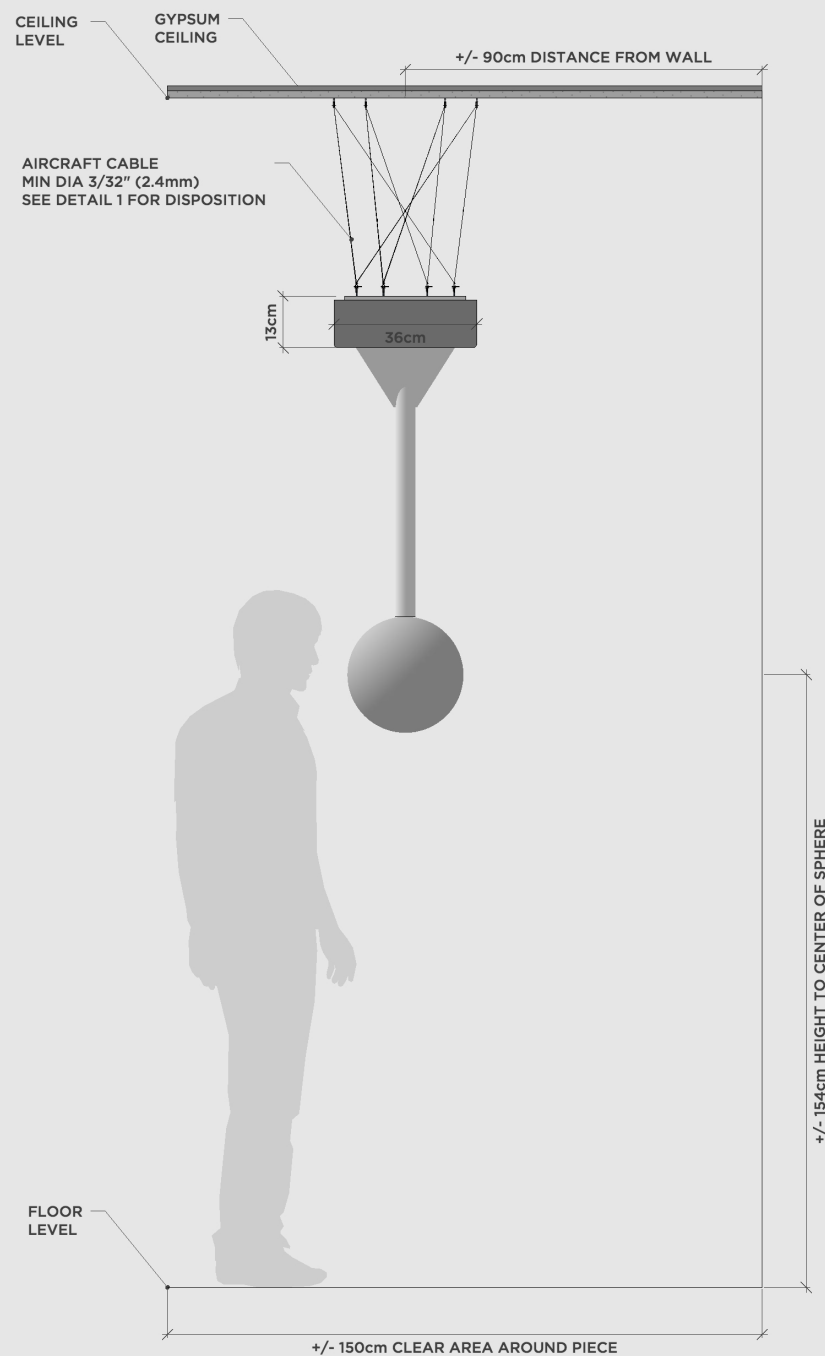
OVERALL WEIGHTS OF MOUNTED HOUSING AND SPHERE WHEN CABLE IS USED:

25Kg

**Contact information:**

**ANTIMODULAR RESEARCH**  
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EMAIL: [tech@antimodular.com](mailto:tech@antimodular.com)

**ELECTRICAL NOTES:**  
PLEASE FURNISH PLUGS COMING FROM THE  
CEILING AS NEEDED. THE PIECE CONNECTS  
DIRECTLY TO THEM AND THE CABLE IS THEN  
CONCEALED IN THE CEILING CAVITY.

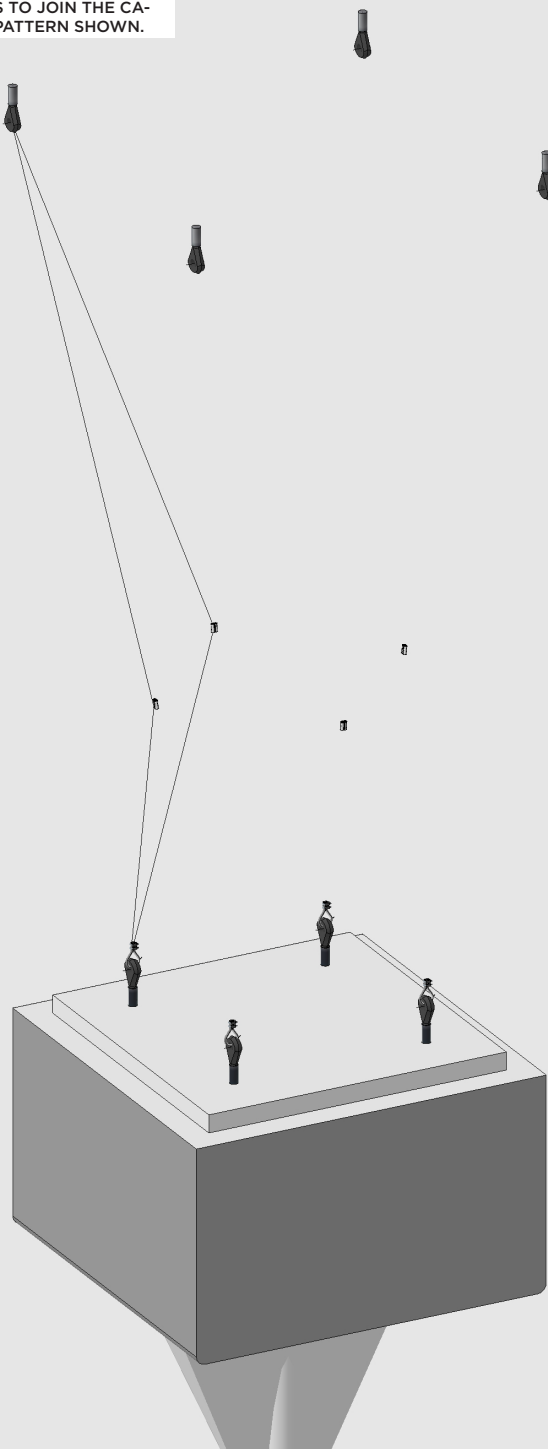


**REMOTE CONTROL:**

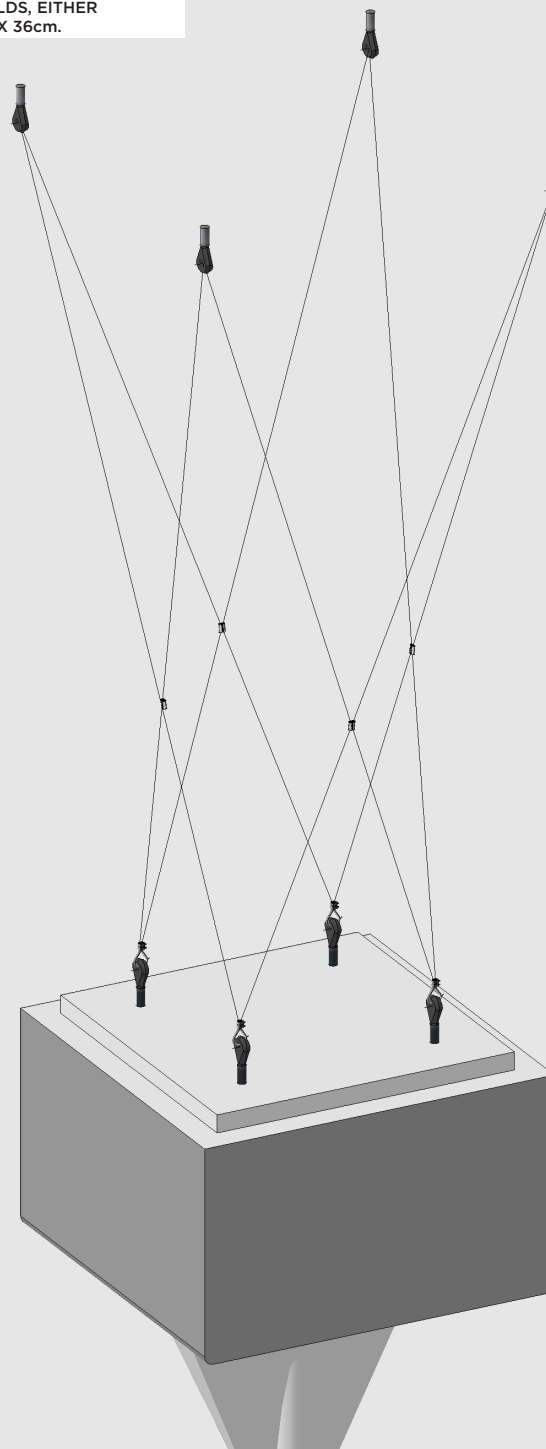




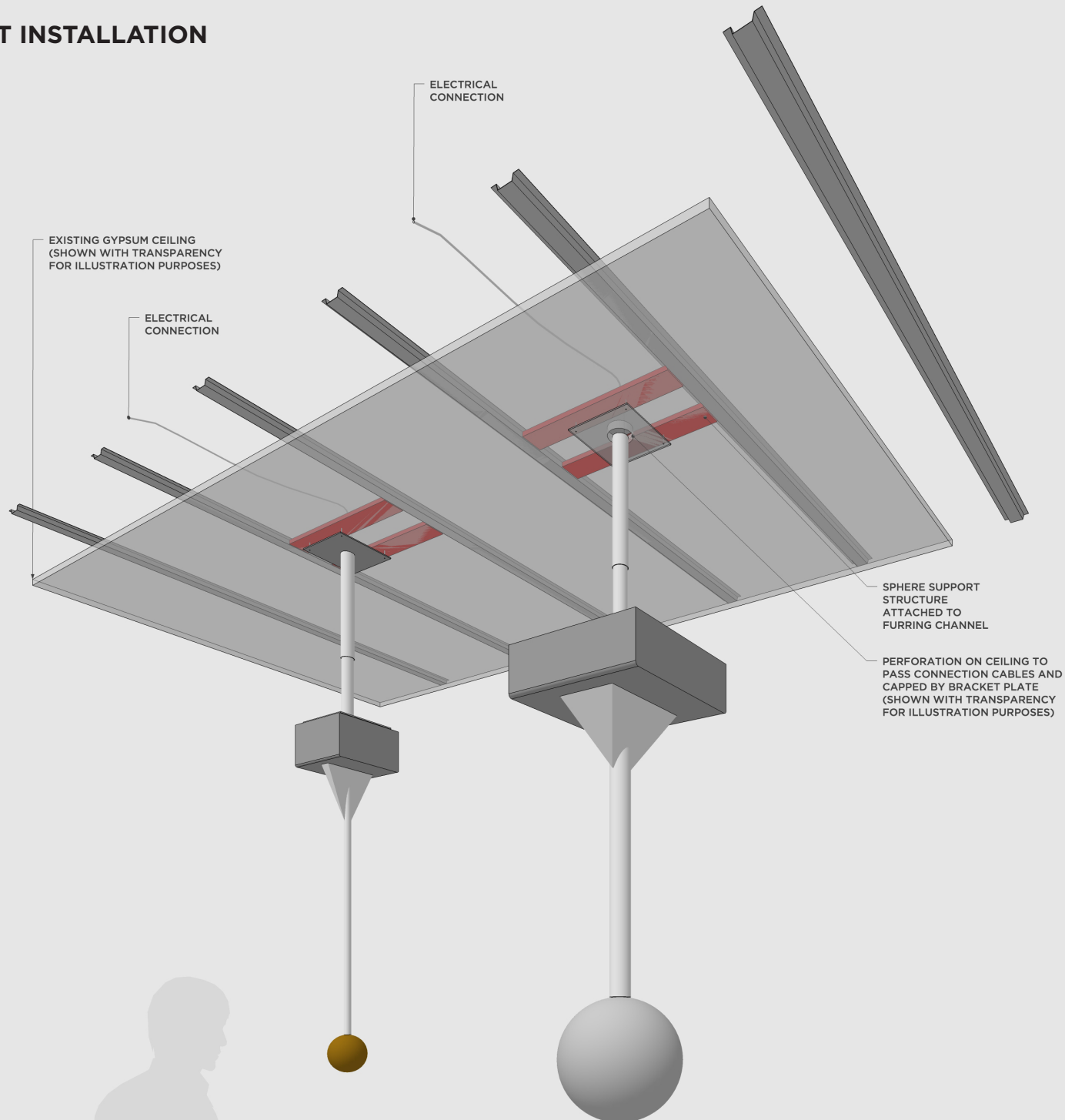
**DETAIL 1:**  
LOOP AIRCRAFT CABLE ON TOP AND BOT-  
TOM CORNERS TO HOLD METAL HOUSING.  
USE ALUMINIUM SLEEVES TO JOIN THE CA-  
BLES IN THE DIAGONAL PATTERN SHOWN.



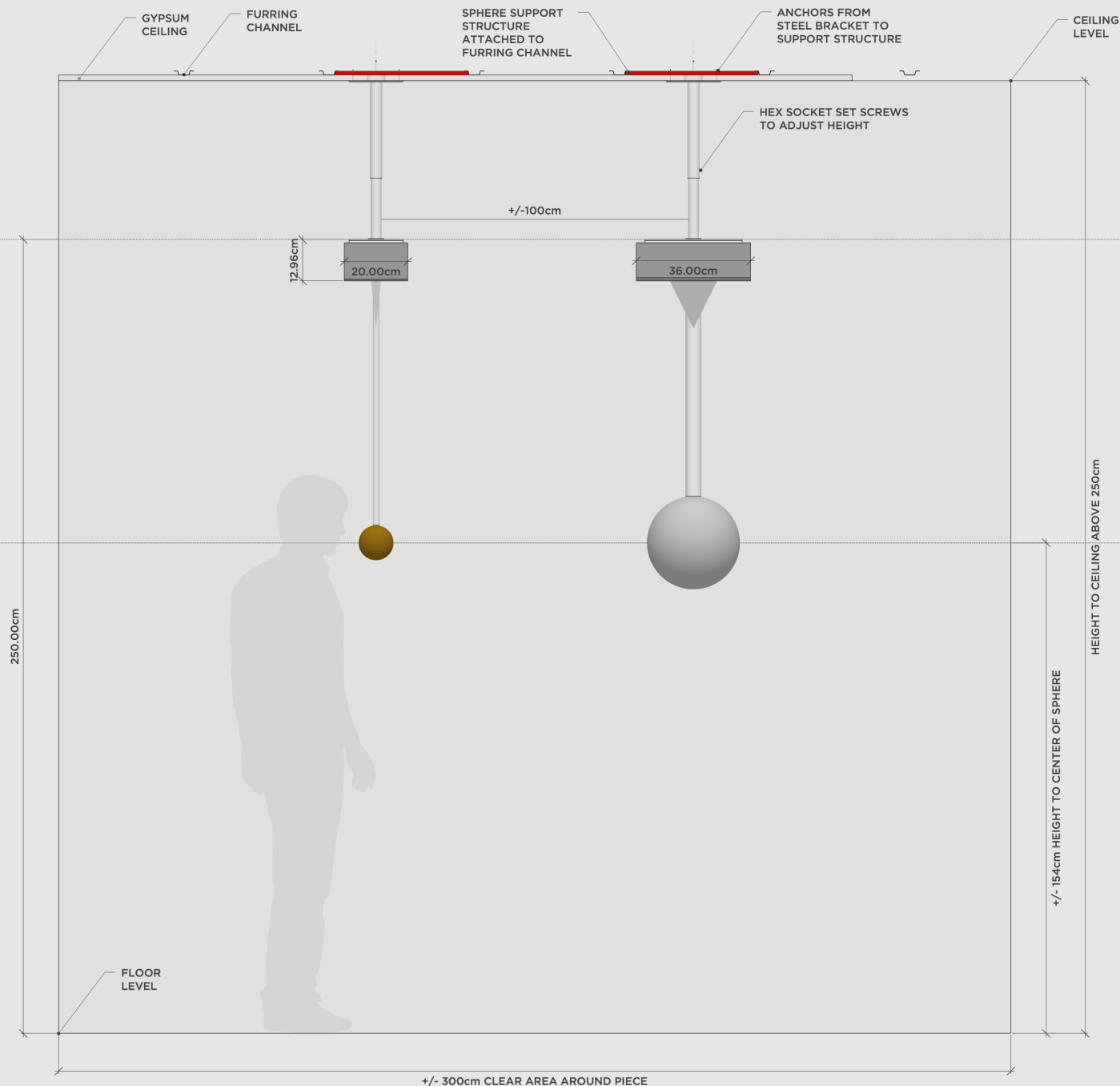
**NOTE:**  
PLEASE NOTE THAT THE TOP HOOKS ARE  
INSTALLED IN ALIGNMENT WITH THE EDGES  
OF THE HOUSING IT HOLDS, EITHER  
20cm X 20cm OR 36cm X 36cm.



## APPENDIX II STEEL BRACKET INSTALLATION



**ELECTRICAL NOTES:**  
PLEASE FURNISH PLUGS COMING FROM THE  
CEILING. THE PIECE CONNECTS DIRECTLY TO  
THEM AND THE CABLE IS THEN IMMERSED IN  
THE CEILING CAVITY.



**NOTES:**

IN THE CRATE YOU WILL FIND SAMPLES OF CLEANING PRODUCTS FOR THE METAL HOUSING, APPLY A SMALL AMOUNT ON A DRY CLOTH AND THEN RUB THE METAL AVOIDING CONTACT WITH THE CABLES. FIRST APPLY **SURFOX RENEW** TO CLEAN THE SURFACE AND THEN USE **SURFOX SHINE** TO FINISH IT.

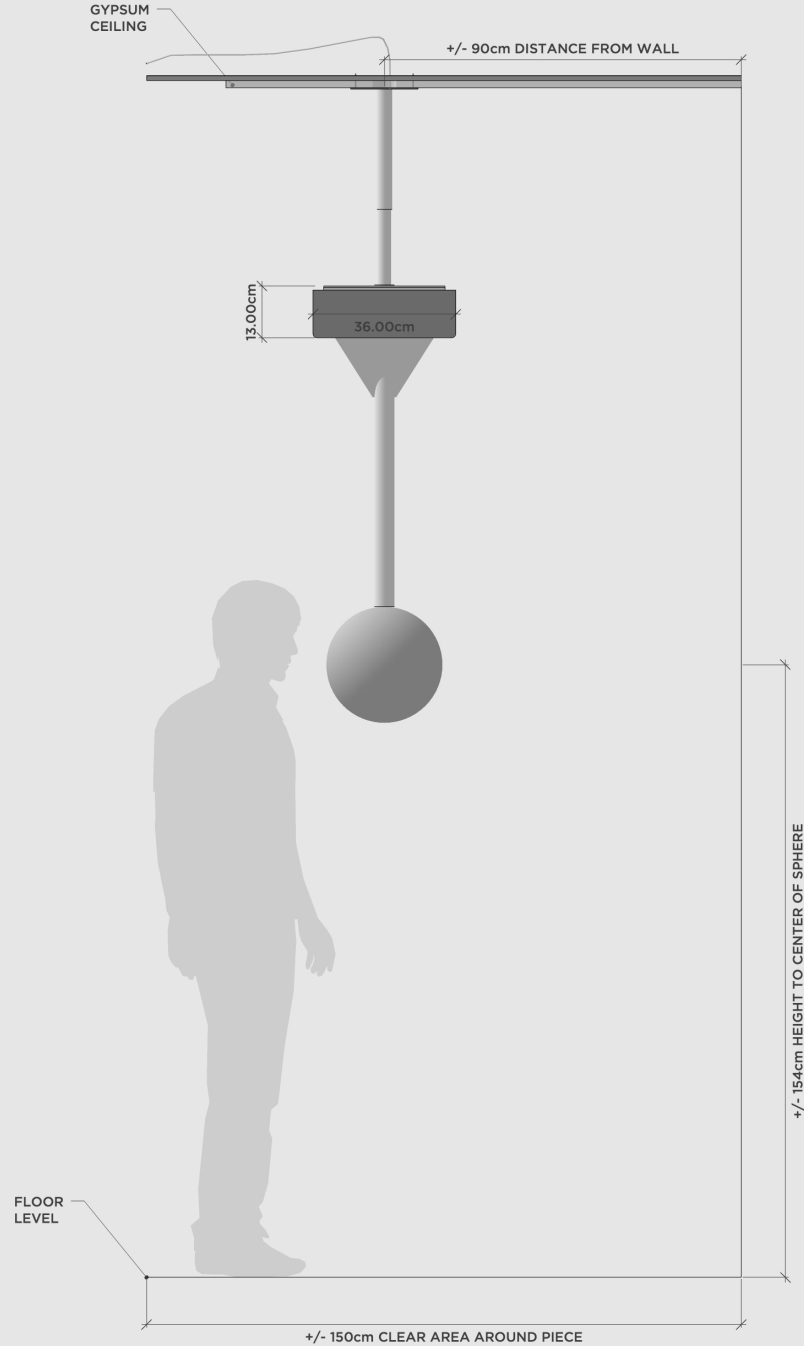
SHOULD THERE BE ANY PROBLEMS,  
PLEASE ADVISE ANTIMODULAR BEFORE  
HANDLING ANY OF THE ELECTRONICS OF  
THE SPHERE OR THE HOUSING.

**OVERALL WEIGHTS OF MOUNTED HOUSING AND SPHERE WHEN BRACKET IS USED:**

30Kg

Contact information:  
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 EMAIL: [tech@antimodular.com](mailto:tech@antimodular.com)

**ELECTRICAL NOTES:**  
PLEASE FURNISH PLUGS COMING FROM THE  
CEILING AS NEEDED. THE PIECE CONNECTS  
DIRECTLY TO THEM AND THE CABLE IS THEN  
CONCEALED IN THE CEILING CAVITY.

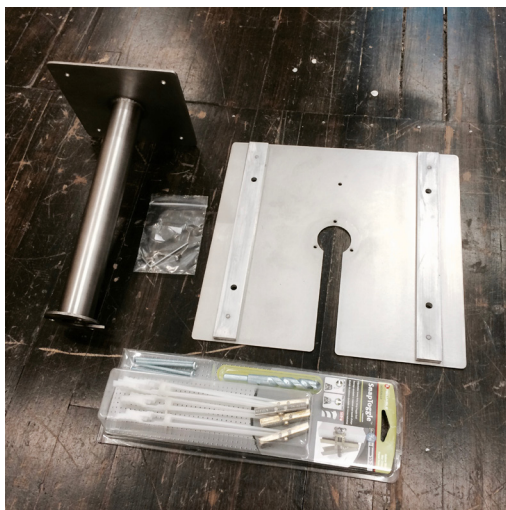


**REMOTE CONTROL:**





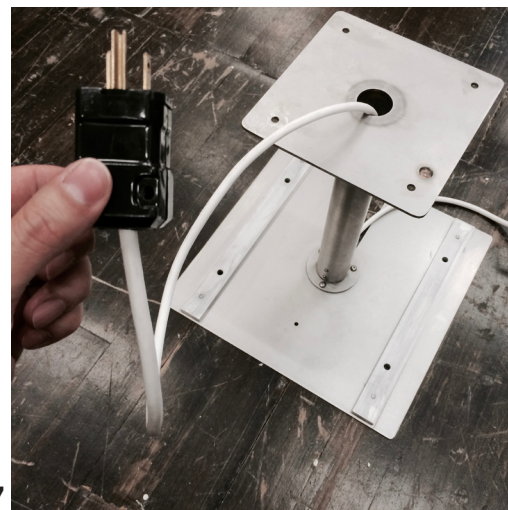
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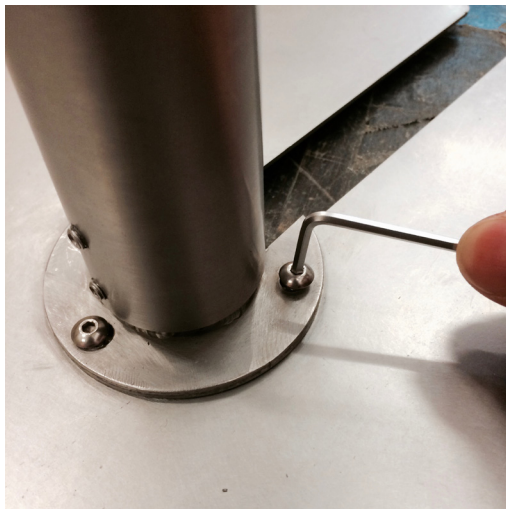
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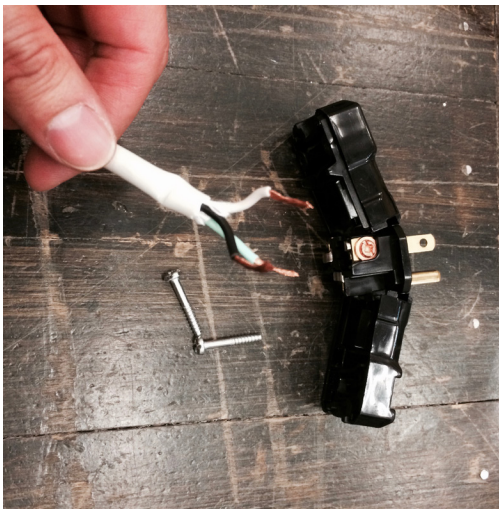
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2



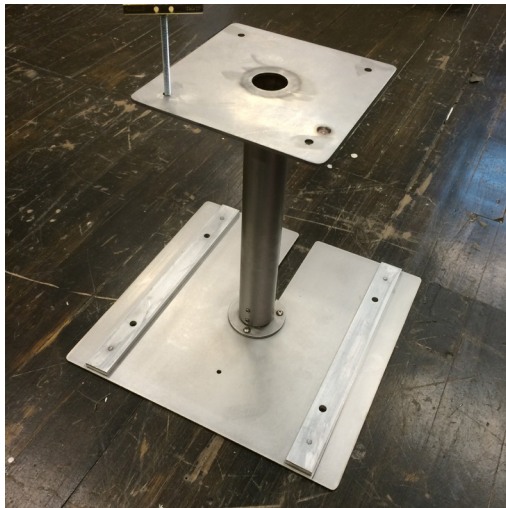
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8



3



6



## INSTALLATION NOTES

- 1- ORGANIZE ALL PARTS ON A HORIZONTAL SURFACE
- 2- CONNECT THE BRACKET'S POLE AND PLATE TOGETHER WITH THE SCREWS PROVIDED
- 3- VISUALIZE HOW THE FOUR ANCHORS WILL WORK IN THE CEILING AND PREPARE THE STRUCTURE FOR THEM
- 4- LOCATE THE PLUG OF THE PIECE
- 5- DISMANTLE THE PLUG
- 6- PASS THE CABLE THROUGH THE POLE AT THE UNDER-SIDE OF THE BRACKET
- 7- ASSEMBLE THE PLUG
- 8- CONNECT PLUG TO AC POWER AND CONCEAL IT IN THE CEILING. INSTALL THE BRACKET AGAINST THE CEILING WITH ANCHORS AND FINALLY SLIDE THE PIECE ONTO THE BRACKET AND GRADUALLY SLIDE THE EXTRA CABLE INSIDE THE POLE TO FULLY HIDE IT. ADJUST HEIGHT WITH THE HEX SOCKET SET SCREWS ON THE BRACKET'S POLE.