INSTRUCTIONS FOR ANALOG MODEL SET-UP

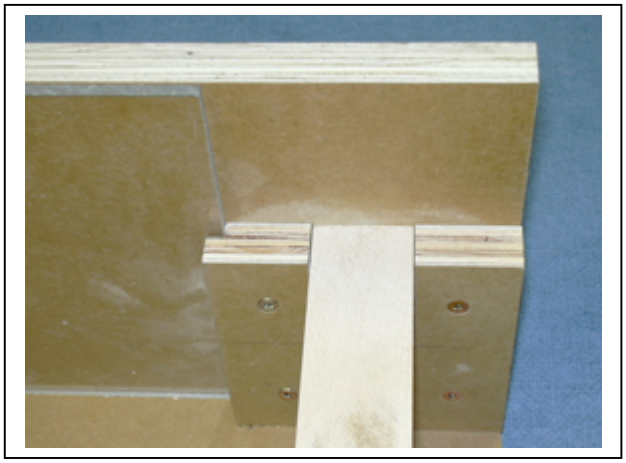
Mario Del Castello 15 January, 2007

Assemblage of the Apparatus
See appendix for part design and sizing and on how to assemble the deformation apparatus.

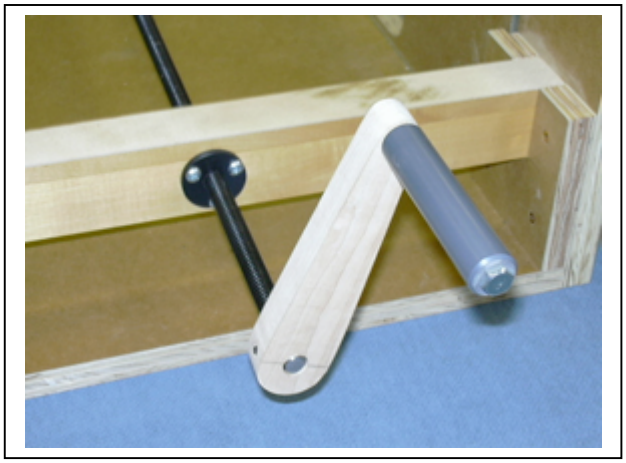
One-time jobs

Bending of metal plates: they must be bent at one side so that they can be screwed to both the fixed and moving vertical walls. 3-4 holes must be drilled in the 1" wide bend to ensure following proper installation. Metal plates must be reinstalled at the beginning of each experiment:

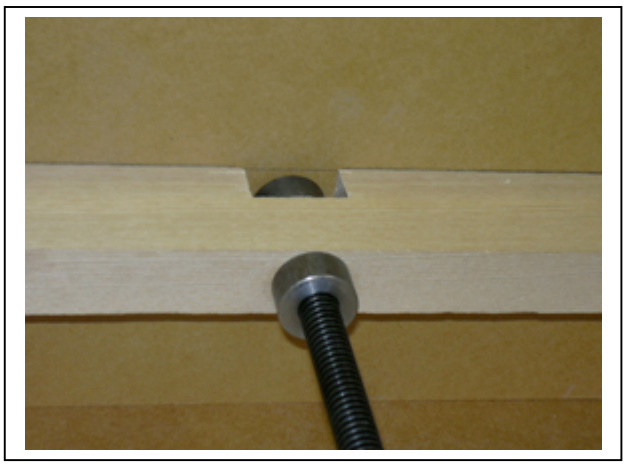
Screw mount supports: they must be glued and screwed to the lateral wall to ensure stability while cranking. 1 _" flat head screws are suitable for this:



Collars: they must be screwed to the head screw mount:



Nut for lead screw: it must be installed on one of the horizontal bars behind the moving wall. The anti-tilting bar (see apparatus design) can be added now and also glued to the moving wall. The two bars must be fastened to each other for maximum stability.



!! All the mounting parts (thread inserts, screws, collars, nuts, lead screw will be provided to teachers from each school). For future reference or to purchase extra parts, you can go to: http://www.mcmaster.com/

These are the parts numbers:

- Thread inserts: 92105A200 (package of 100)
- Machine screws: 91770A546 (package of 50)
- Collars: 6435K14 (two per sandbox)
- Lead Screw: 99030A005 (1 per sandbox)
- Standard nut for lead screw: 6350K41 (1 per sandbox)

All the other apparatus parts (plexiglass/glass, wood, aluminum plates, adhesive pads) can be easily purchased at any hardware store.

Glass or Plexiglass Cleaning

We recommend using glass for your experiments. Glass is much more resistant to scratches than plexiglass (sand is usually made of quartz grains that are highly abrasive), time lasting and can be wiped many times with more commercial/less expensive/hassle-free cleaning products. On the other hand, care must be taken when handling it. Glass is much heavier than plexiglass and can be very dangerous for students if broken. However, our previous experience taught us that high school students could safely handle glass panels and their experimental results improved accordingly.

If you still want to use plexiglass, bear in mind that some cleaning products are too aggressive and may spoil the plexiglass surface. In any case, experimental results imaging will rapidly degrade after a few experiments due to the unavoidable scratches.

!! IT IS IMPORTANT THAT YOU USE THE RIGHT KIND OF PRODUCT TO CLEAN THE PLEXIGLASS, AS IT IS SYNTHETIC. SOME COMMERCIAL PRODUCTS ARE INTENDED FOR GLASS ONLY. FOR A QUICK REFERENCE CHECK: www.tulsaenterprises.com/hints.html

A commercial cleaner (e.g. Windex) should work well to clean the glass/plexiglass on both sides. After using the plexiglass cleaner add also a polymer to make the glass/plexiglass surface hydrophobic. Rain-x or similar products should work fine (remember to ask the reseller whether they might damage the plexiglass). This should be done on the inner side of the glass/plexiglass only, which will be in contact with the sand. This is intended to reduce the sand-glass/plexiglass friction and prevent sand smearing along the glass/plexiglass wall (which prevents you from seeing the faults and folds). Smearing is more evident in contraction because the amount of deformation is usually greater and the sand grains travel longer particle paths. This increases the chances that smearing can occur.

STEP 1 – First clean the outerside of the plexiglass. Use paper towel to spread the cleaner until it dries out

!! Use the paper to grab the plexiglass any time you have to handle it. This is the only way to avoid leaving fingerprints, which will alter the sand/plexiglass coefficient of friction (sand smearing) as well as photo capturing.

!! When you lay the plexiglass down after you've cleaned one surface use rubber pads underneath to keep the plexiglass from getting dirty again on the working surface.

!! Remember that electrostatic forces become very big at the scale of the sand grains, therefore even a few dust particles or a little skin grease can deteriorate the experimental results

STEP 2 – Repeat step 1 on the other side. After the first cleaner, add a few drops of the polymer all along the plexiglass and wipe thoroughly until it evaporates.

!! You don't need to apply the polymer throughout the plexiglass/glass panel. It can be used only on the area that will stay in contact with sand.

NOW THE PLEXIGLASS IS READY AND CAN BE PUT IN PLACE IN THE APPARATUS, SLIDING IT THROUGH THE GROOVES (see exploded sketch in the Appendix)

Aluminium Plates and Rubber Sheet.

There are two ways of attaching the rubber to the metal plates. You can either use duct tape (the best is 3M) or you can use superglue (Loctite).

USE THE SUPERGLUE WITH CARE. ALTHOUGH IT'S BETTER THAN DUCT TAPE FOR YOUR PURPOSES, IT'S A CHEMICAL AND CAN BE SUPERDANGEROUS!

You can find information about these products at: Duct tape:
http://products3.3m.com/catalog/us/en001/government/innovative_solutions/node_KL2R7R1S64gs/root_GS3RBW6QFVgv/vroot_31S2JJ7584ge/bgel_SLSM8G5R6Sbl/gvel_J2C5RMSLGCgl/theme_us_innovativesolutions_3_0/command_AbcPageHandler/output_html

Superglue:
http://www.loctite.com/int_henkel/loctite_us/index.cfm?layout=6&productline=380&path=Assembly%20Products

For removing the superglue, you can use a chemical solvent:
http://www.loctite.com/int_henkel/loctite_us/index.cfm?&pageid=19&layout=3
(type solvent in the appropriate search box, and then choose for XNMS solvent)

In our common lab practice we use the superglue. It ensures a long lasting bond and higher resistance to tearing when the experiment needs to last for several hours. However, the technique requires more attention and a longer work in order to remove the superglue residues. We recommend you to consider testing the duct tape first, before trying the superglue for your specific needs.

USE OF THE DUCT TAPE:

- Cut three stripes of the same length and attach them carefully, parallel to the rubber/metal plates edge.
- Do this on the bottom side of the rubber/metal plates assemblage. Duct tape/sand has different frictional coefficient than the rubber/sand, so this would affect faulting at the boundaries of the deforming area. You always want to minimize edge effects.
- Try to avoid the formation of air bubbles while sticking the tape, as they would significantly weaken the bond and the tape would give away before the end of the experiment
- The three stripes should be overlapped in order to have a strong bond, but without being too thick altogether.
- The duct tape is very easy to remove

!! Do not put too much tape on the rubber sector. This will resist stretching of the rubber itself.

USE OF THE SUPERGLUE:

- Lay a thin, but continuous line of super glue along the edge of the metal plate that must be attached to the rubber. You don't need too much glue. The bond is very strong and resistant through time
- Carefully, align the rubber and stick it to the metal plate.
- Place some weights along the bonded side
- Repeat the last two steps for the other edge and allow at least one hour for an optimal sticking

- In order to remove the superglue, you will first carefully slide a sharp blade between the rubber and the metal plate. This will allow detaching the rubber. You then will have to use the XNMS solvent to remove the glue left on the metal plate, by brushing a little solvent on the surface and wipe off the glue stains.

!! In case you use duct tape for rubber bonding, cut a slightly wider piece of rubber for better attaching of the tape.

!! When using superglue, you can protect your hands with latex gloves to prevent "unwanted" fingers sticking.

NOW THE RUBBER/ALUMINUM PLATES ASSEMBLAGE IS READY AND CAN BE INSERTED IN THE APPARATUS, BEING SCREWED TO THE BACKWALL AND MOVING WALL, RESPECTIVELY (see exploded sketch in the Appendix).

Sand Layering

!! BEFORE STARTING TO LAYER THE SAND, PUT THE RUBBER IN SUFFICIENT TENSION SO THAT IT'S NICELY FLAT. SO SLIGHTLY PULL THE MOVING WALL BEFORE LAYERING.

For experiment of extension, the sand pack must be 7 cm thick. This thickness must be reduced to 5 cm maximum for experiment of contraction. It is important that you try obtaining a constant total thickness of the sand pack throughout the model (it will take you a while!).

The colored sand can be layered just along the two sides of the sand box, where the glass/plexiglass panel will allow you observing in detail progressive faults nucleation and evolution. You are free to choose the width of each band of colored sand.

- Differently coloured sand can be sprinkled through a sieve. This will allow obtaining nearly perfectly horizontal layers (BEST RESULT/ TIME CONSUMING!).
- Alternatively, the sand can be poured by a cup. Care must be taken in doing so to minimize "wavy" aspect of the layers and, perhaps, each layer might require leveling (MEDIUM RESULT/LESS TIME CONSUMING!)
- The same rule applies when you pour sand in the center of the sand pack. Do not pour too much all at once to prevent inhomogeneous sand packing!

!! We recommend using the following layering code, from top to bottom:

FOR EXTENSION	FOR COMPRESSION
WHITE – 2 cm	WHITE - 1 cm
COLORED – 0.5 cm	COLORED – 0.25 cm
WHITE - 1 cm	WHITE - 0.5 cm
COLORED – 0.5 cm	COLORED – 0.25 cm
WHITE – 3 cm	WHITE – 3 cm

Operate this way:
1) - Layer the first one cm thick, white sand horizon, 2) – make layer even with a trowel, 3) sieve two bands of the same color, one on each side of the sand box. Repeat step 1), 2) and 3) for successive stages. The white sand horizons will prevent mixing of the colored sand.

!! Feel free to decrease the thickness of each layer in order to increase the number of coloured layers. The thinner the layers are the better the resolution of the fault will be. Of course, this will be more time consuming.

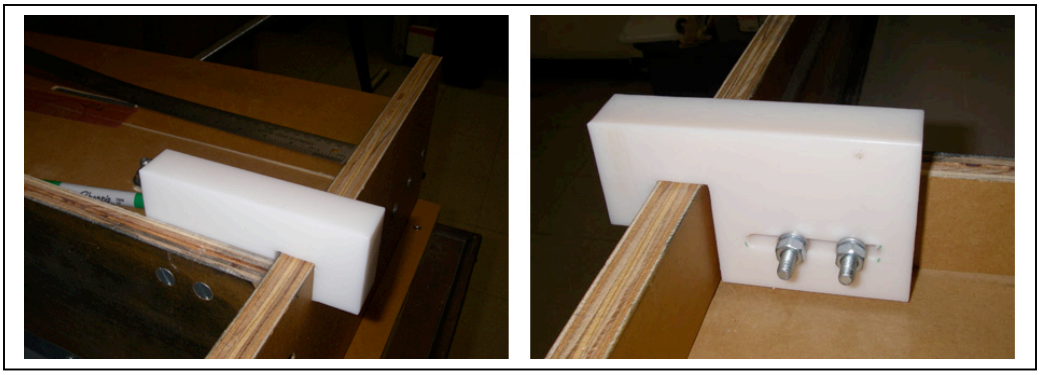
!! If you use different colors, arrange them in symmetrical way. This helps observation

!! Use disposable masks while layering, the sand is very fine and it goes everywhere.

Suggested modification to the apparatus design provided

Some teachers have previously reported a tedious back-tilting of the moving wall when this is moved by the lead screw. This may be due to the fact that the screw mount on the moving plate has only one anchor point. The problem could be solved by adding an extra horizontal bar behind the moving plate and connect it to the existing bar. This would increase the number of anchor points on the moving plate and make it more stable during horizontal shifts.

In addition, if you observe the lateral wall bowing while you are cranking the lead screw, you may want to use lateral fasteners to resist this effect (see pictures).



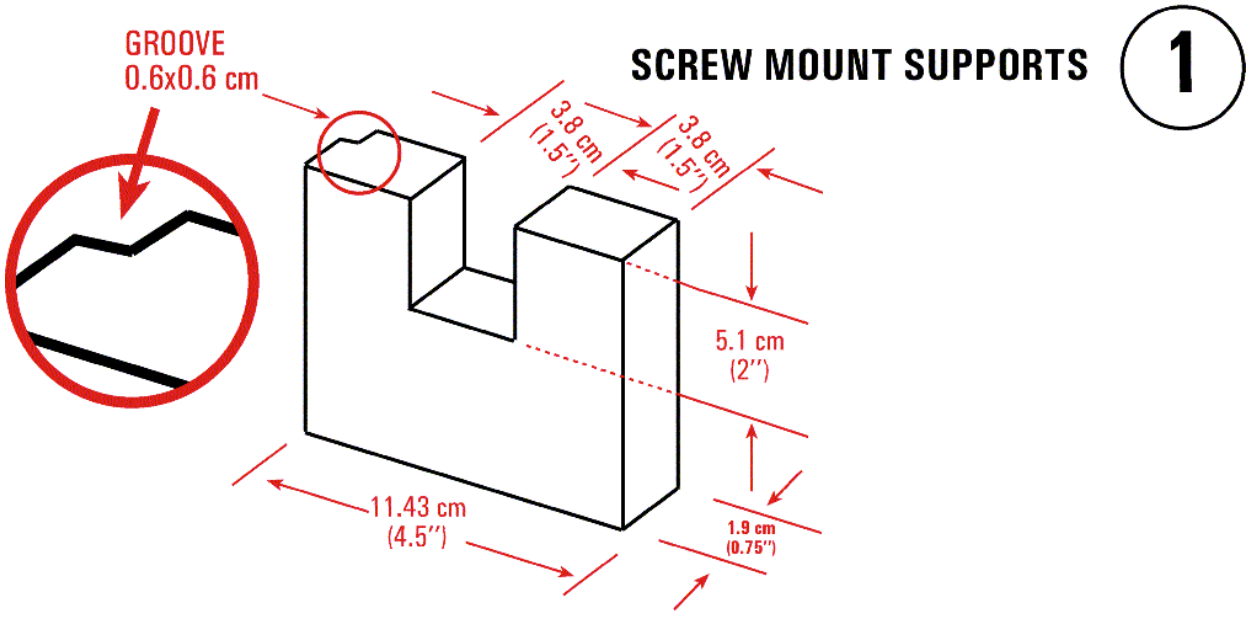
P.S. I apologize if, at places, it seems I was writing for kindergardeners. However, my experience with sand box modeling is: everything seems simple, indeed it is mechanic, you'll feel repetitive, but keep focused!

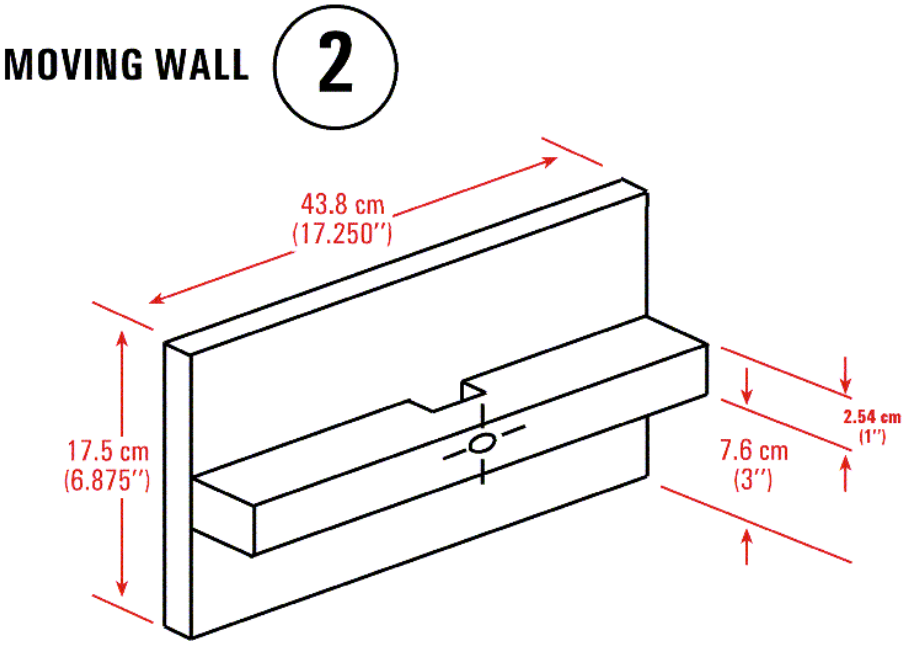
If something goes wrong during experimental set up, you need to start everything from scratch!

…welcome to the big family of analog modelers!

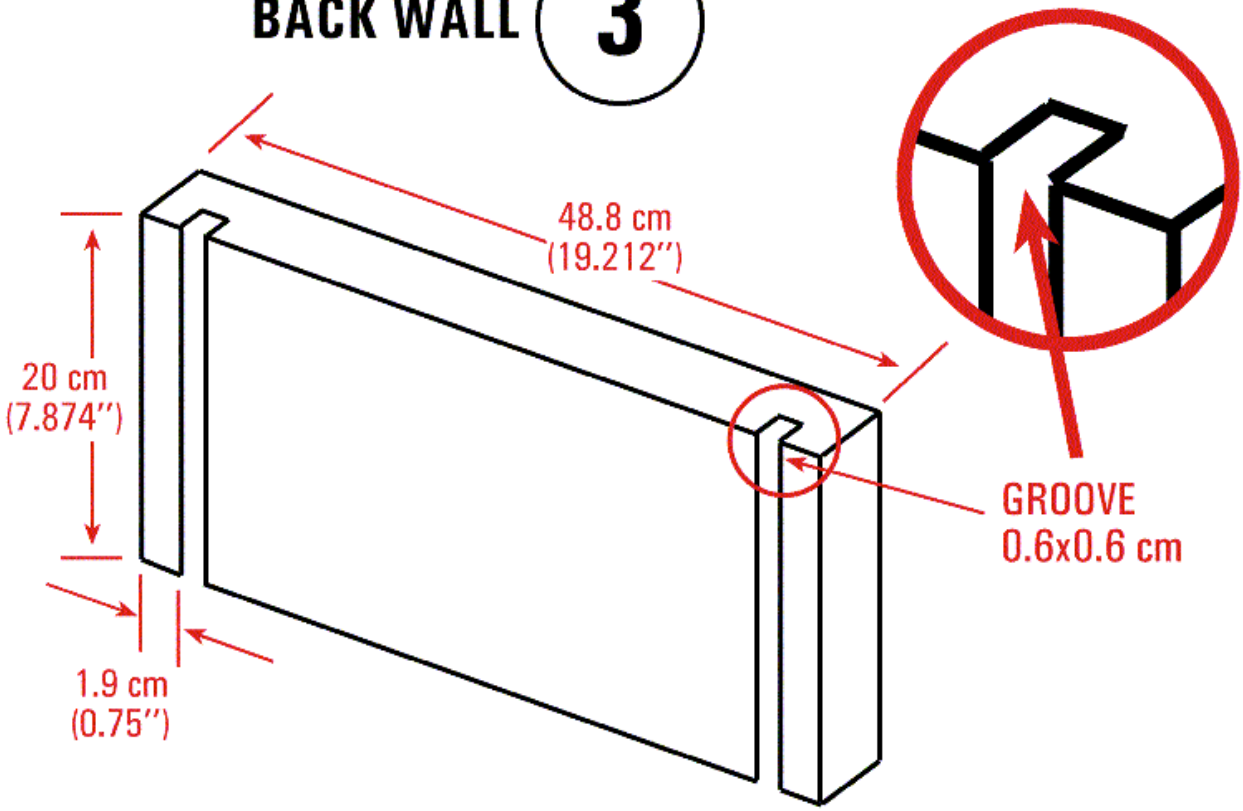
Experiment Design by John Sweeney
Figures by Mario Del Castello

3/4" STOCK (1.9 cm)

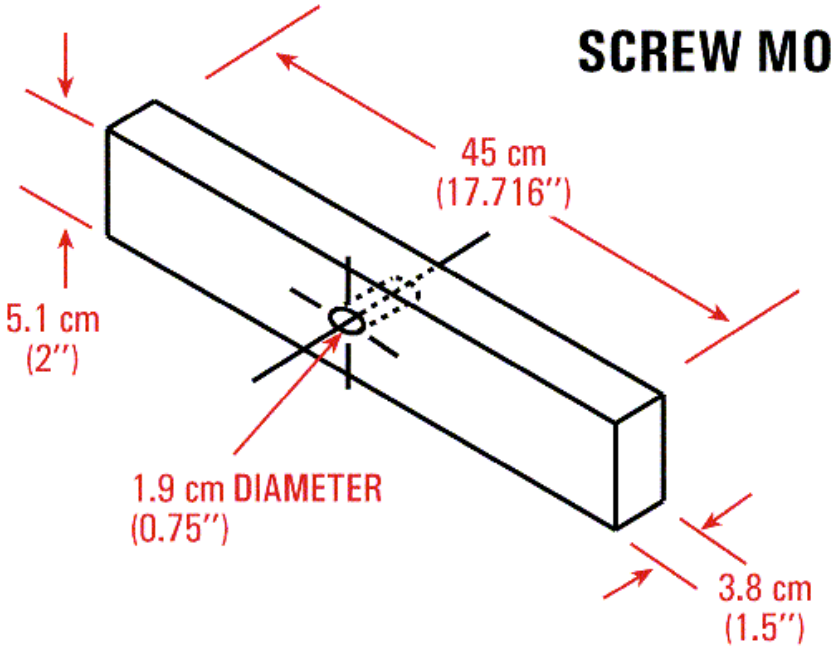


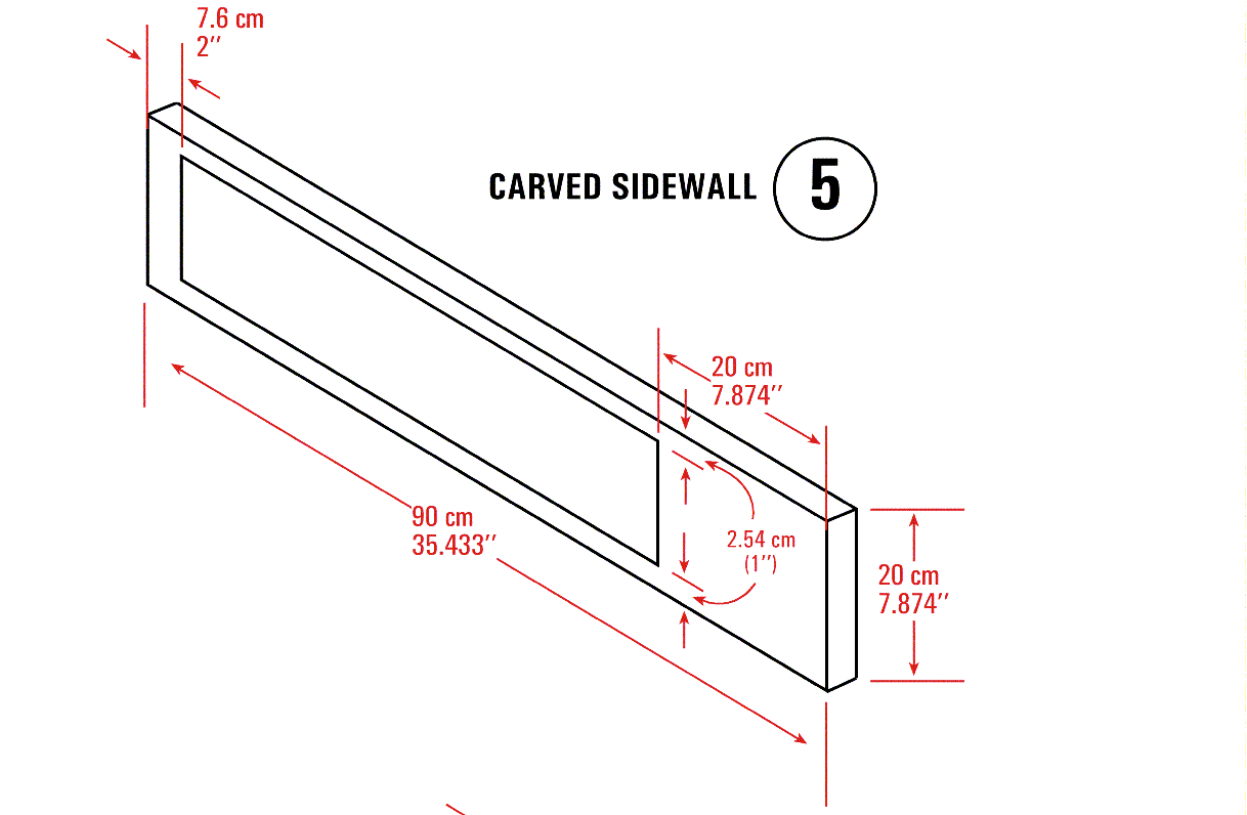


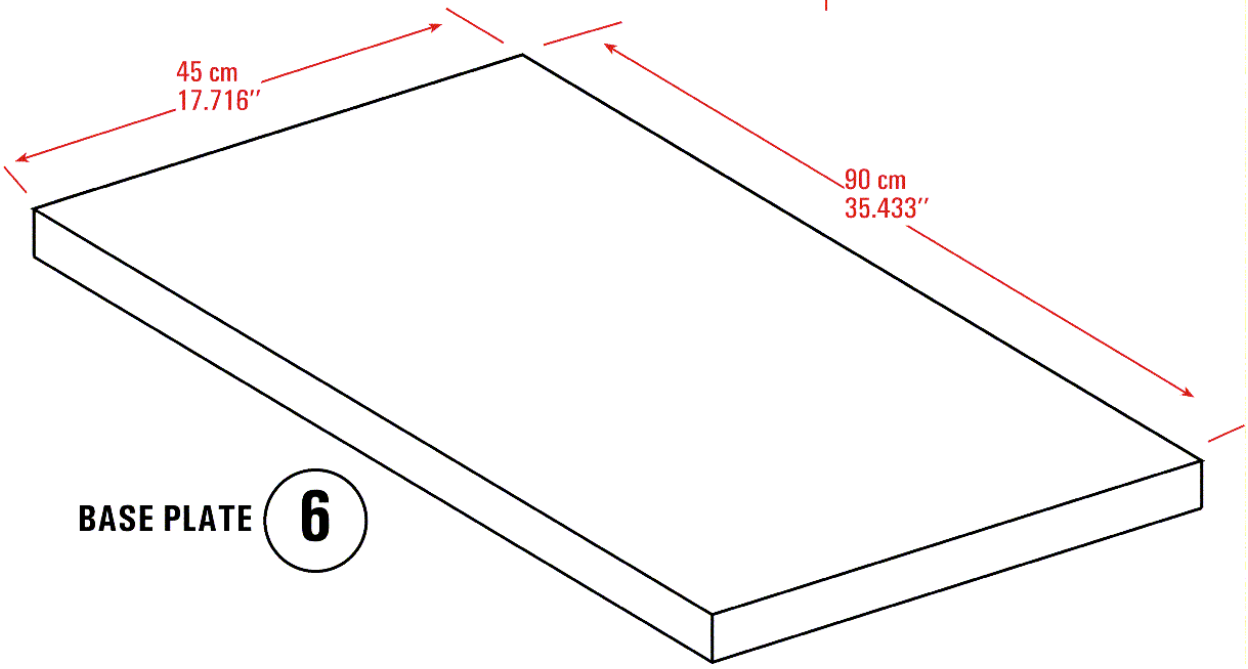
BACK WALL 3

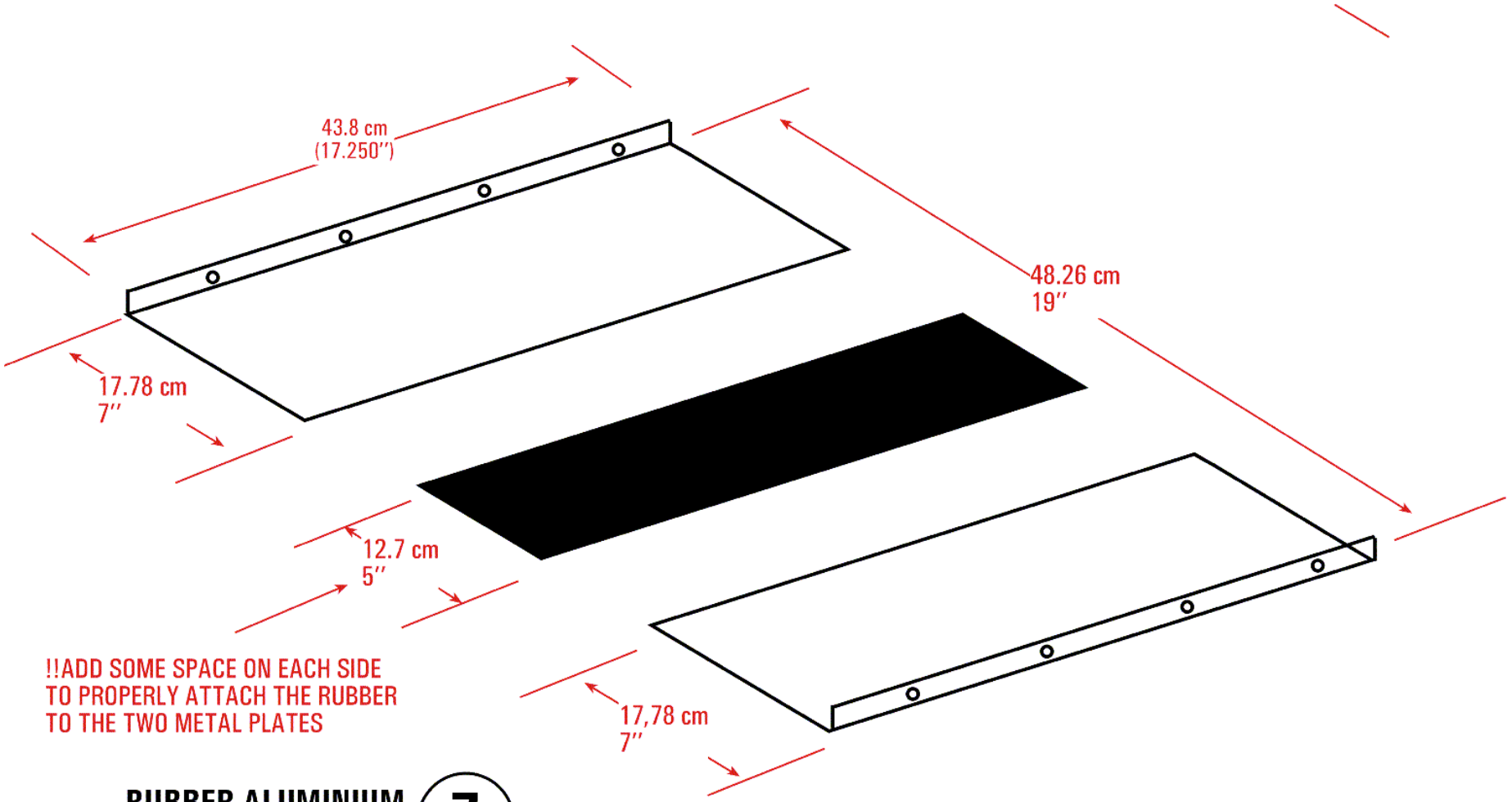


SCREW MOUNT 4

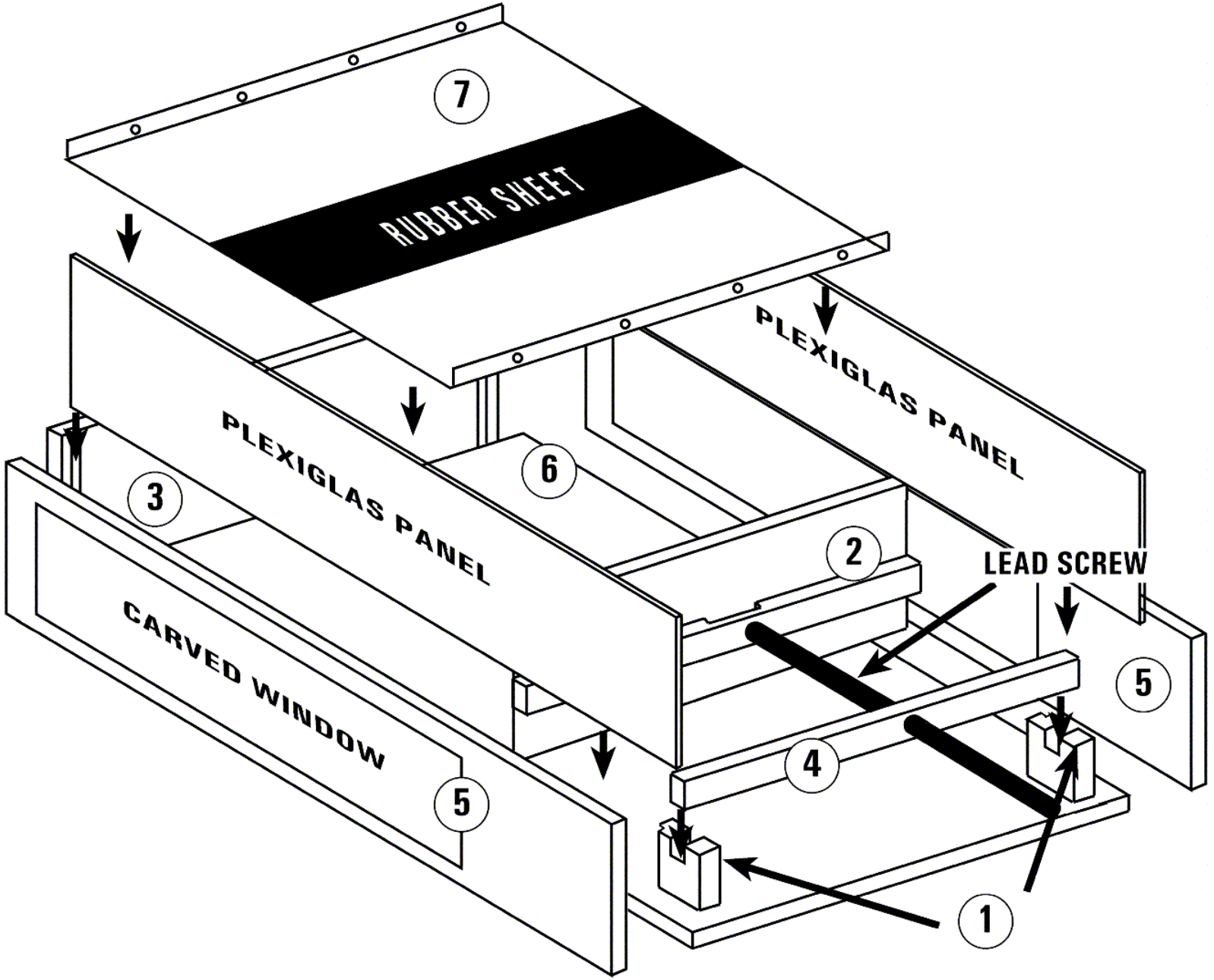



7.6 cm
2''
CARVED SIDEWALL
5
20 cm
7.874''
90 cm
35.433''
2.54 cm
(1'')
20 cm
7.874''


45 cm
17.716''
90 cm
35.433''
BASE PLATE
6



RUBBER ALUMINIUM ASSEMBLAGE **7**


7
RUBBER SHEET
PLEXIGLAS PANEL
PLEXIGLAS PANEL
6
3
2
LEAD SCREW
CARVED WINDOW
5
5
4
1