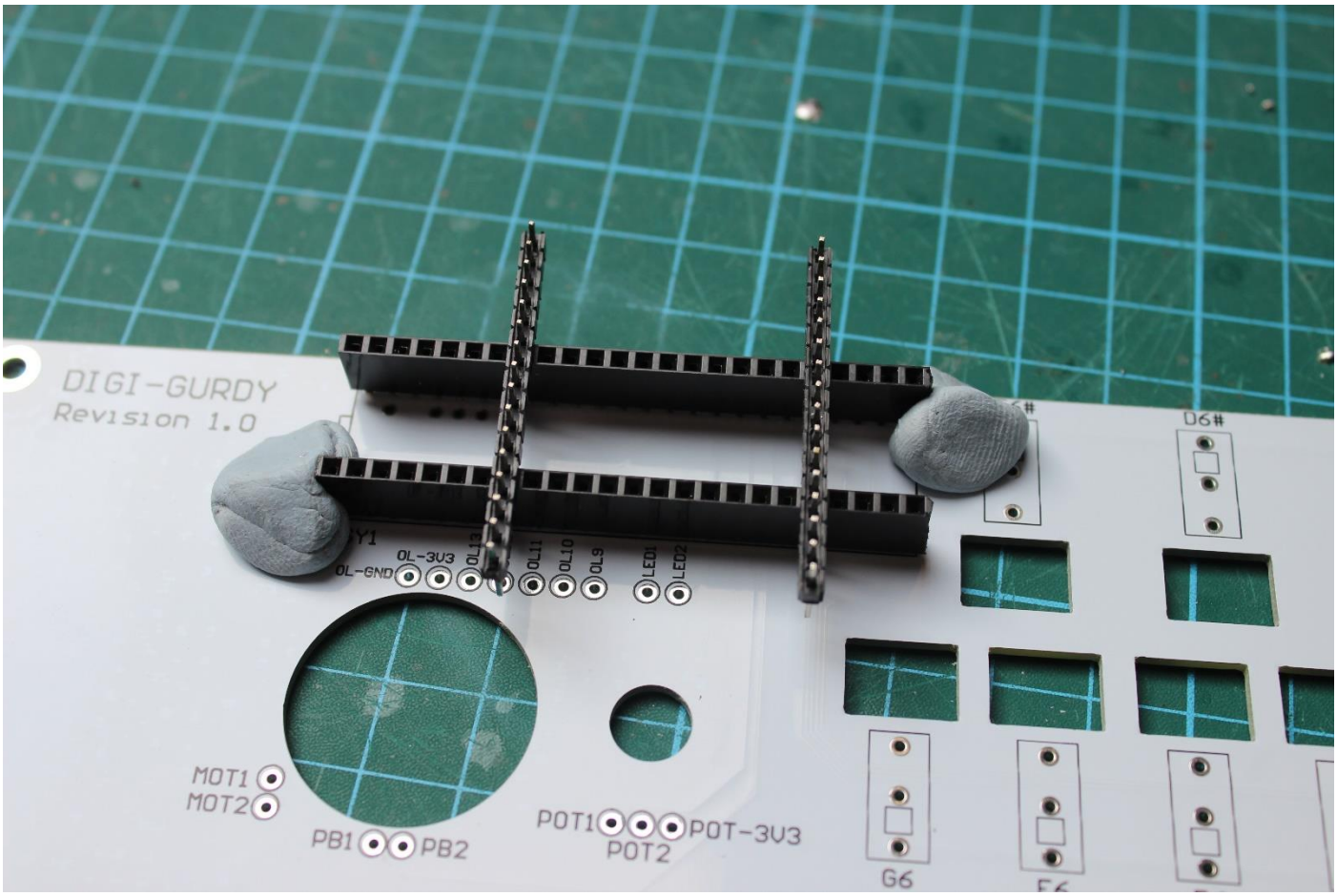
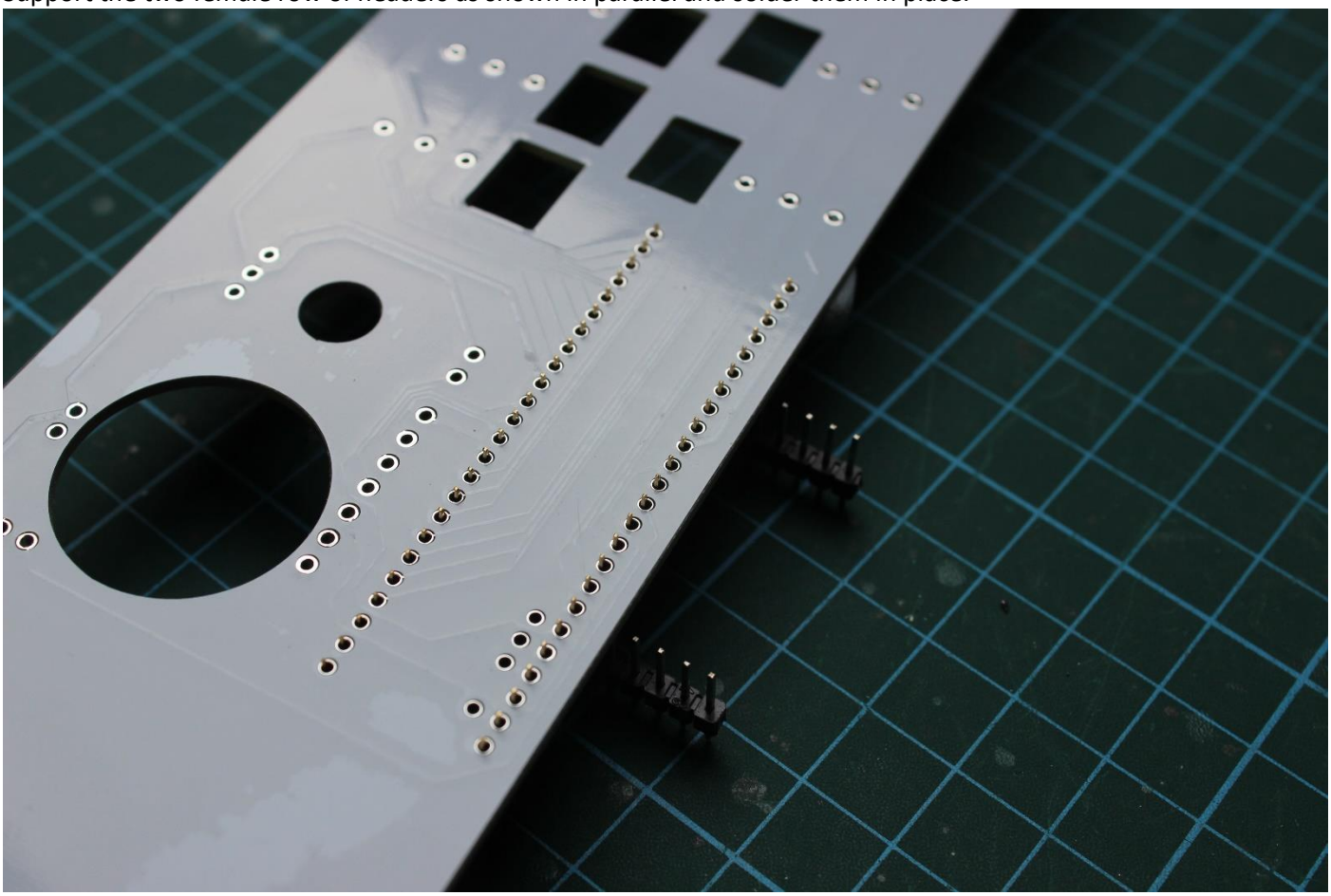
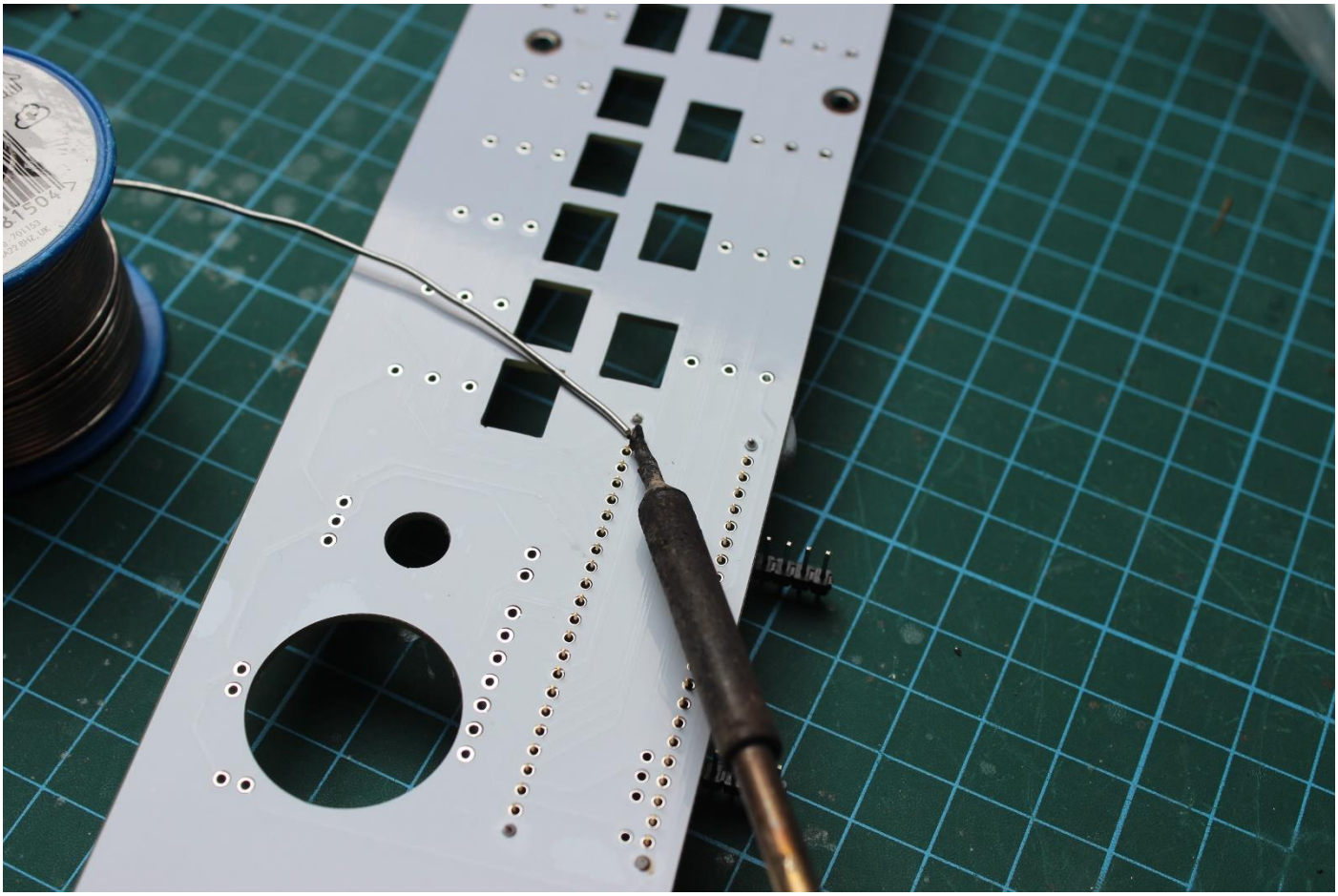


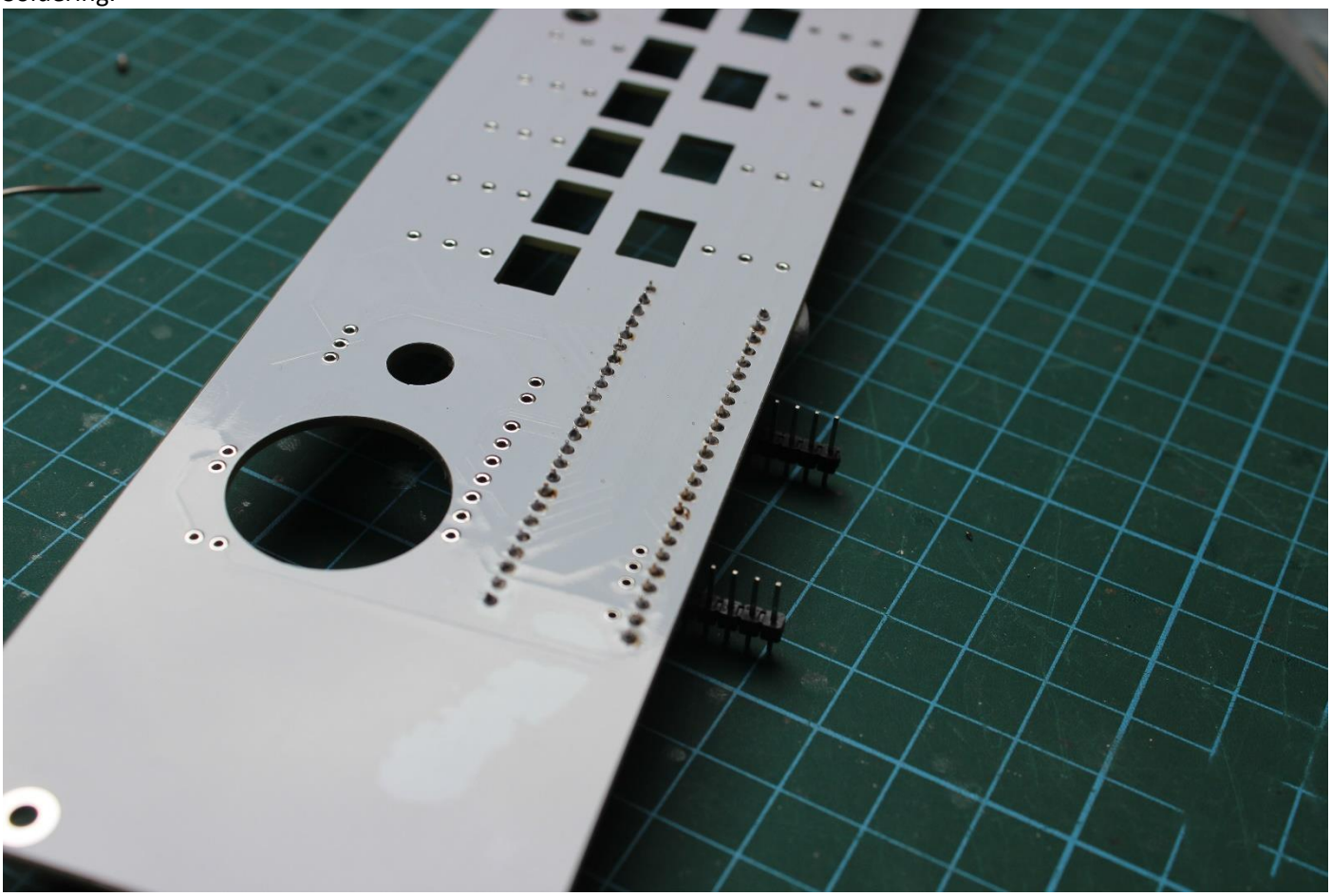
Support the two female row of headers as shown in parallel and solder them in place.



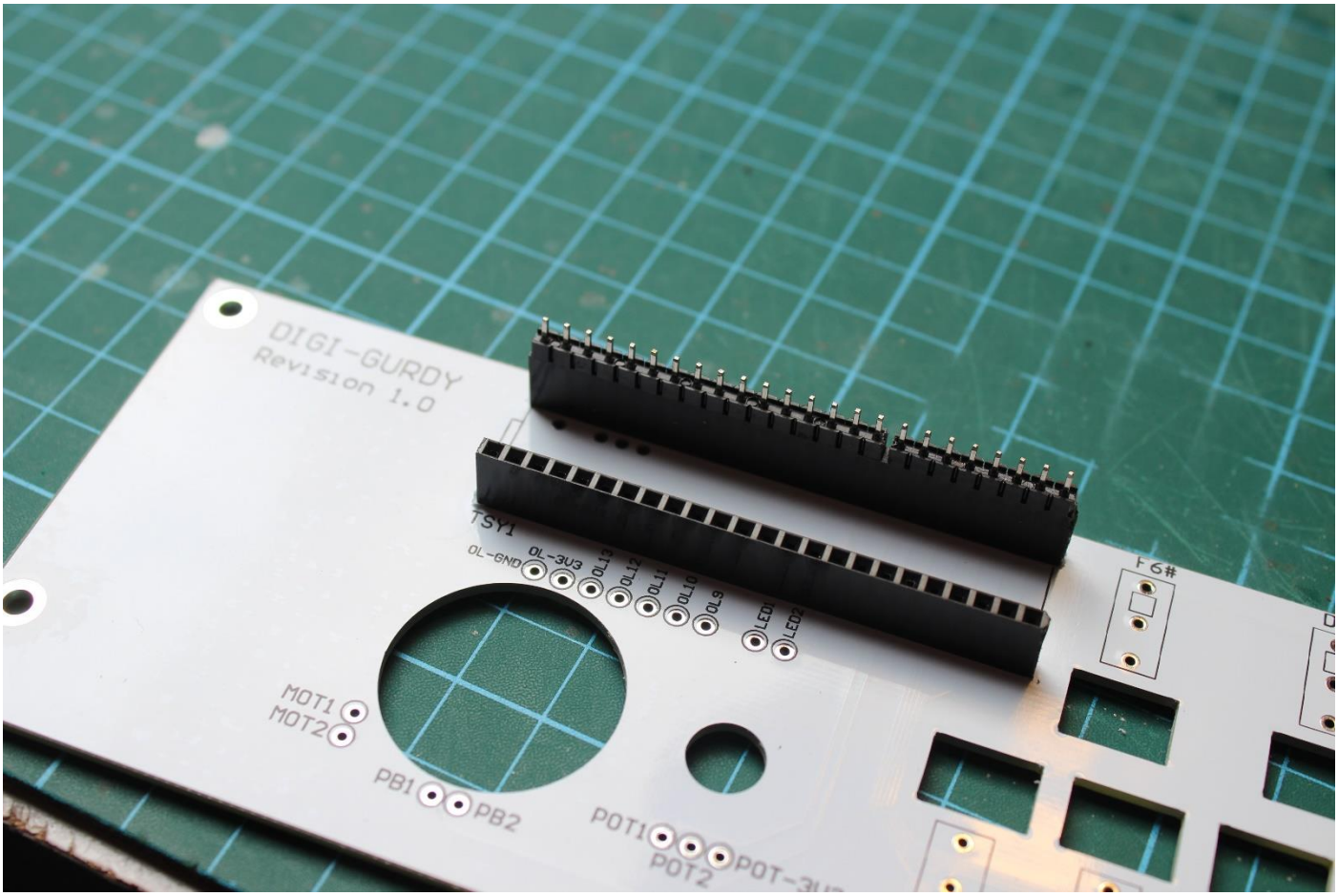
Solder the two rows of pins on back of the main circuit board.



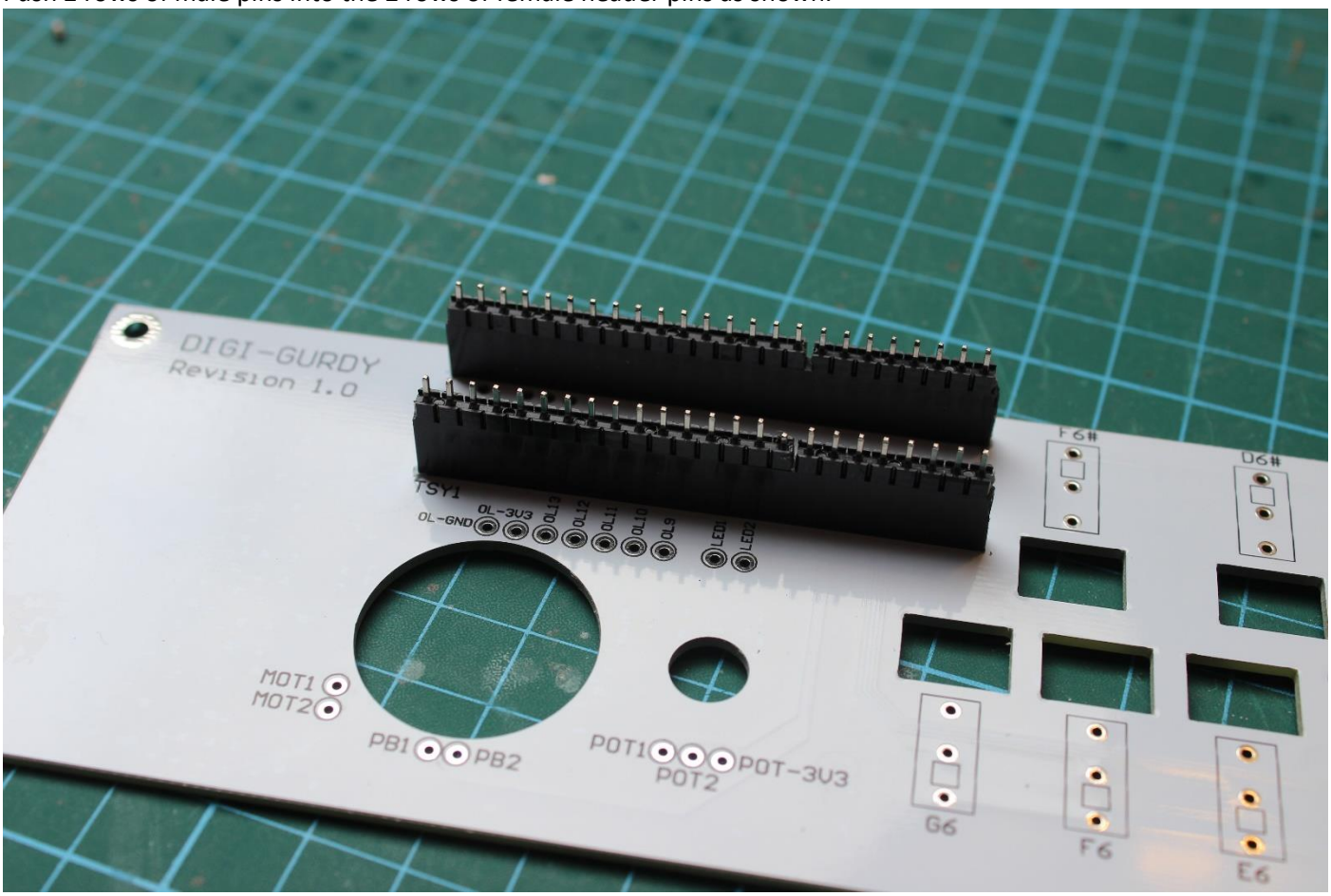
Soldering.



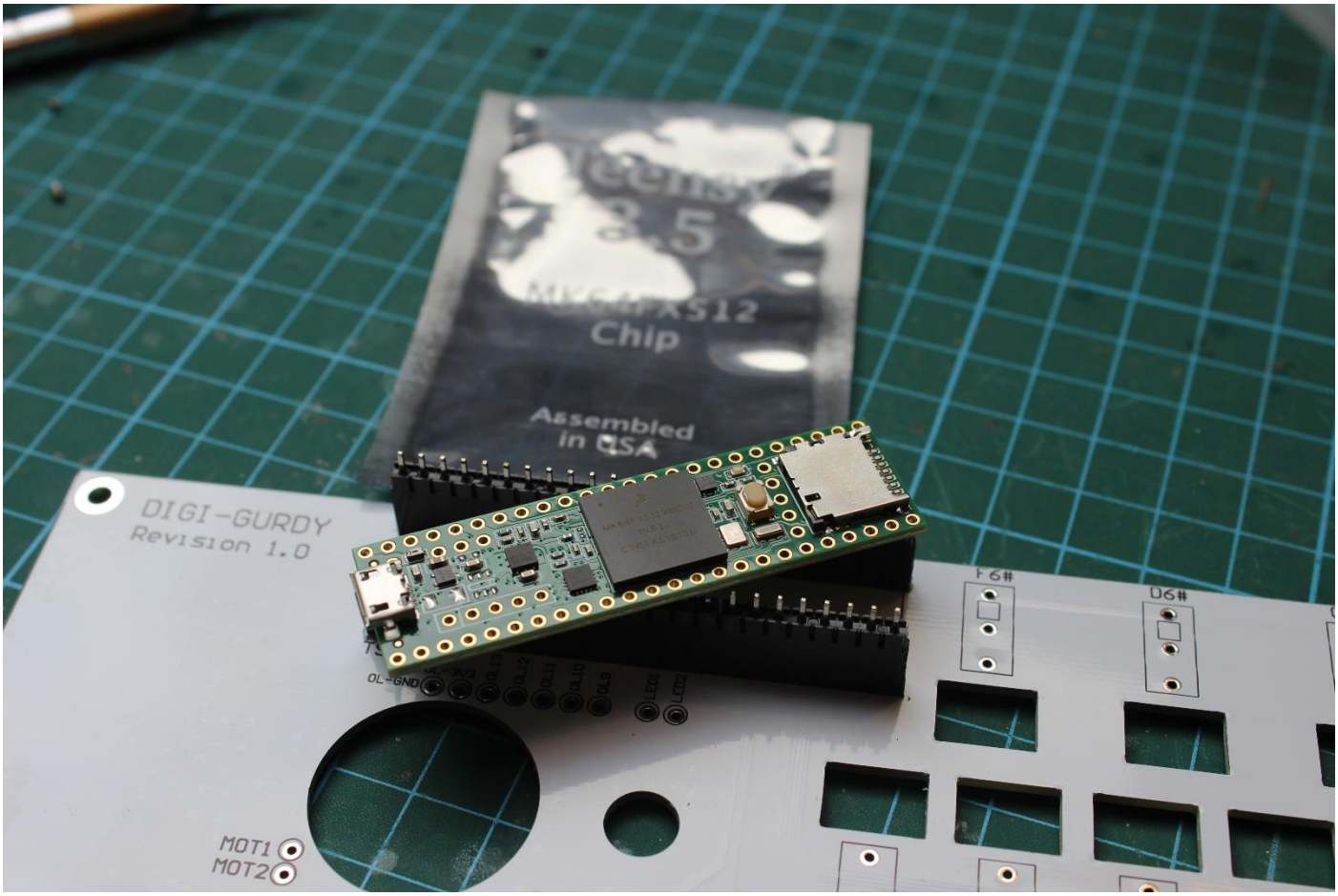
All done.



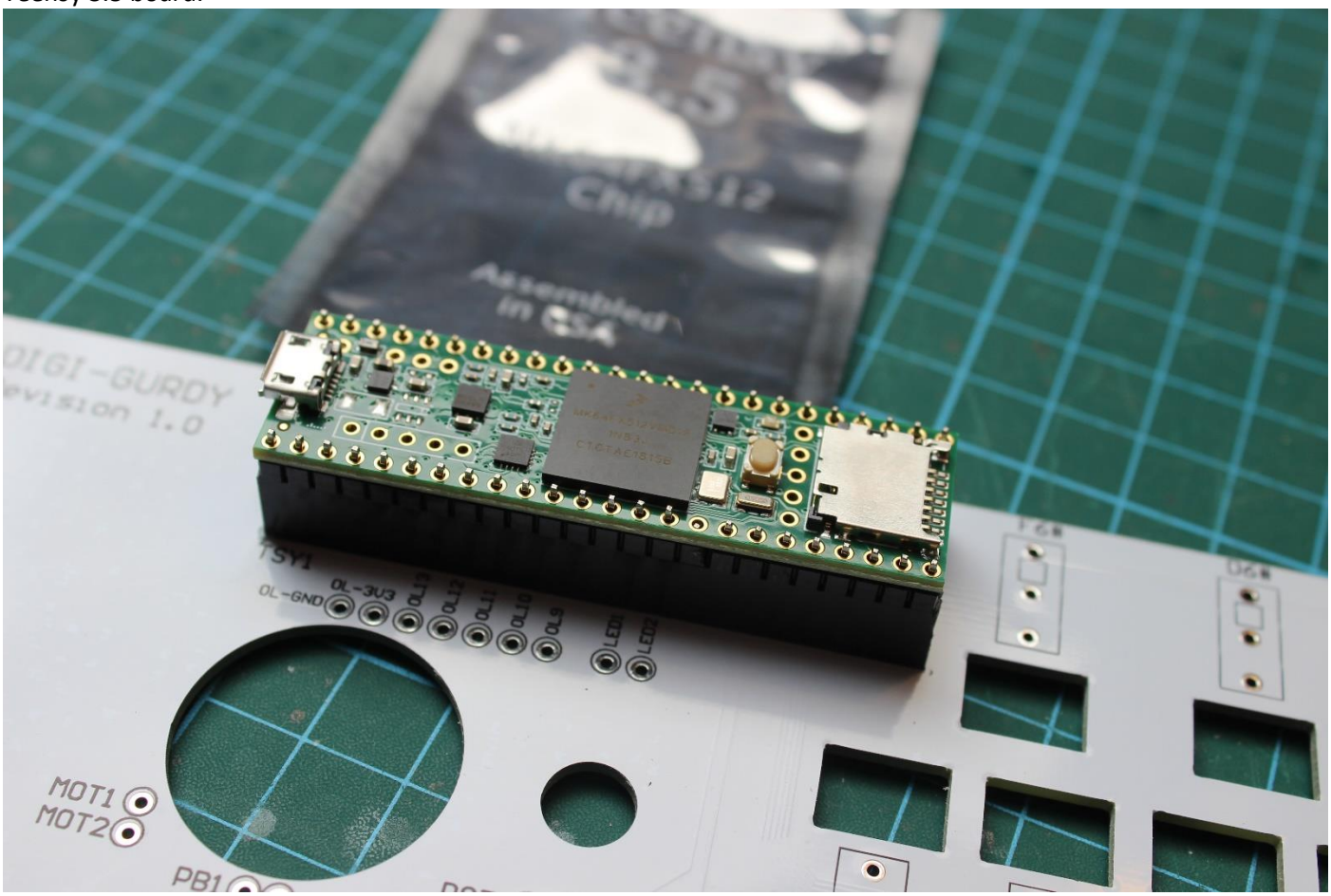
Push 2 rows of male pins into the 2 rows of female header pins as shown.



All ready to place the Teensy board on top of them.



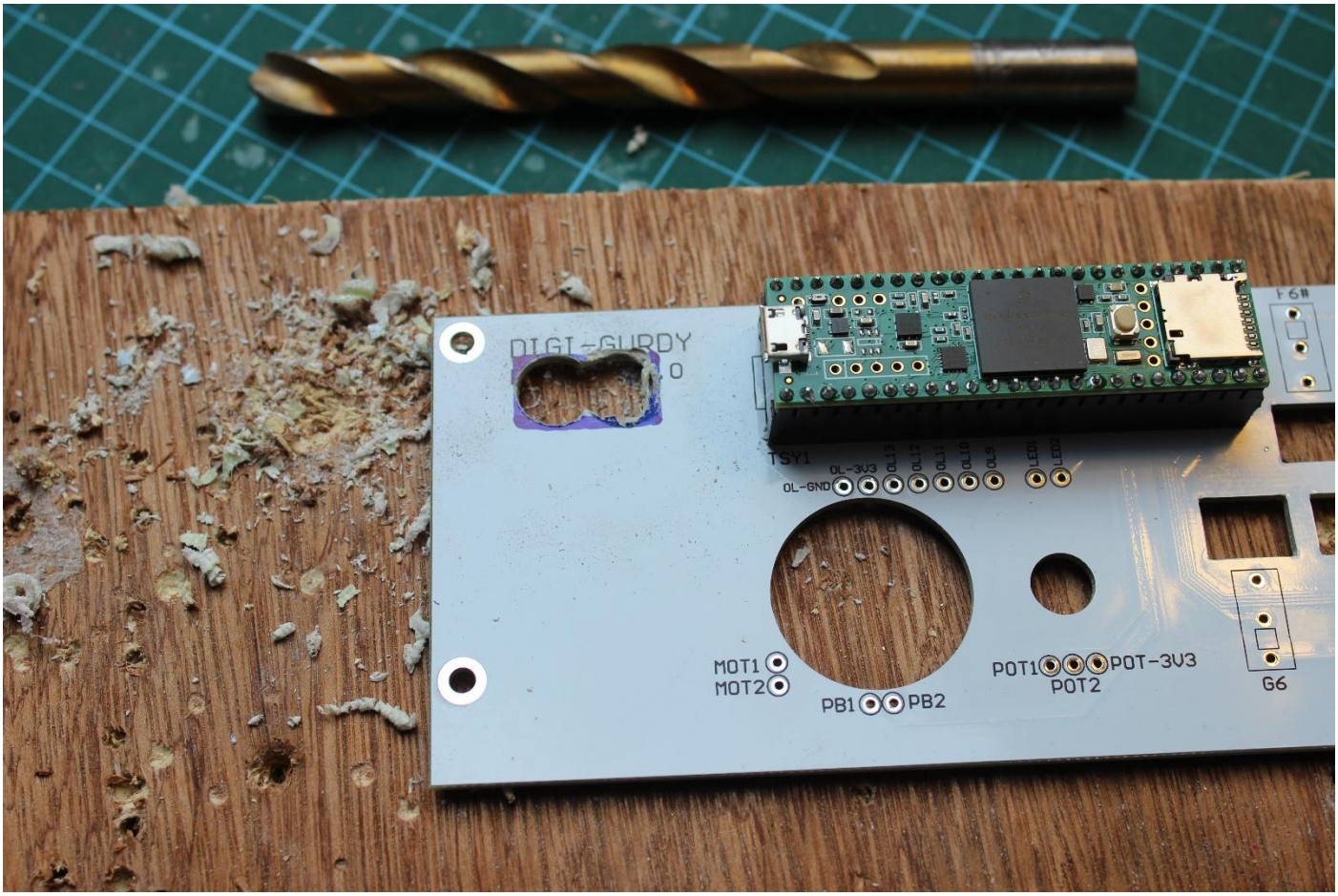
Teensy 3.5 board.



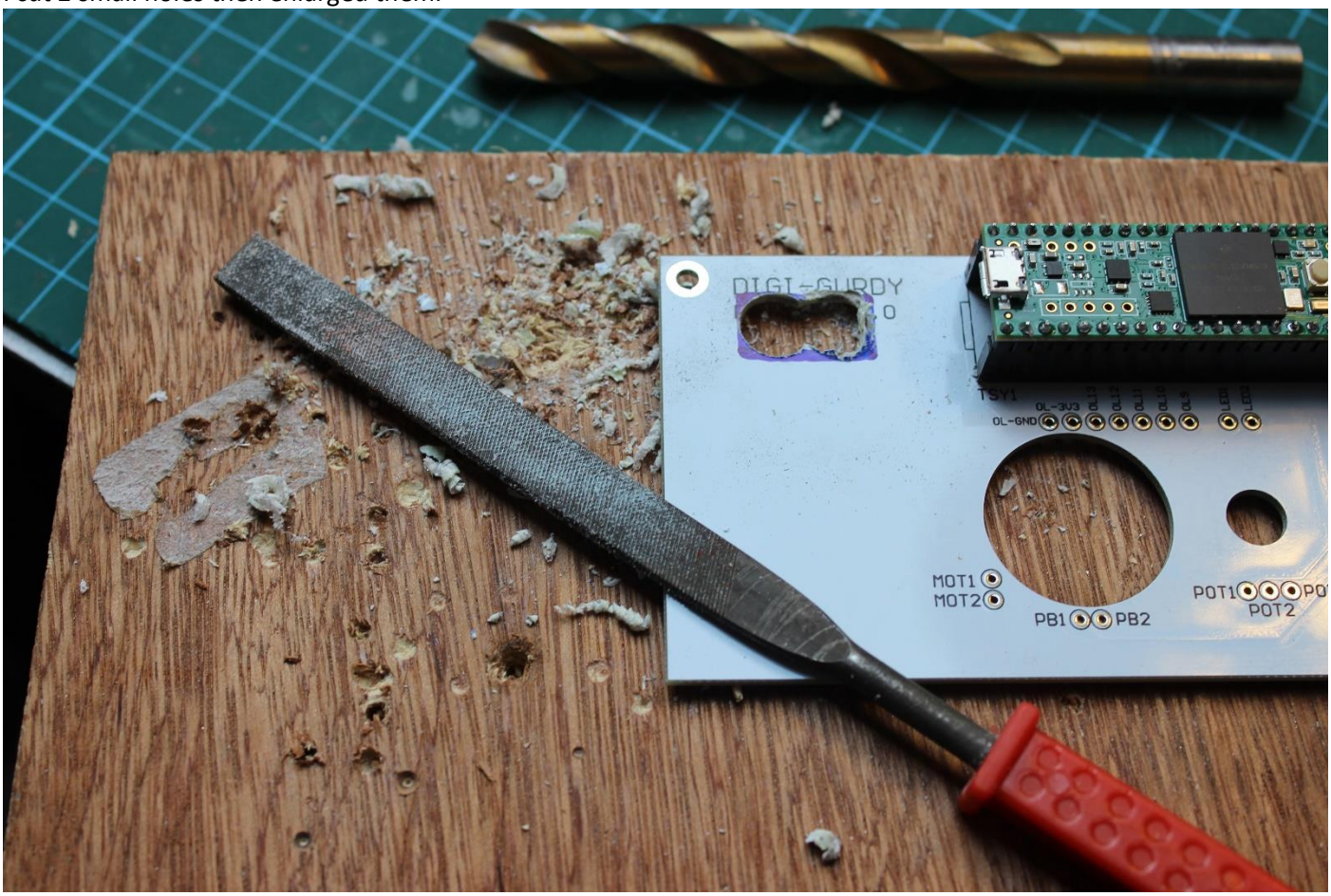
Place the Teensy onto the male pins and carefully solder it to them. You can also buy the Teensy with pins already soldered in if you prefer.

Teensy soldered in. In this way, the Teensy is removable should you ever wish to do that.

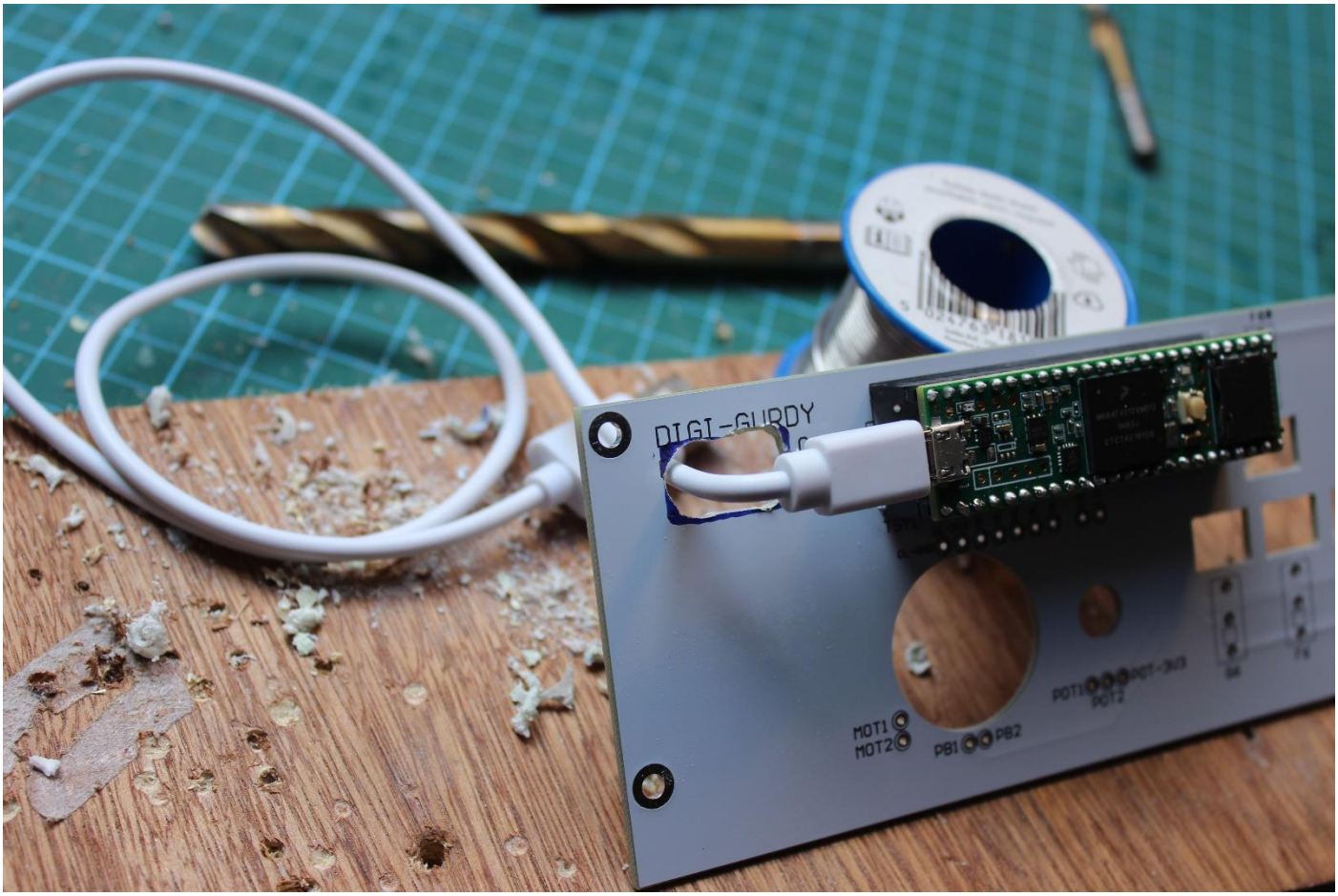
This next modification is to allow the USB cable to emerge from left hand end of the DigiGurdy, which originally was not the case. Where I have marked in blue ink, you need to cut a hole through the circuit board, big enough for the micro-USB plug that goes into the Teensy to fit through. There are no copper traces where this hole is so you do not damage the circuit board. Just cut the hole roughly where I have shown in the above photo!



I cut 2 small holes then enlarged them.

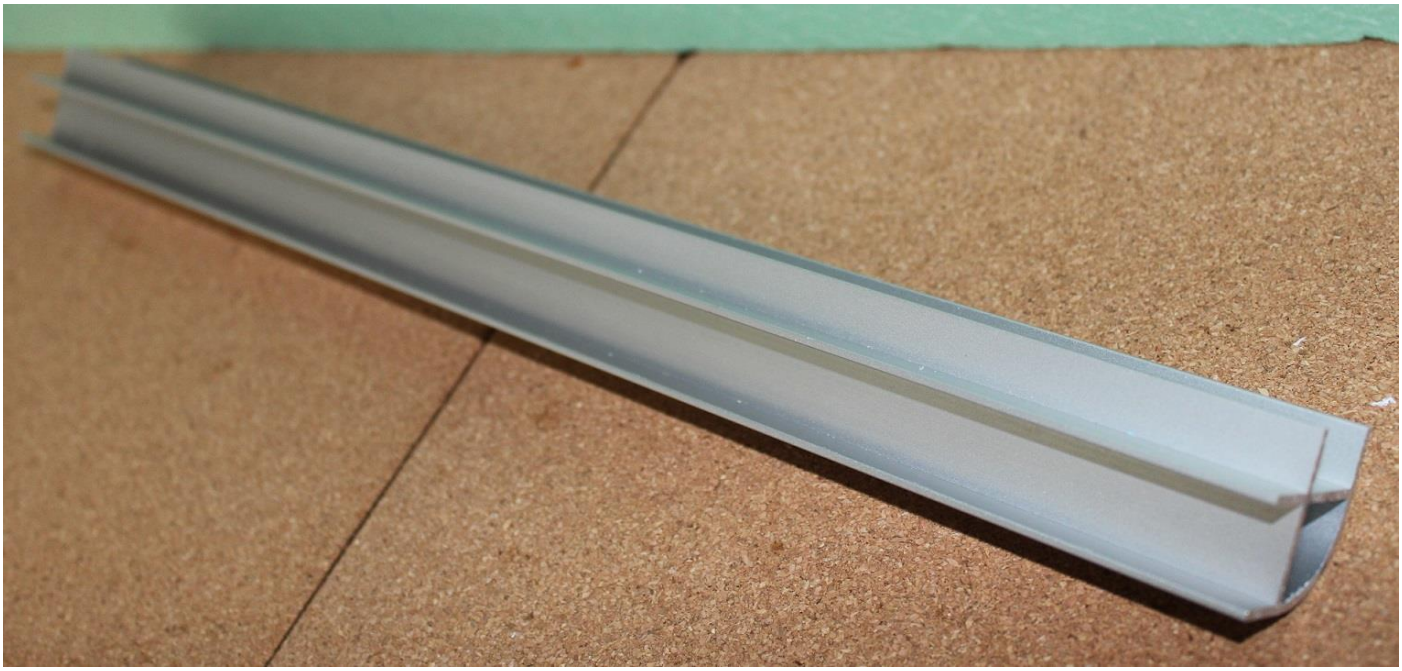


Then use a file to neaten up the hole you have made.

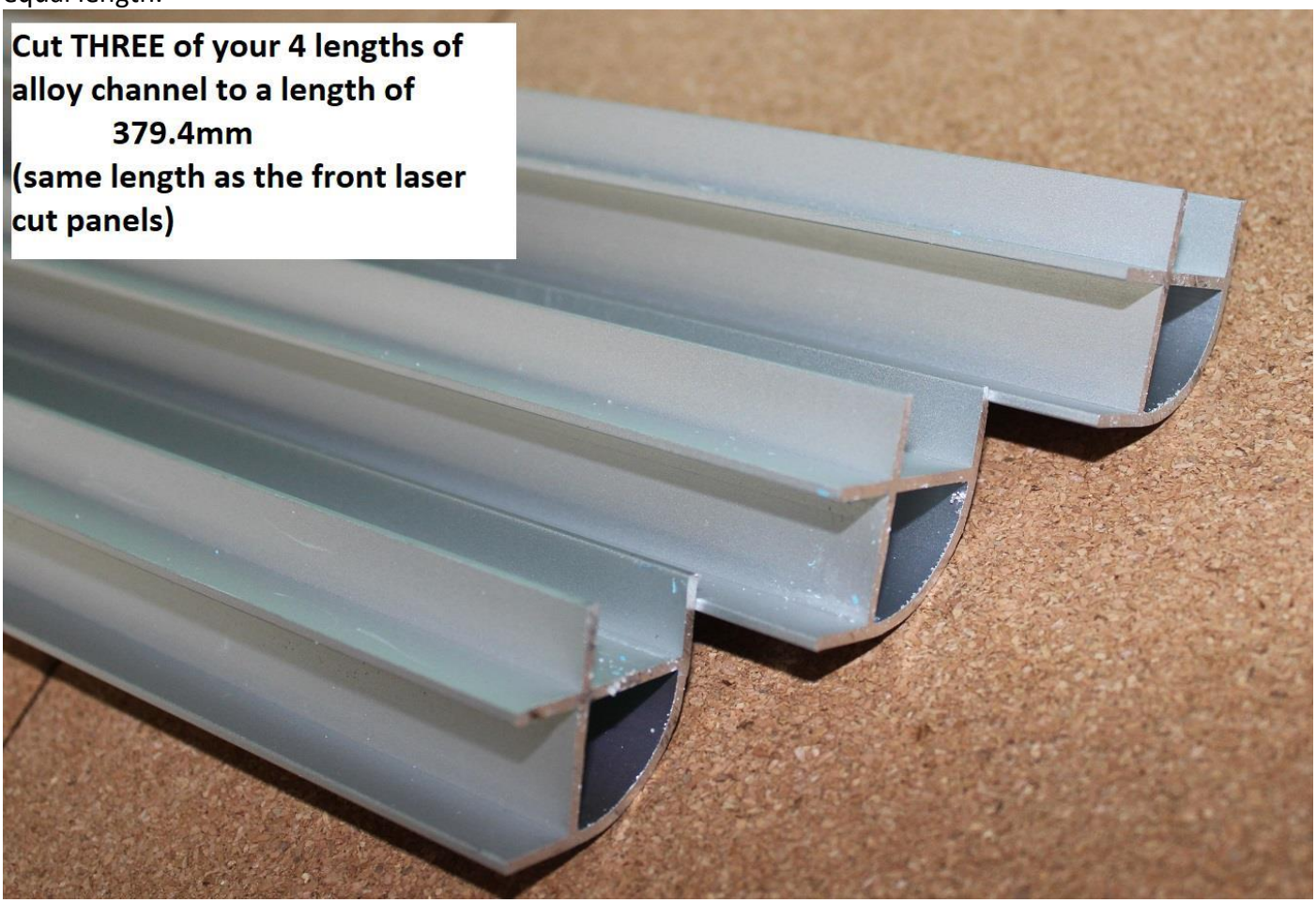


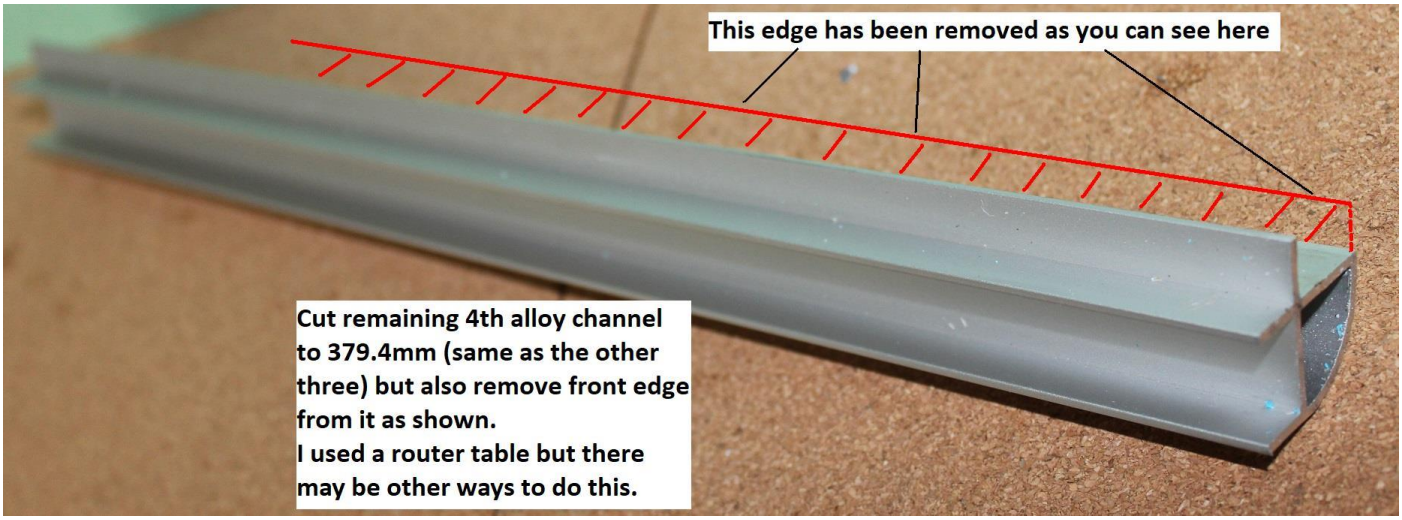
Make sure the plug just fits through this hole as shown.

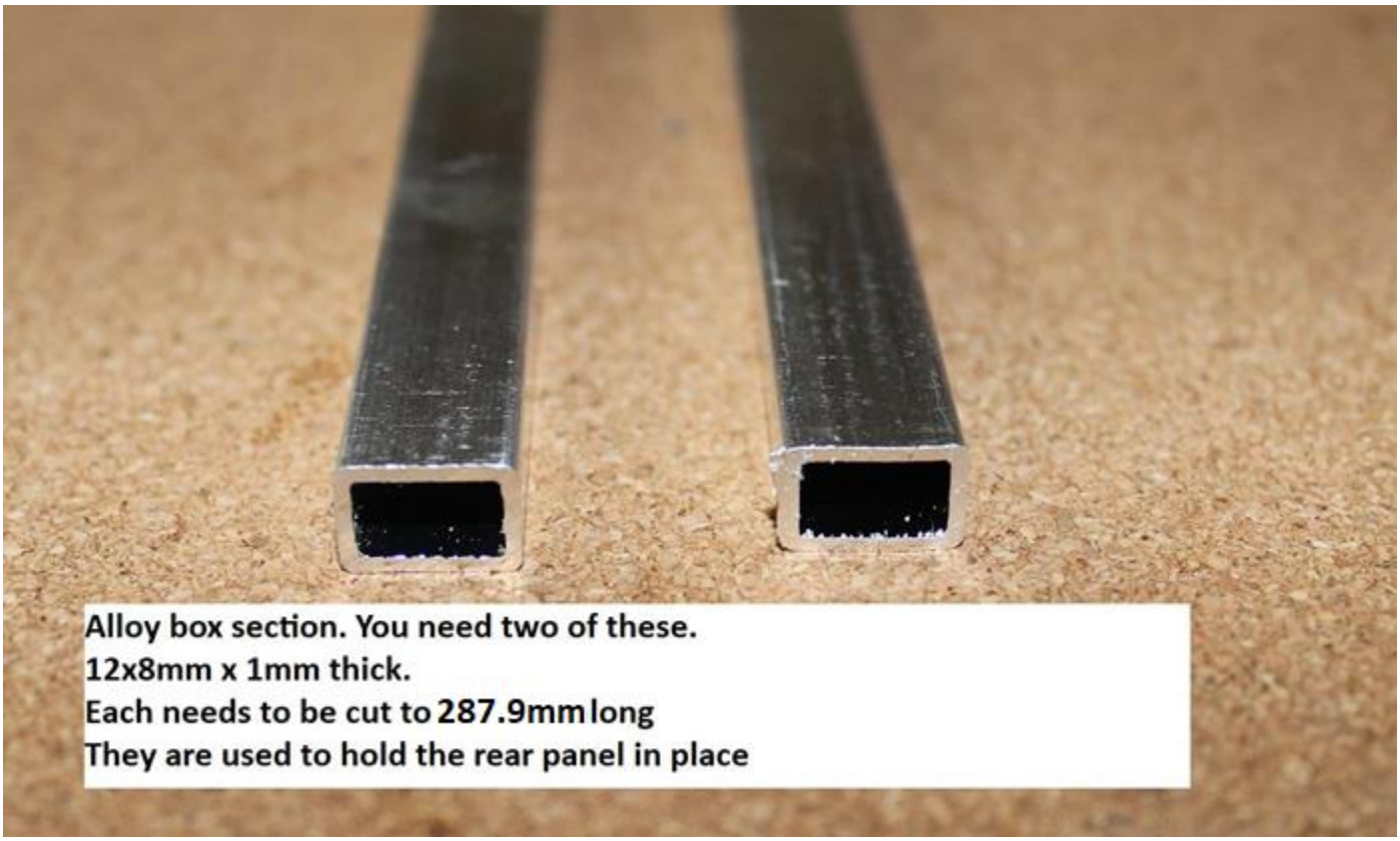
The main parts of the frame. Here are the main parts for the structure of the device

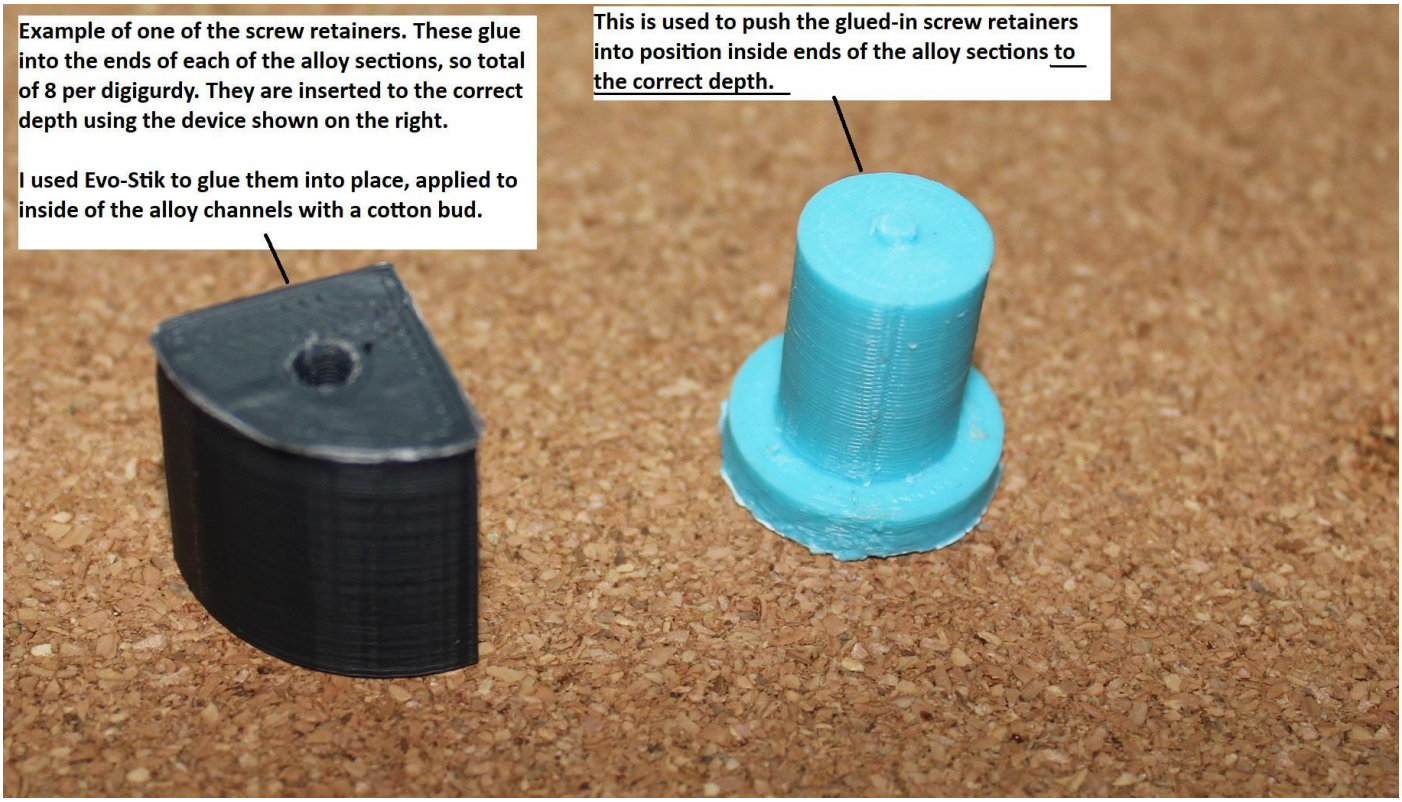


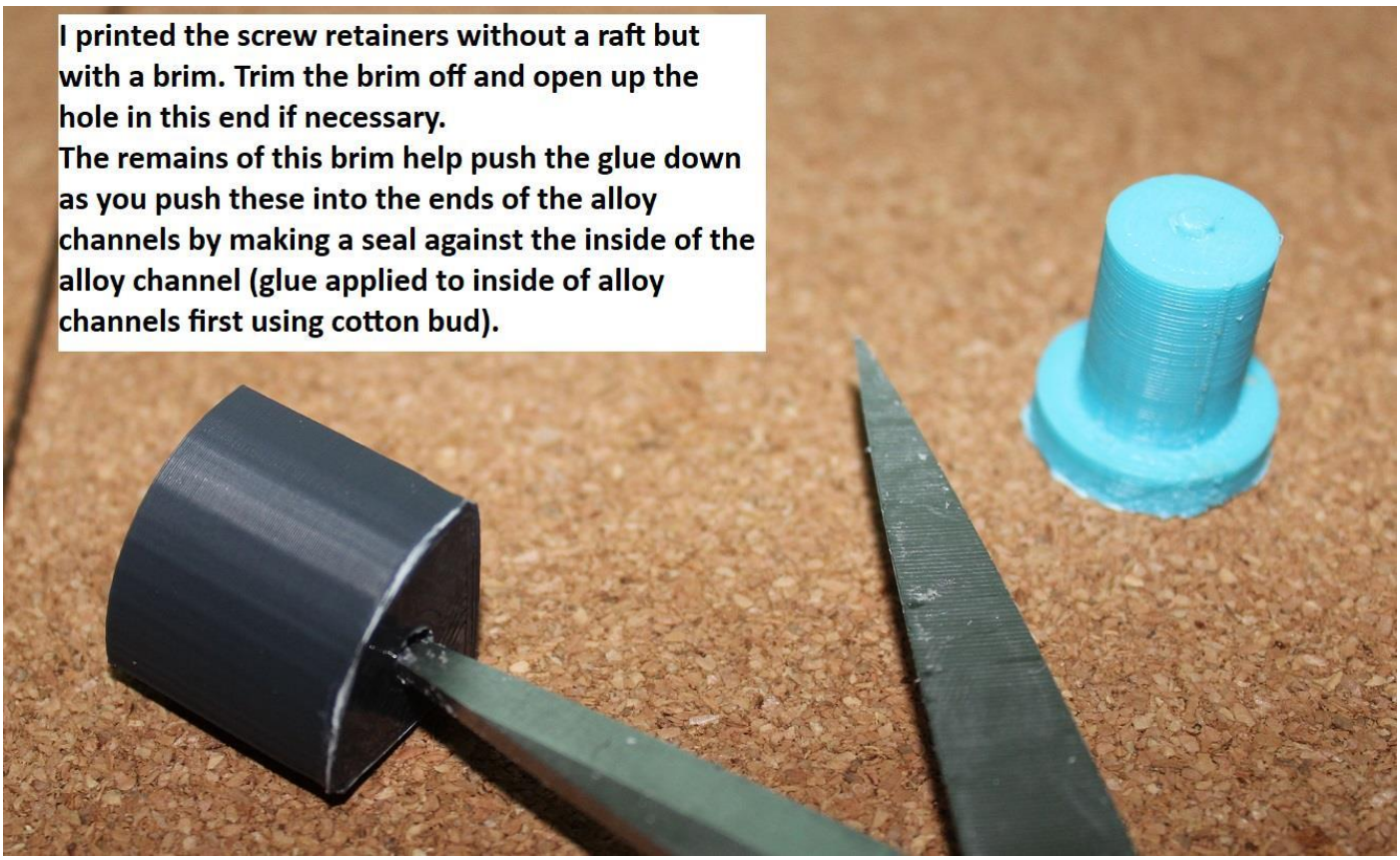
There are a set of 4 lengths of alloy channel. Each is cut to a length of 379.4mm long and must all be of equal length.

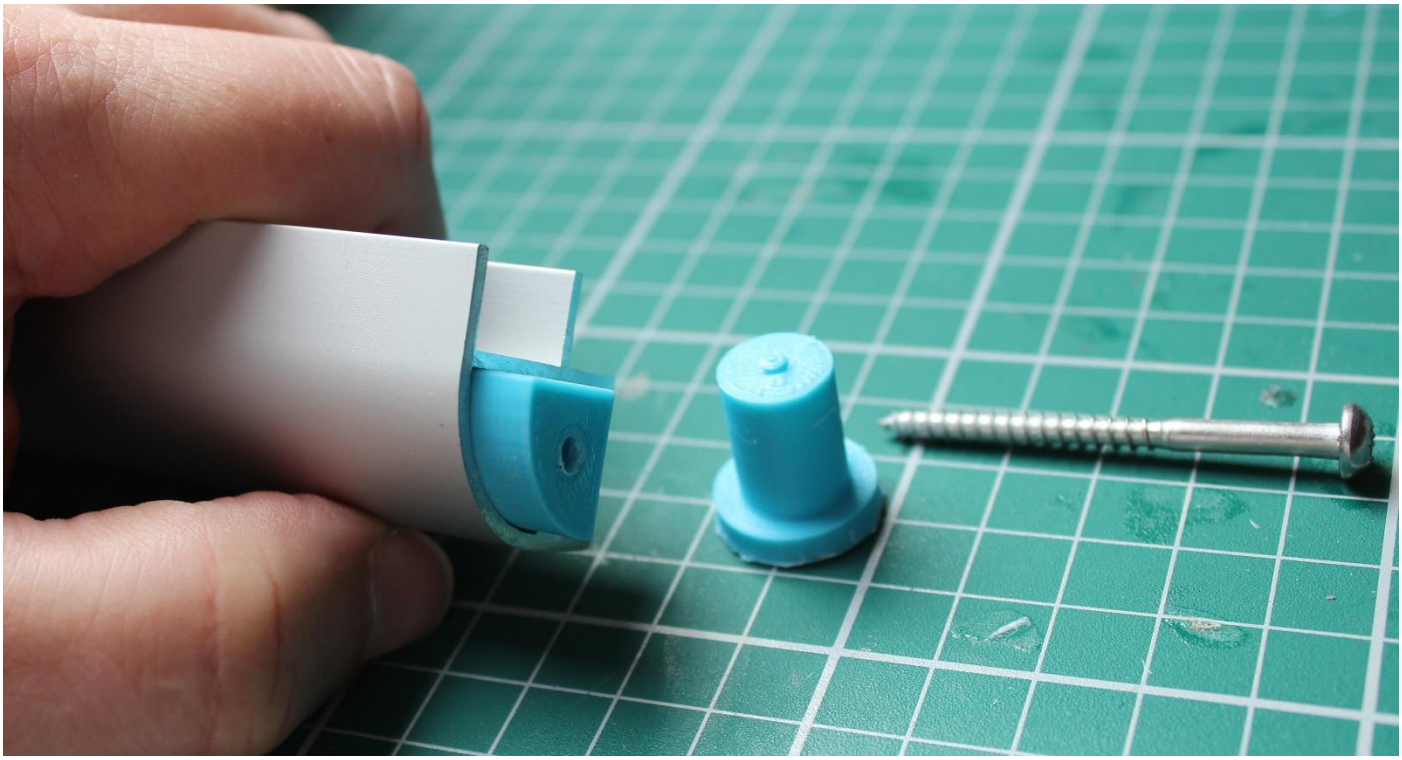



This edge has been removed as you can see here
Cut remaining 4th alloy channel to 379.4mm (same as the other three) but also remove front edge from it as shown.
I used a router table but there may be other ways to do this.


Alloy box section. You need two of these.
12x8mm x 1mm thick.
Each needs to be cut to 287.9mm long
They are used to hold the rear panel in place


Example of one of the screw retainers. These glue into the ends of each of the alloy sections, so total of 8 per digigurdy. They are inserted to the correct depth using the device shown on the right.
I used Evo-Stik to glue them into place, applied to inside of the alloy channels with a cotton bud.
This is used to push the glued-in screw retainers into position inside ends of the alloy sections to the correct depth.


I printed the screw retainers without a raft but with a brim. Trim the brim off and open up the hole in this end if necessary.
The remains of this brim help push the glue down as you push these into the ends of the alloy channels by making a seal against the inside of the alloy channel (glue applied to inside of alloy channels first using cotton bud).

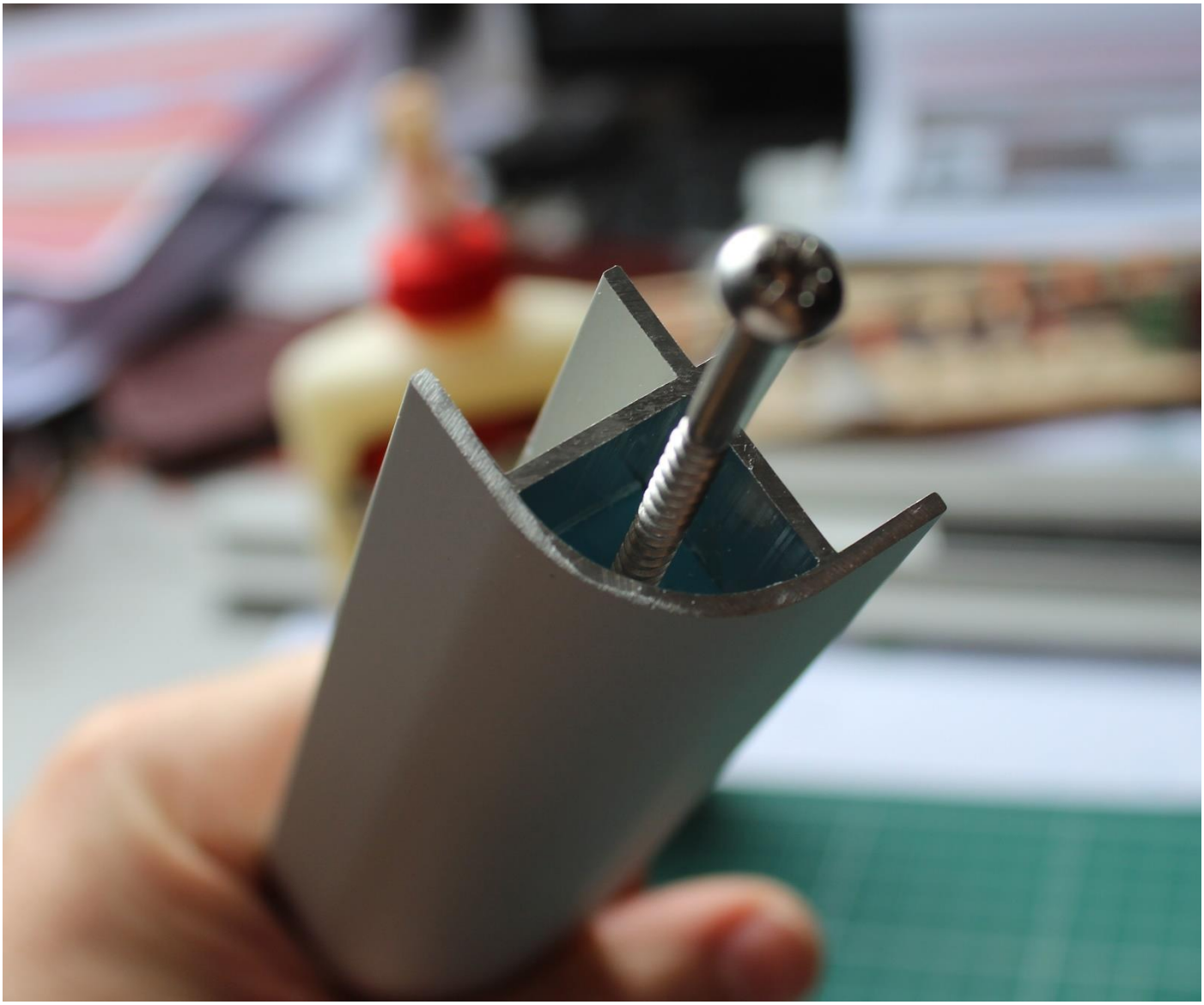


Push in the insert partially like this. *Test fit the insert in this way first* before applying glue to inside of the alloy extrusion. You will find one end of each insert fits a little more easily than the other, this is deliberate. The parts are a close fit. Then apply the glue inside the extrusion, with a cotton bud.

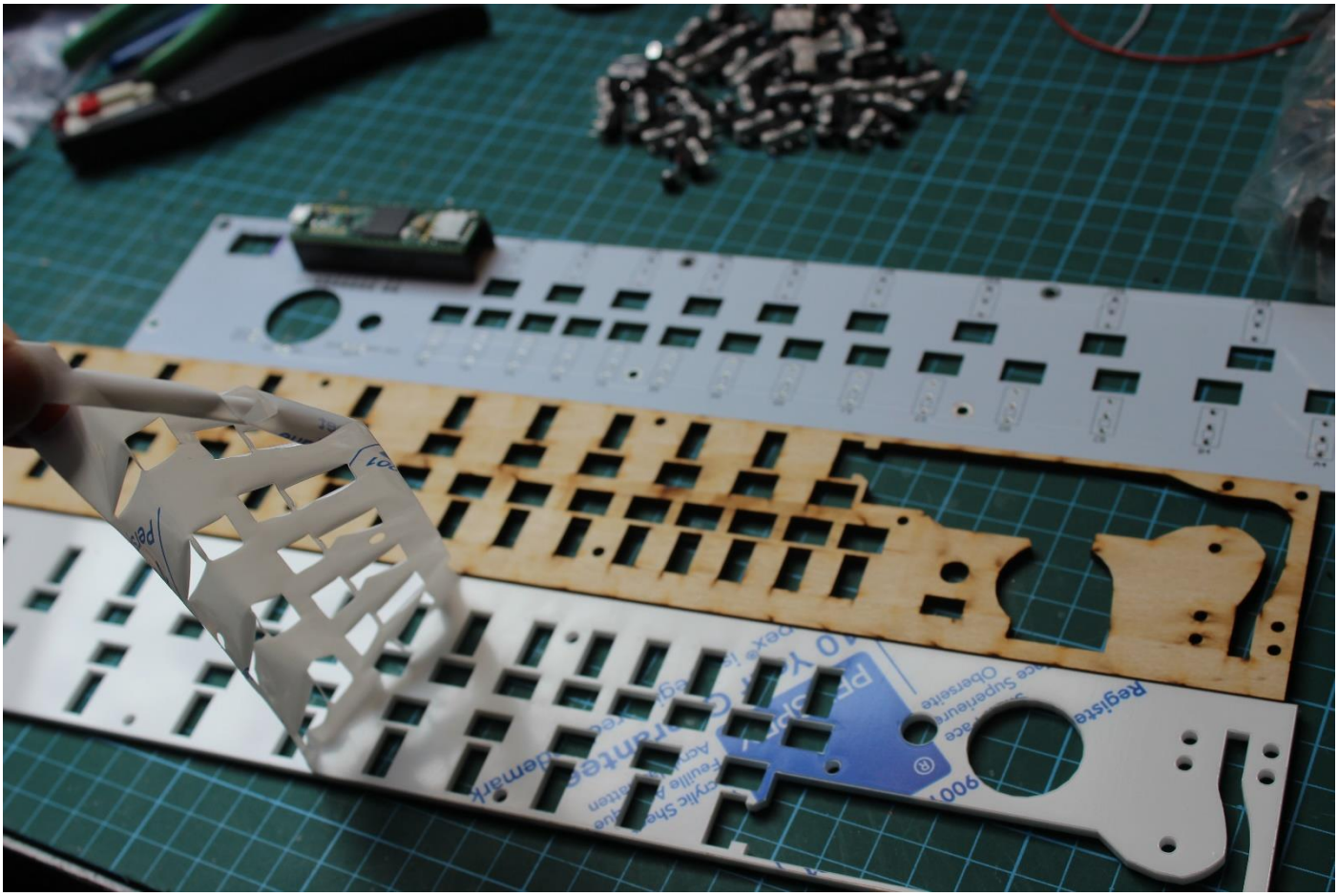
Next, locate the “pusher” tool. This has a raised central pin which fits into the hole on the top of the plastic insert.

Hold everything upright against a bench. Quickly, before the glue has set, press hard on the “pusher” until it has pushed the plastic insert into the alloy extrusion to a depth of about 15mm.

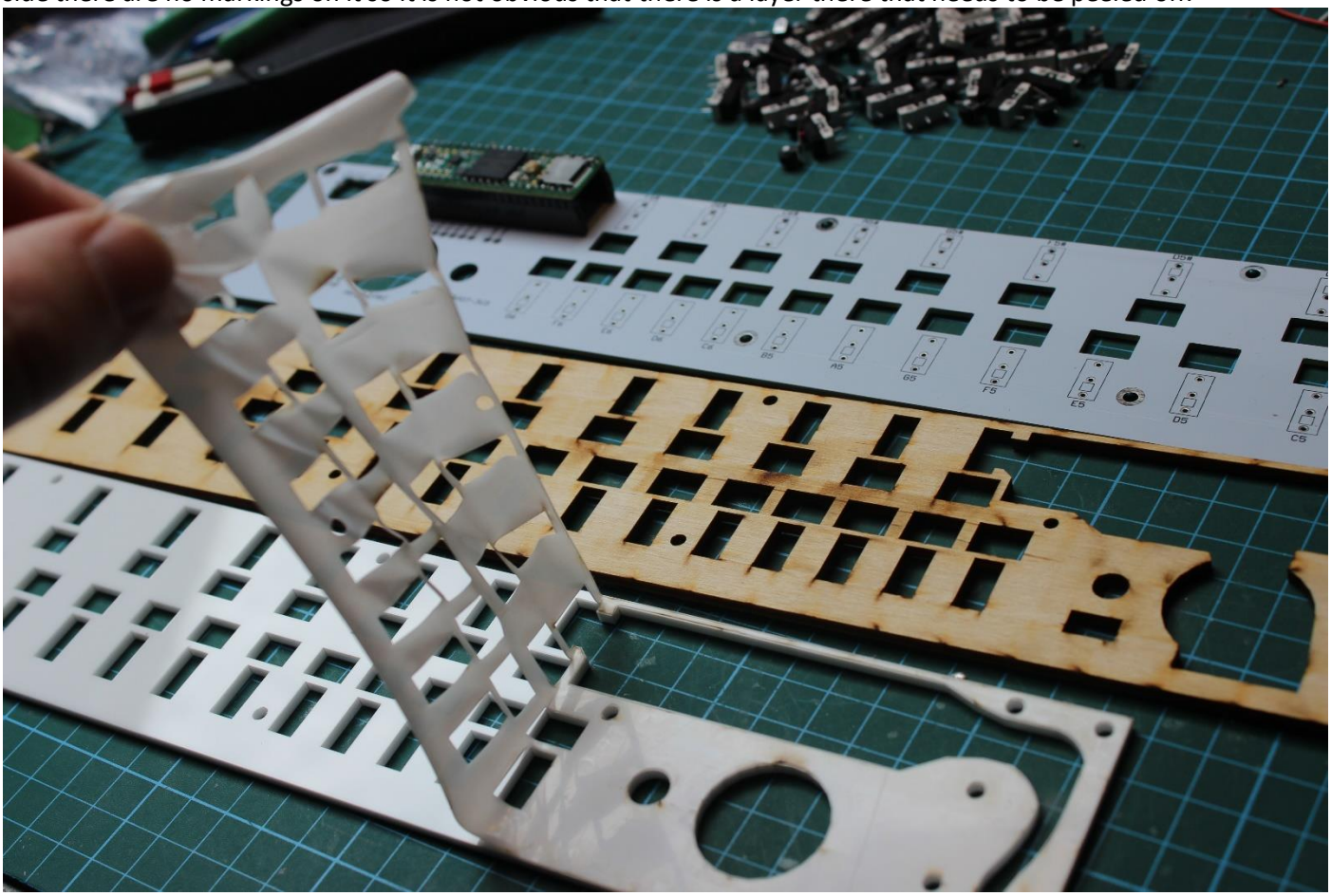
Here is a view of the “pusher” pushed all the way in until it stops. Next, remove the pusher, leaving the plastic insert inside the alloy extrusion and with a cotton bud, remove any excess glue in the end of the alloy extrusion.



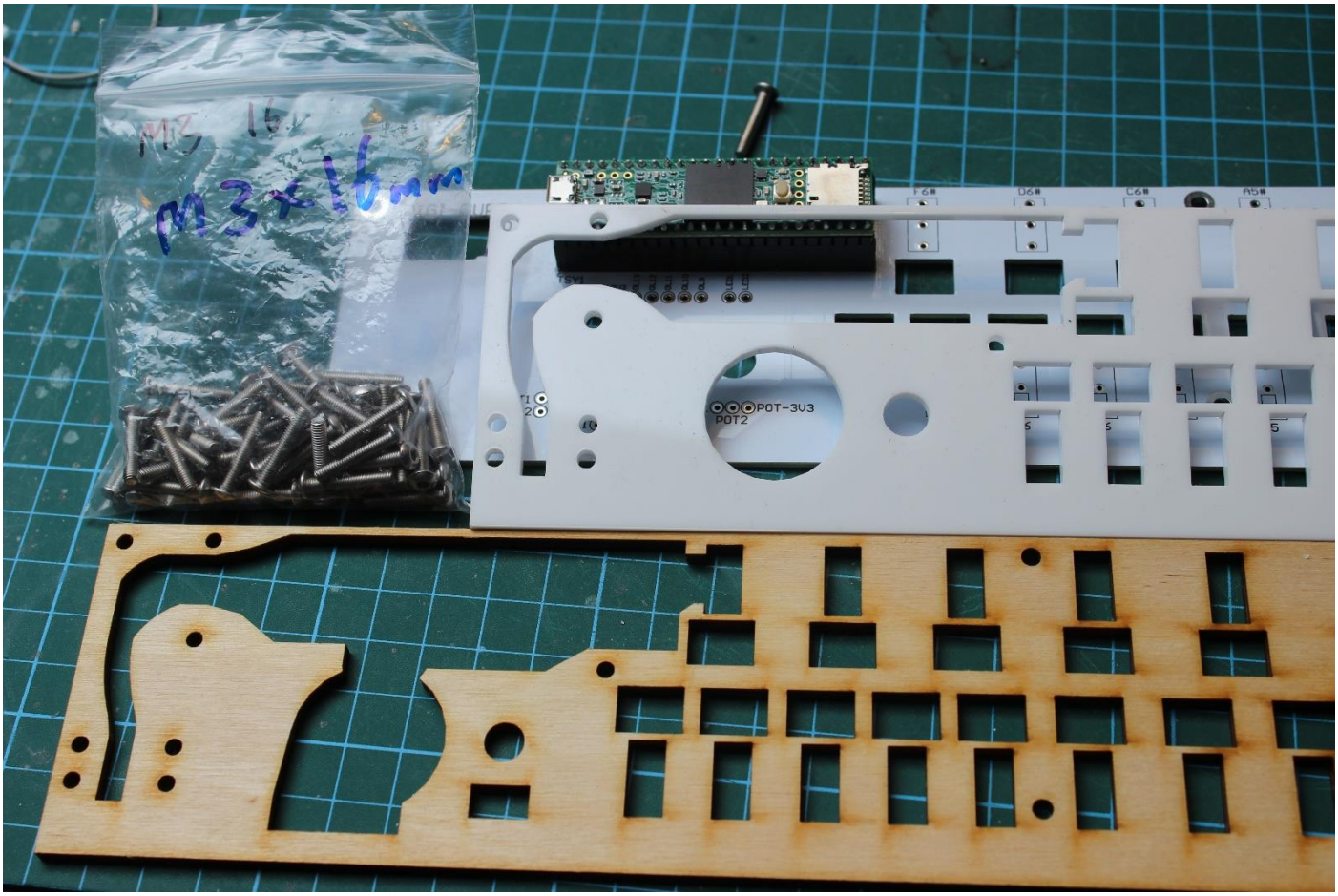
Pusher now removed, excess glue quickly removed with cotton bud from inside of the alloy extrusion. Here a screw has been put into the hole within the plastic insert just to show how these work at each end to hold on the 3D printed end pieces. Now, repeat this process for each end of all 4 alloy extrusions, i.e. 8 plastic inserts in total.



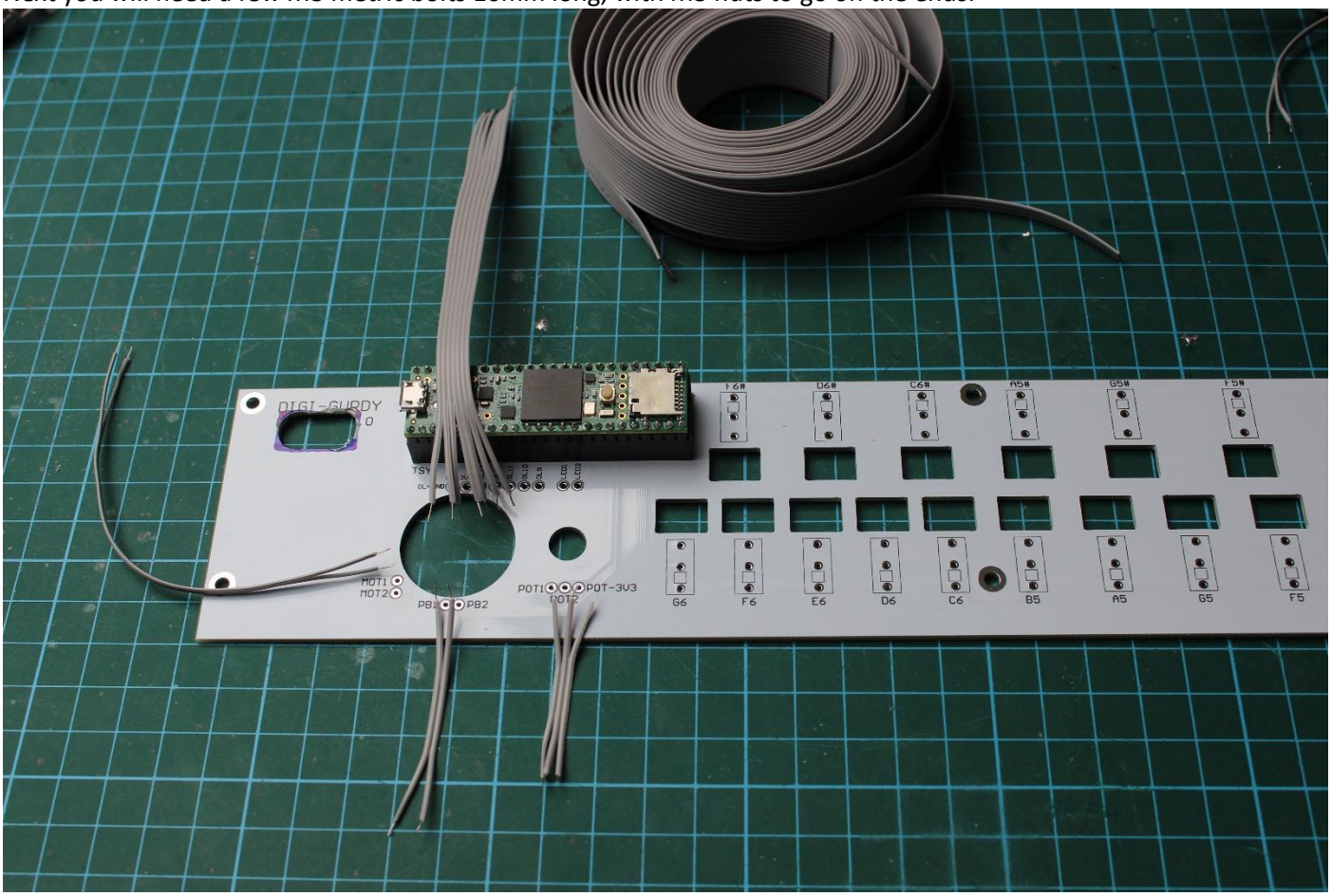
Take the two front laser cut layers. The front white acrylic layer has a protective film on BOTH sides. On the reverse side there are no markings on it so it is not obvious that there is a layer there that needs to be peeled off.



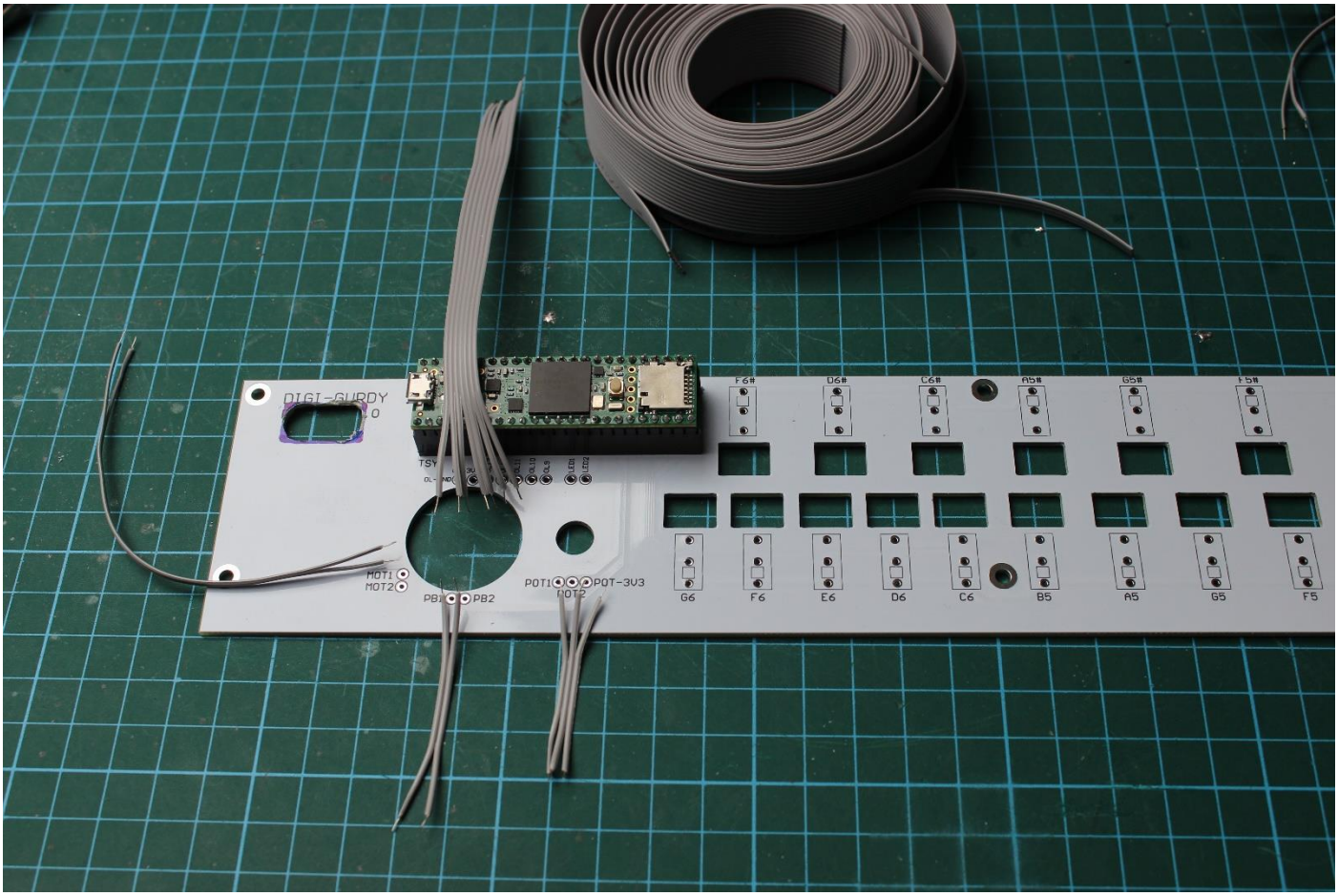
x



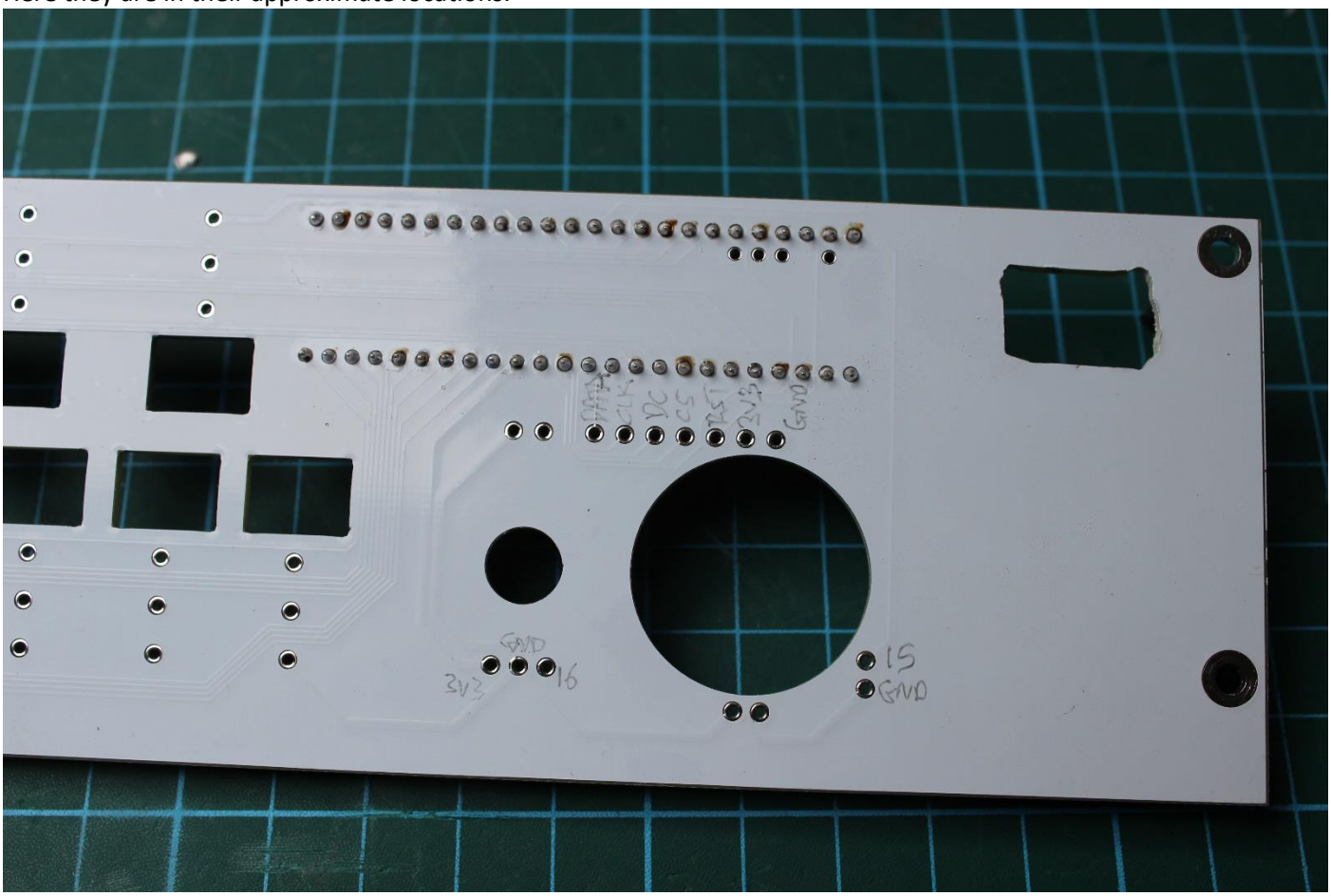
Next you will need a few M3 metric bolts 16mm long, with M3 nuts to go on the ends.



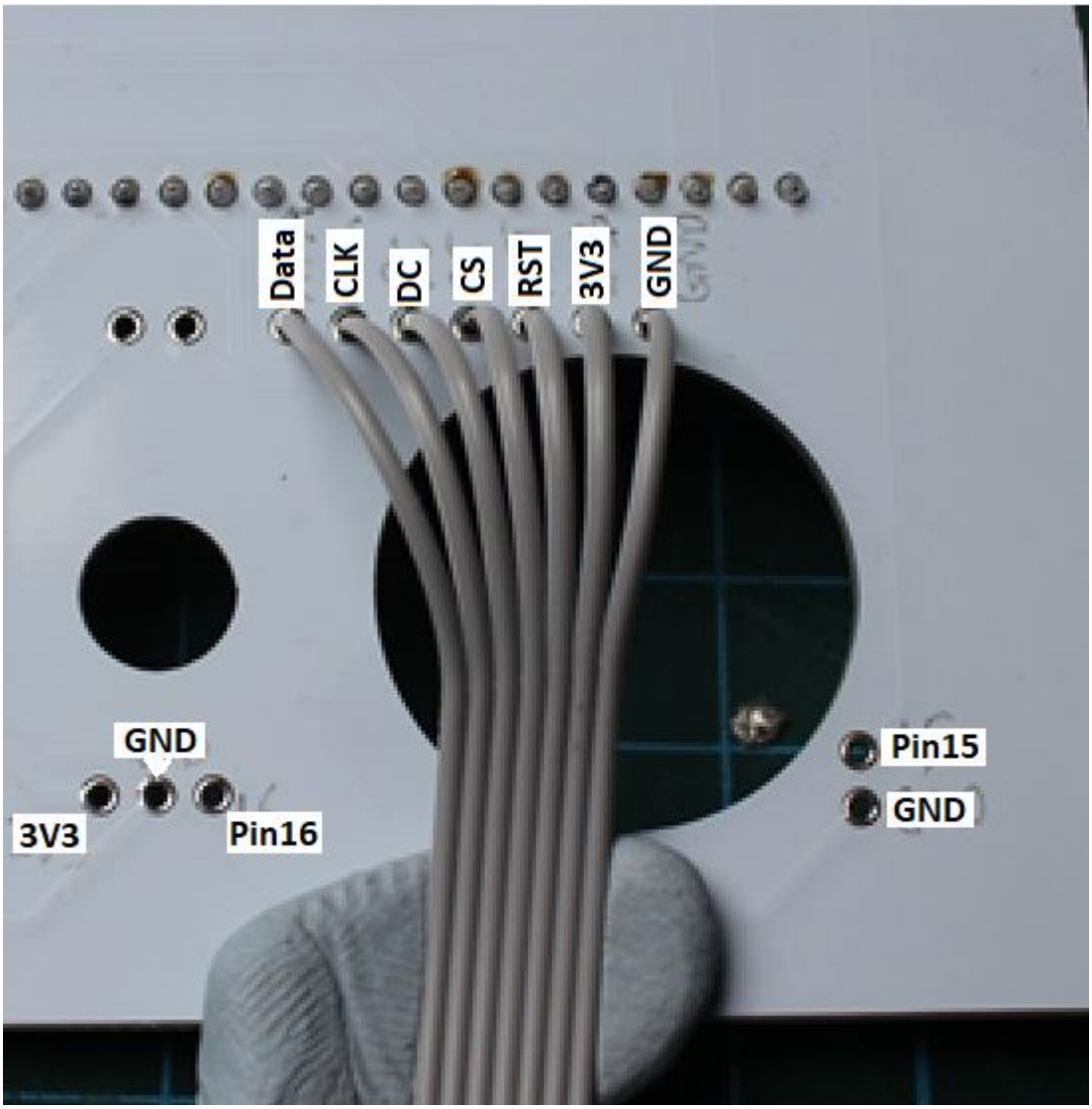
Prepare some lengths of ribbon cable: One has 3 strands (for the potentiometer). One has 2 strands for the pushbutton switch. One has 2 strands for the crankmotor. One has 7 strands for the OLED display.



Here they are in their approximate locations.



Label the Pins on the reverse side of the circuit board exactly as shown.



Close up view. Use a sharp pencil or very fine pointed felt pen.

OLED display	<u>Pin on Teensy board</u>
DATA	9
Clk	10
DC	11
CS	12
Reset	13

Plus also

Vcc	3.3V	(The board is supplied with power at 3.3V). This wire goes ***FROM*** 3.3V on the Teensy ***TO*** Vcc on the OLED screen, NOT to the 3.3V Pin on the screen.
GND	GND	

<u>Other components to be wired up</u>

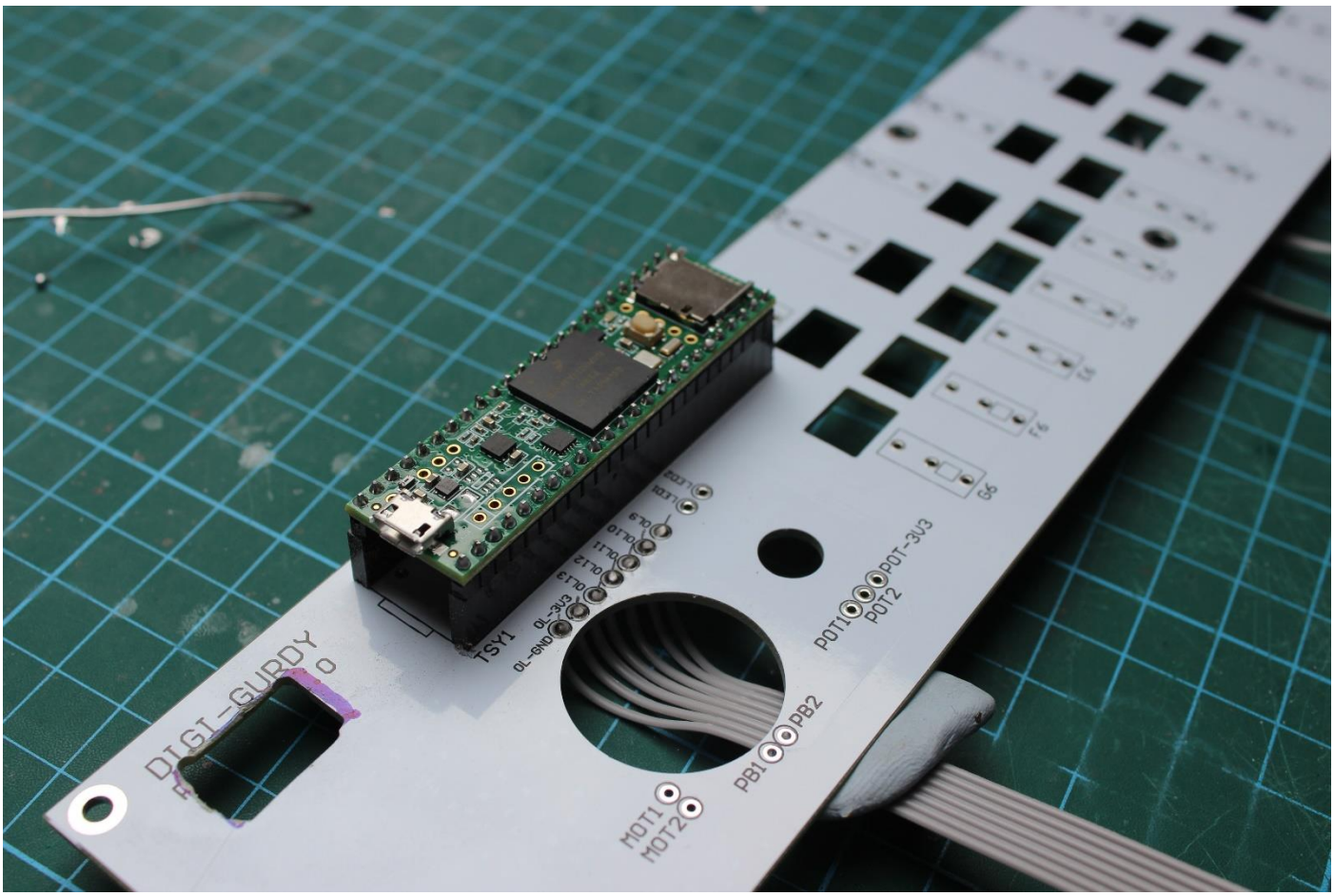
Gaming console push button switch

2 wires from switch to Pin 39 and GND (2 solder holes we marked earlier on rear of the printed circuit board).

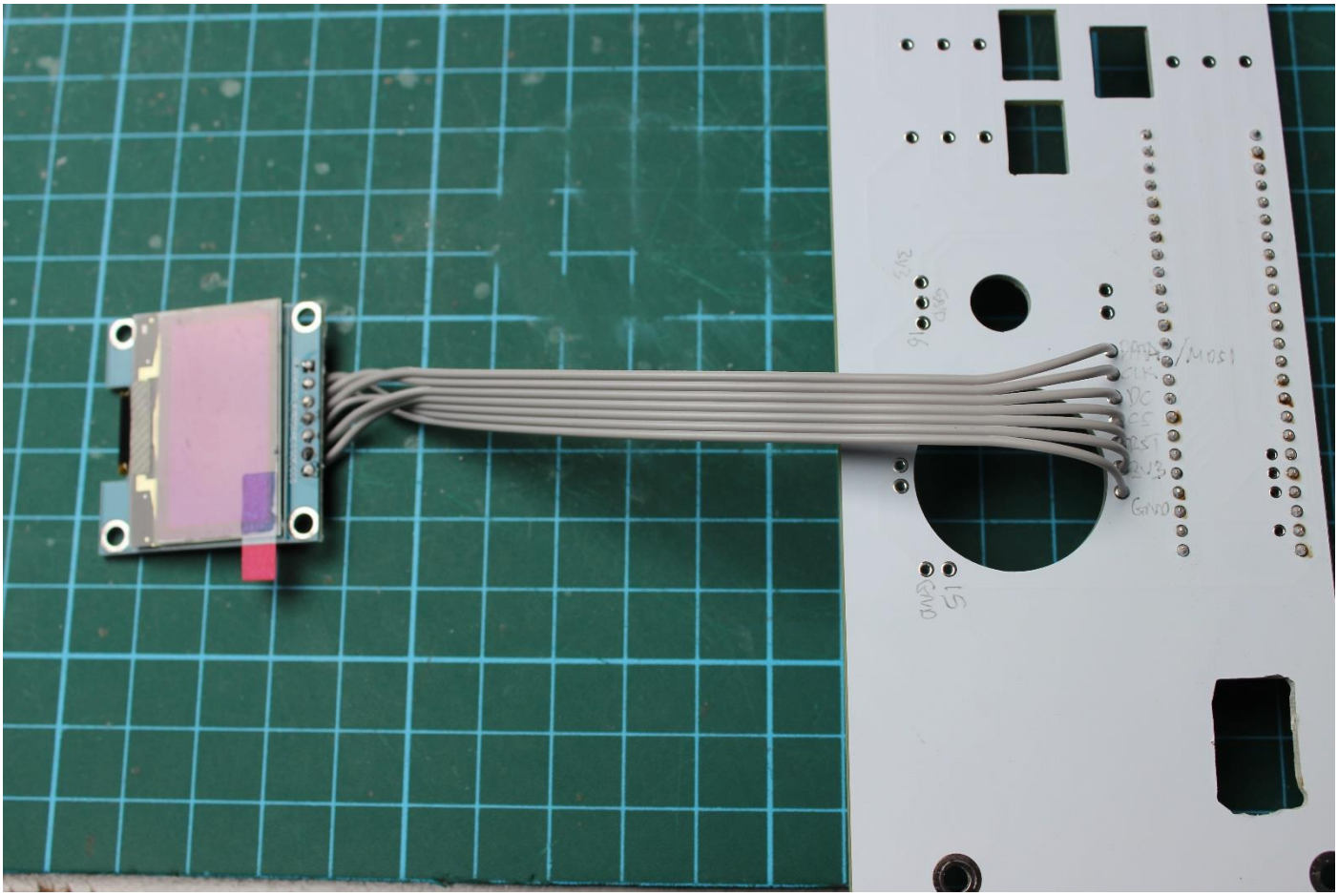
Potentiometer that adjusts buzz sensitivity. 3 wires to a row of 3 holes we marked earlier on rear of the printed circuit board.

<u>Teensy</u>	<u>Potentiometer viewed from rear with its 3 solder terminals facing downwards</u>
GND	Left terminal
3.3V	Right terminal
Pin 16	Middle terminal

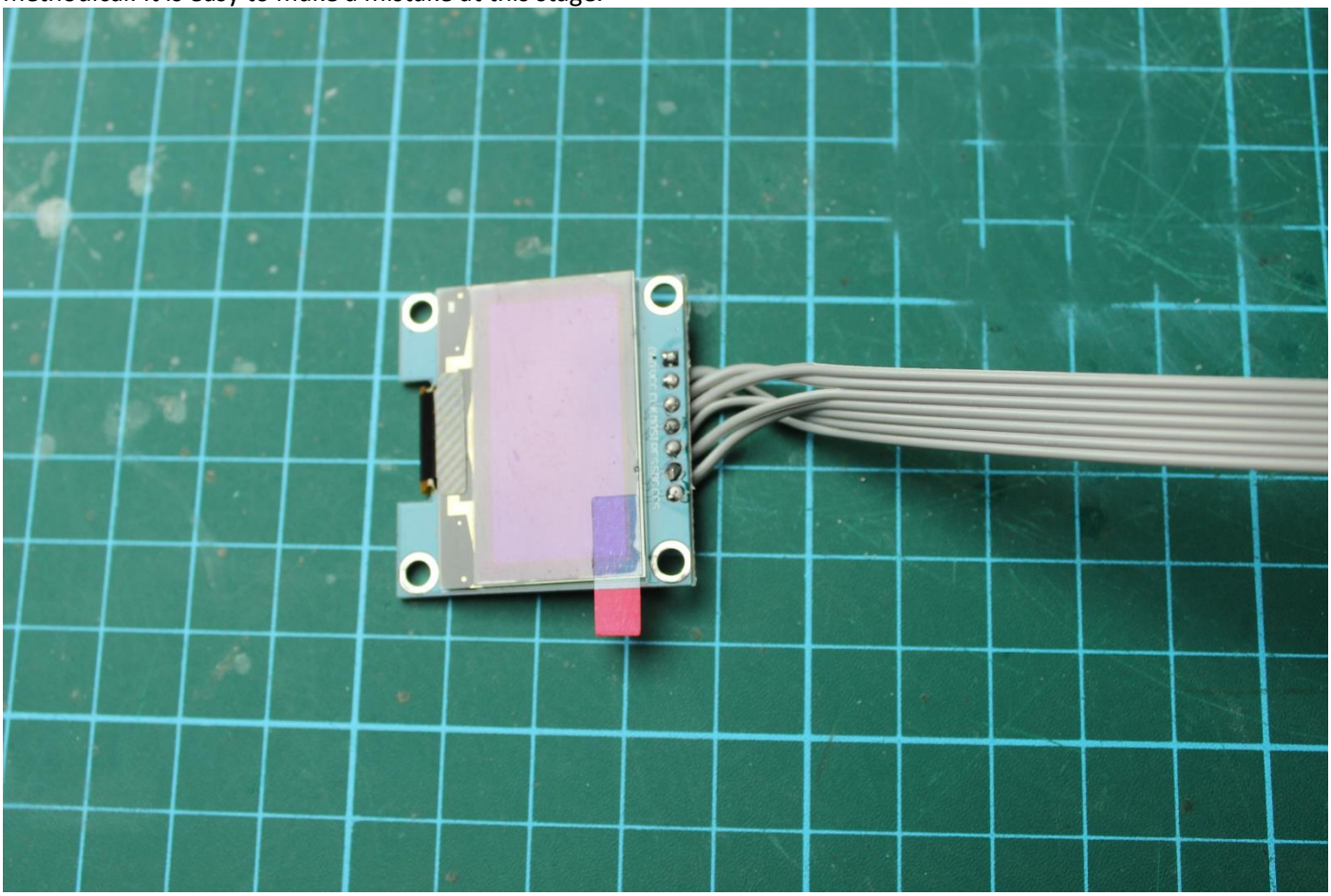
2 wires running from the ***crank gearmotor*** that we are using as a dynamo to generate a voltage when you crank it, that the Teensy board can then measure and respond to:
GND
Pin 15 (solder holes we marked earlier on rear of the printed circuit board).

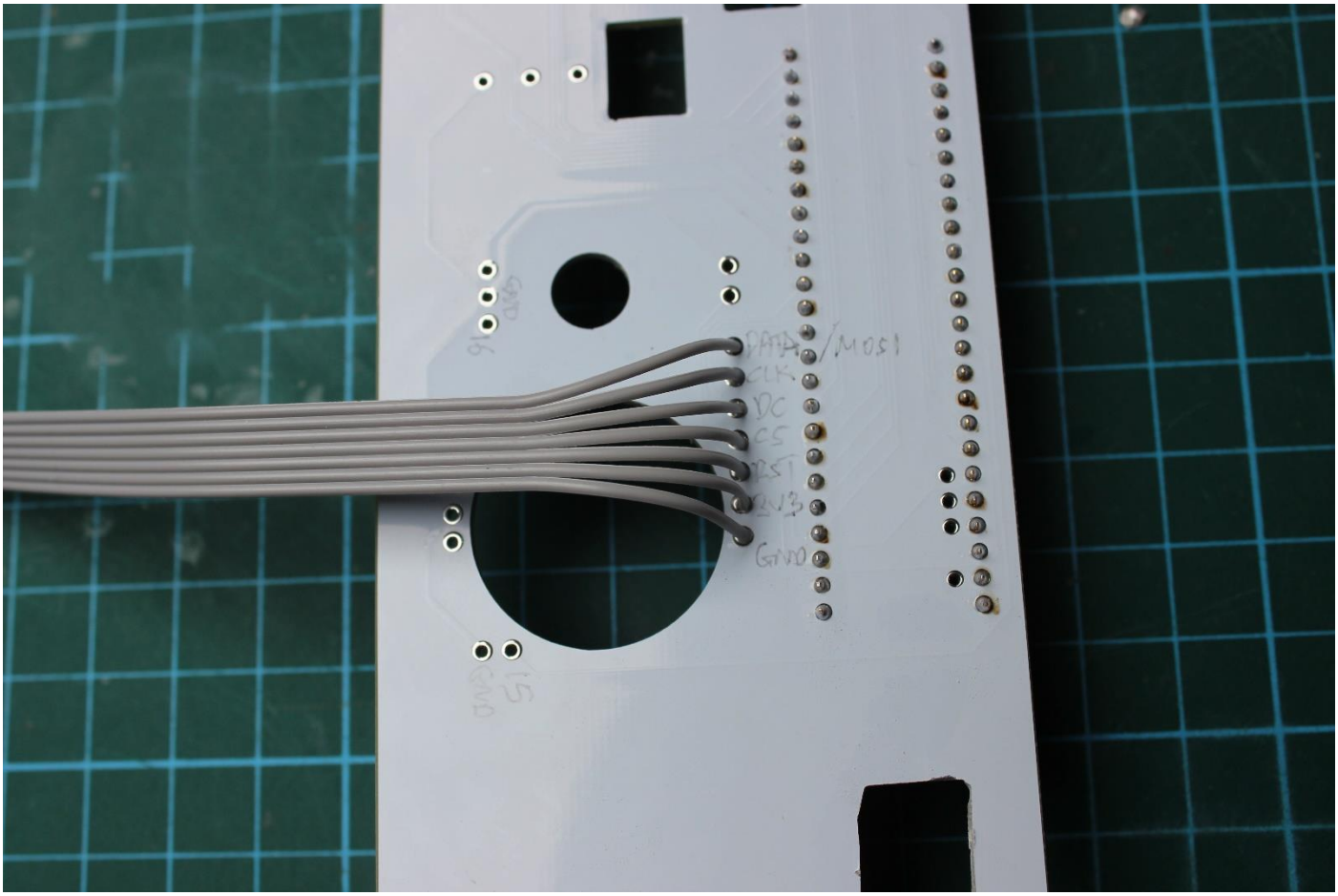


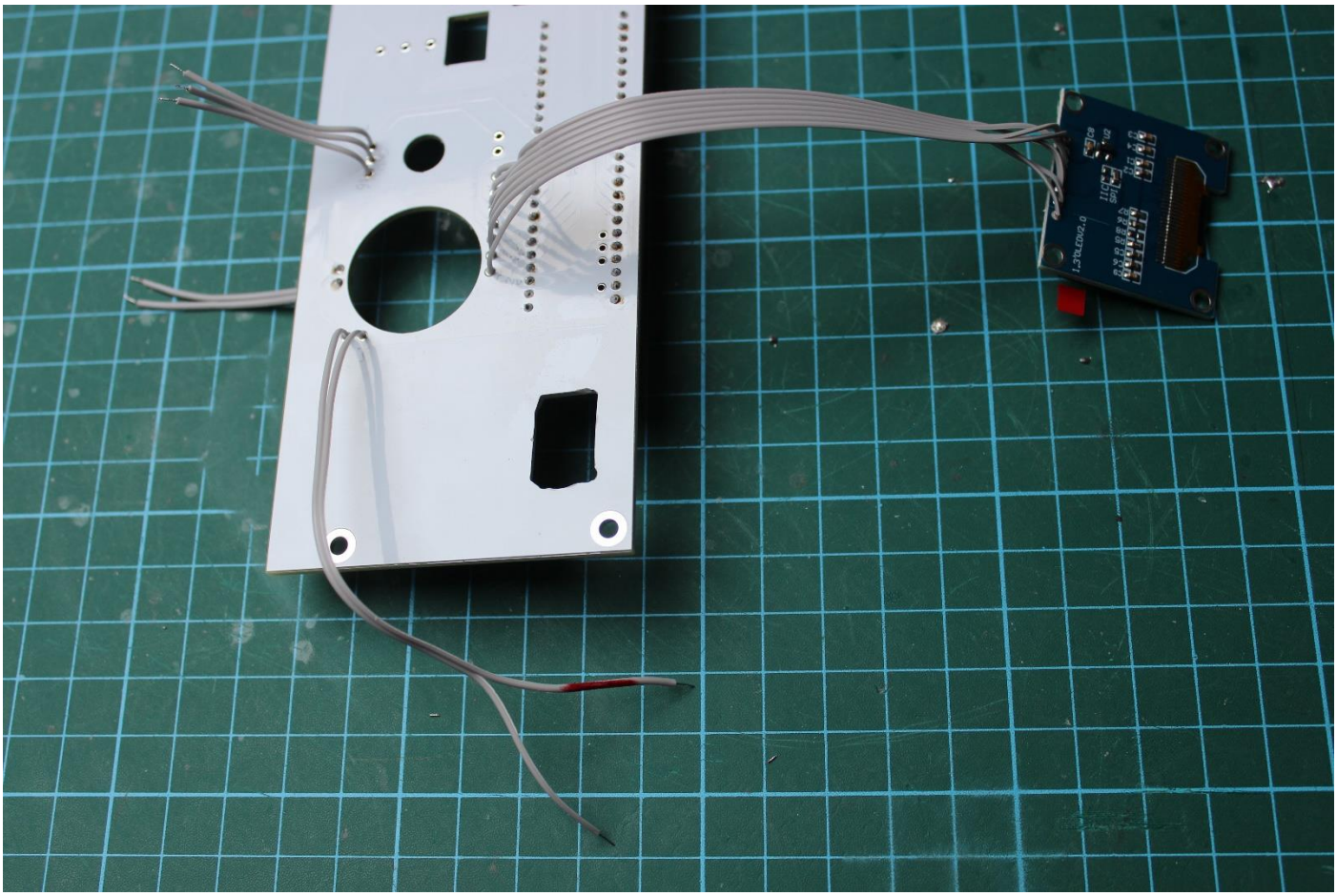
Solder in the 7 strand ribbon cable you made earlier from behind as shown above.



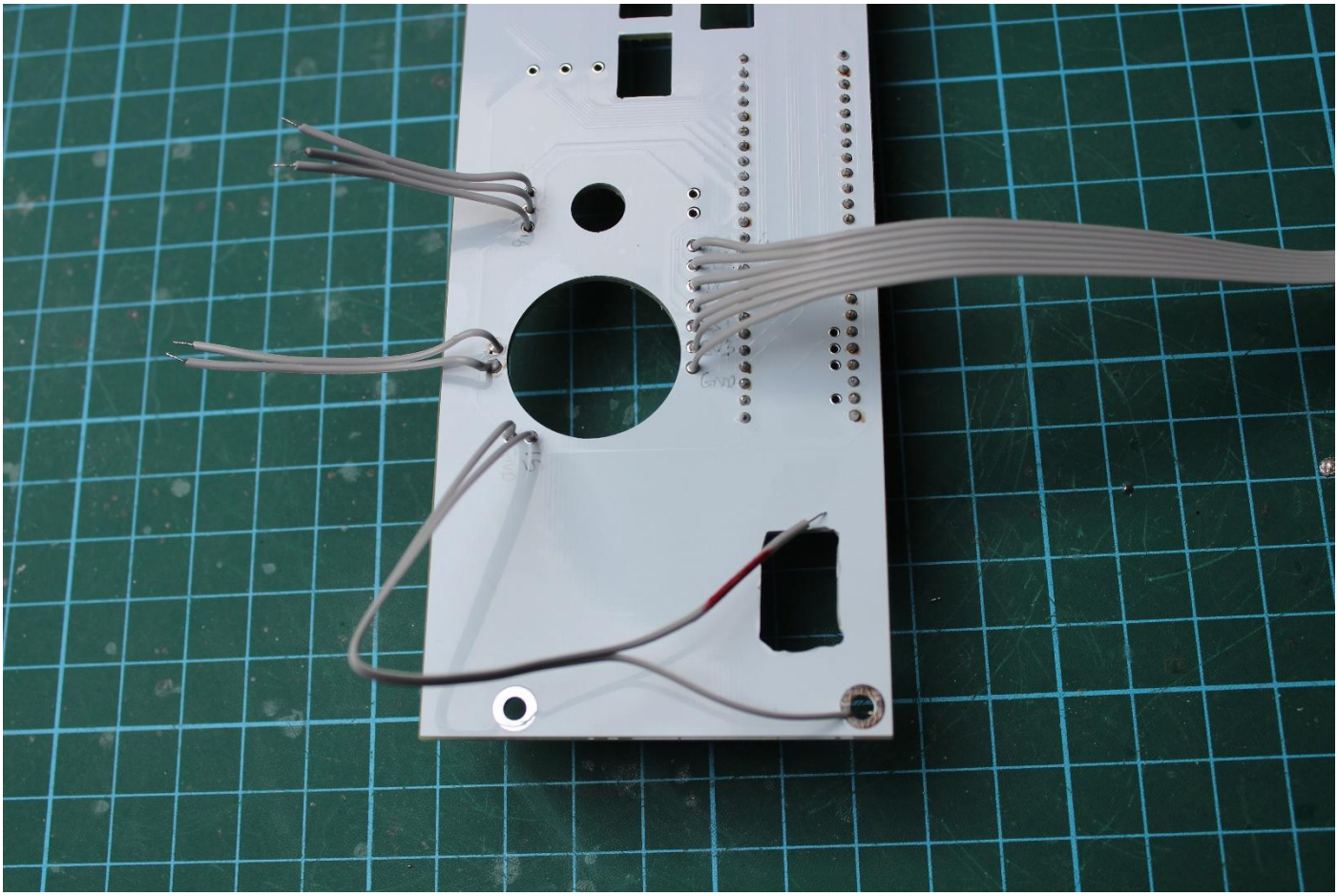
Solder the other ends into the OLED screen module according the way you have labelled the wires earlier. Be methodical. It is easy to make a mistake at this stage.



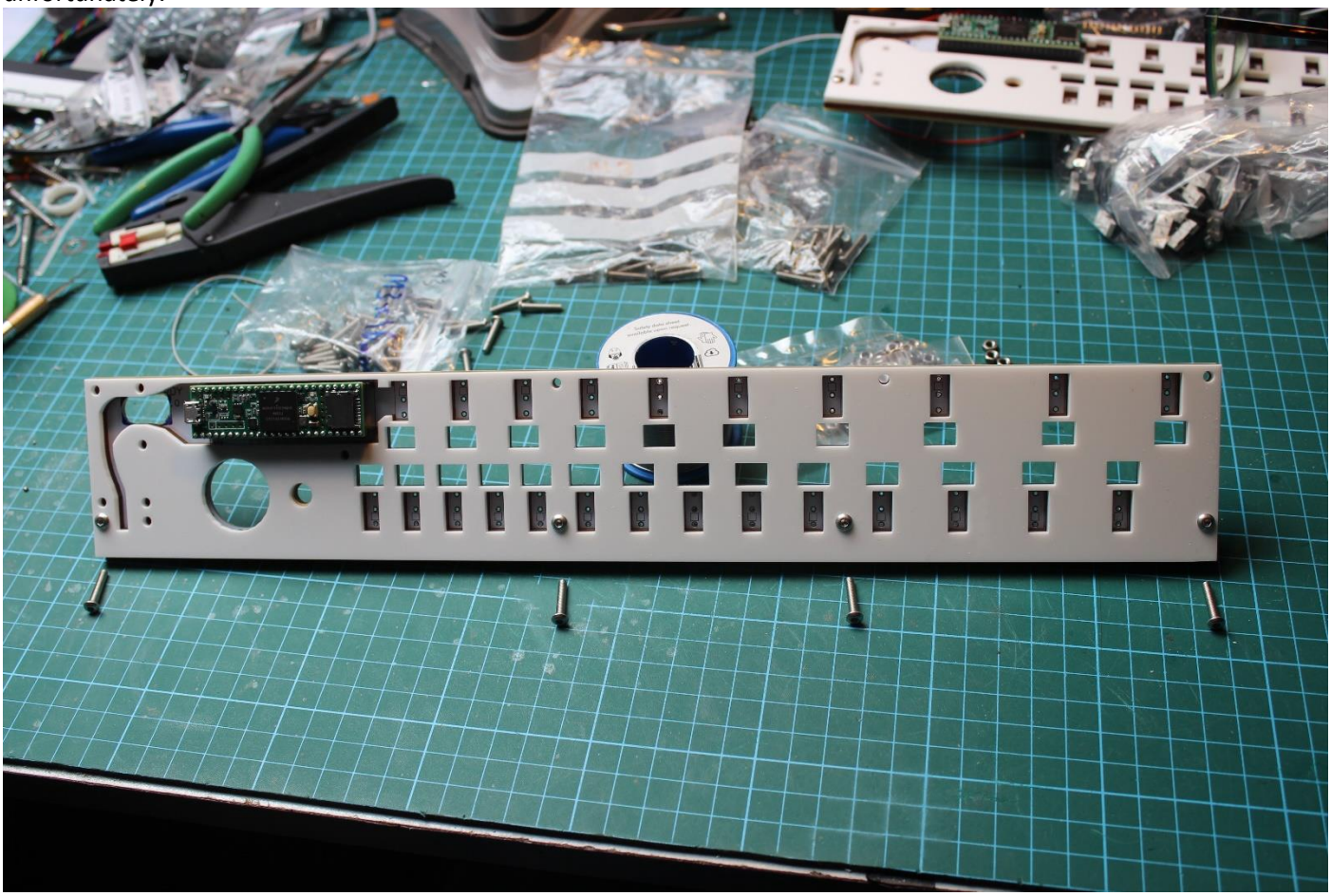




Next, solder in the remaining lengths of ribbon cable that you made earlier as shown.



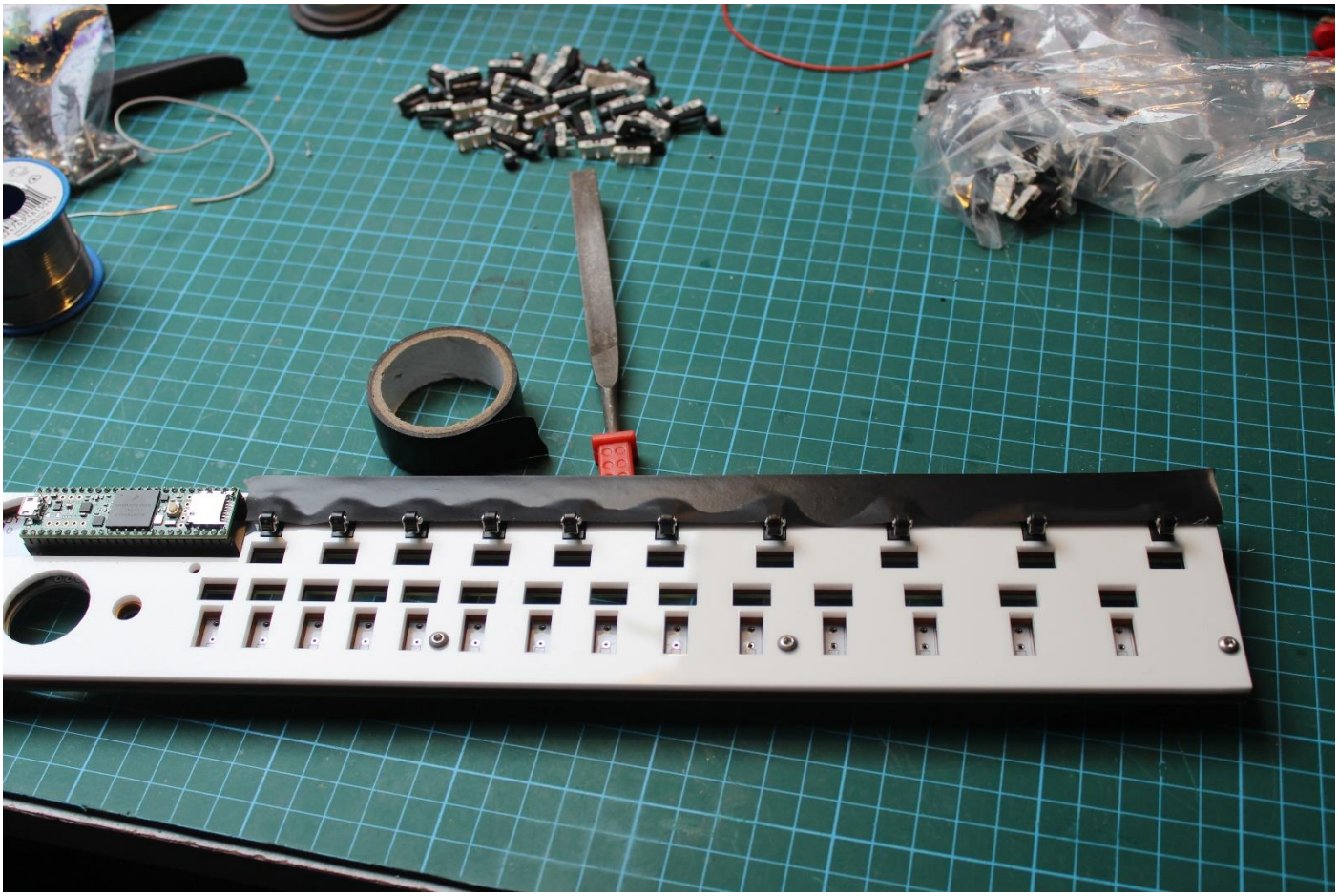
Mark the cable end from the Pin16 solder hole in red with a red felt pen. It is not shown very well in this photo unfortunately.



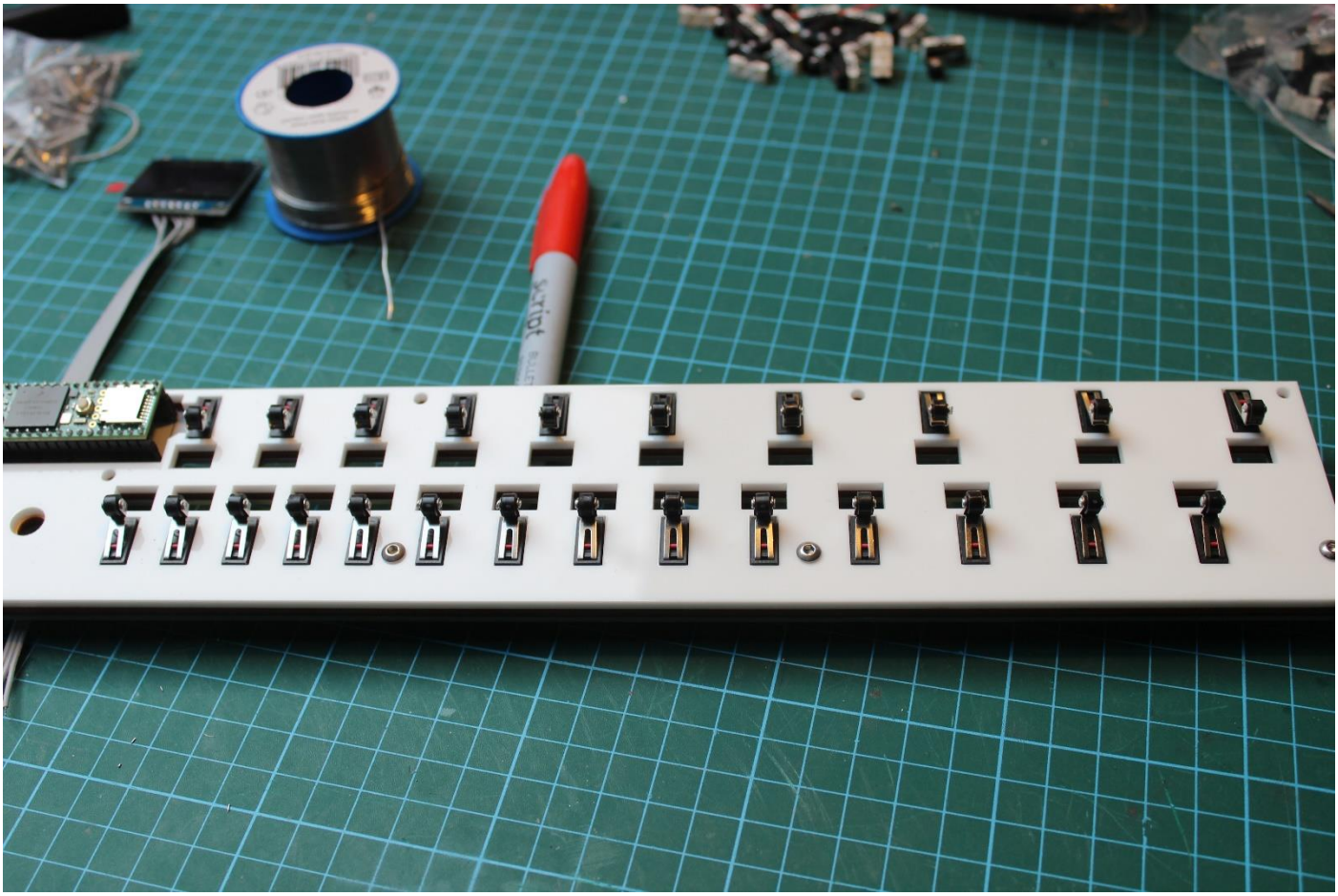
Put the 2 laser cut layers as shown with the PCB as the third layer. Then, bolt them together at the 4 points shown.

This is just temporary to hold the first 3 layers (with the circuit board as the third layer) together.

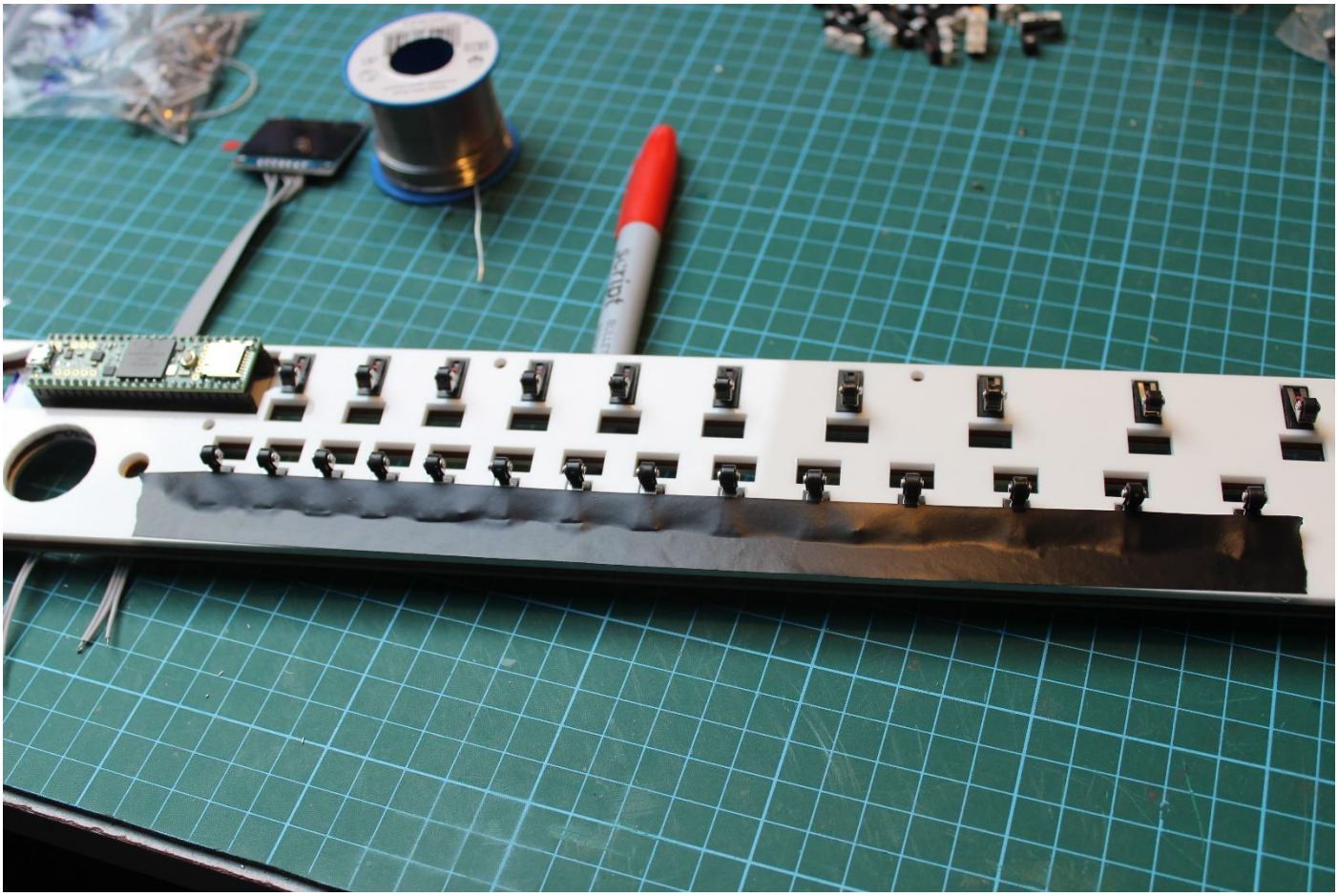
Place the top row of microswitches in place into the holes in the printed circuit board.



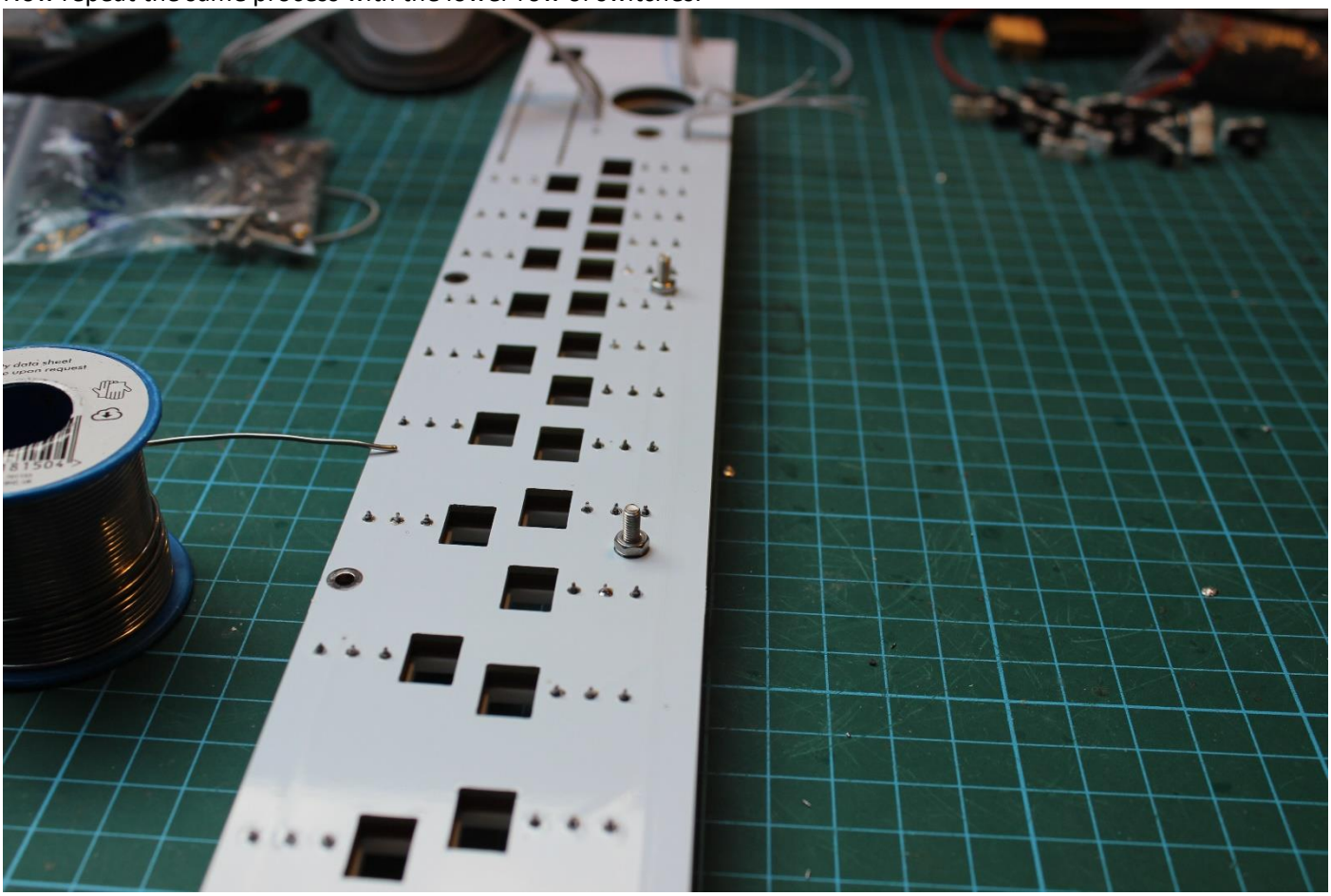
Use electrical tape to temporarily hold them in place. Do NOT stretch the tape as you do it, just press it down, otherwise it distorts the end switches inwards which you do not want to happen.



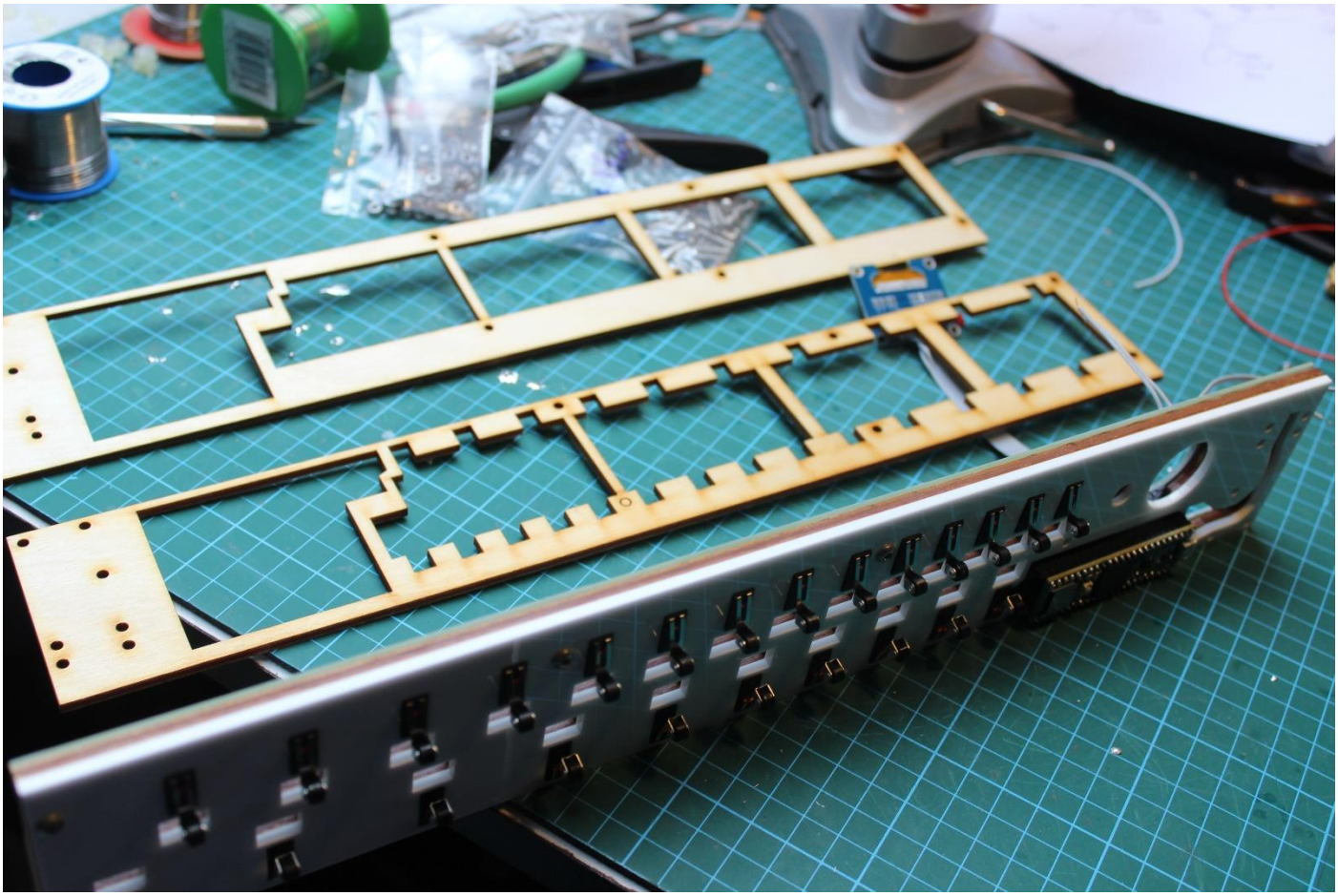
Top row is now soldered in and tape has been very carefully removed without damaging the switches.



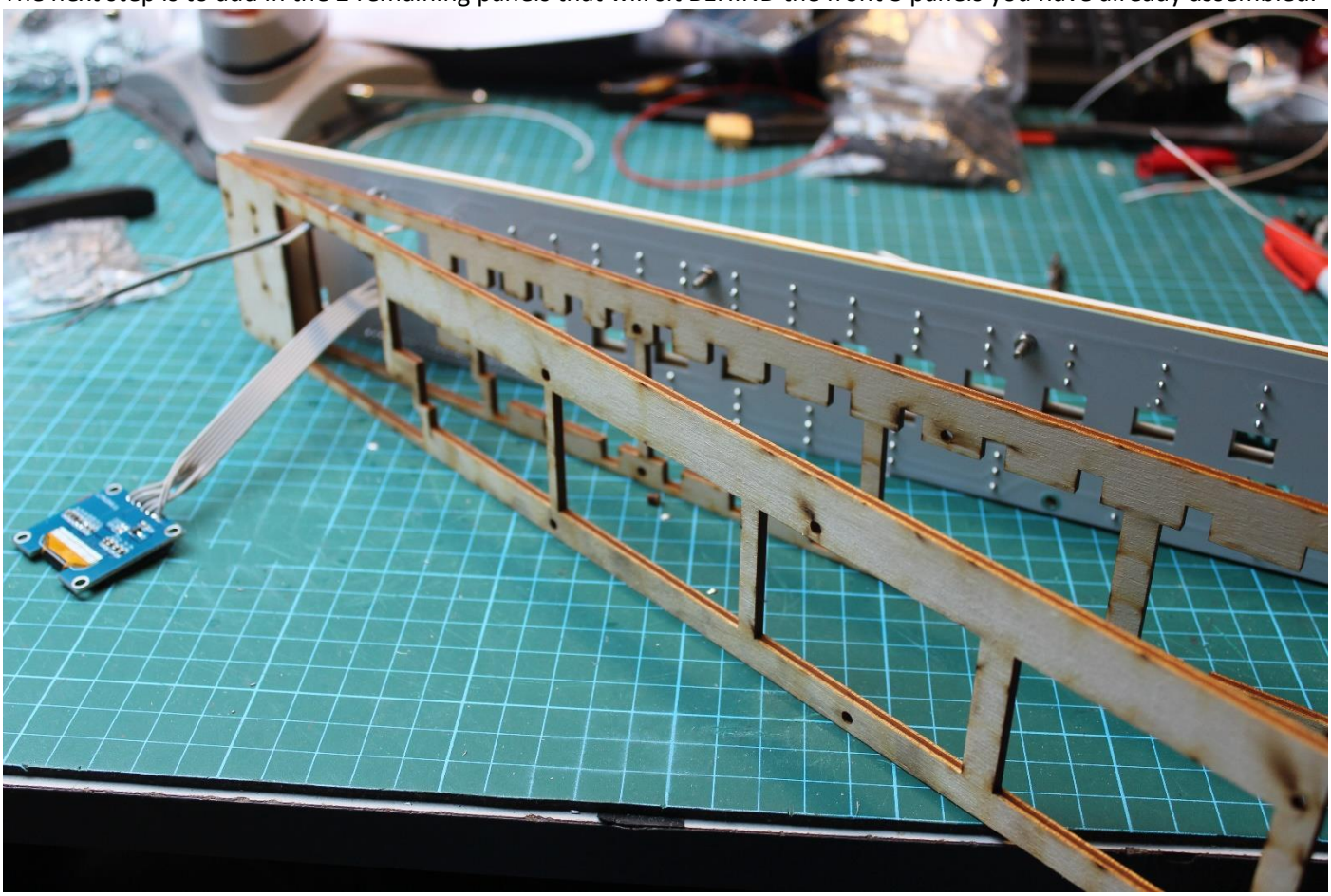
Now repeat the same process with the lower row of switches.



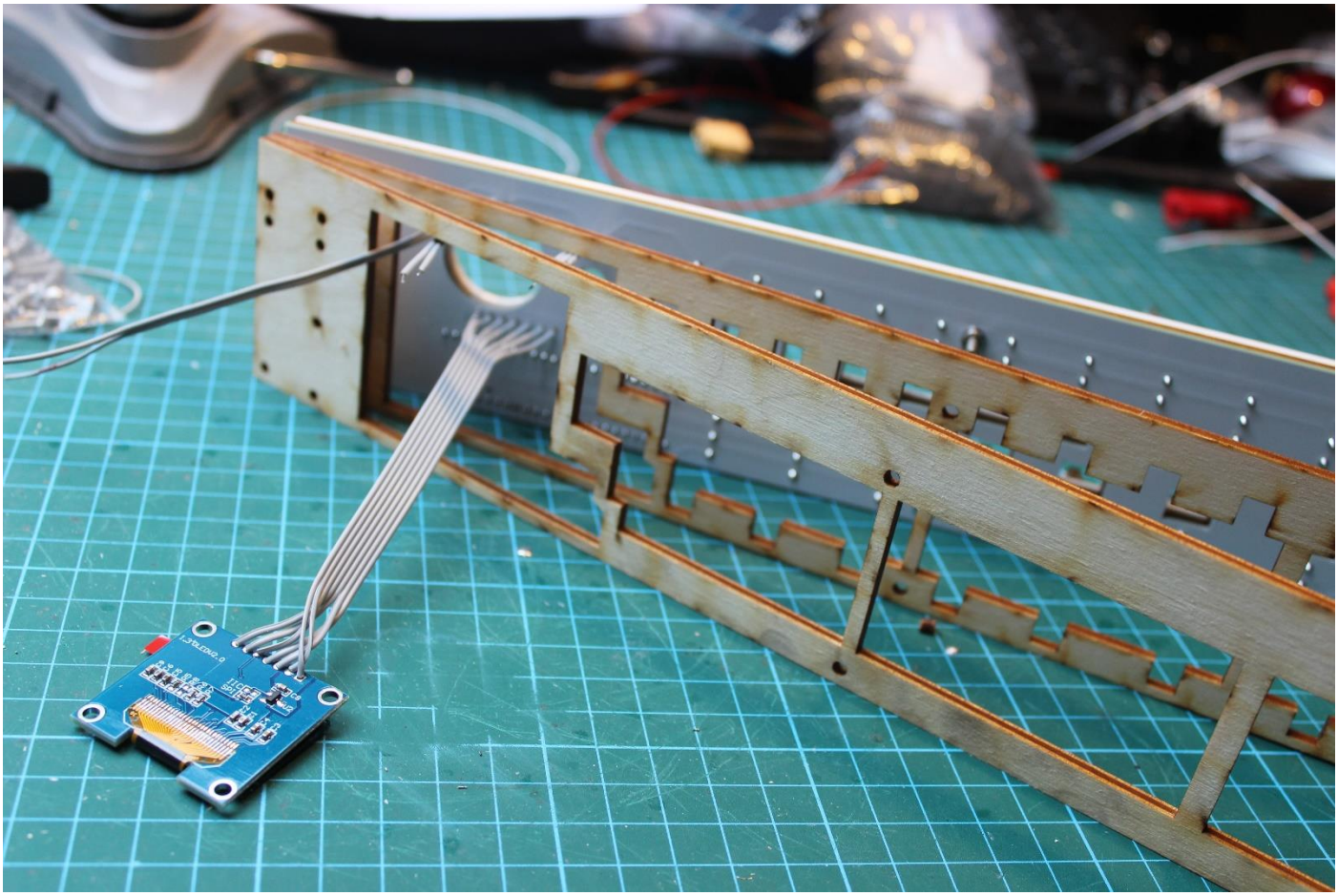
x



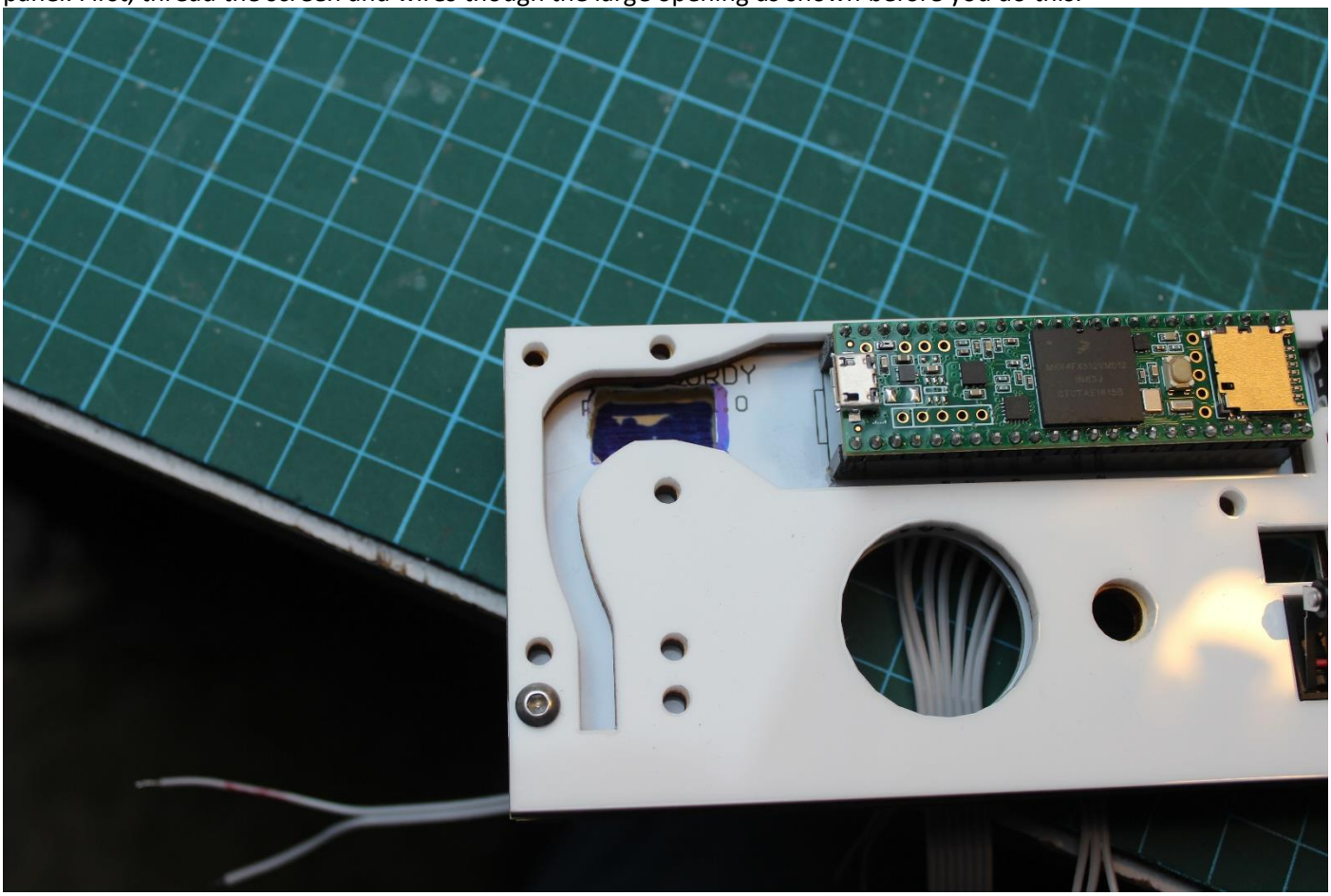
The next step is to add in the 2 remaining panels that will sit BEHIND the front 3 panels you have already assembled.



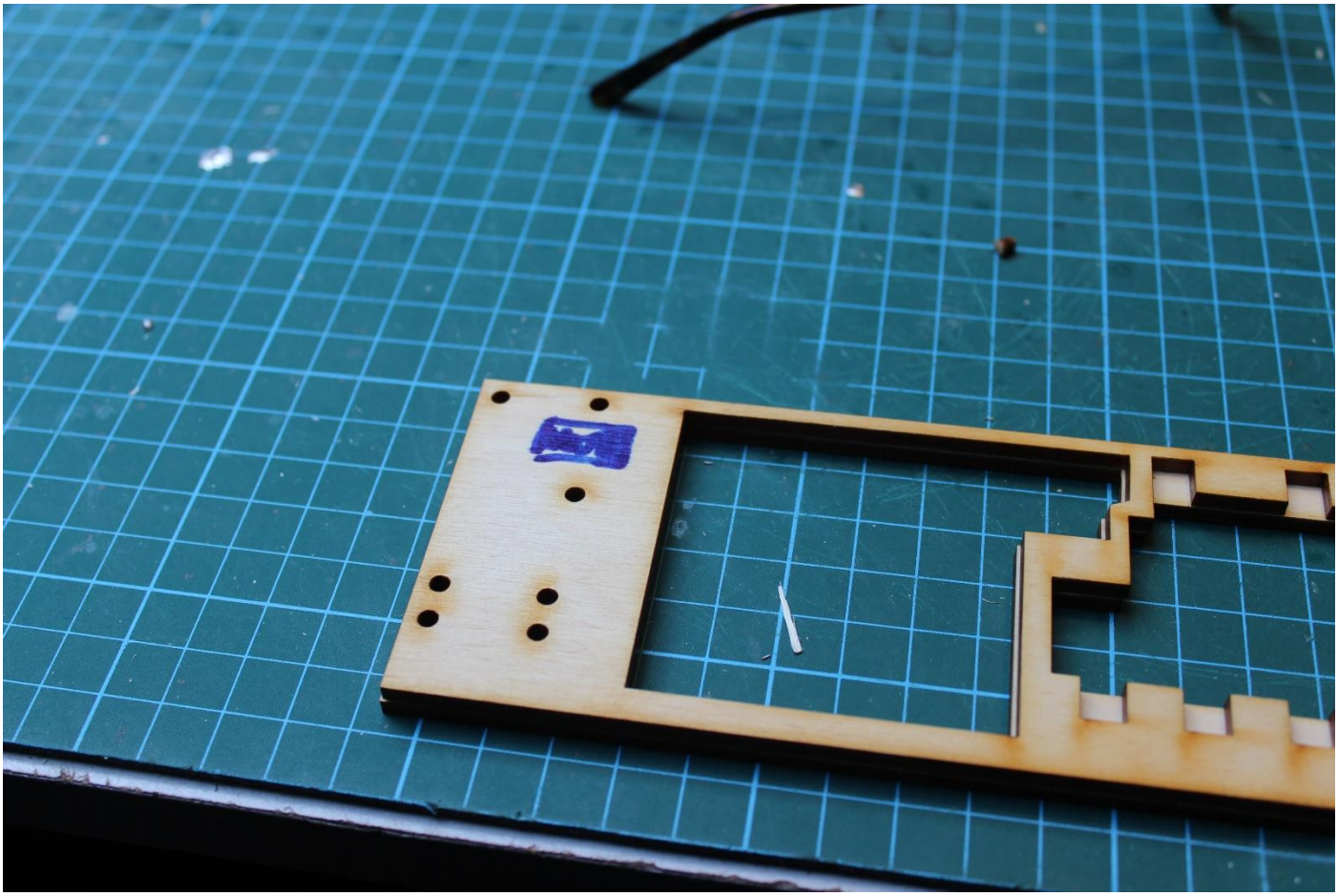
Unbolt the four nuts and bolts you used earlier to bolt the first 3 panels together.



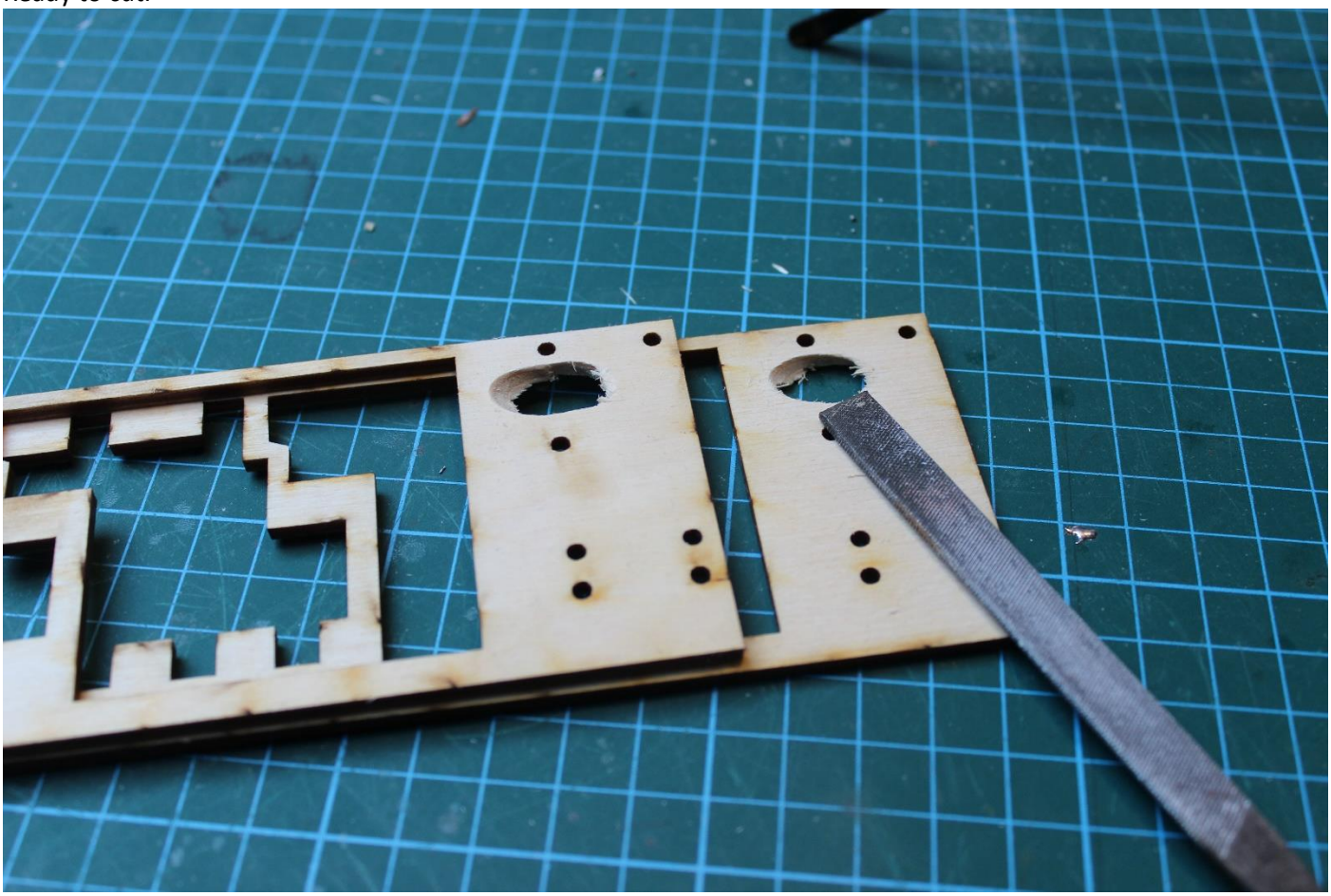
Add in the 2 remaining laser cut layers to make a 5 layer sandwich with the printed circuit board as the middle of 3rd panel. First, thread the screen and wires though the large opening as shown before you do this.



Before you bolt it all together, you need to extend the hole you made in the PCB so it also runs through the laser cut 2 rear panels you are about to add in. Mark the wood panels as shown and cut them to match the hole you made in the printed circuit board.



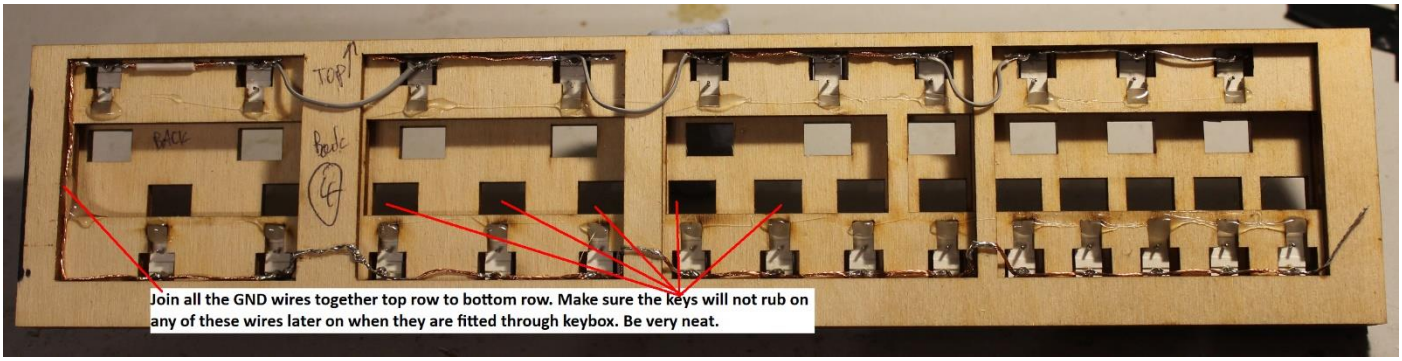
Ready to cut.



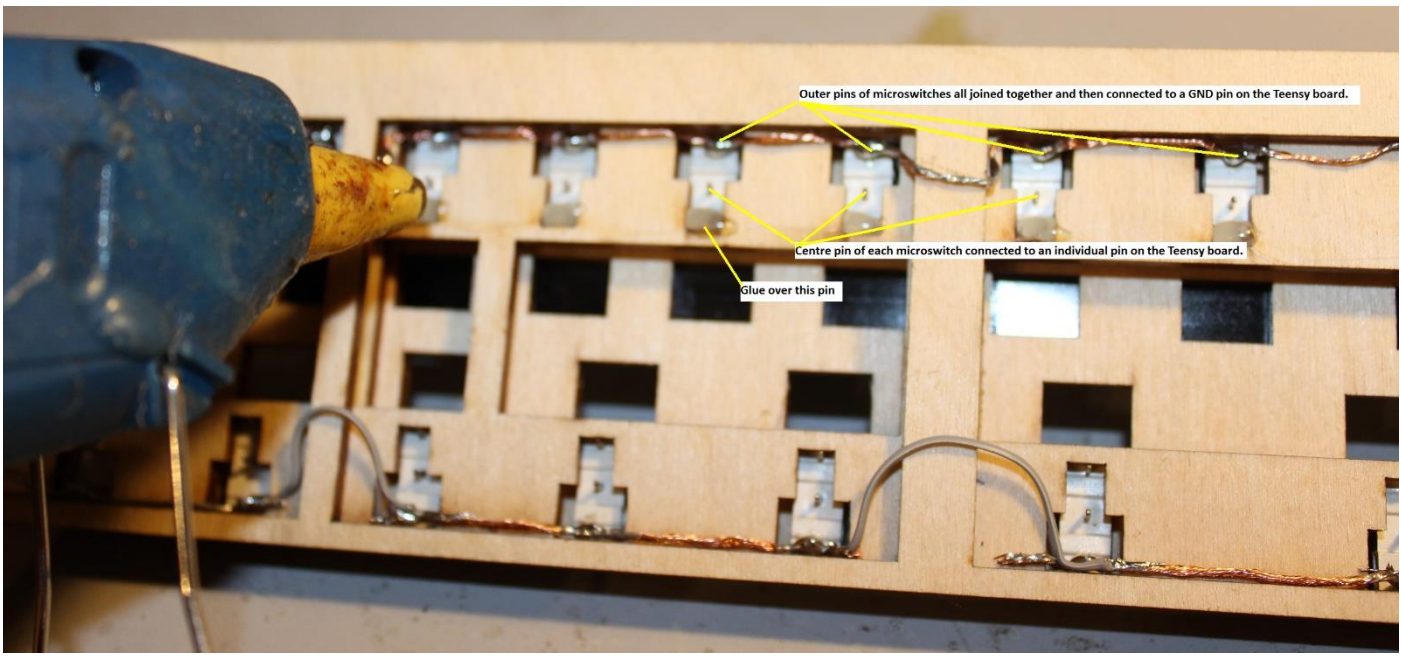
File the holes to tidy them up and make them a bit more like a rectangle. File off any burrs so that when you eventually bolt the layers together no loose wood fragments get trapped between them.

OK, now bolt the 5 layers (where the printed circuit board is layer 3) together with the 4 nuts and bolts you originally used.

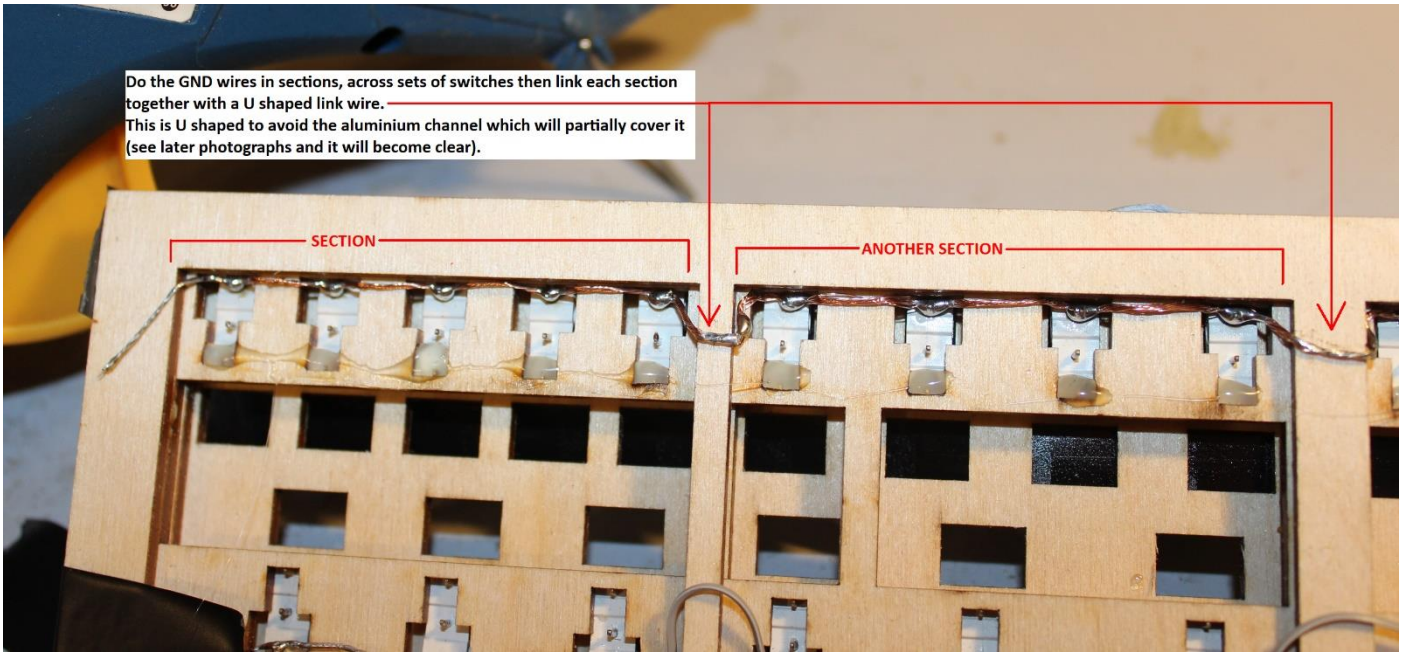
ALTERNATIVE METHOD OF WIRING KEYS IF YOU DO NOT USE A PRINTED CIRCUIT BOARD



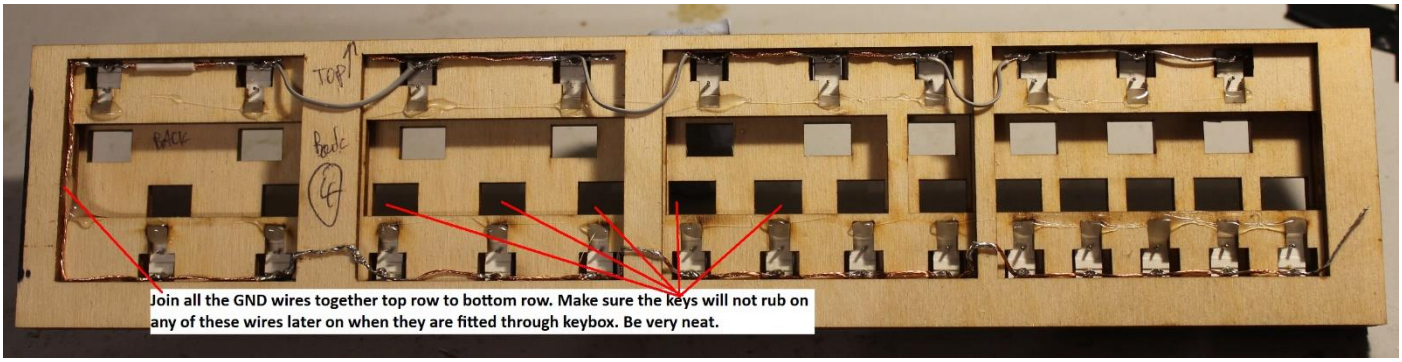
Join all the GND pins (the outer pins next to upper and lower edges of the ply panel) together. Do this very neatly so wires will not foul the keys as they run through the keybox – see later steps (slightly older version of the DigiGurdy shown here but the principles are the same).



Glue, using a hot glue gun or epoxy glue in small amounts, the inner pins of the switches to the surrounding wood. Do not cover the central pin of each switch with glue however, take it slowly.



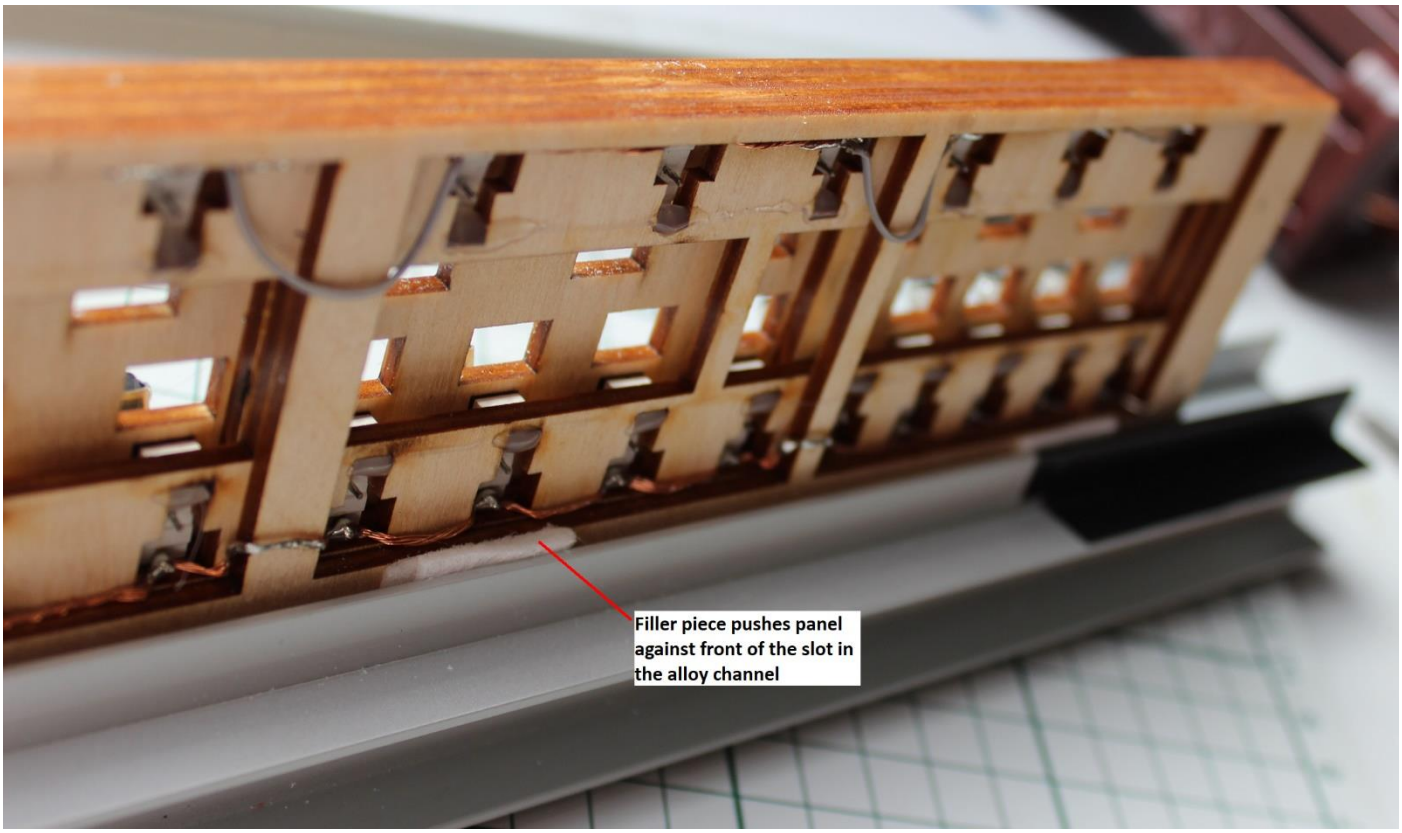
Join the sections of GND linked switches together with U wires.



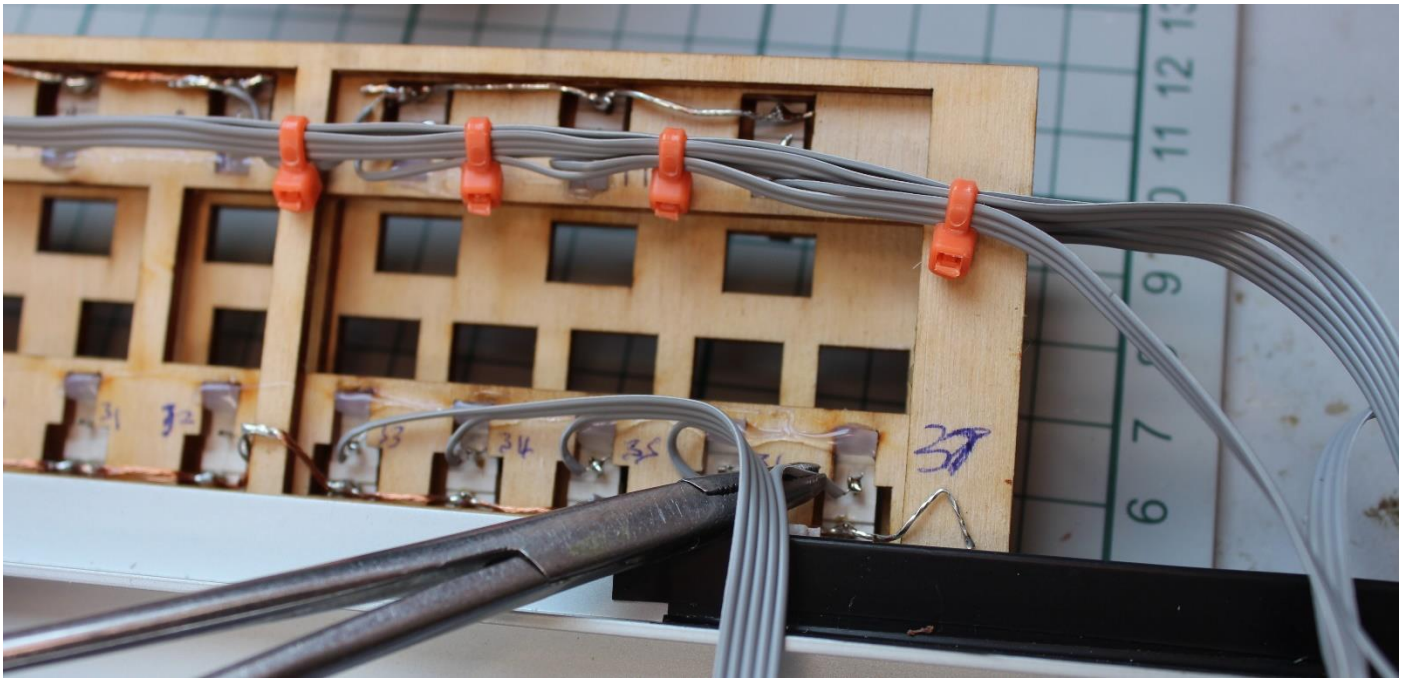
Link the upper and lower runs of GND wires together.

Part 4: *Test assembly and routing of the wires so they do not conflict with the keys that will run through the keybox from front to rear sides.*

Insulate part of extrusion with electrical tape so it does not short out any pins on the Teensy board later on, which will be located here.



Insert front panel sandwich of 4 layers into the lower front piece of alloy extrusion. Use cardboard filler strips or similar about 2mm thick to push the wooden section forwards against front edge of the slot it is resting inside, so that it is gripped quite tightly within the lower front alloy channel.

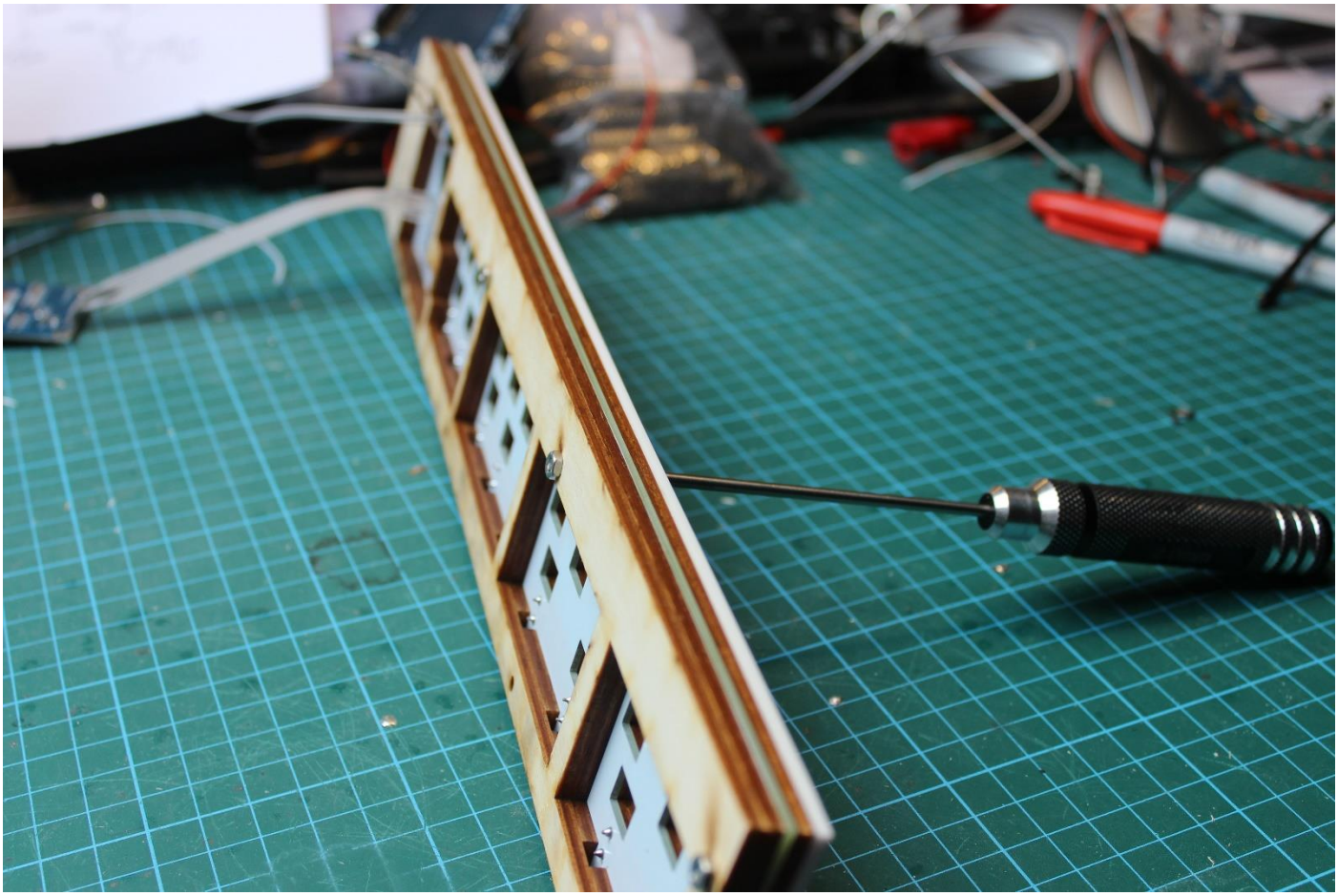


Start soldering wires to centre pin of each microswitch as in the wiring diagram. Each wires runs to a specific pin on the Teensy board (see separate wiring diagram document).

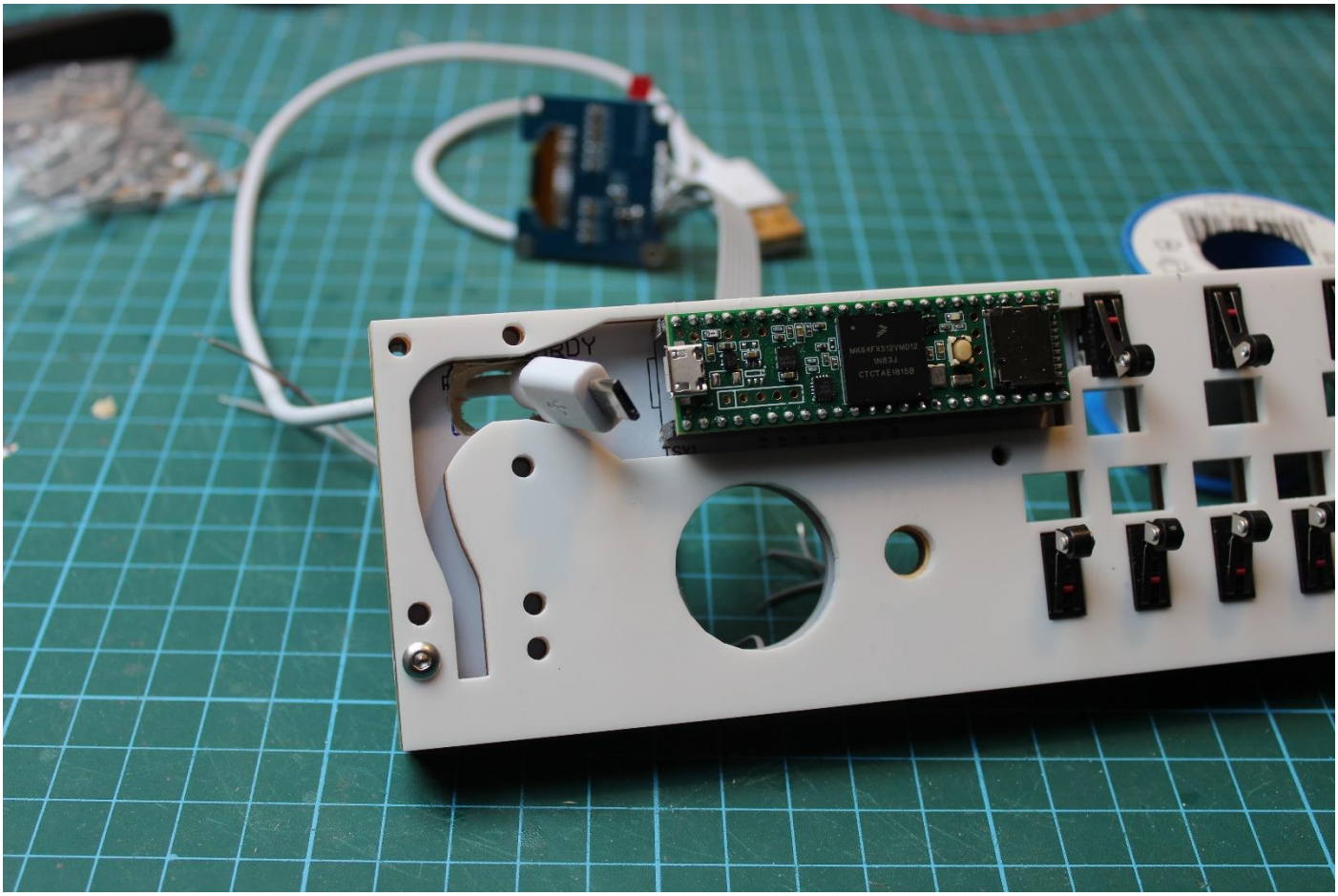
Wires from upper row of microswitches arc around to right then into the Teensy, as shown here, so they will miss the keys once tidied up and stowed inside the right hand end 3D printed assembly (not shown here).
NB: Remember to solder a wire from the end of the wire that runs continuously joining all the GND terminals of the microswitches to a single GND pin on the Teensy (I forgot this and had to take whole thing apart to remedy it).

---------- END OF ALTERNATIVE METHOD OF WIRING EVERYTHING UP ----------

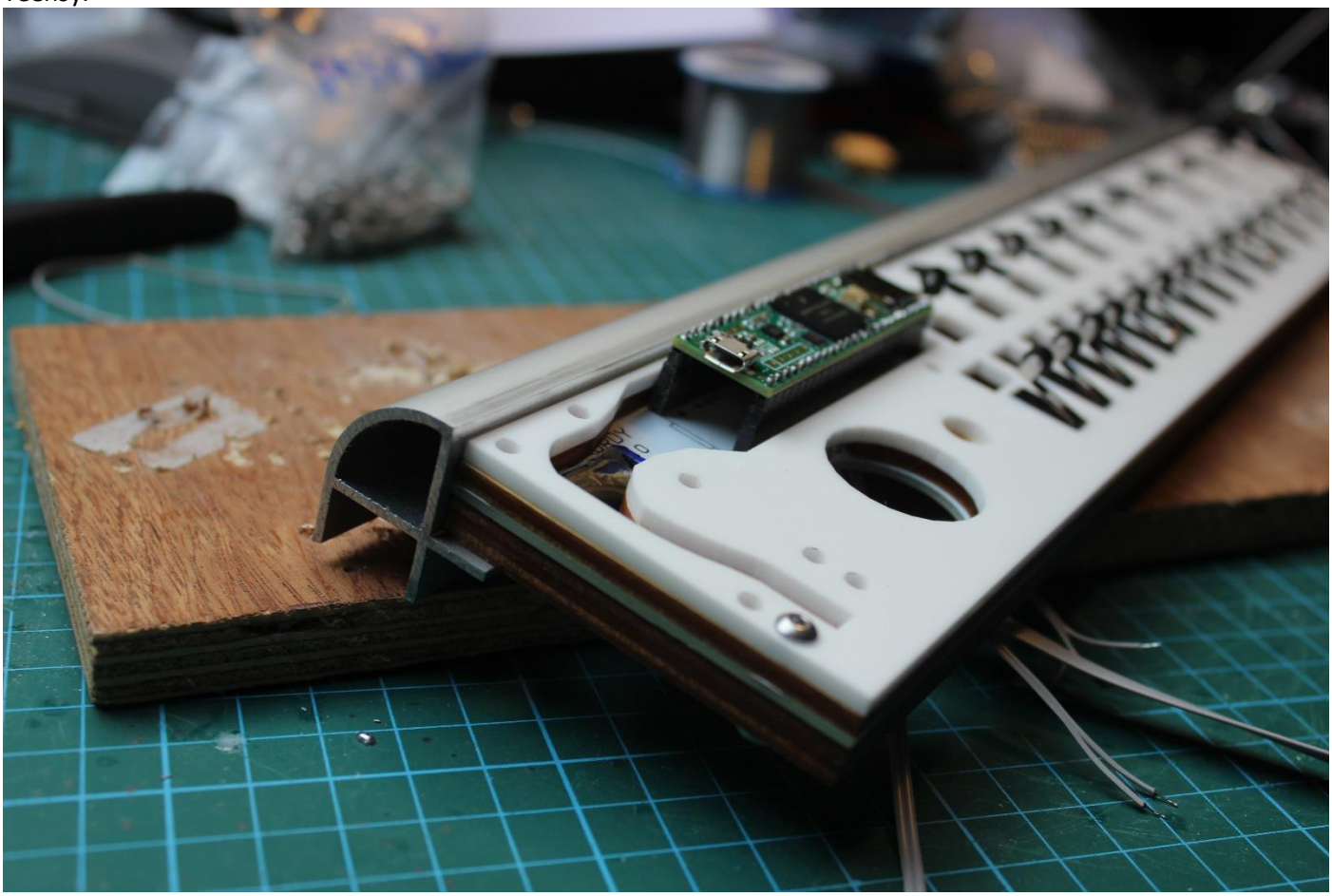
Continuing the build ……



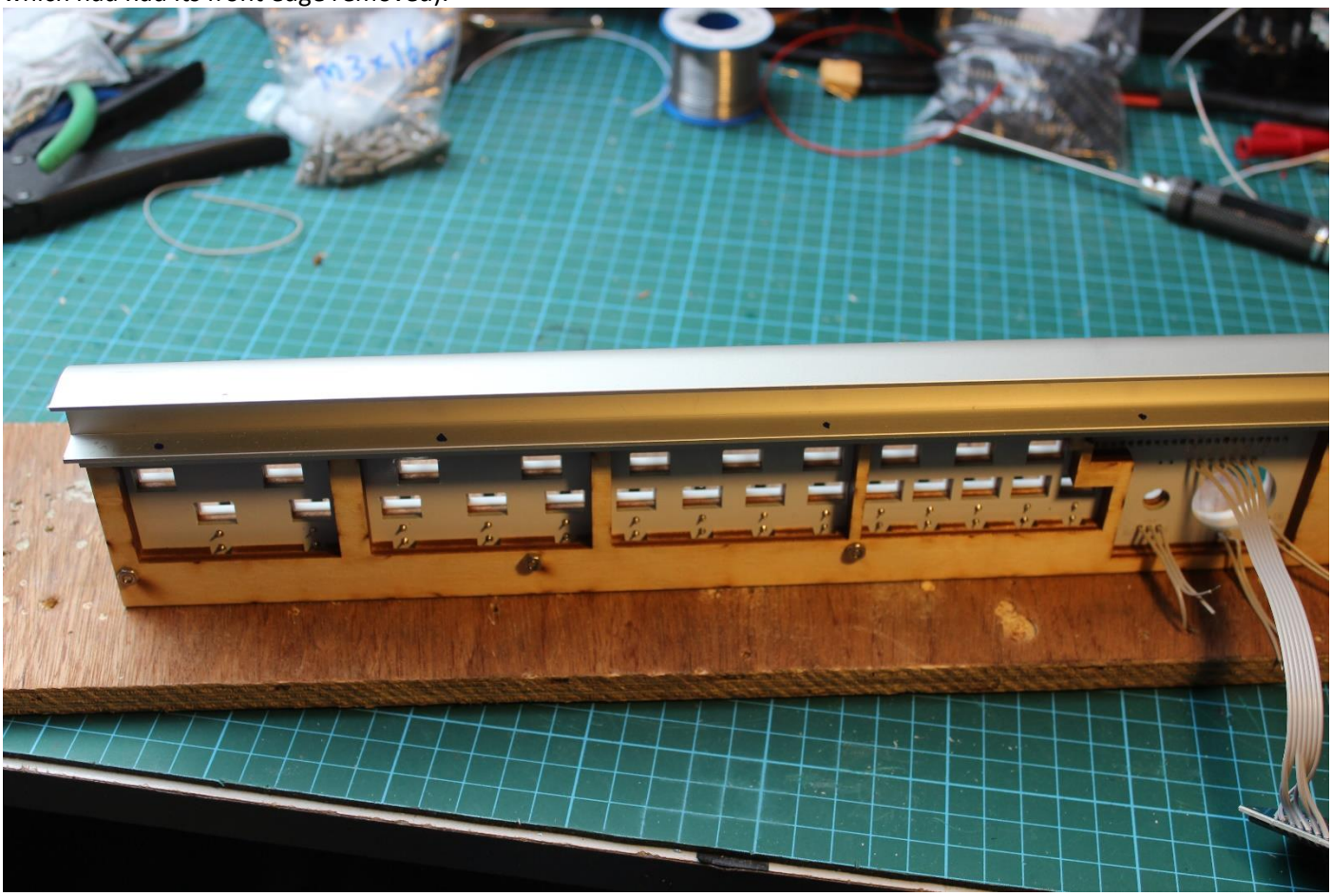
x



Check the micro-USB plug will still fit OK through the holes you have made so it can be plugged into the end of the Teensy.

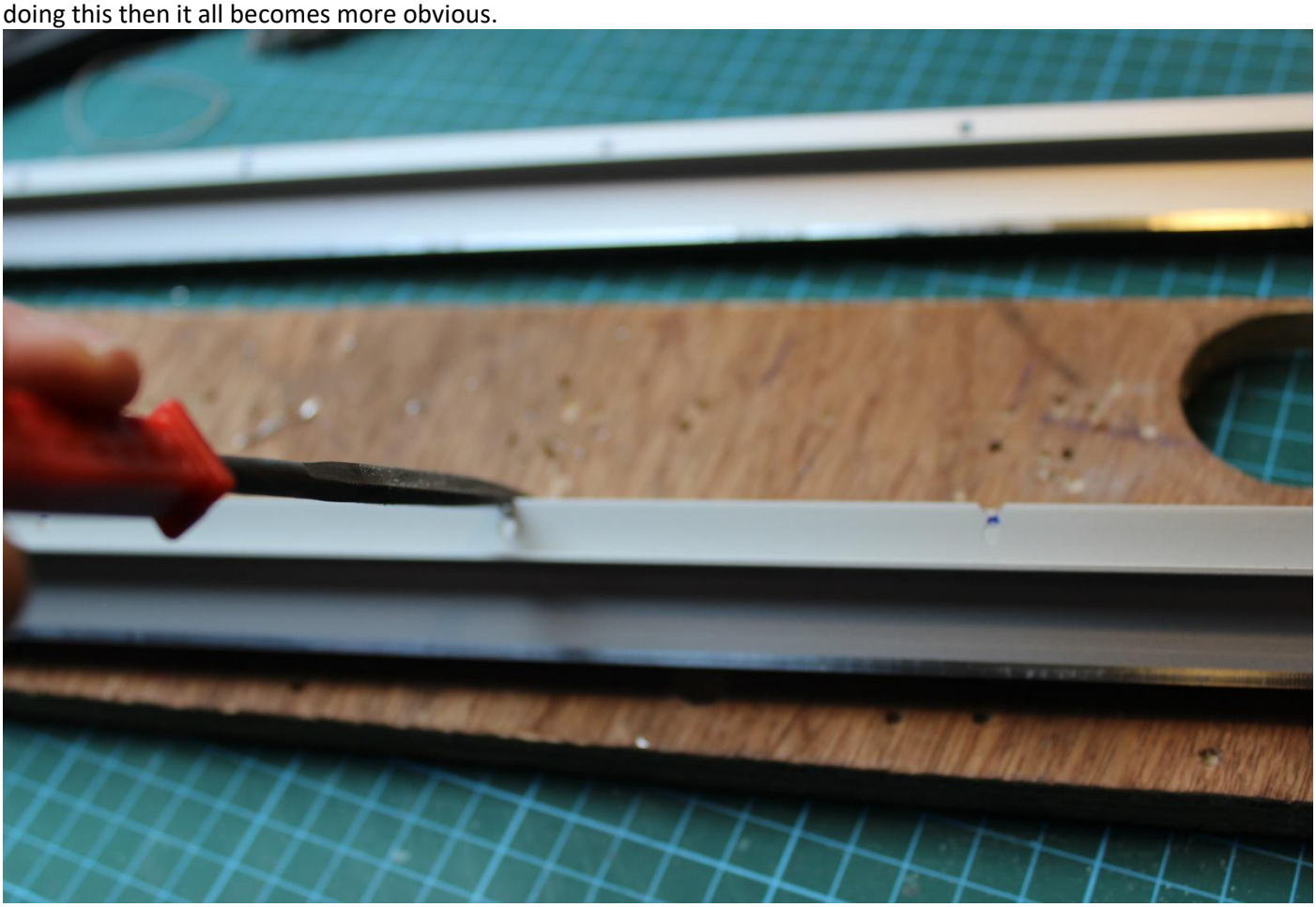


Next step. As a test, line up your 5 layer front sandwich of panels carefully with the top front alloy extrusion (the one which had had its front edge removed).



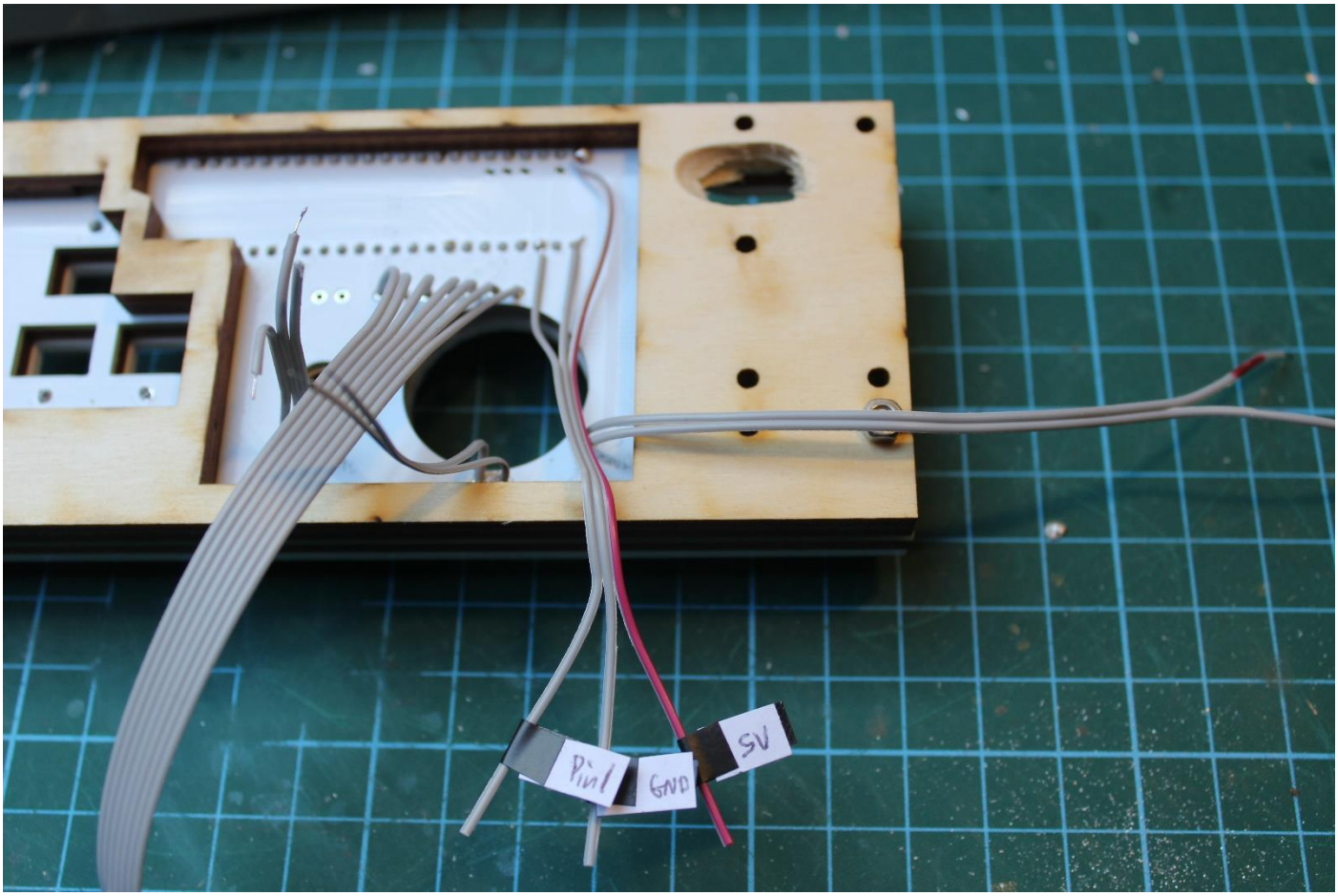
Make a row of dots with a felt tipped pen approximately as shown. These will be drilled to make holes to take cable ties. These cable ties will hold the USB cable away from the key stems as it runs though the body of machine and out if its left hand end.

Drill them out with a 3mm or similar drill bit. Take care, be patient. Look at next few images to see why you will be doing this then it all becomes more obvious.

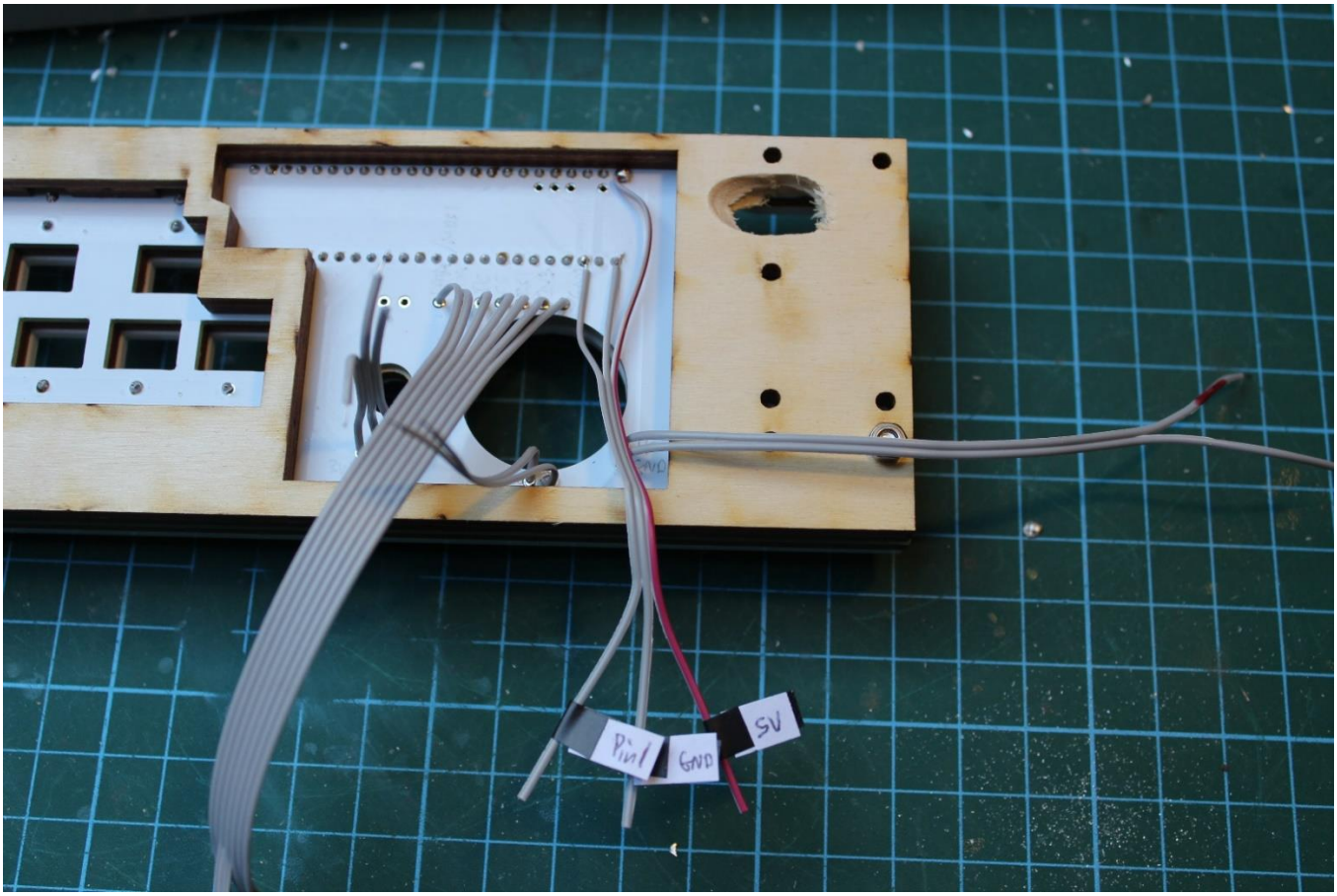


File a notch directly adjacent to each hole as shown.

A better view.

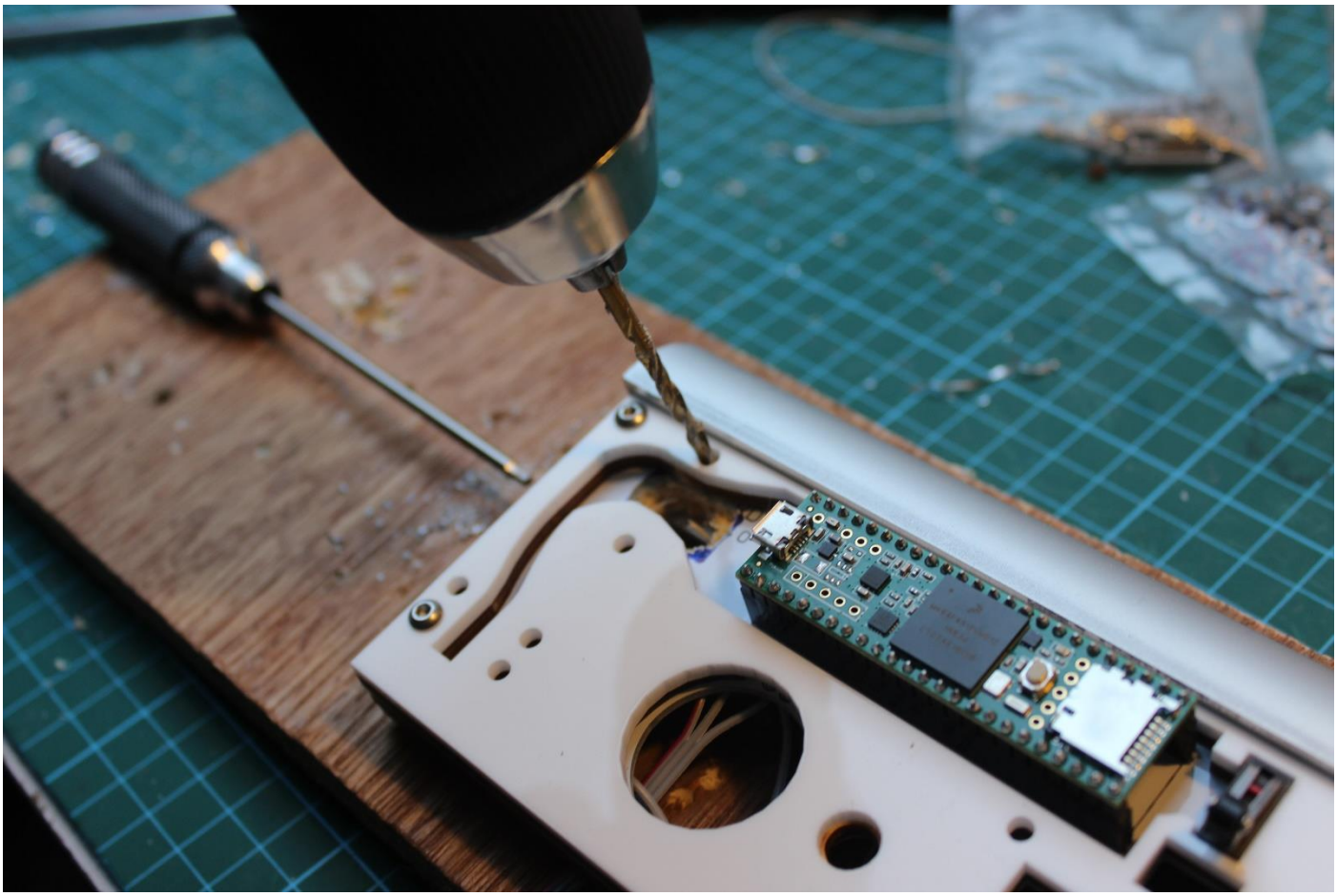


Next, we make a wire with 3 strands as shown. Solder it to the BACKS of the following pins on the Teensy: Pin 1 (Tx), GND(Ground) and Vin(which is where the 5V power comes into the Teensy). Label the ends of the wires as once you assemble things they will be partially covered up.

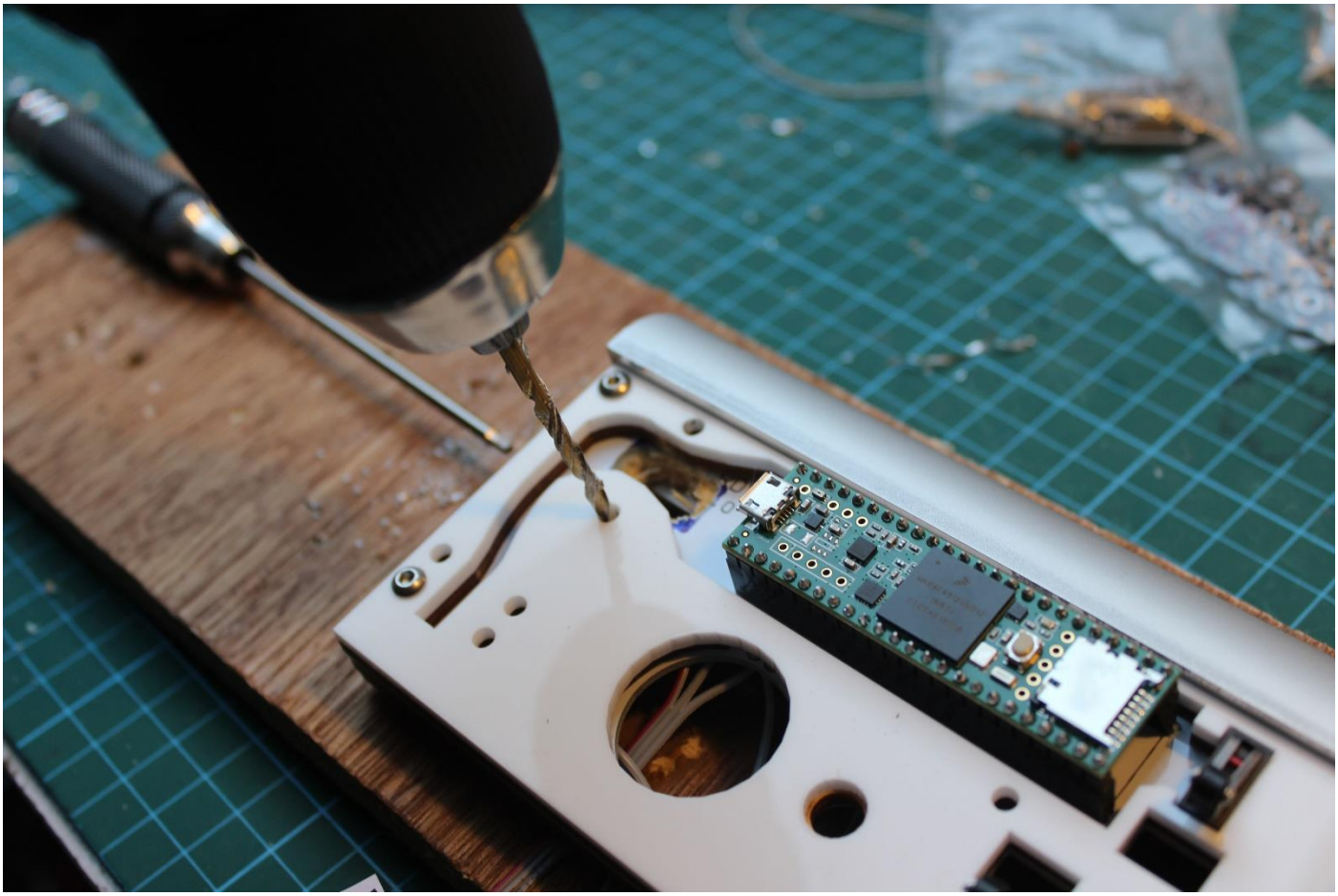


Drill the top row of holes in the white panel with a 3mm drill bit so you now go all the way through the alloy behind. Make sure it is lined up as shown and central. Put a 3mm (M3) 20mm long bolt through each hole and essentially bolt the top front alloy extrusion to the front sandwich of 5 panels.

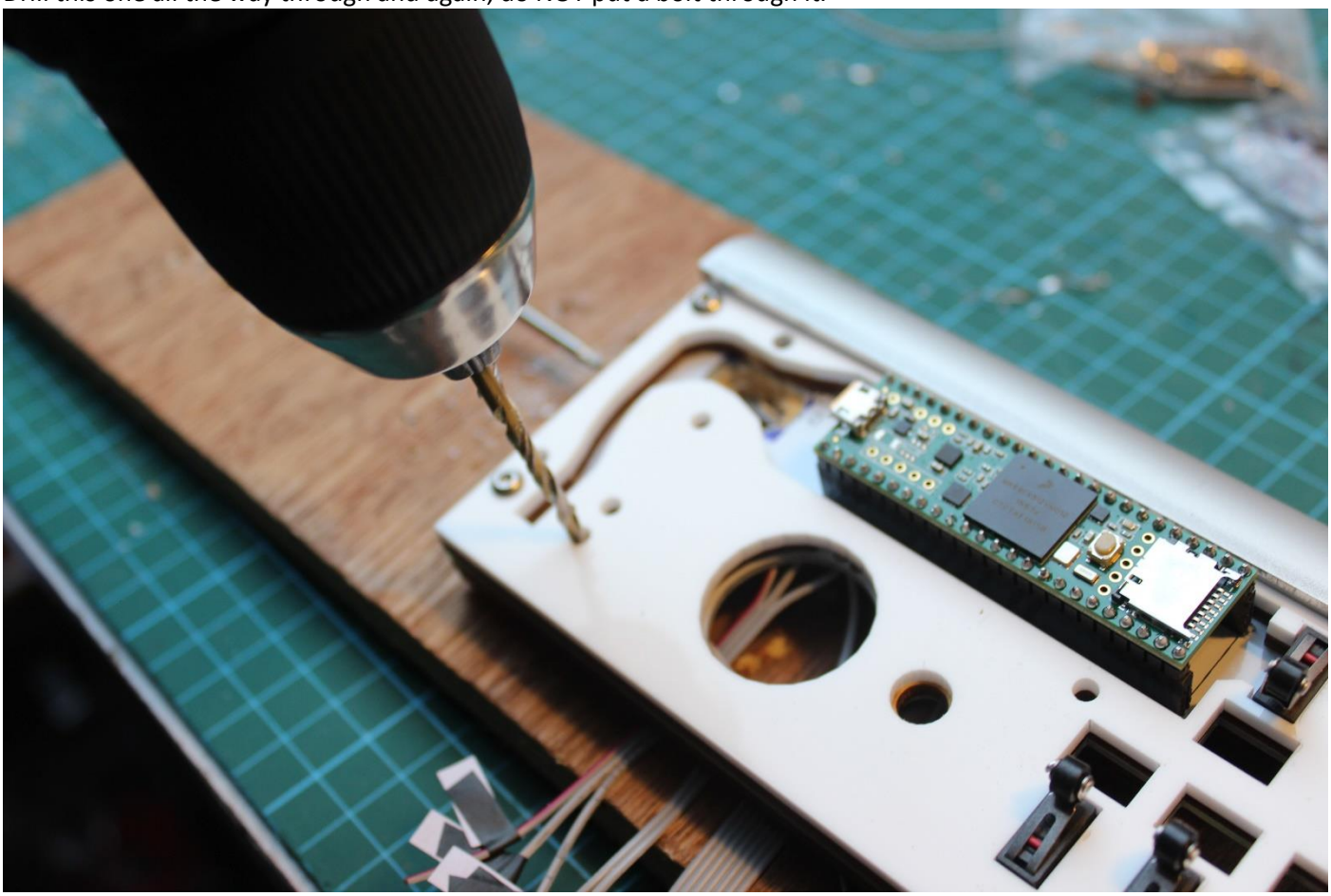
x



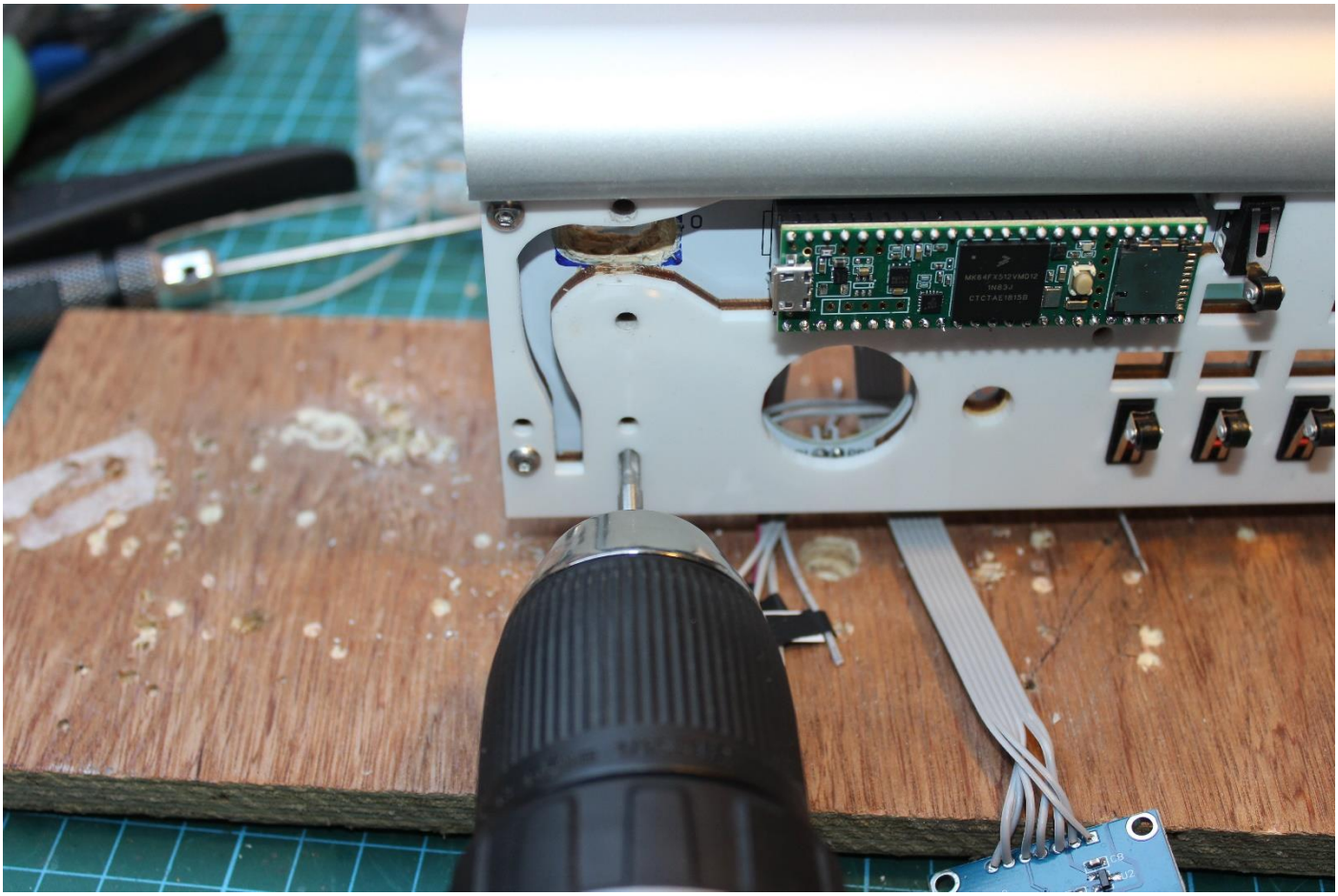
Drill this hole in the upper row but unlike the other top row holes, do NOT put a bolt through it.



Drill this one all the way through and again, do NOT put a bolt through it.

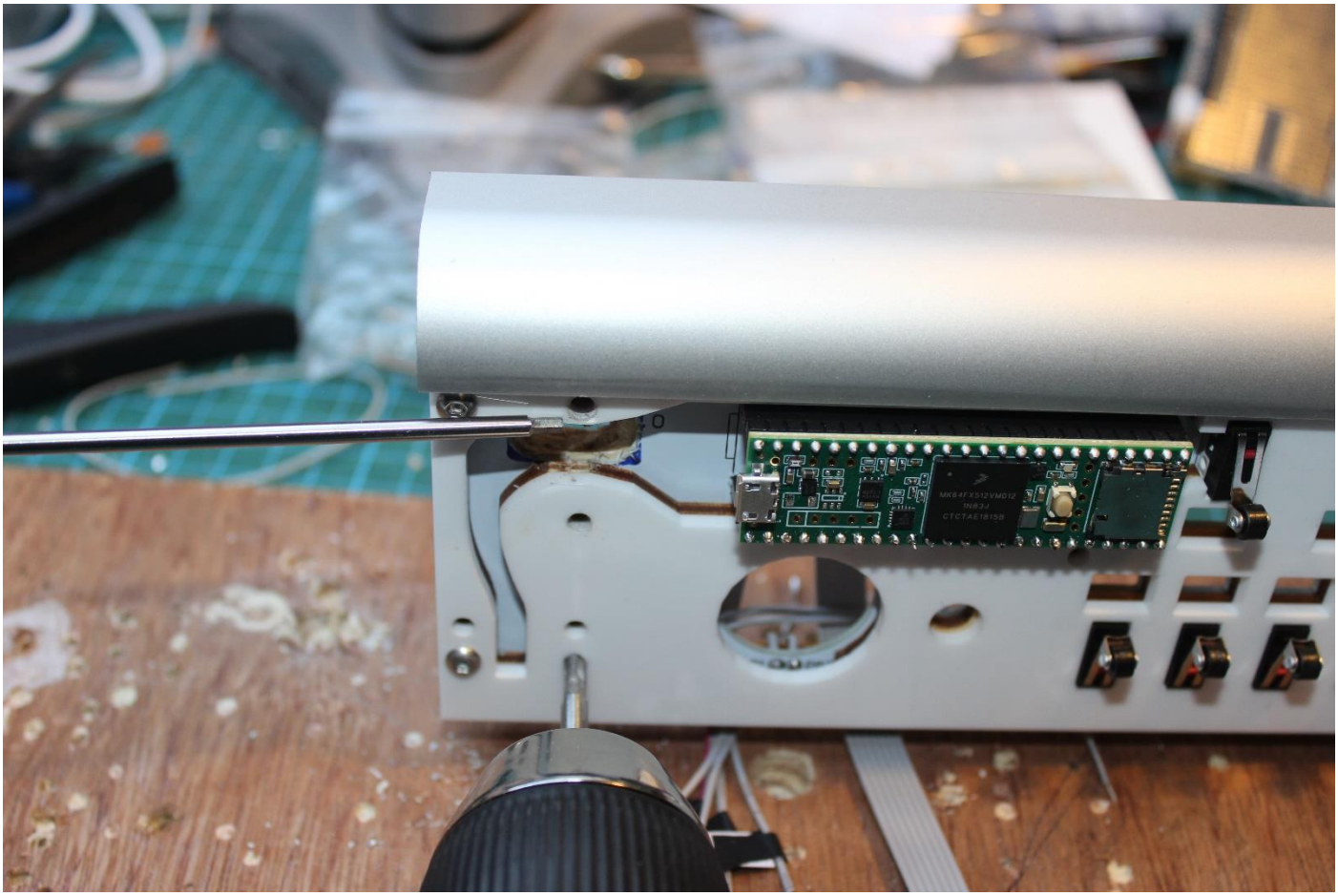


Finally, drill this hole all the way through and again do NOT put a bolt through it.

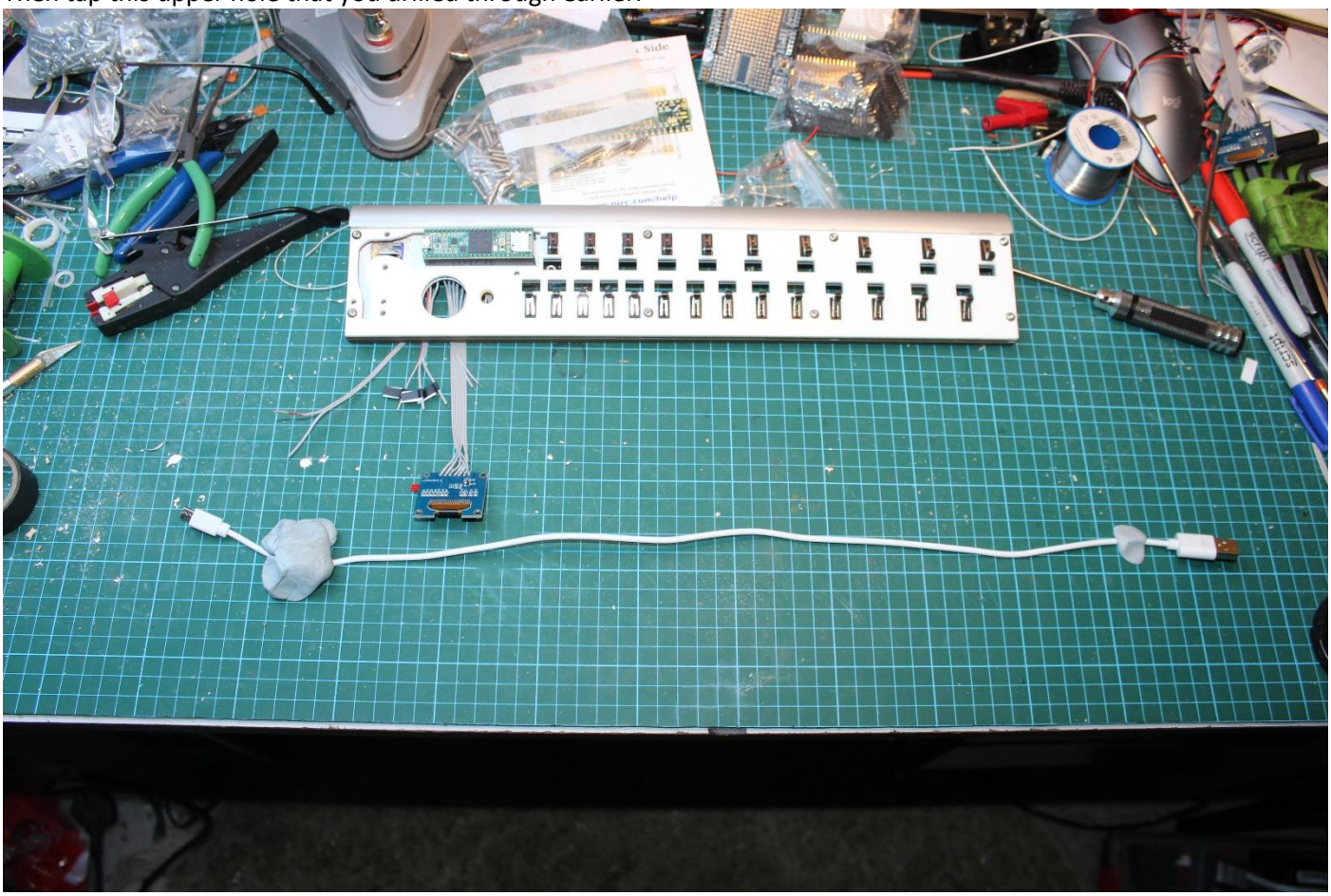


Using a 3.5mm (M3.5) thread tap, tap a thread into this hole.

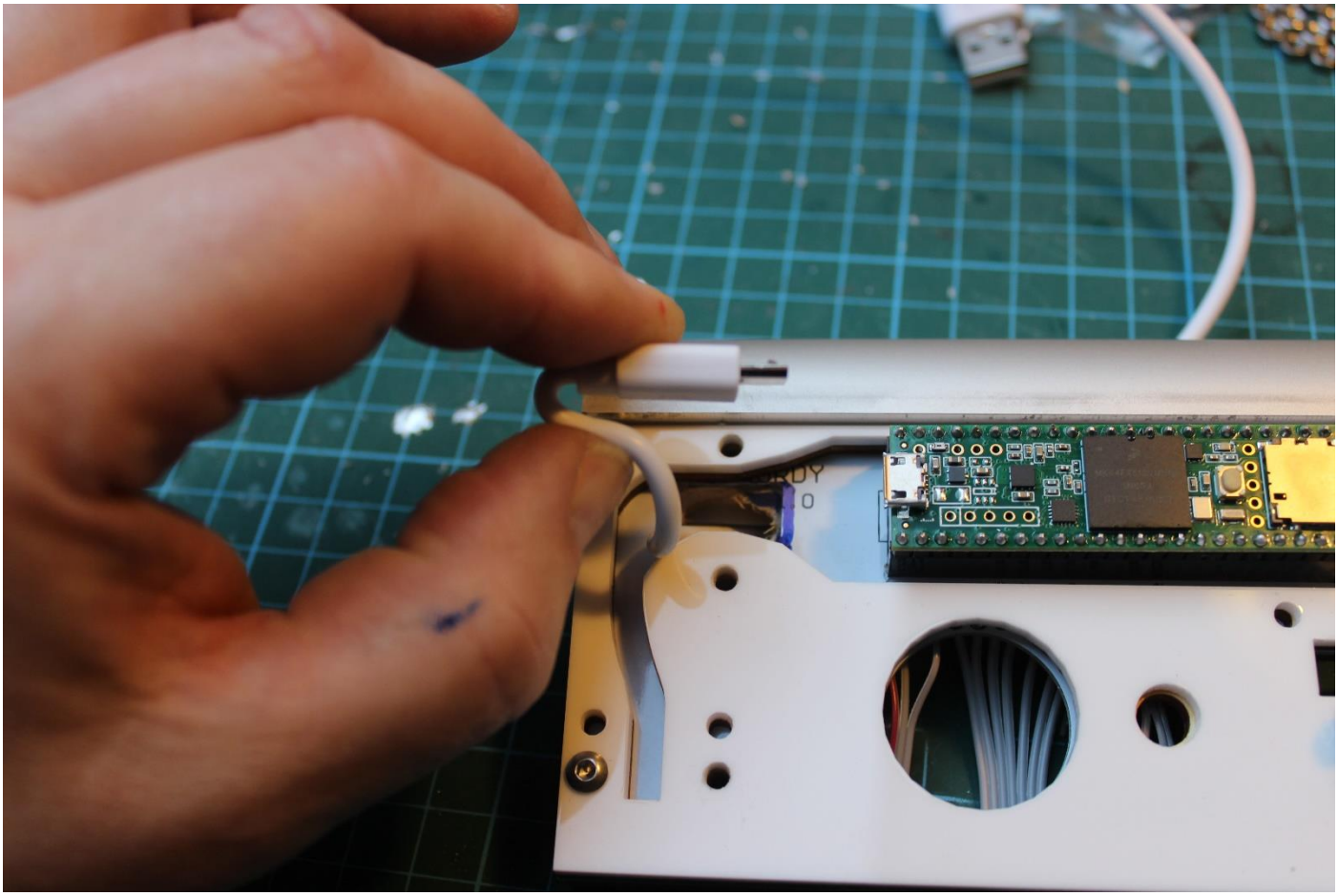
Here you see a tap in a slow rotating drill. Also then tap the hole I am pointing to here.



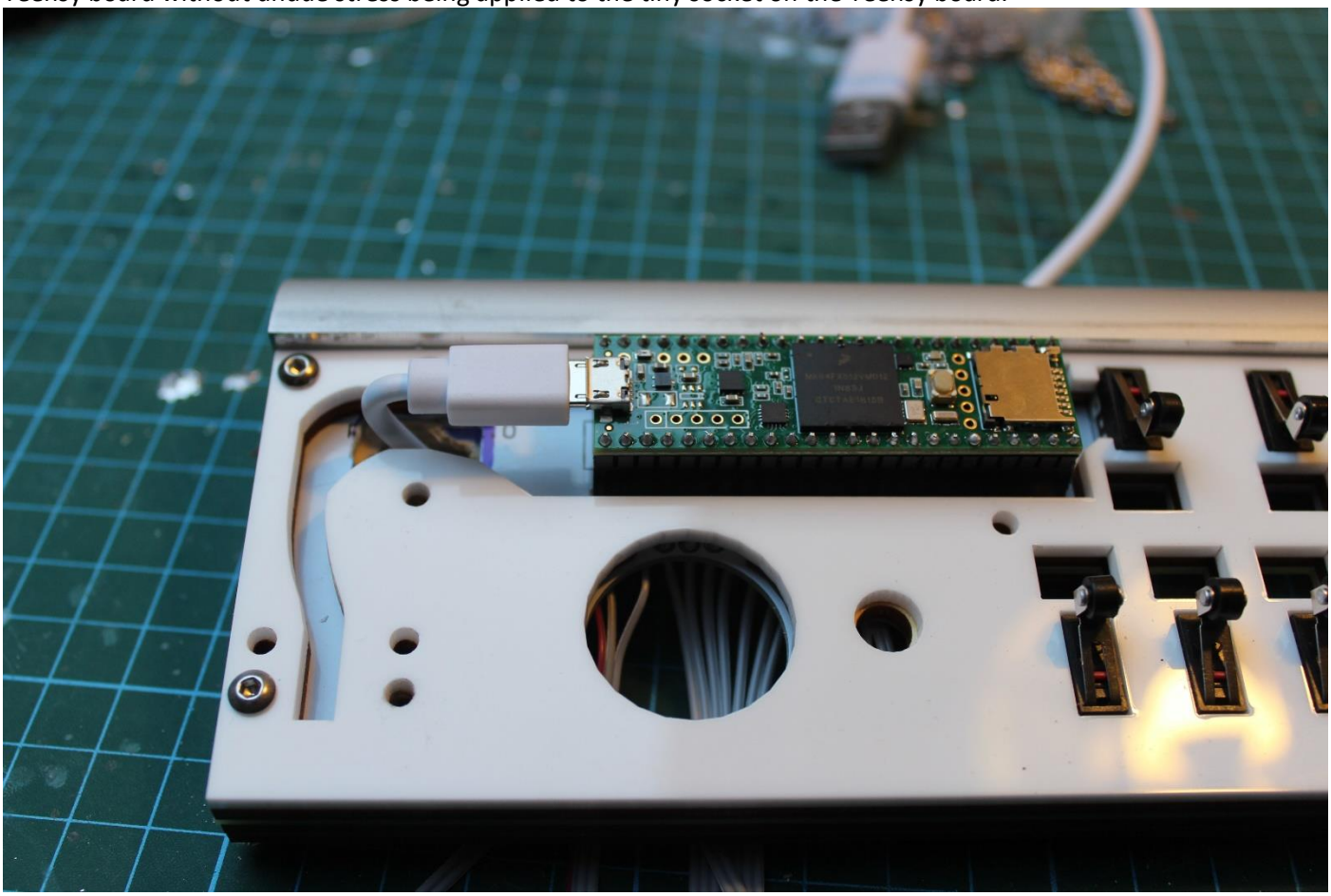
Then tap this upper hole that you drilled through earlier.



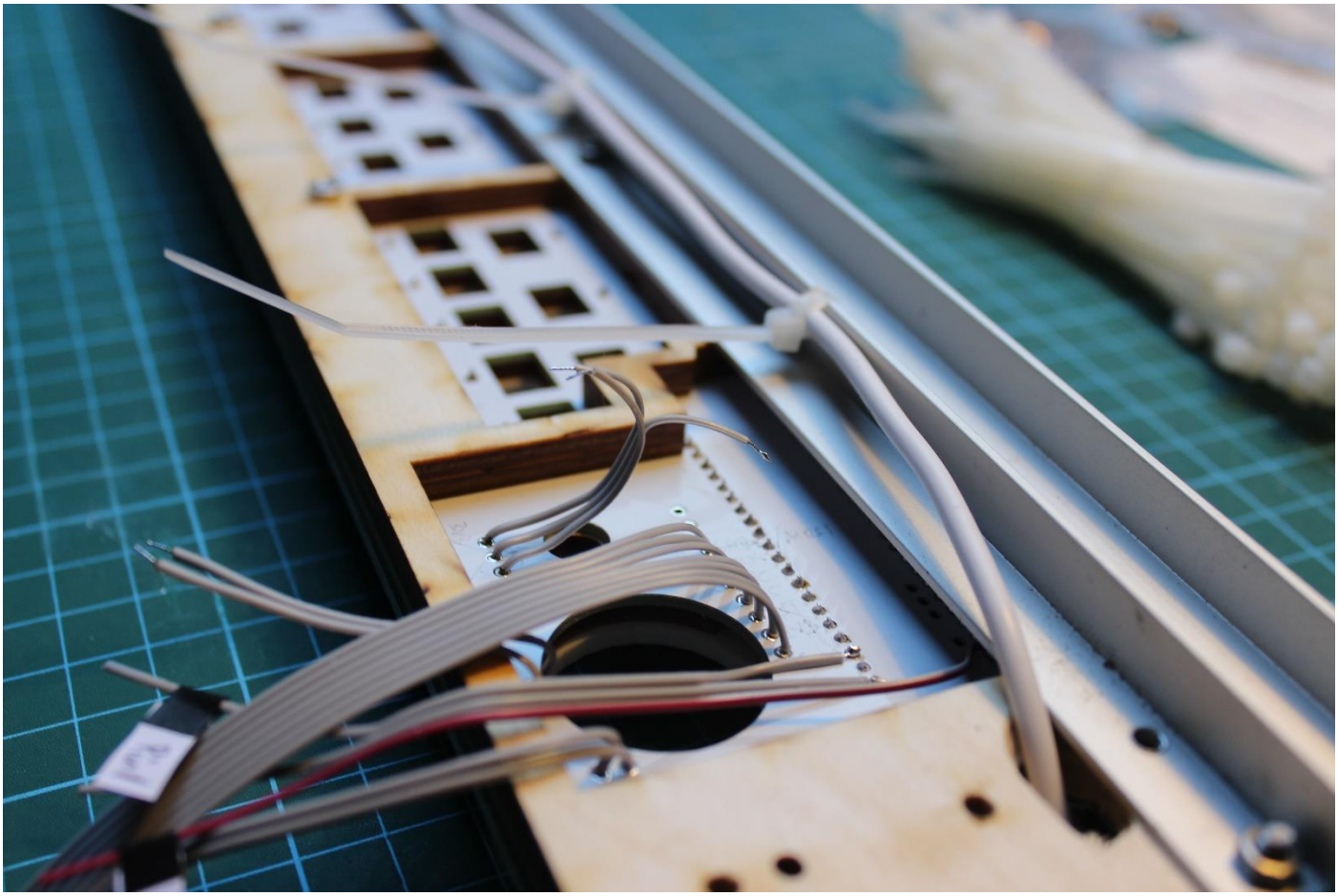
Here I am showing you that the USB lead has a male full sized plug one end and a micro-USB plug the other end which plugs into the Teensy board. It is about 10cm longer than the length of the DigiGurdy but it does not matter that much if you use a longer cable.



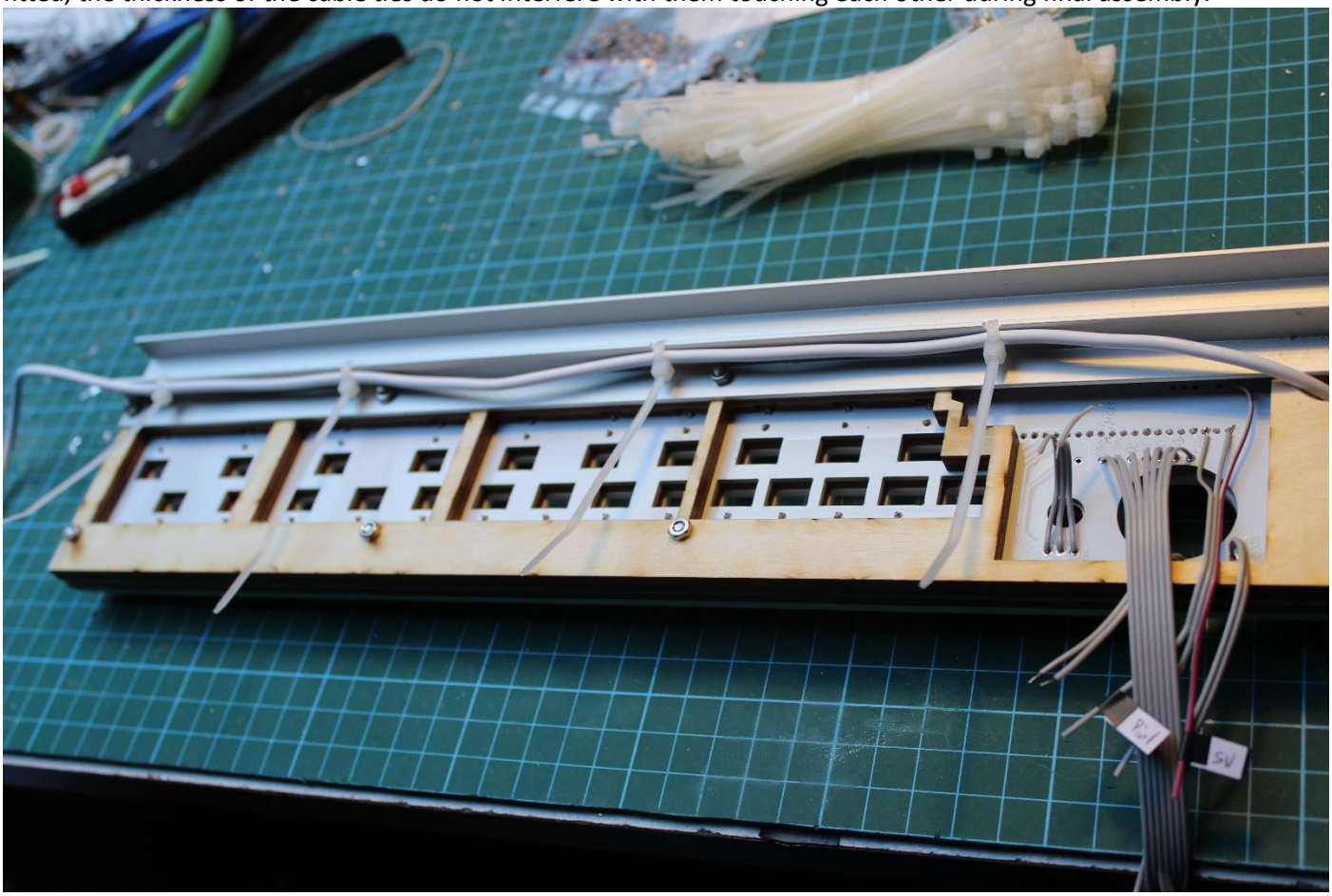
Thread the micro-USB plug through from the back, shape the end of the cable like this so you can plug it into the Teensy board without undue stress being applied to the tiny socket on the Teensy board.



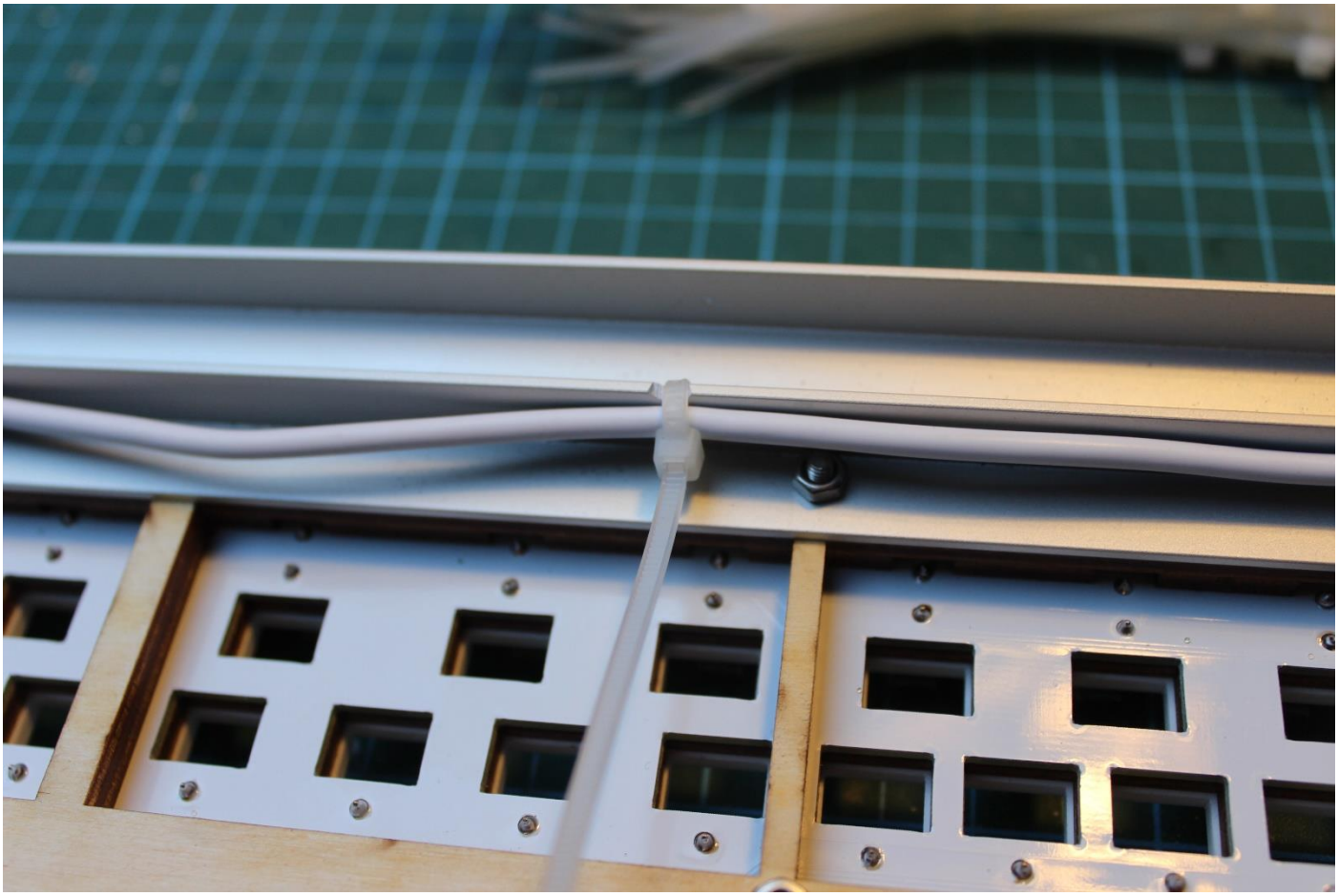
Plug in the micro-USB plug into the Teensy board.



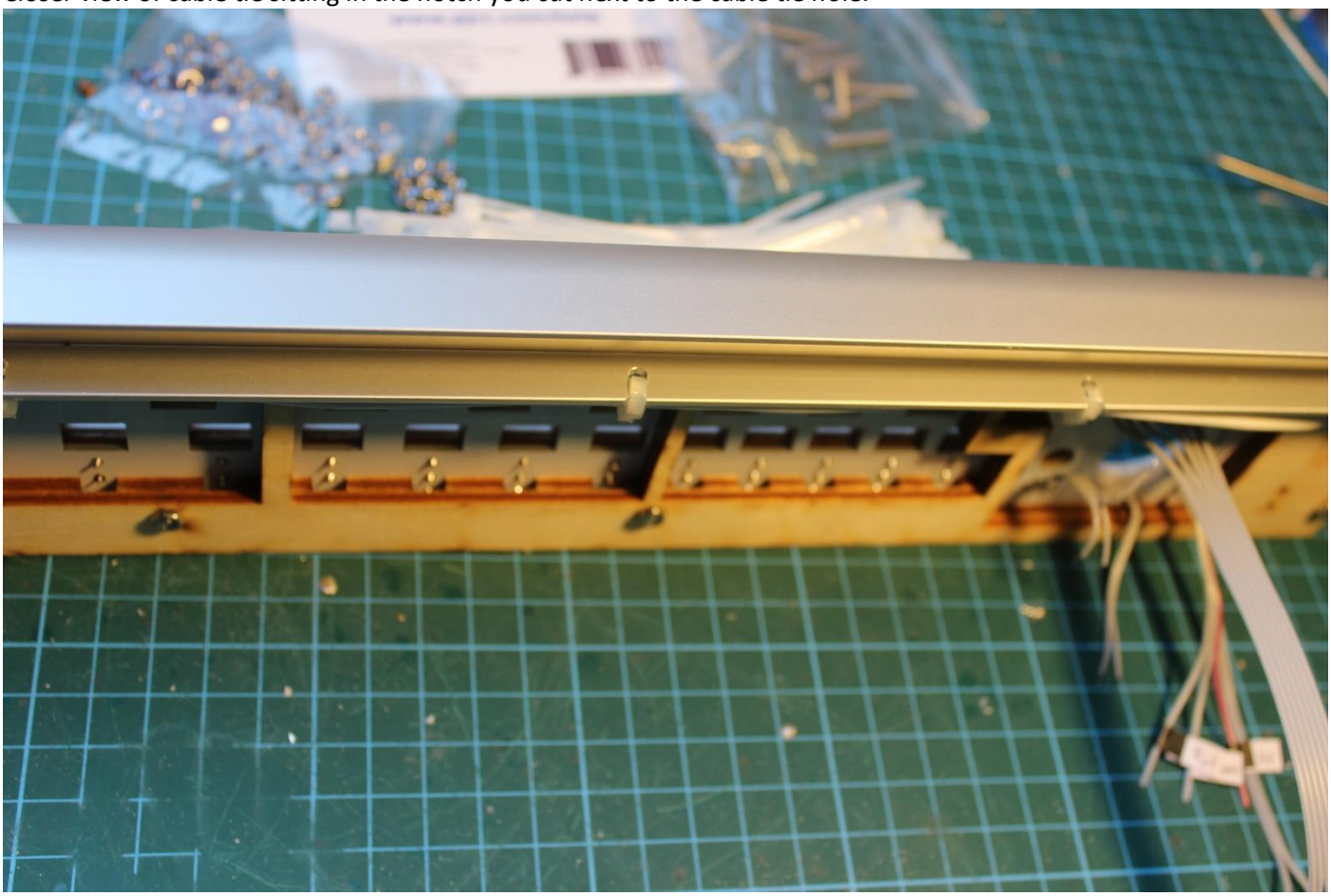
Using the smallest size cable ties, tie down the USB cable as shown along the length of the upper front alloy extrusion, the one you have bolted to the 5 layer sandwich. This will stop the cable fouling the key stems when they are inserted. The ties run through the notched grooves you filed earlier so that when the top rear alloy extrusion is fitted, the thickness of the cable ties do not interfere with them touching each other during final assembly.



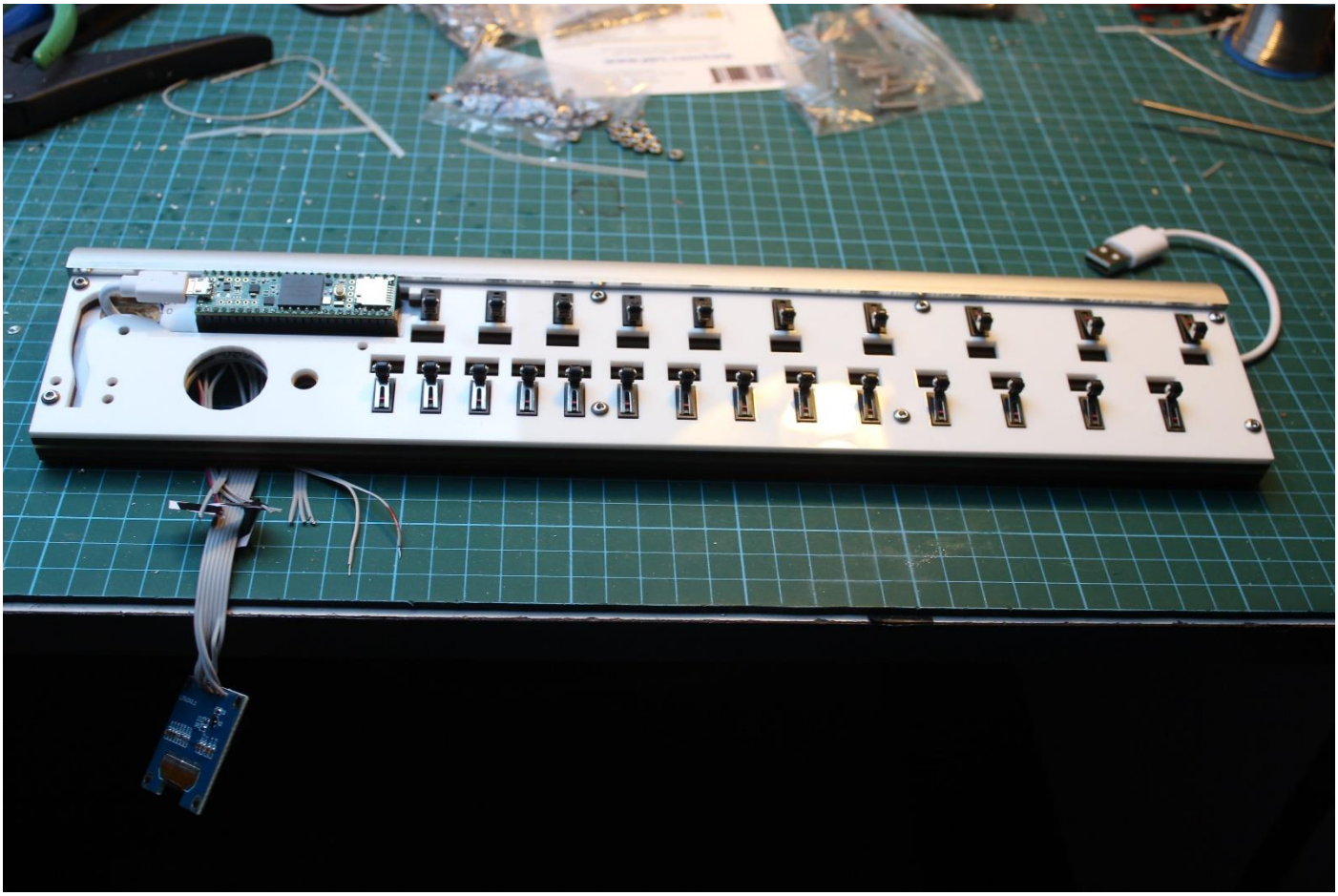
x



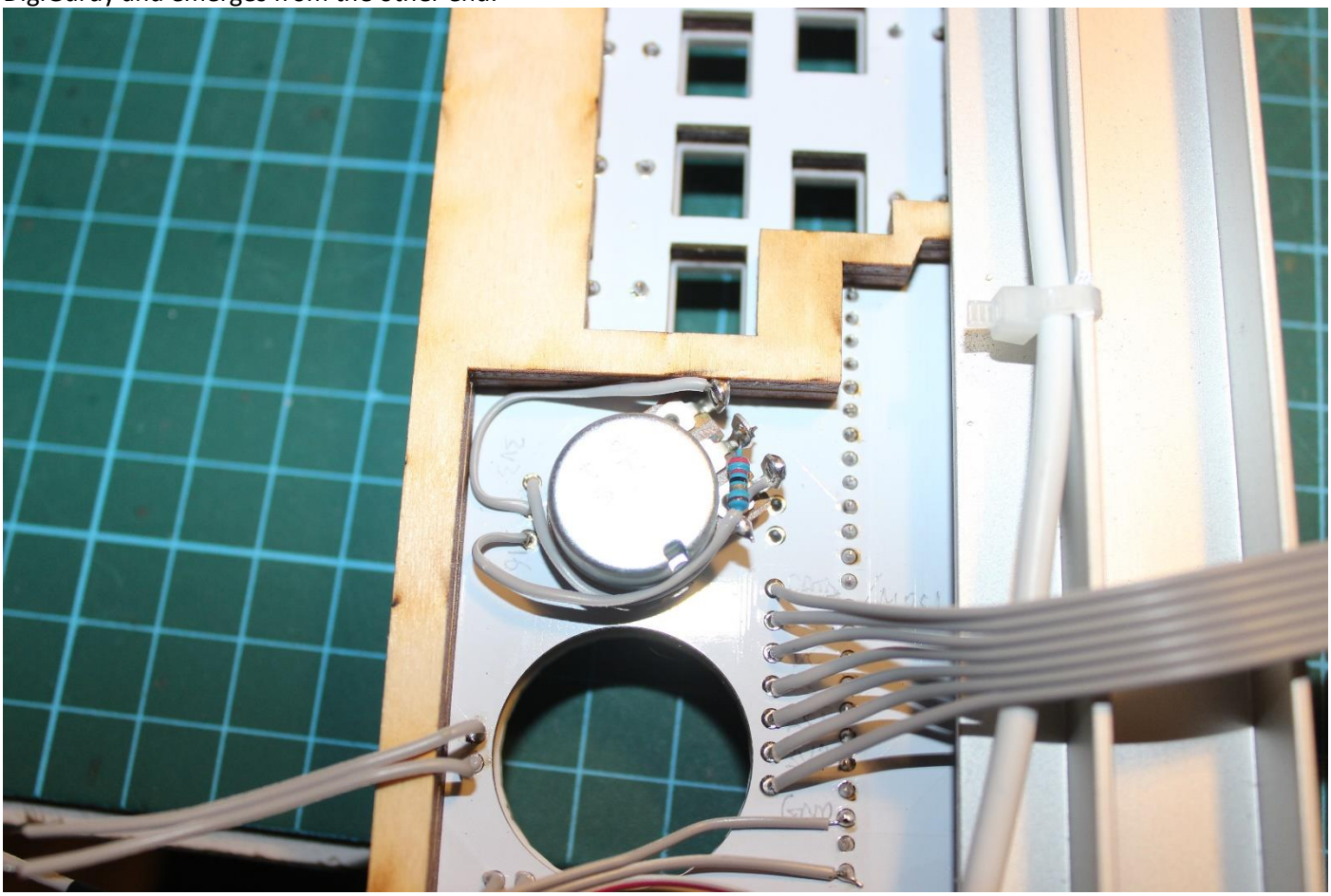
Closer view of cable tie sitting in the notch you cut next to the cable tie hole.



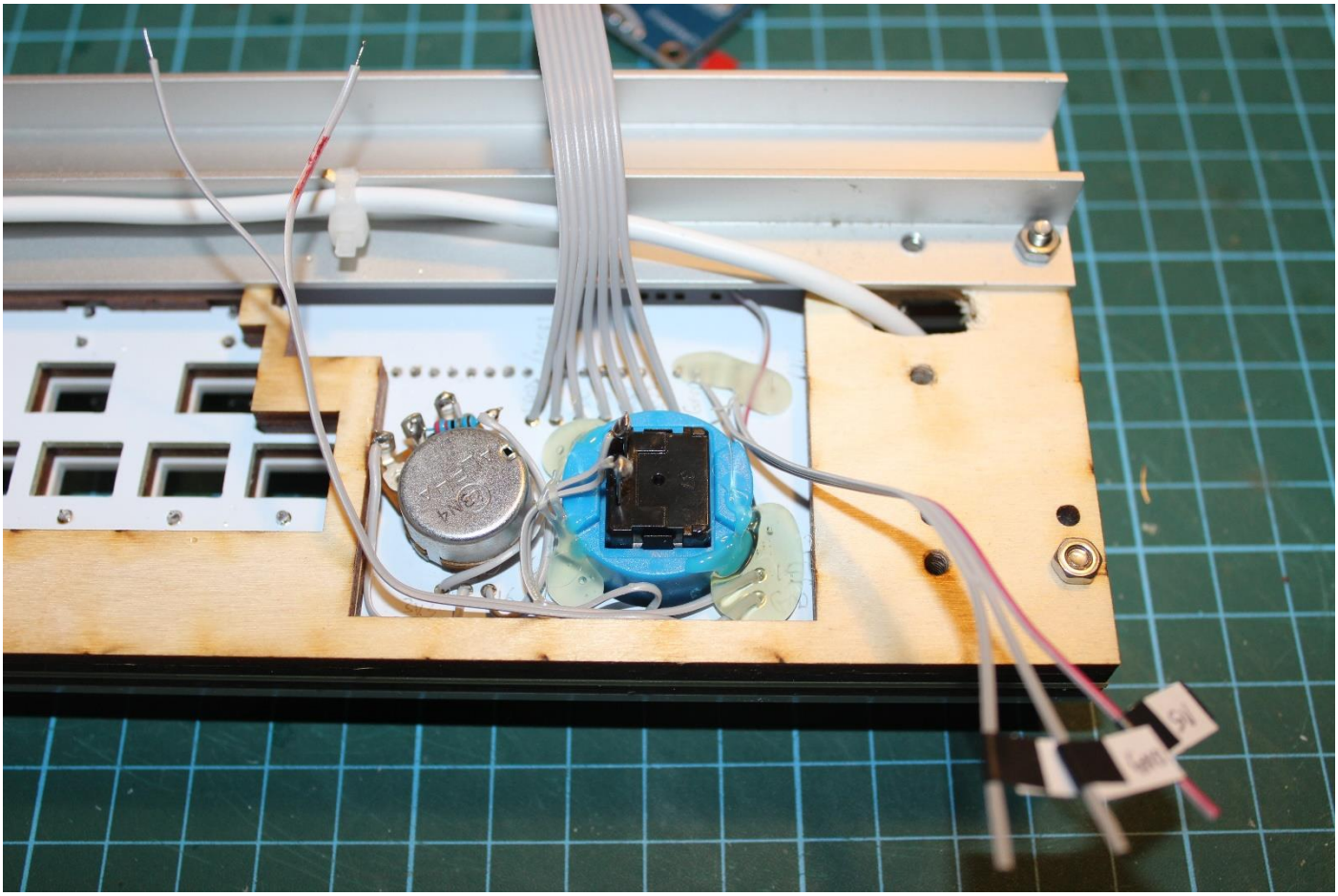
Trim the ends off the cable ties.

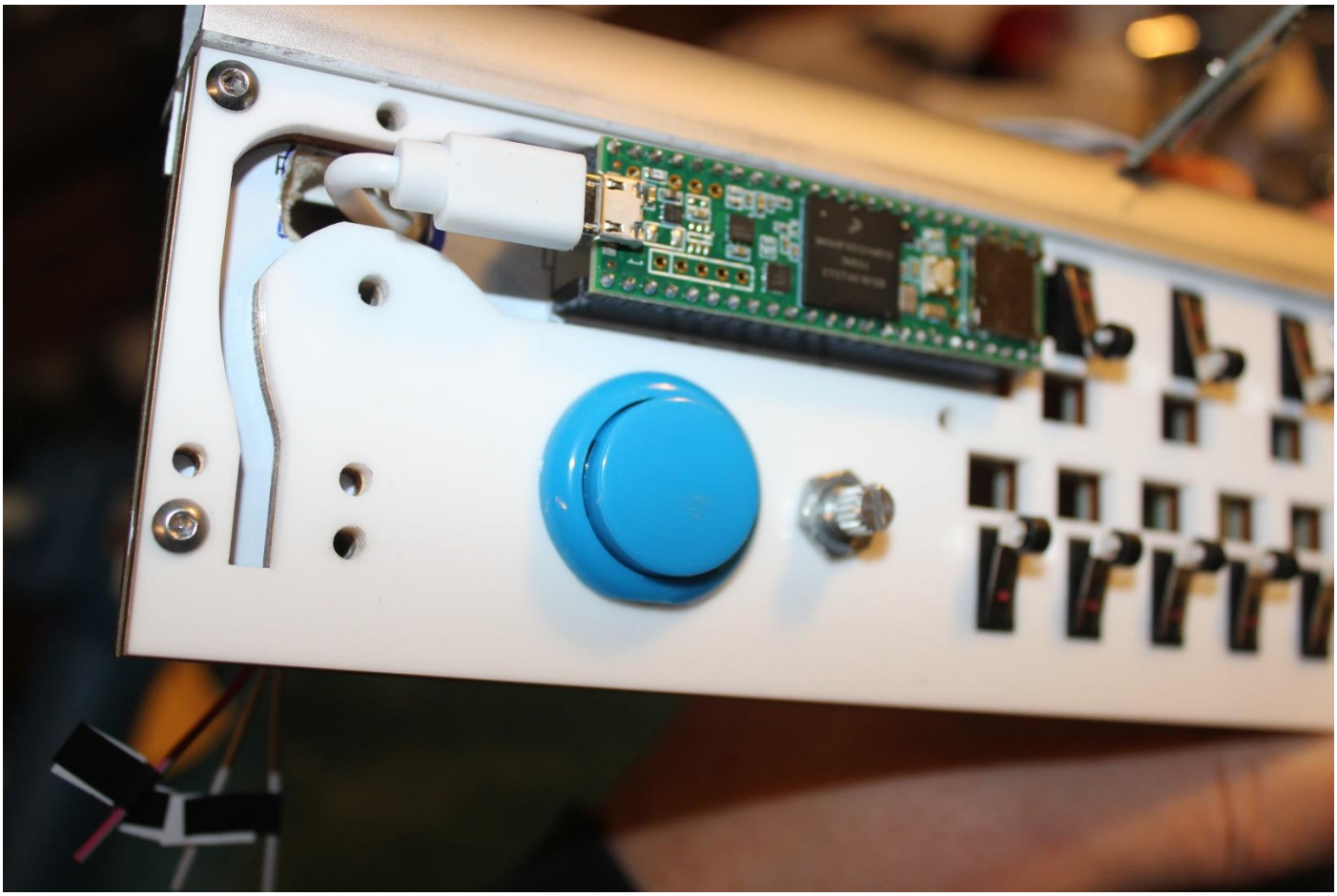


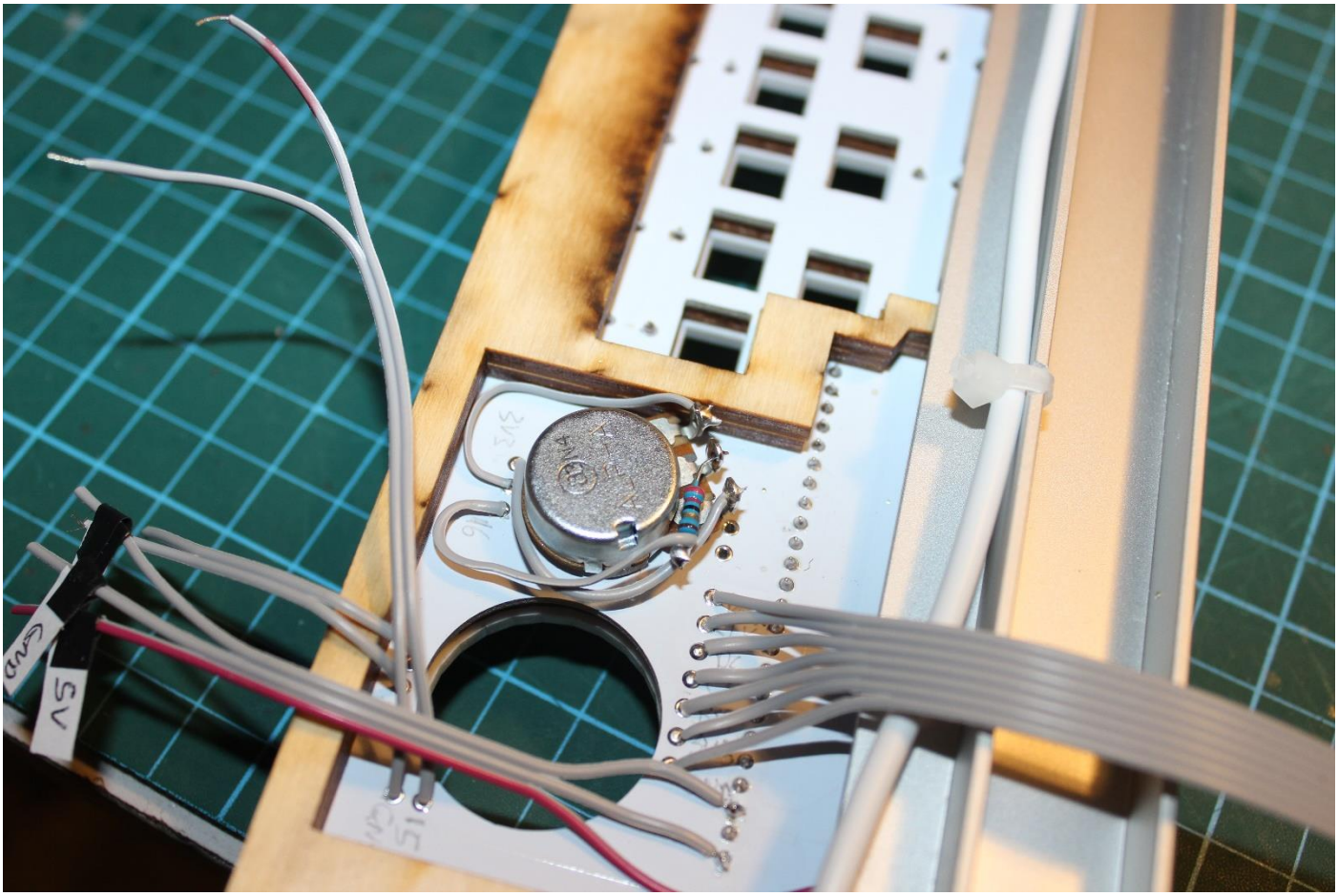
So, now we can see we have the USB cable plugged into the Teensy board, it runs neatly through the body of the DigiGurdy and emerges from the other end.



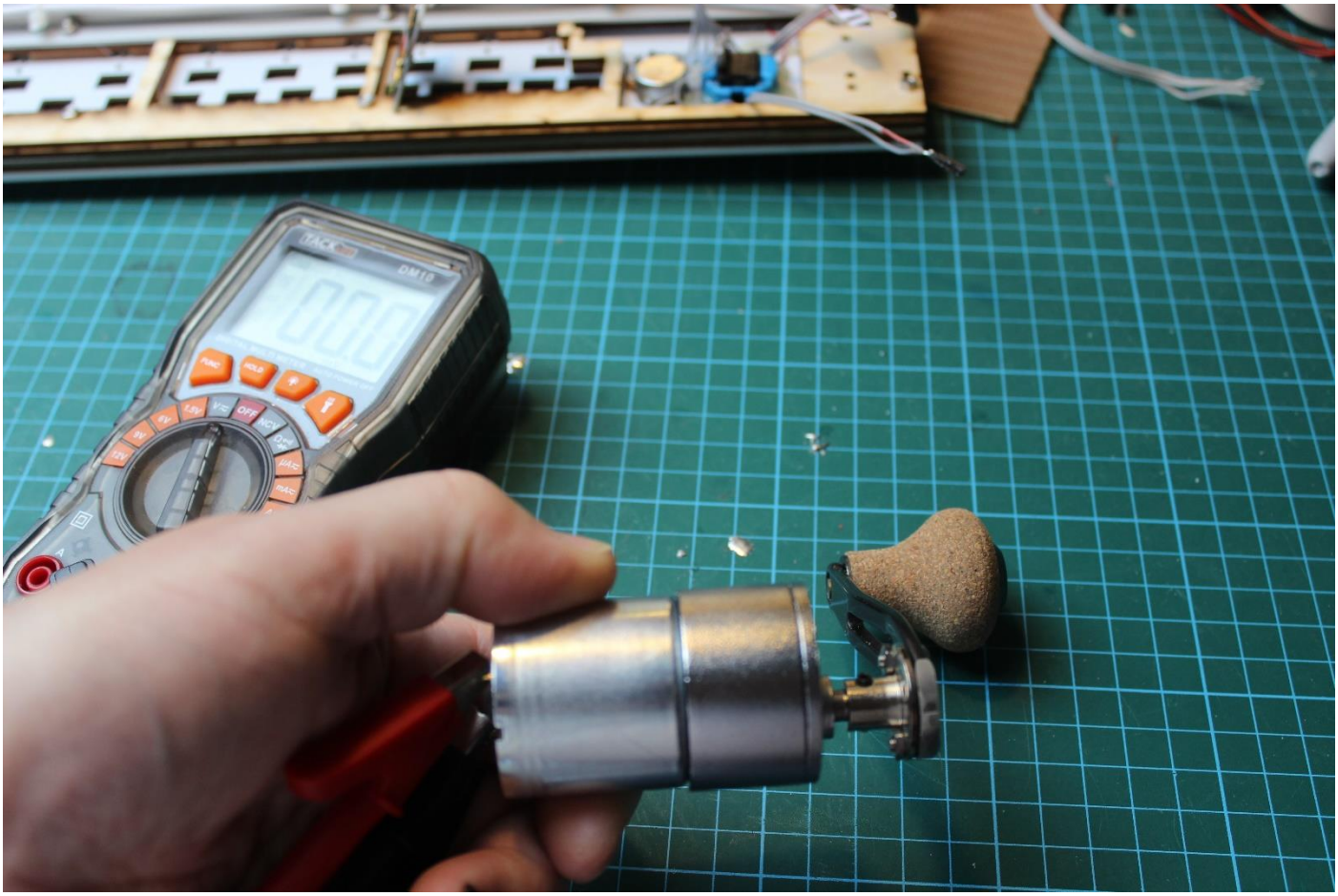
Wire up the potentiometer.





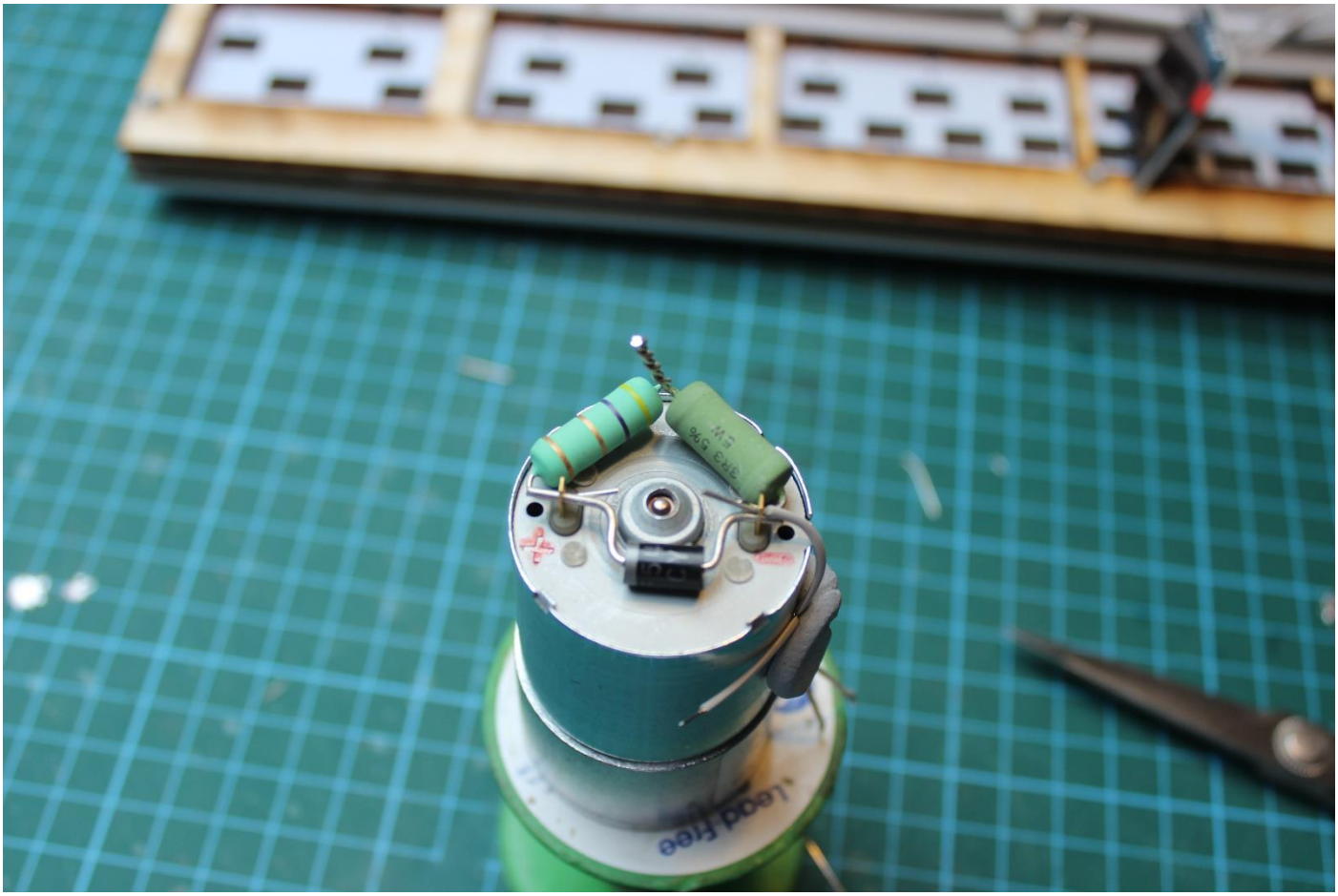


x

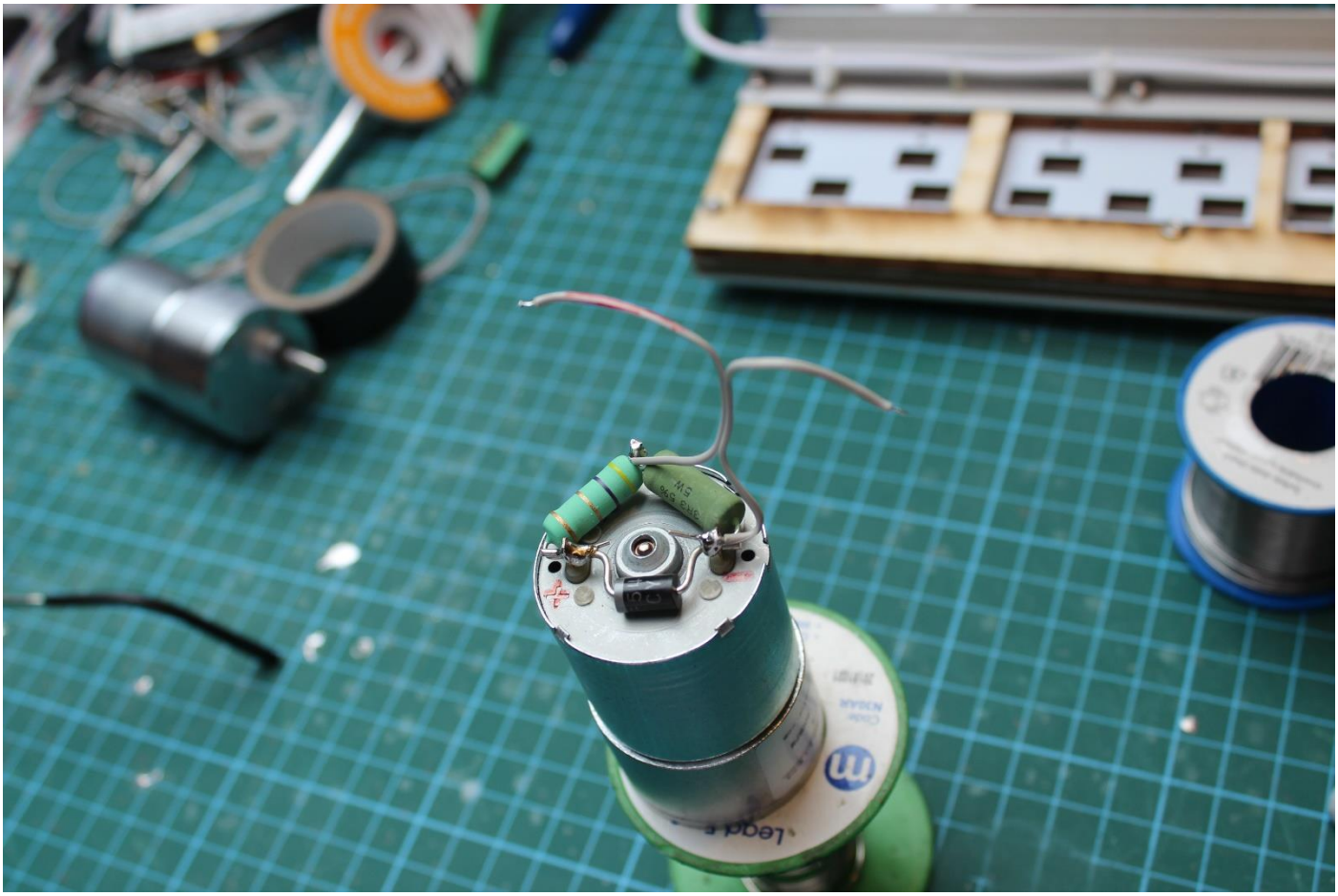


Fit a crank handle to the crank motor. Turn it clockwise. Using a voltmeter, connect the red and black probes such that the voltage generated is a positive value. Next to your red probe, draw a + onto that pin of the motor.

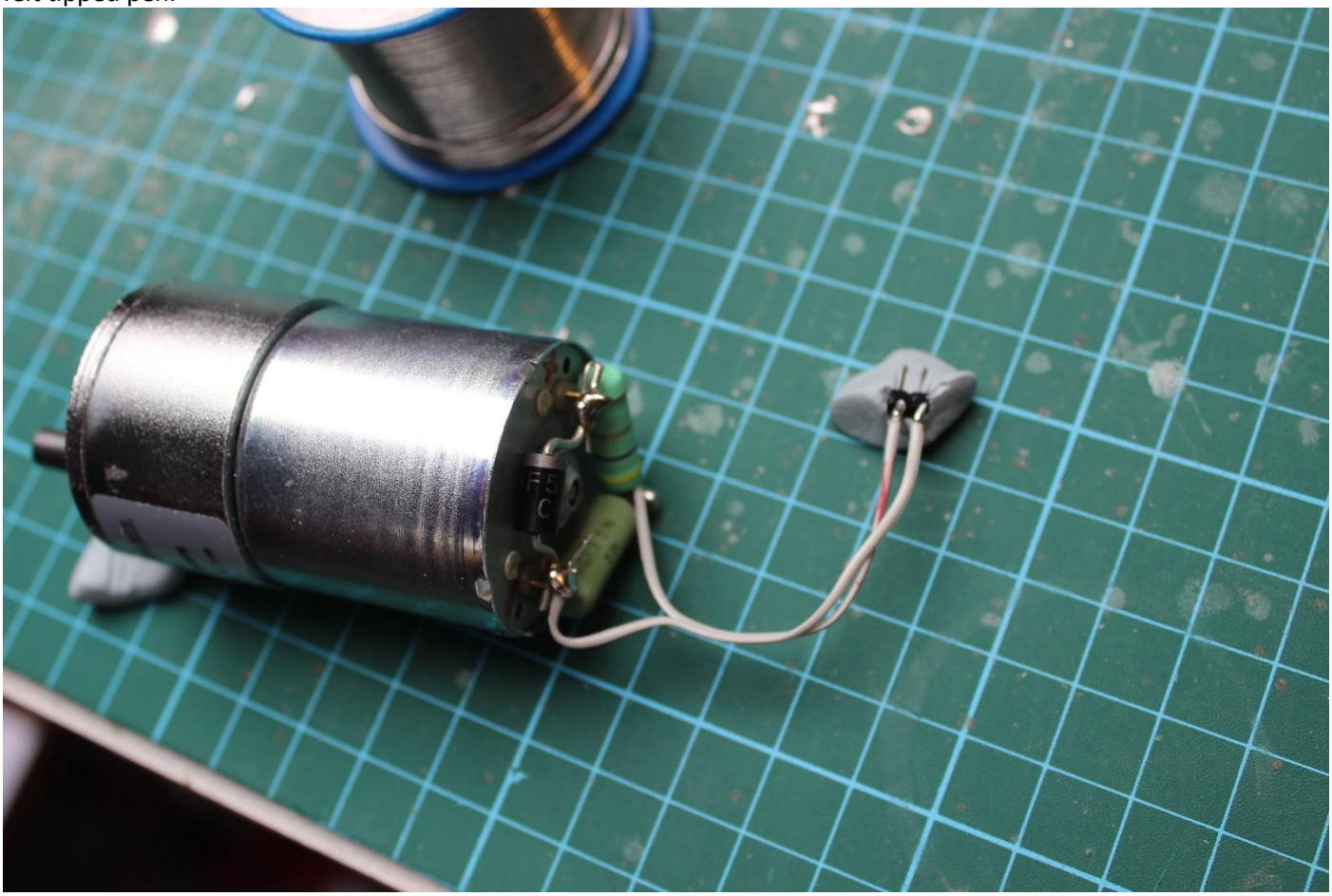
Fit a diode with the solver line facing the terminal you just labelled with the + sign.



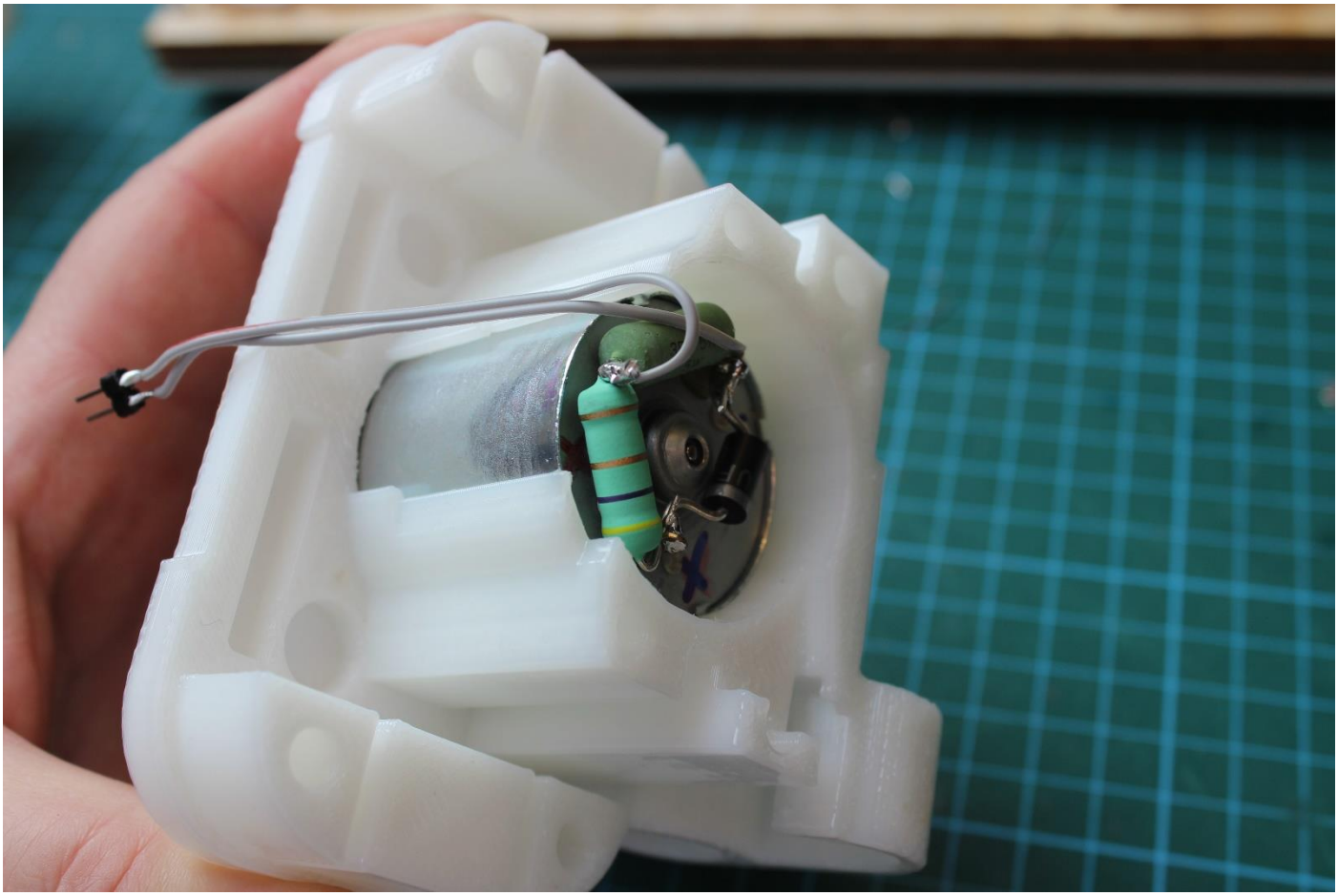
Add 2 wire-wound resistors. The one on the left is 4.7 Ohms (that is Ohms, not kilo-Ohms but Ohms i.e. a low resistance value). The one on the right is 3.3 Ohms. Twist them together where they join in the centre.



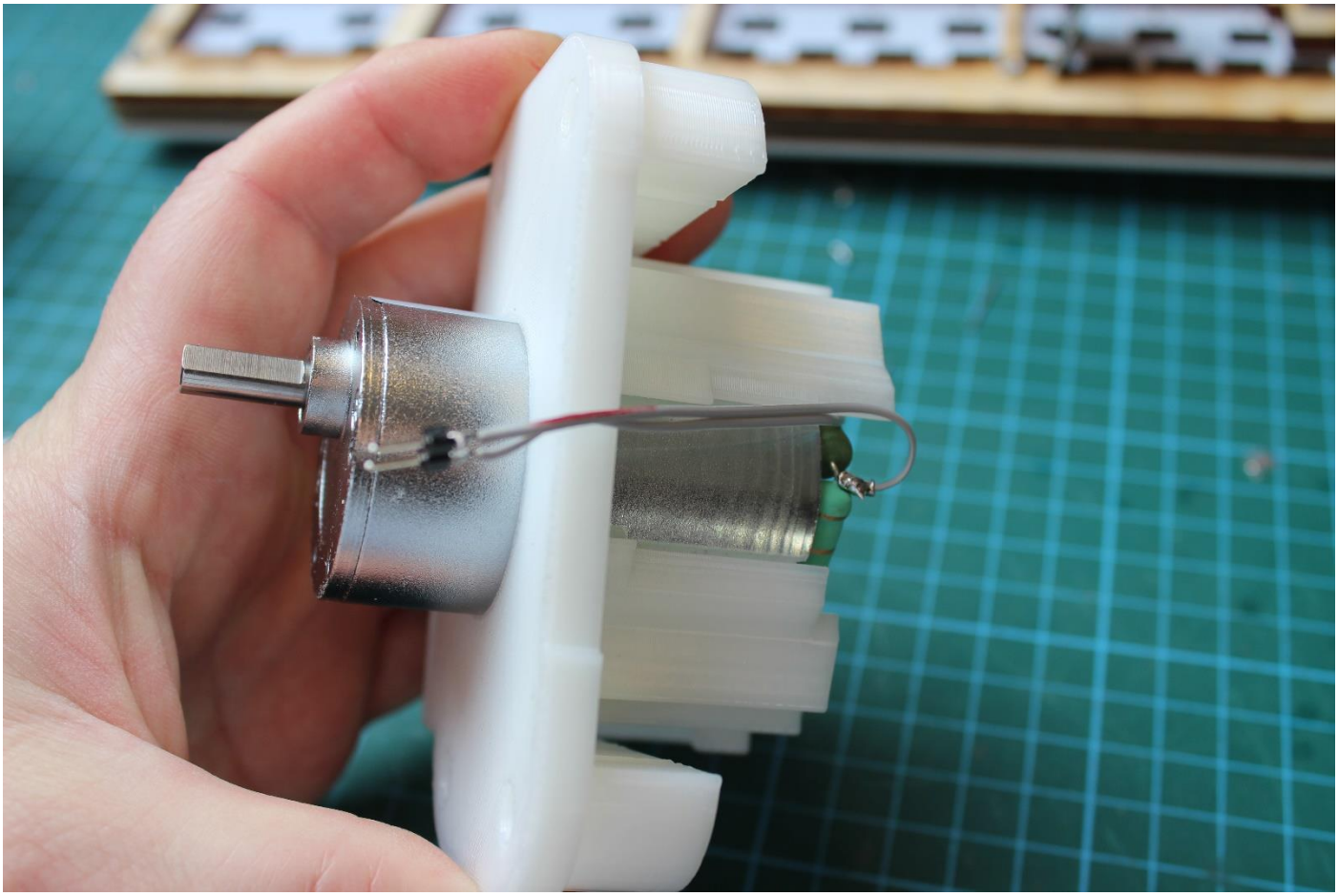
Solder in 2 wires as shown. Mark the wire that has been connected to the joint between the two resistors with a red felt tipped pen.



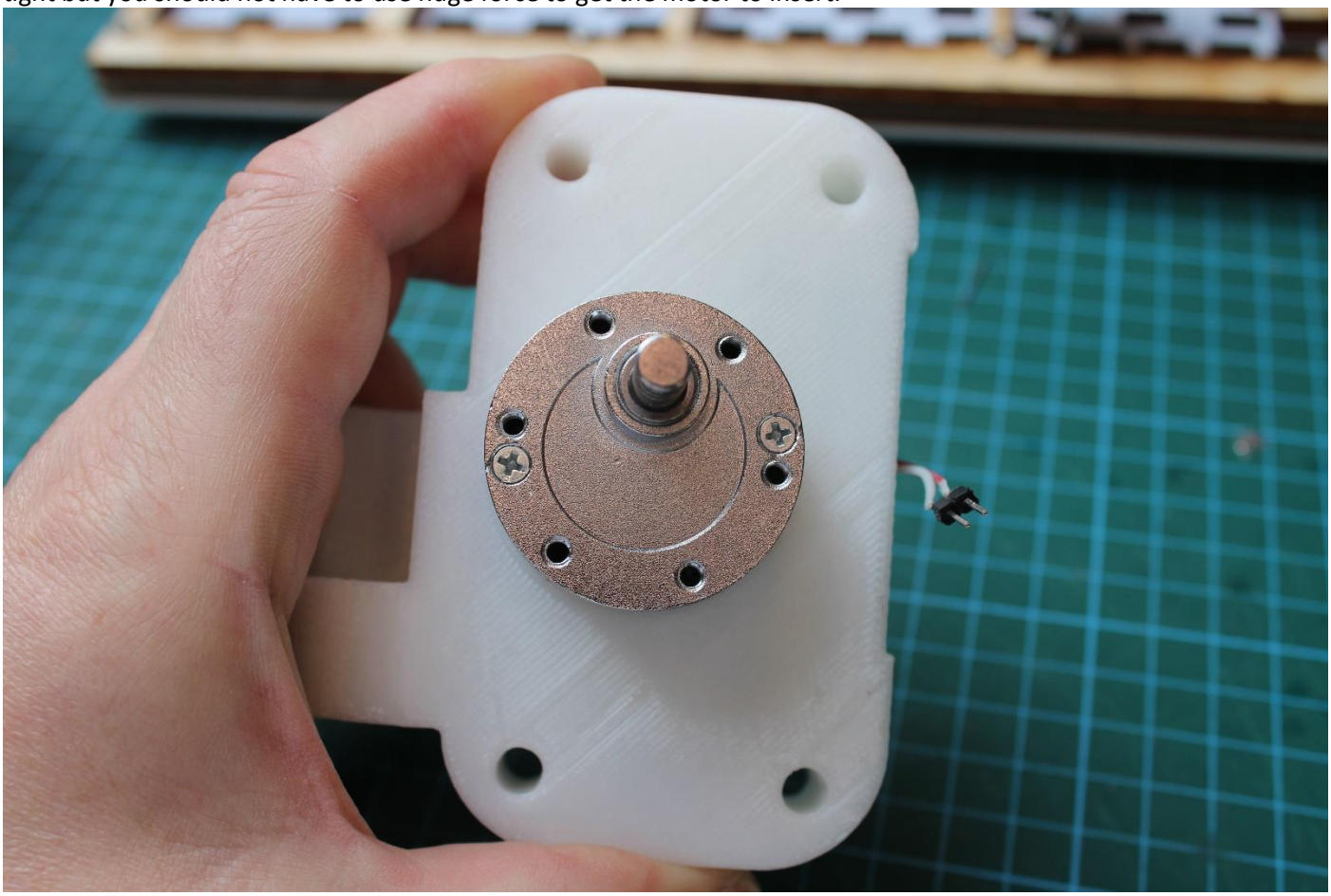
Solder 2 header pins carefully to the ends of the 2 wires. You can just about se that I have marked one of the wires in red ink.



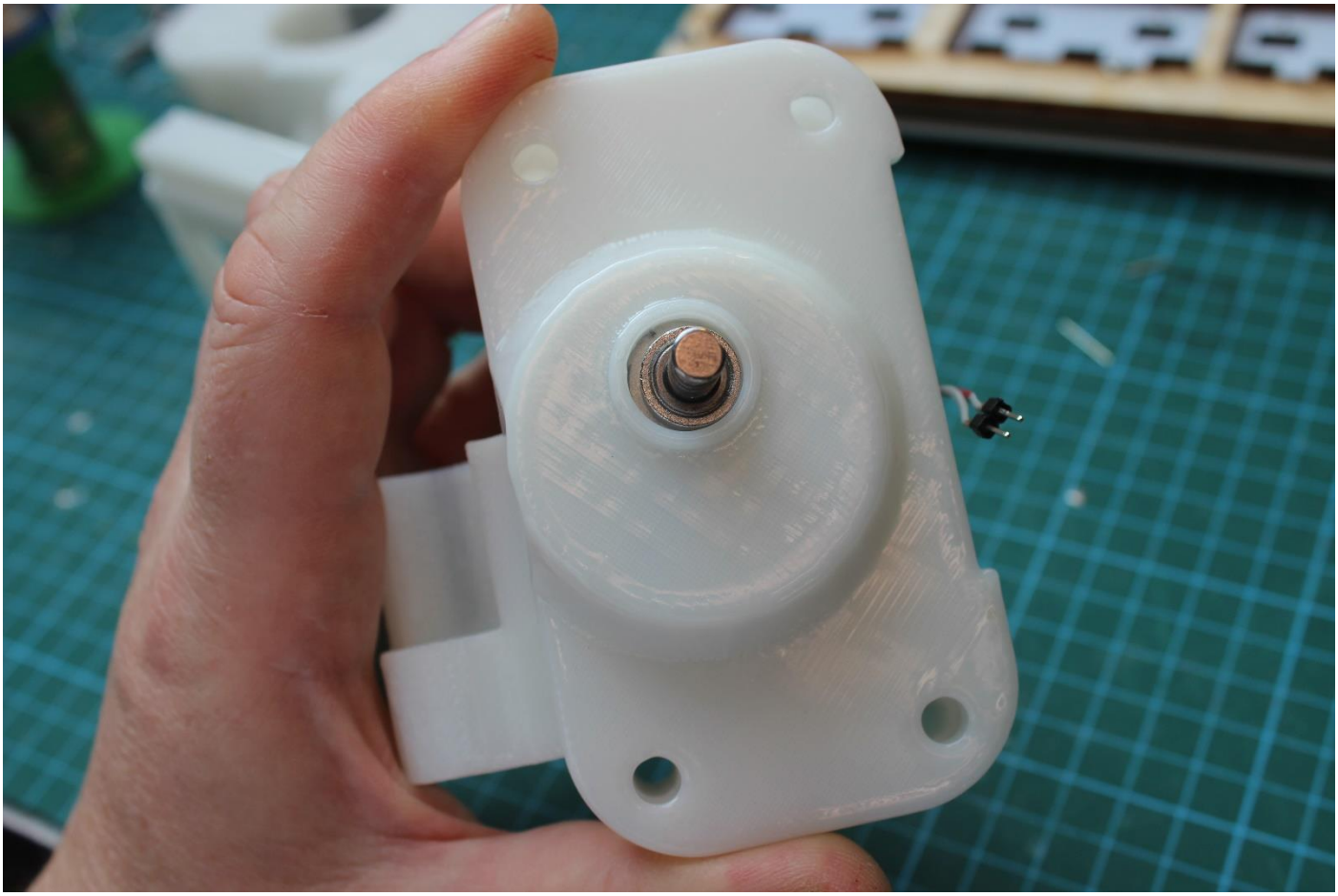
x



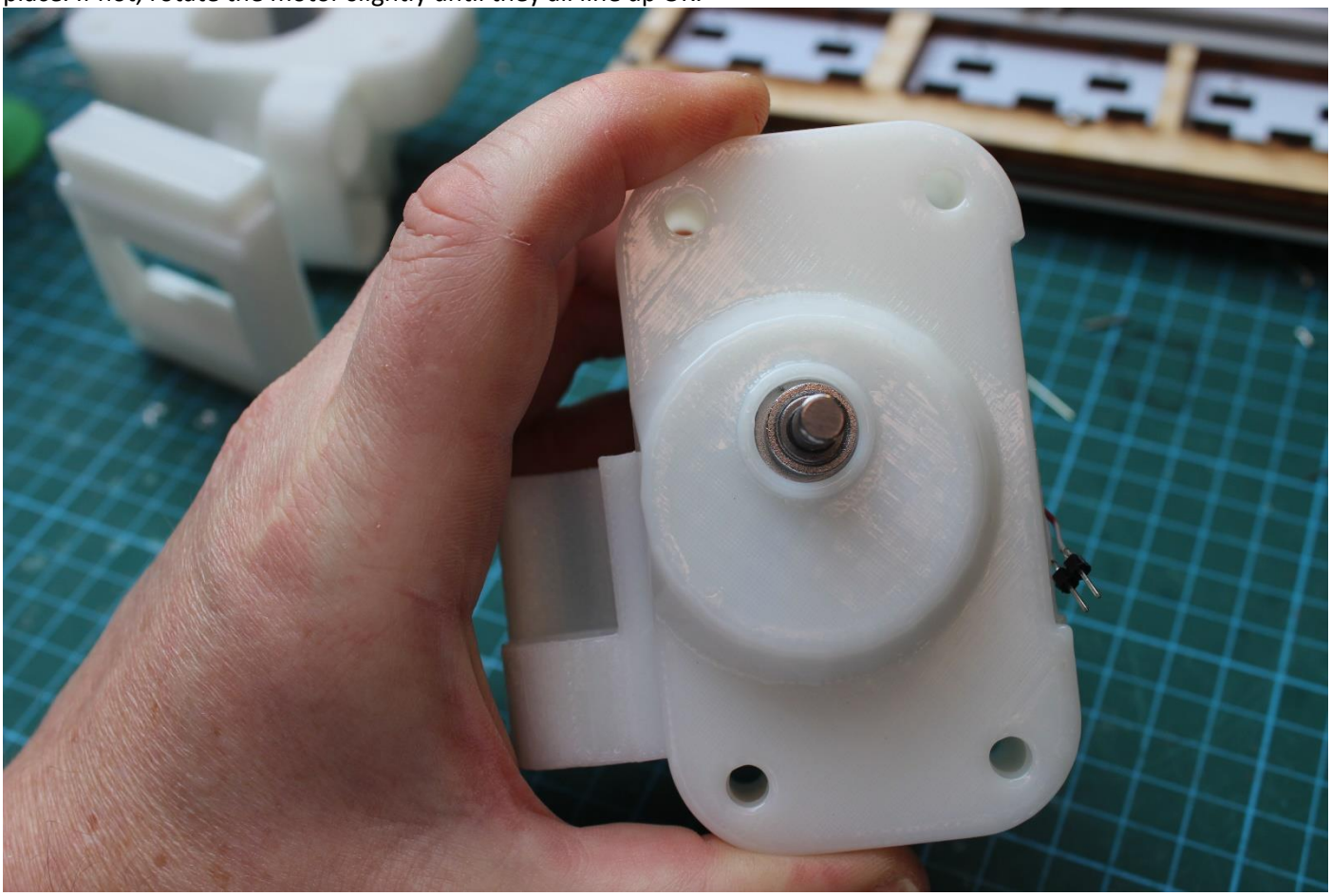
Push motor into the right hand end 3D printed structure. File the inside first if you need to. It should be medium tight but you should not have to use huge force to get the motor to insert.



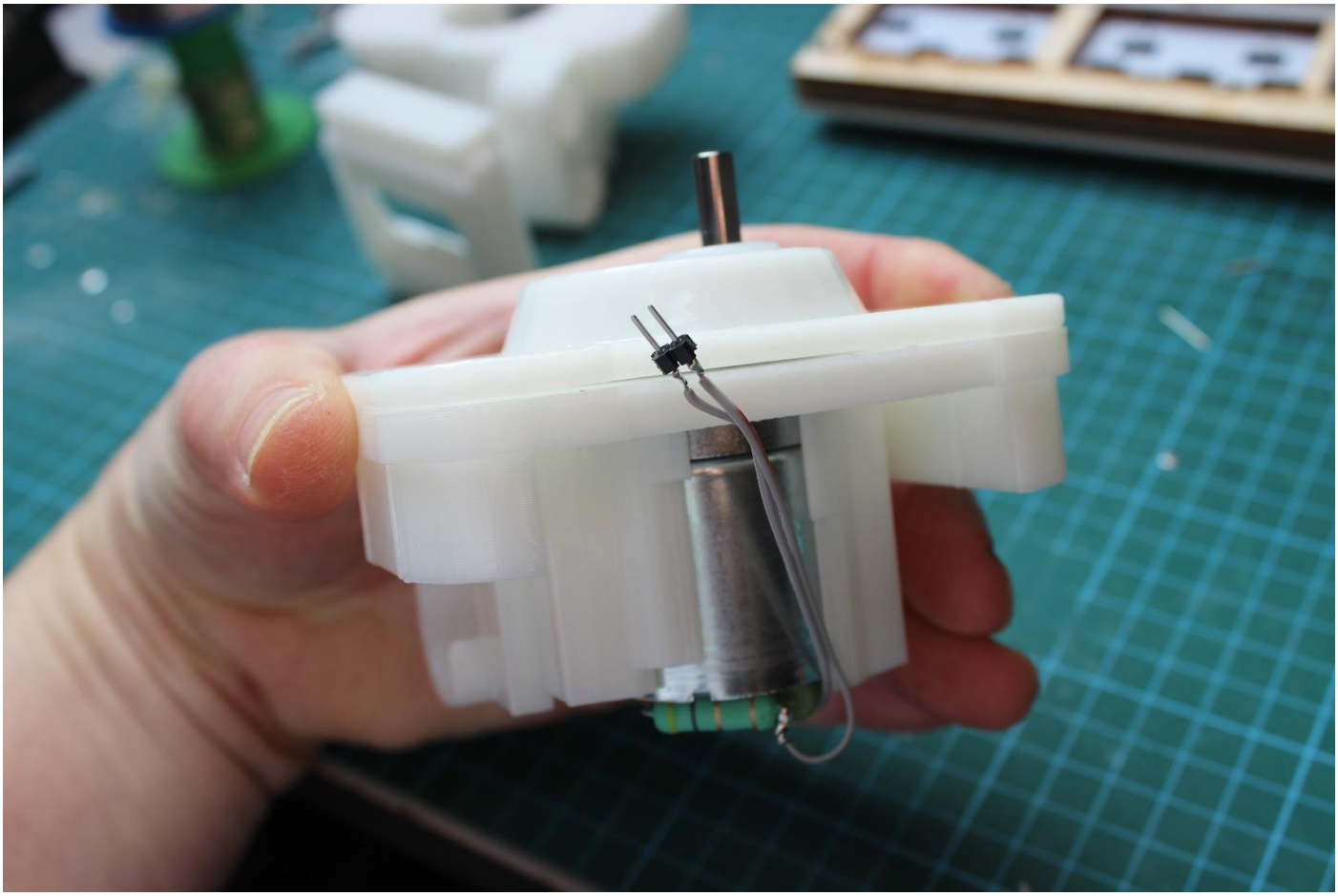
Locate the motor spindle uppermost as shown.



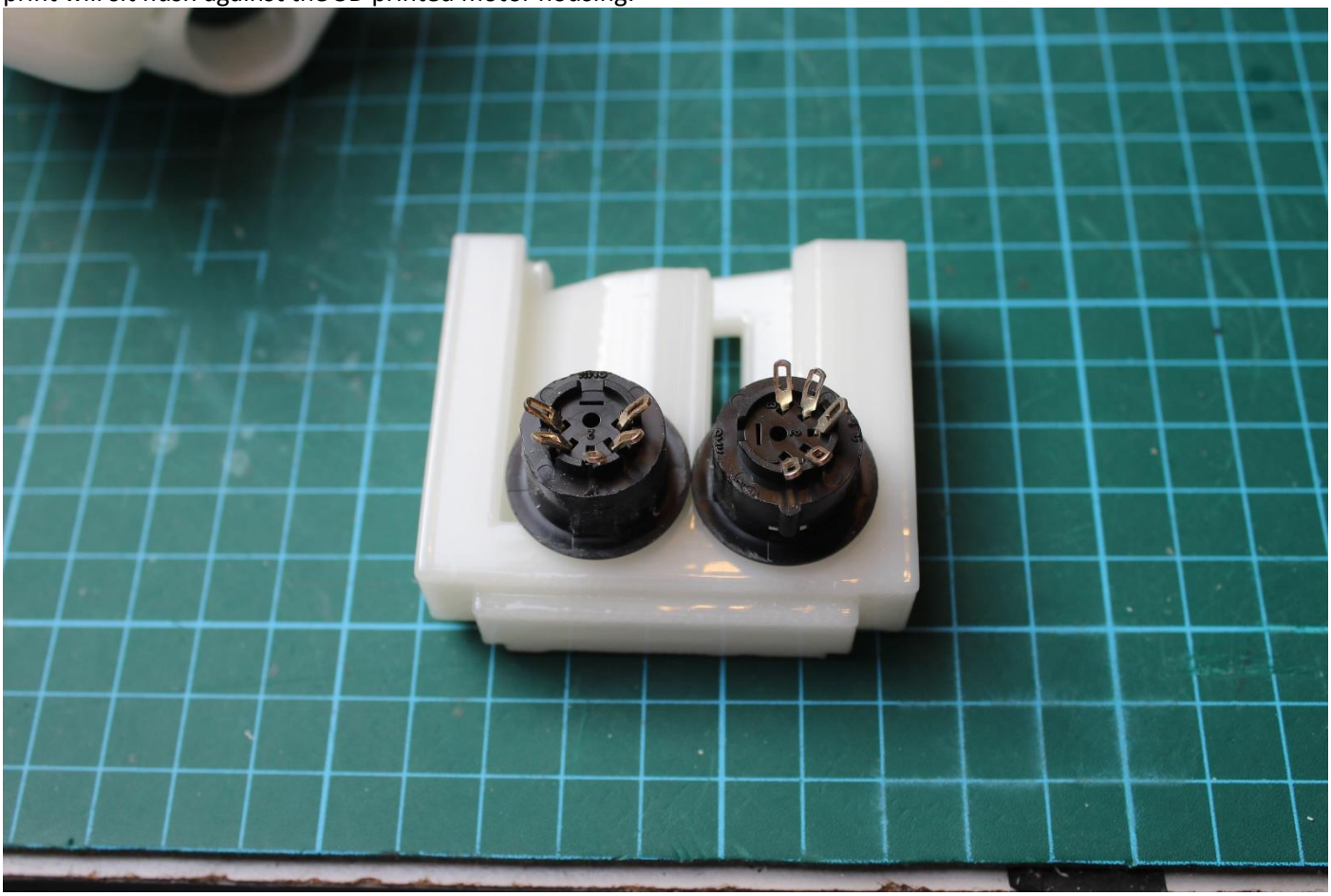
Test fit the motor cover so that the screw holes line up in the corners AND the crank spindle emerges in the correct place. If not, rotate the motor slightly until they all line up OK.



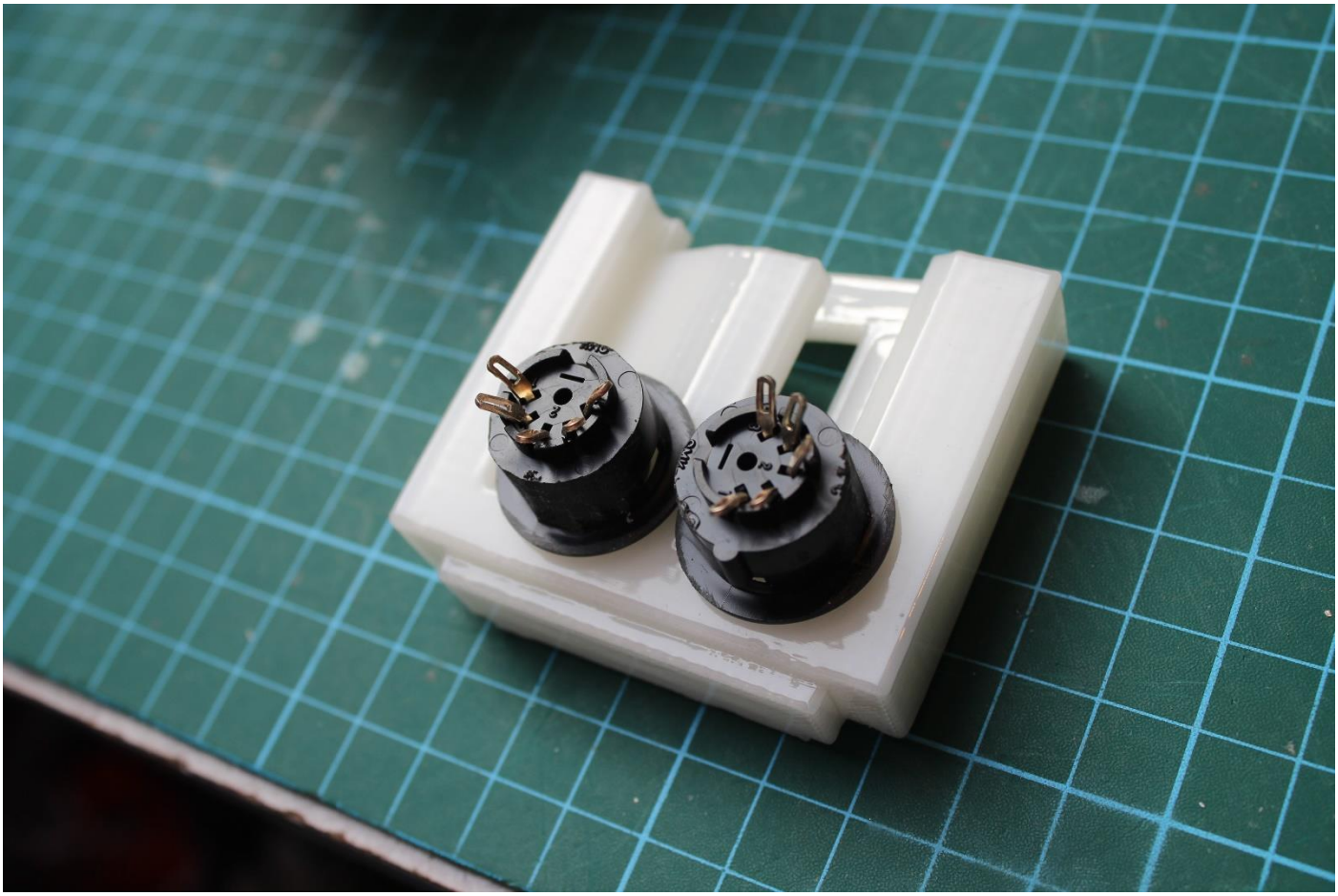
Looks OK.



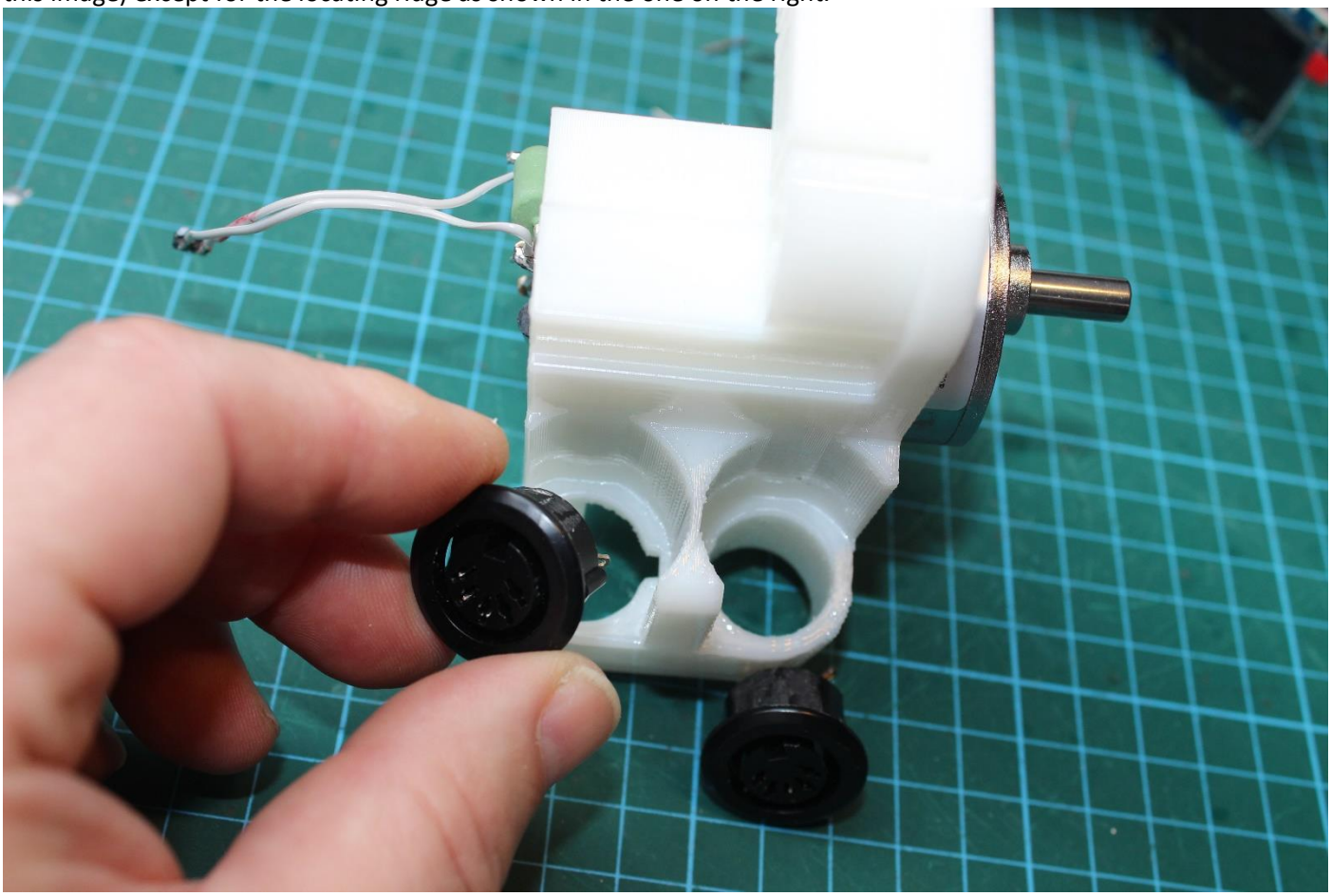
Press the motor into its housing using the end cap to do so. Press motor in only just enough so that the end cap 3D print will sit flush against the 3D printed motor housing.



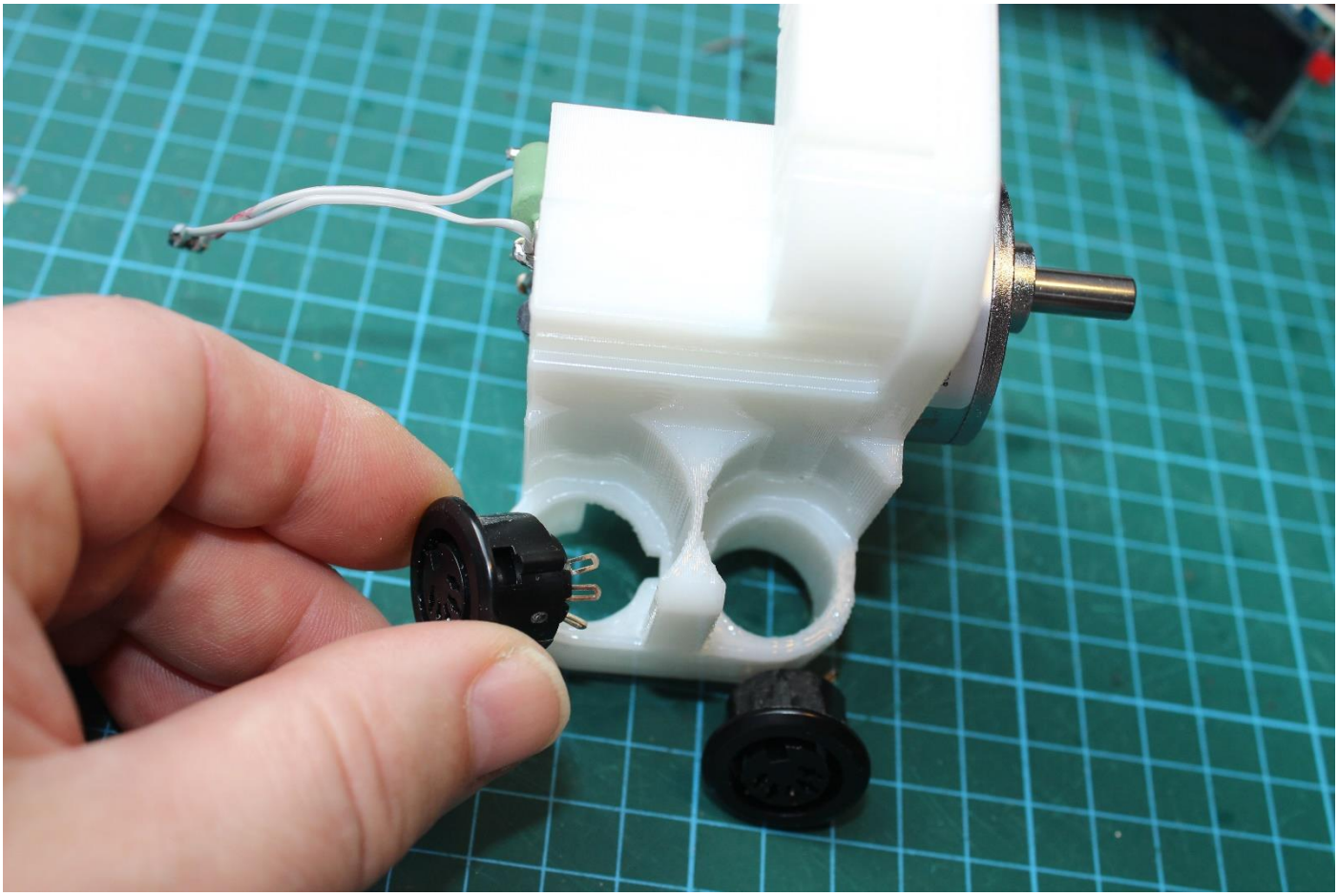
Next step is to prepare our MIDI 5 pin sockets for our wireless Bluetooth transmitter should you wish to use one of those right away or add it later.



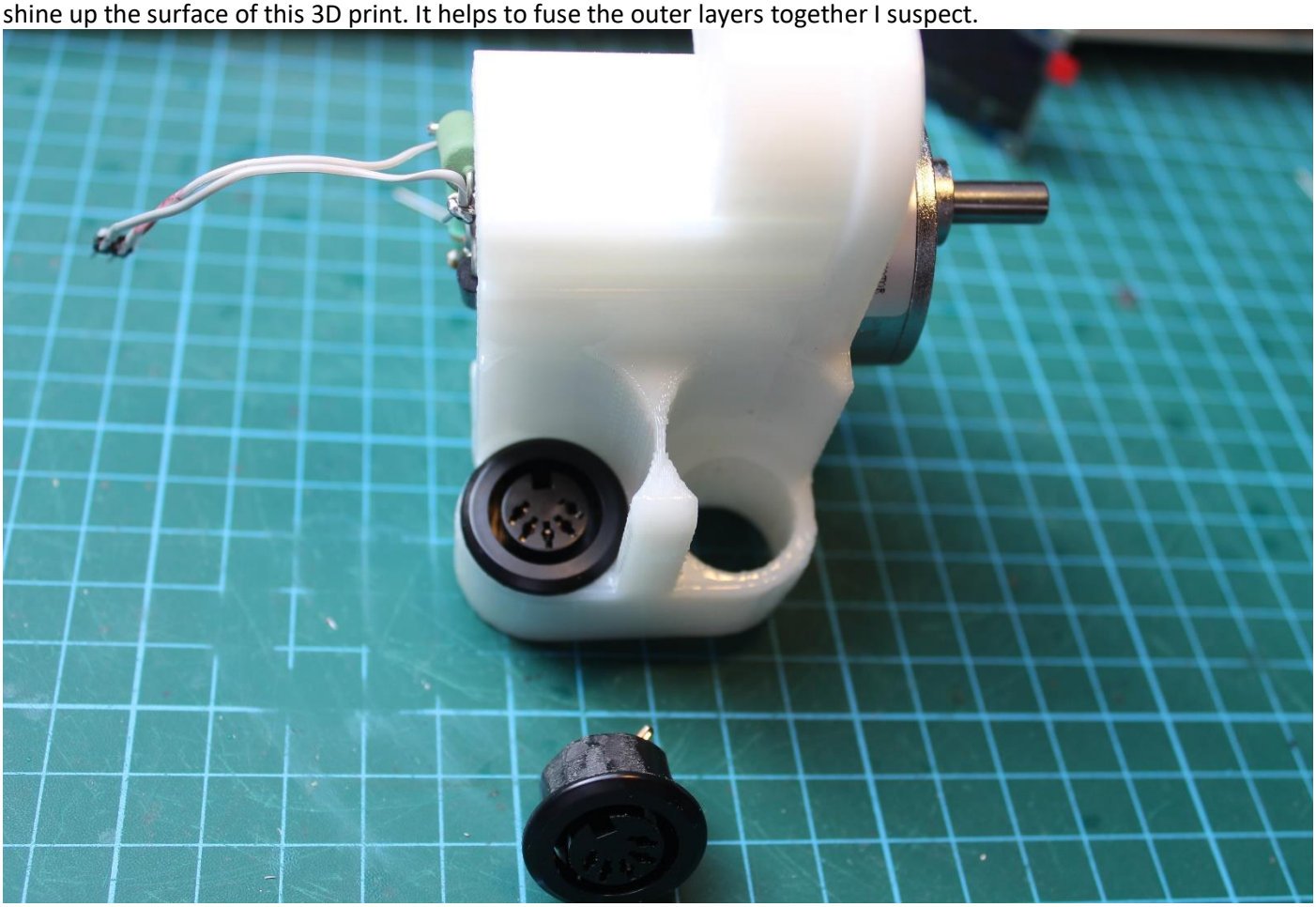
File all the projections and clips off one of the sockets until it is cylindrical. Do the same for the other one (on right of this image) except for the locating ridge as shown in the one on the right.



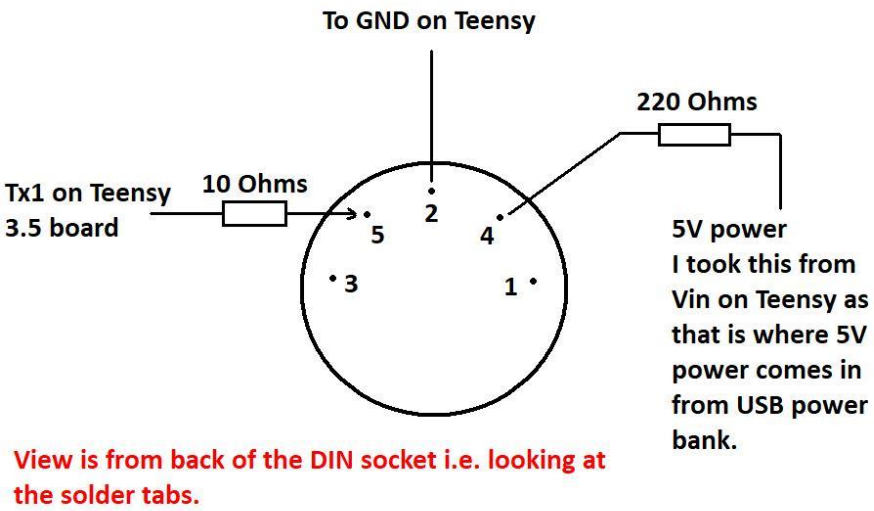
Push the one with the locating ridge into the hole shown here on the left.

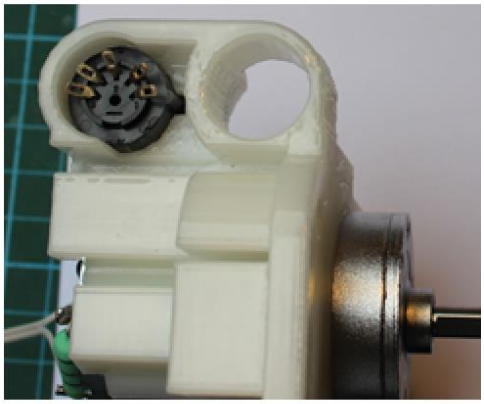


Carefully use a round file in the hole in the 3D print if you have to. It should be good fit but you should not have to use force to get it into the hole otherwise you might damage the 3D print. I used an acetone polishing technique to shine up the surface of this 3D print. It helps to fuse the outer layers together I suspect.



The left hand one is wired to transmit MIDI data. The right hand one is just used to neatly park the unused receive side of MIDI Bluetooth devices like the Yamaha one that come in 2 parts with a linking cable.



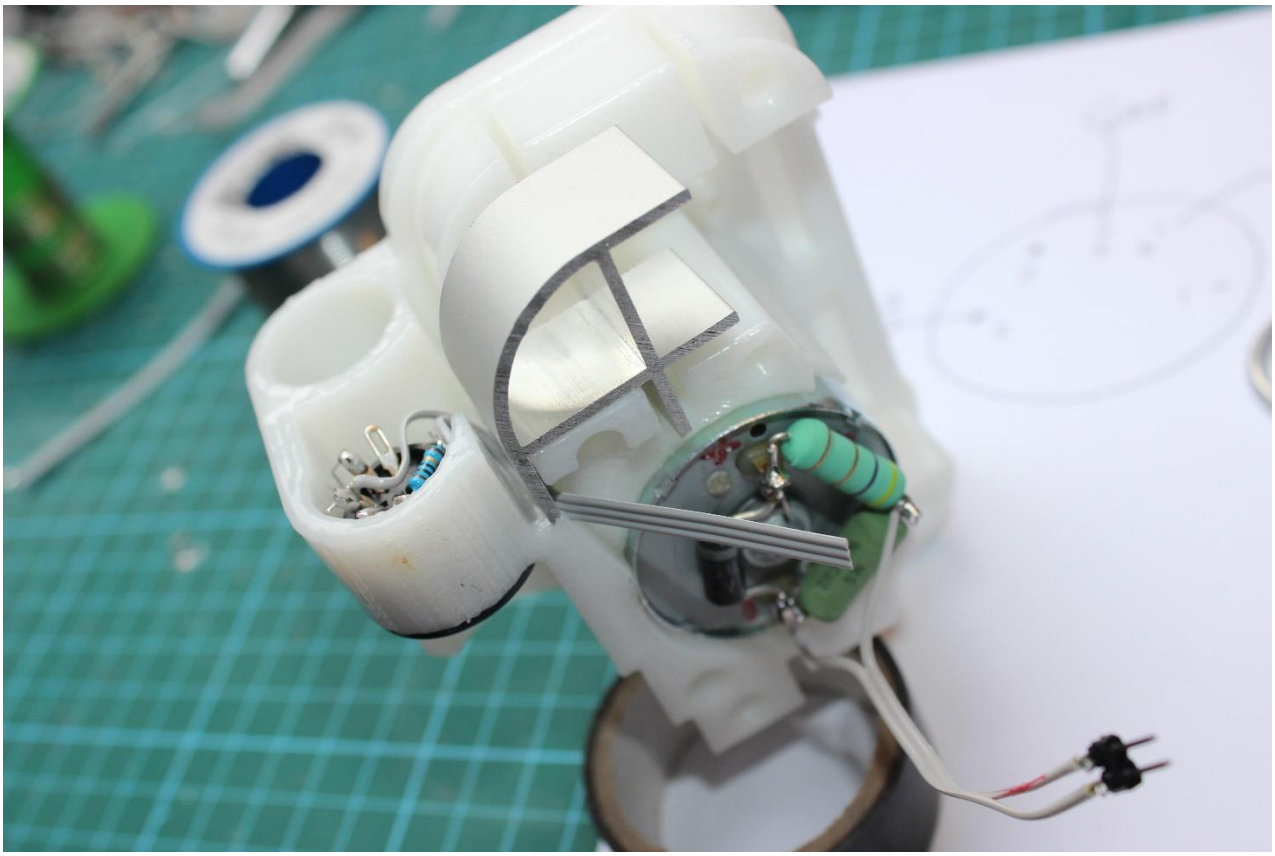


View is from back of the DIN socket i.e. looking at the solder tabs.

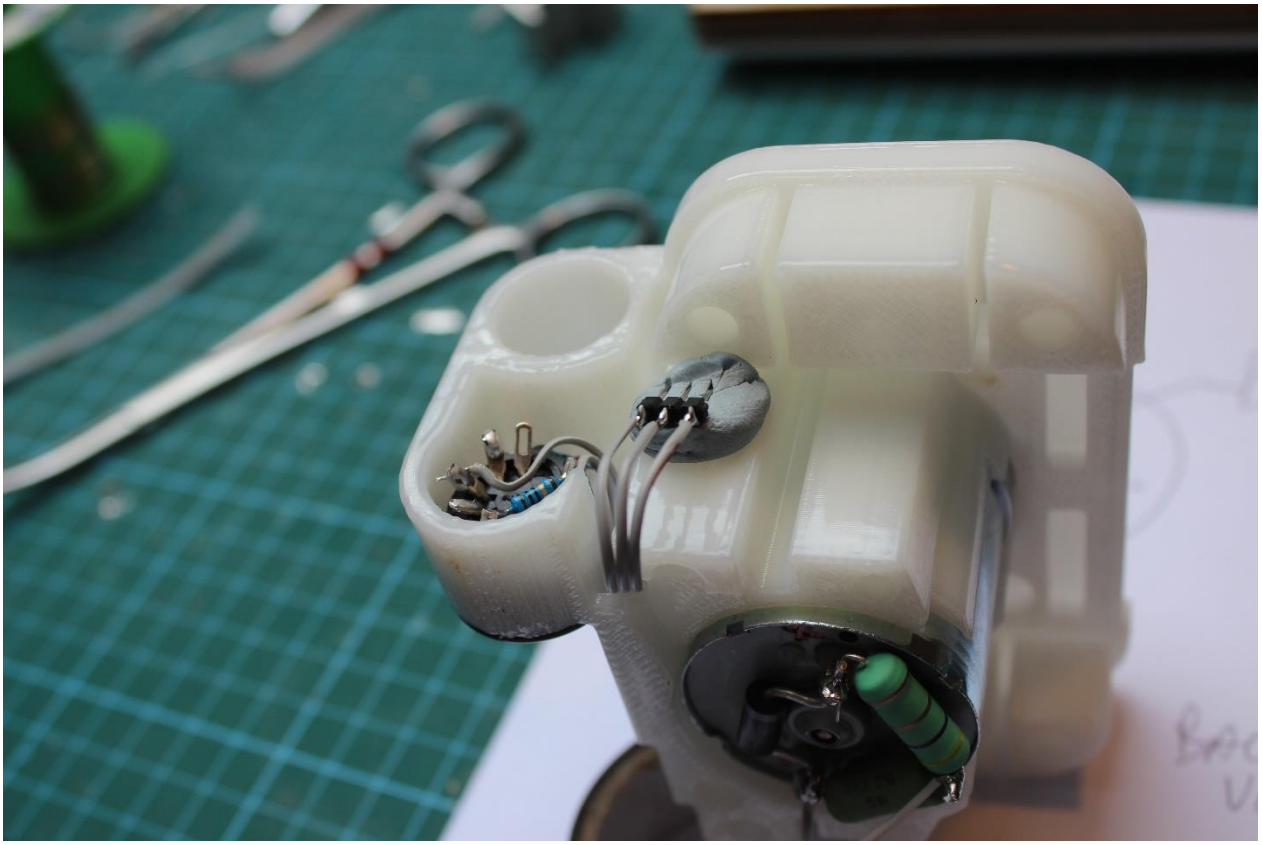
Note: To make DIN socket fit hole in 3D print, file off any tabs and clips on the DIN housing until it is circular, push into place and glue.

Left hand DIN socket wired as above for the MIDI tranmitter to plug into. Second DIN socket is not wired. It is there to park receive side neatly.

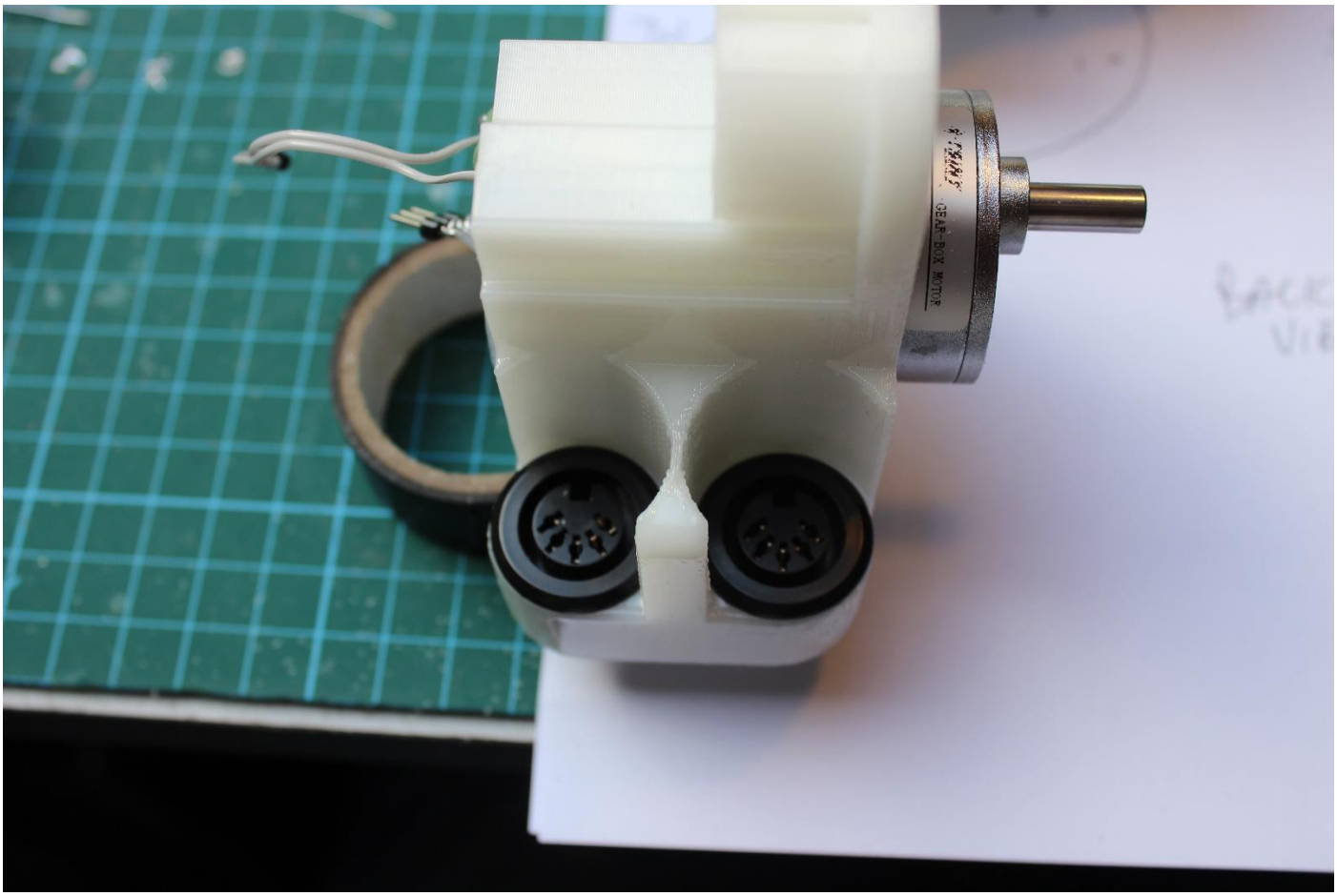
Wire the MIDI socket up as in this diagram. The one shown in the image to the right. This is why we labelled the ends of the 3 wire cable from Vin, GND and Pin1(Tx) on the Teensy board.



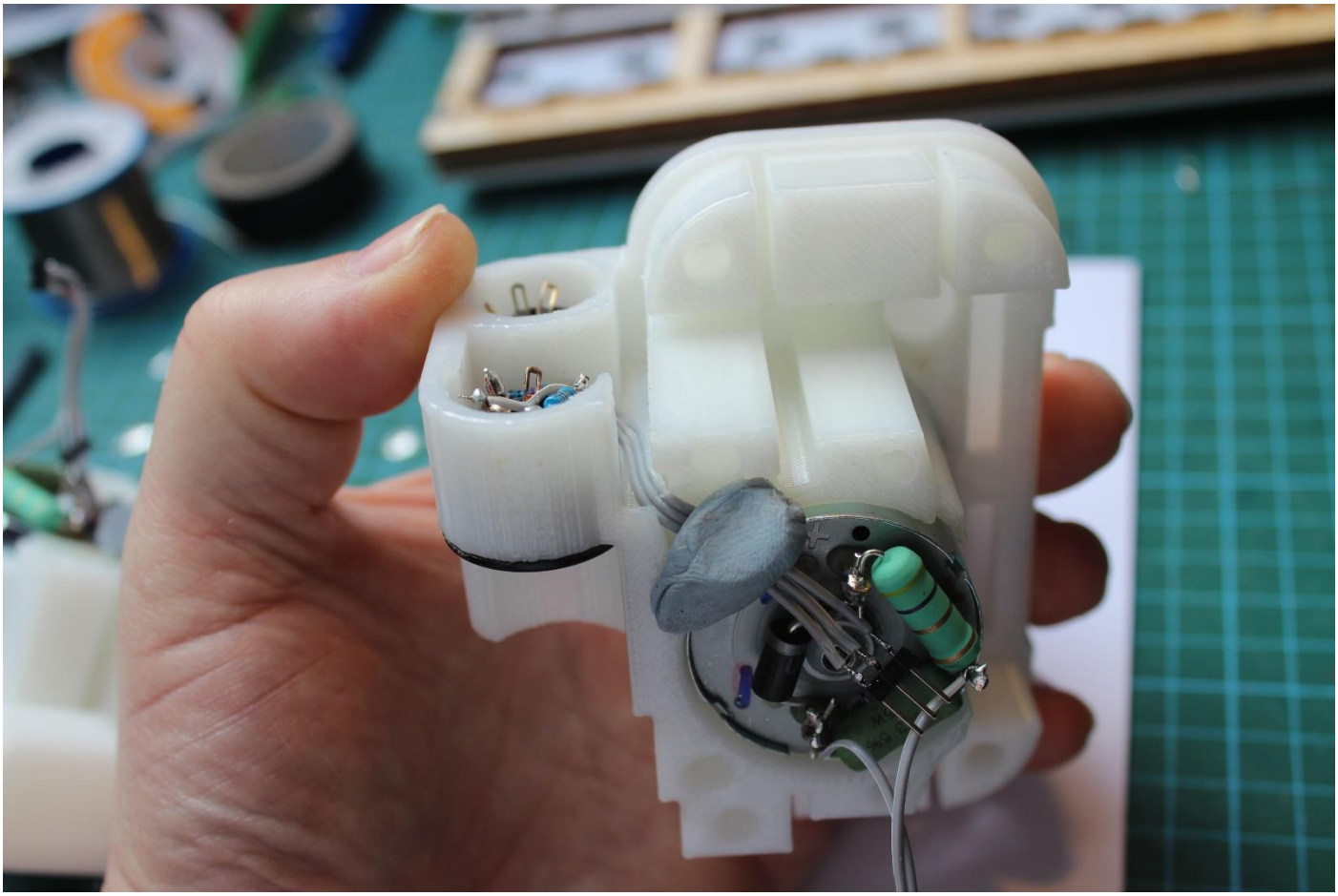
Keep it neat. Make up a 3 wire cable as shown with relevant resistors in place next to the solder terminals on the DIN socket. Then, run the 3 wires neatly as shown in the groove provided in the 3D print so they run under the alloy extrusion when it is all finally assembled without getting jammed with risk of a short-circuit. I am using a short piece of alloy extrusion here in this photo to just illustrate what I mean.



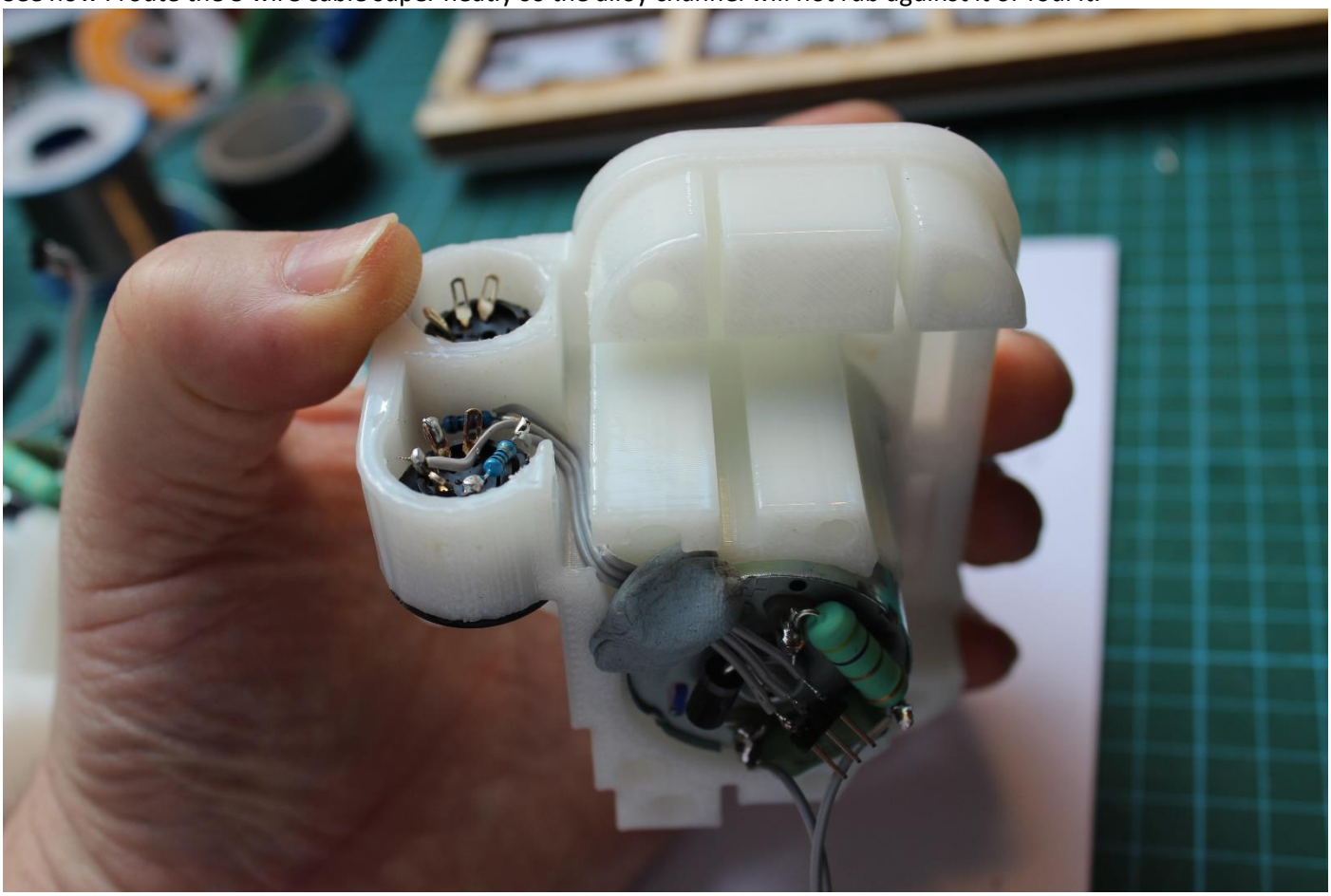
Solder 3 male header pins to the ends of your short length of cable. Make sure they will match the labelled ends of the 3 wire cable you earlier soldered to the back of the Teensy board pins, i.e. 5V Power, GND, and Pin(Tx).



x

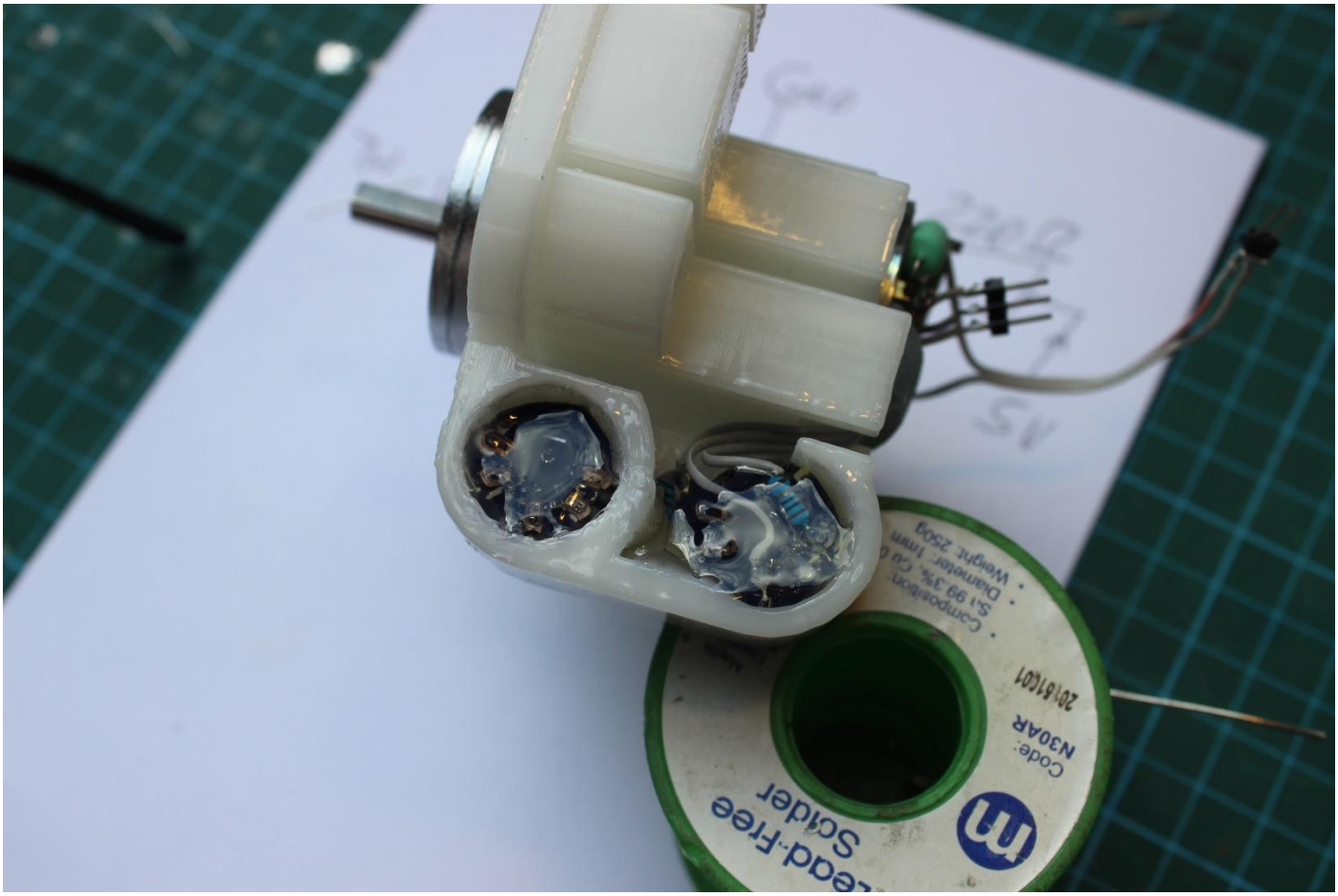


See how I route the 3 wire cable super neatly so the alloy channel will not rub against it or foul it.

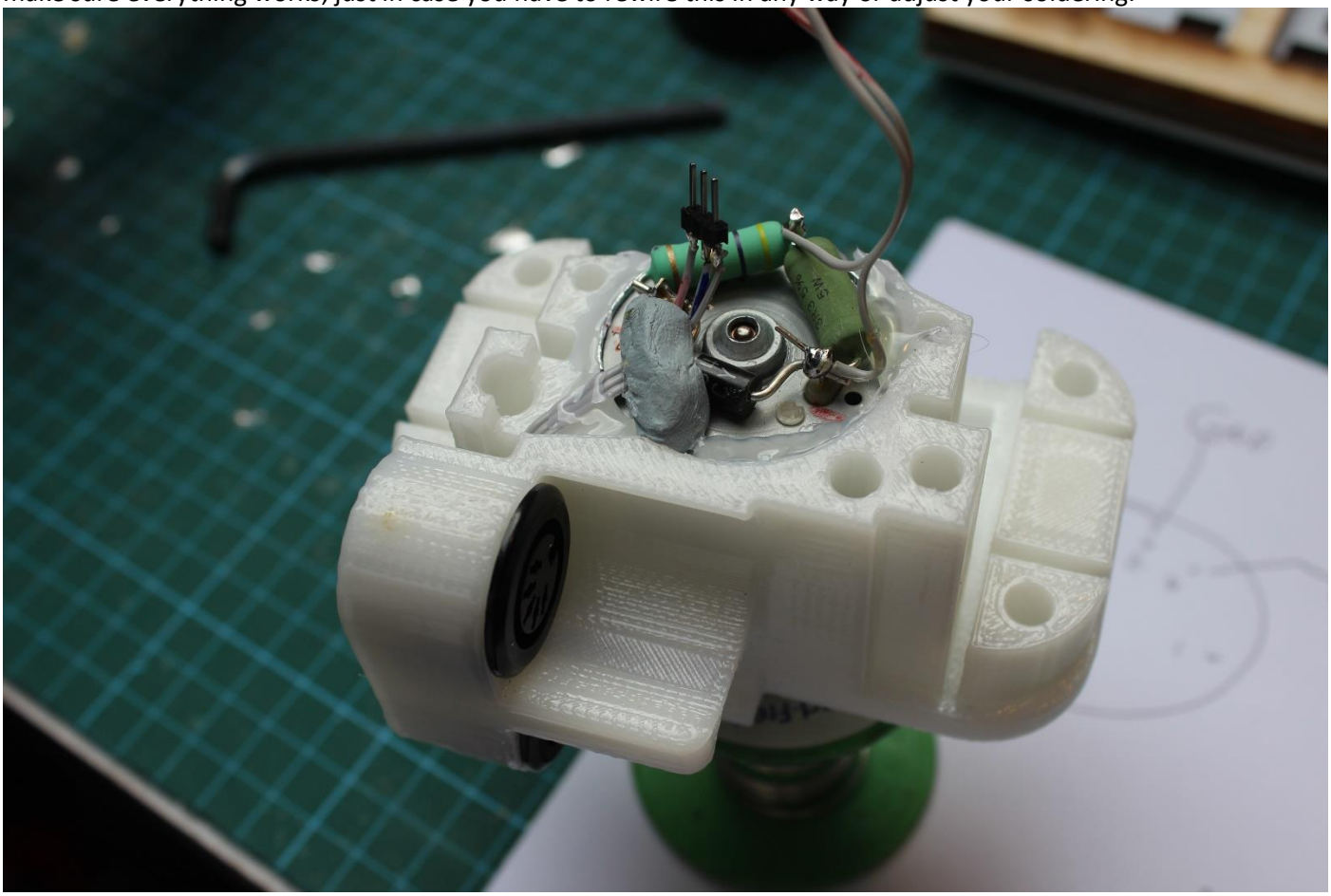


x

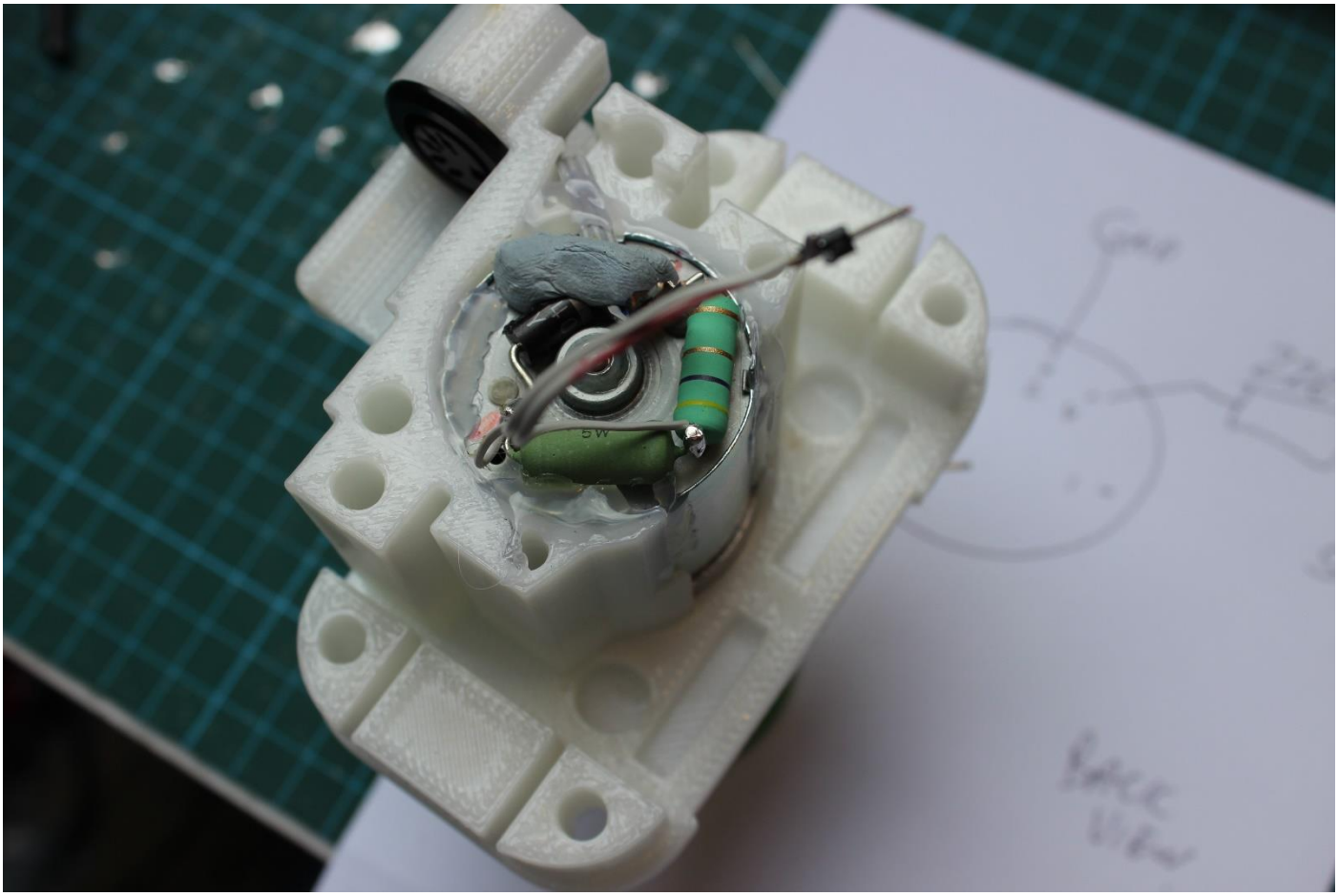
x



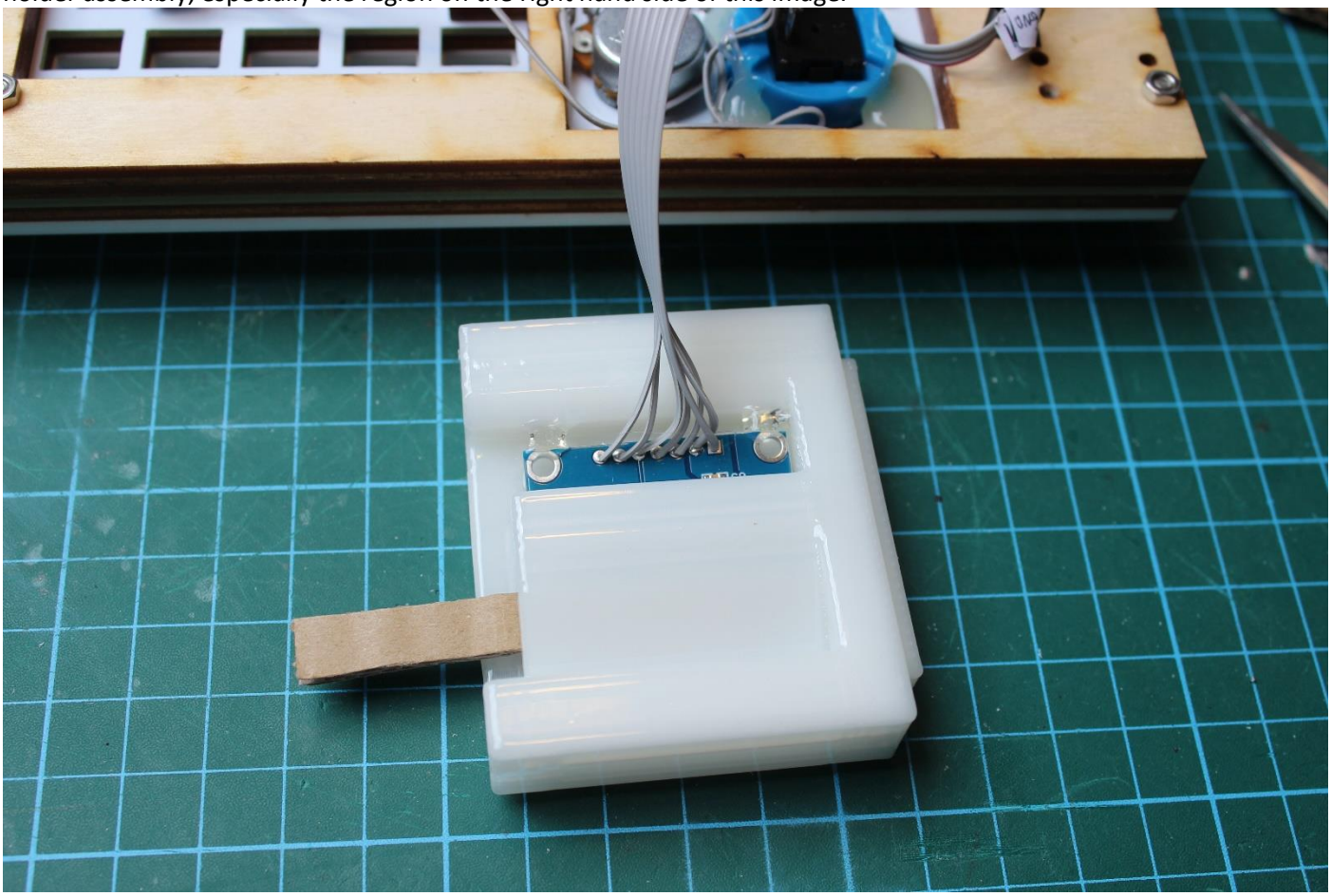
Pot the undersides of the DIN sockets in hot glue. NOTE: I suggest you only do this ***after*** you have done a full test to make sure everything works, just in case you have to rewire this in any way or adjust your soldering.



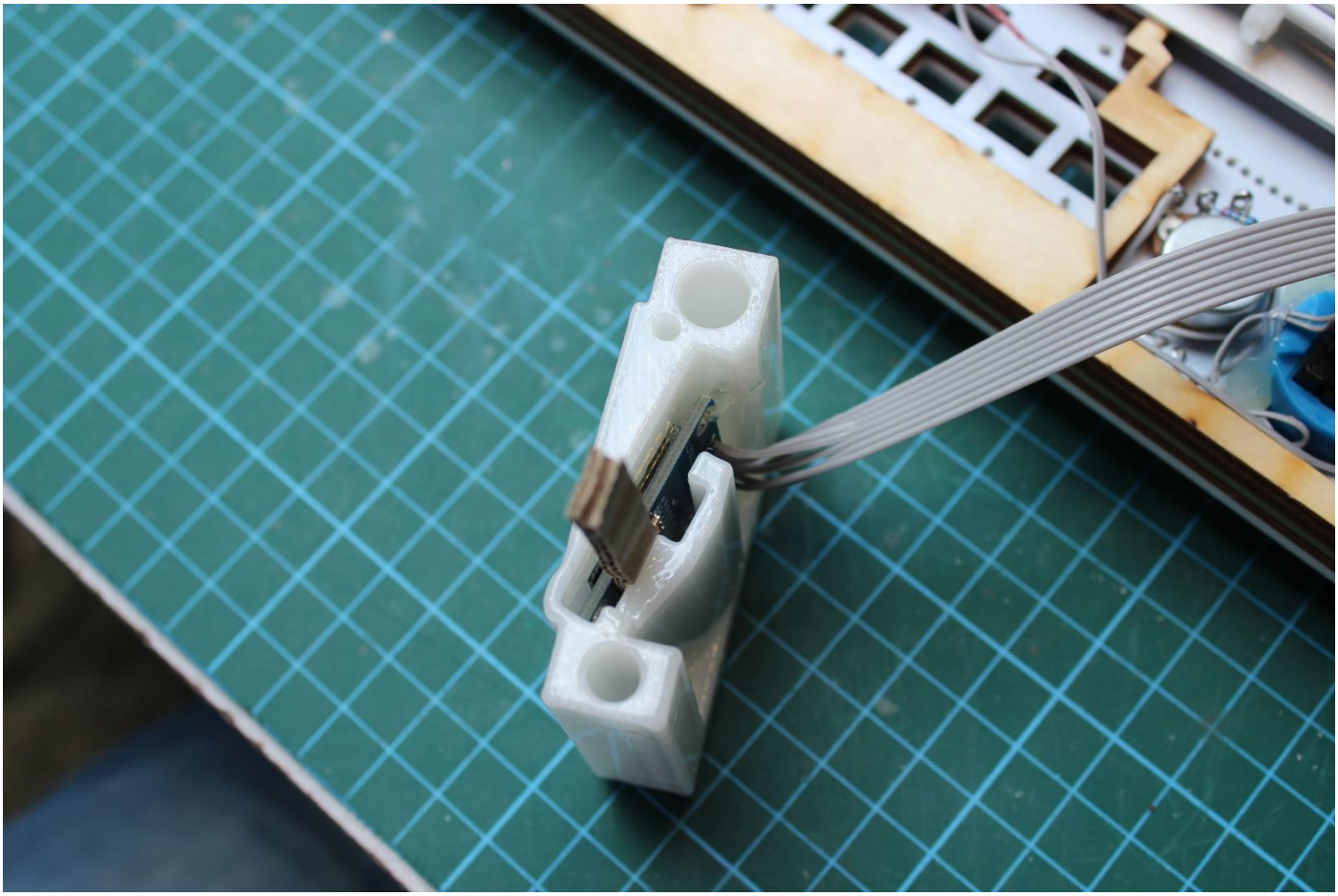
Glue motor in place.



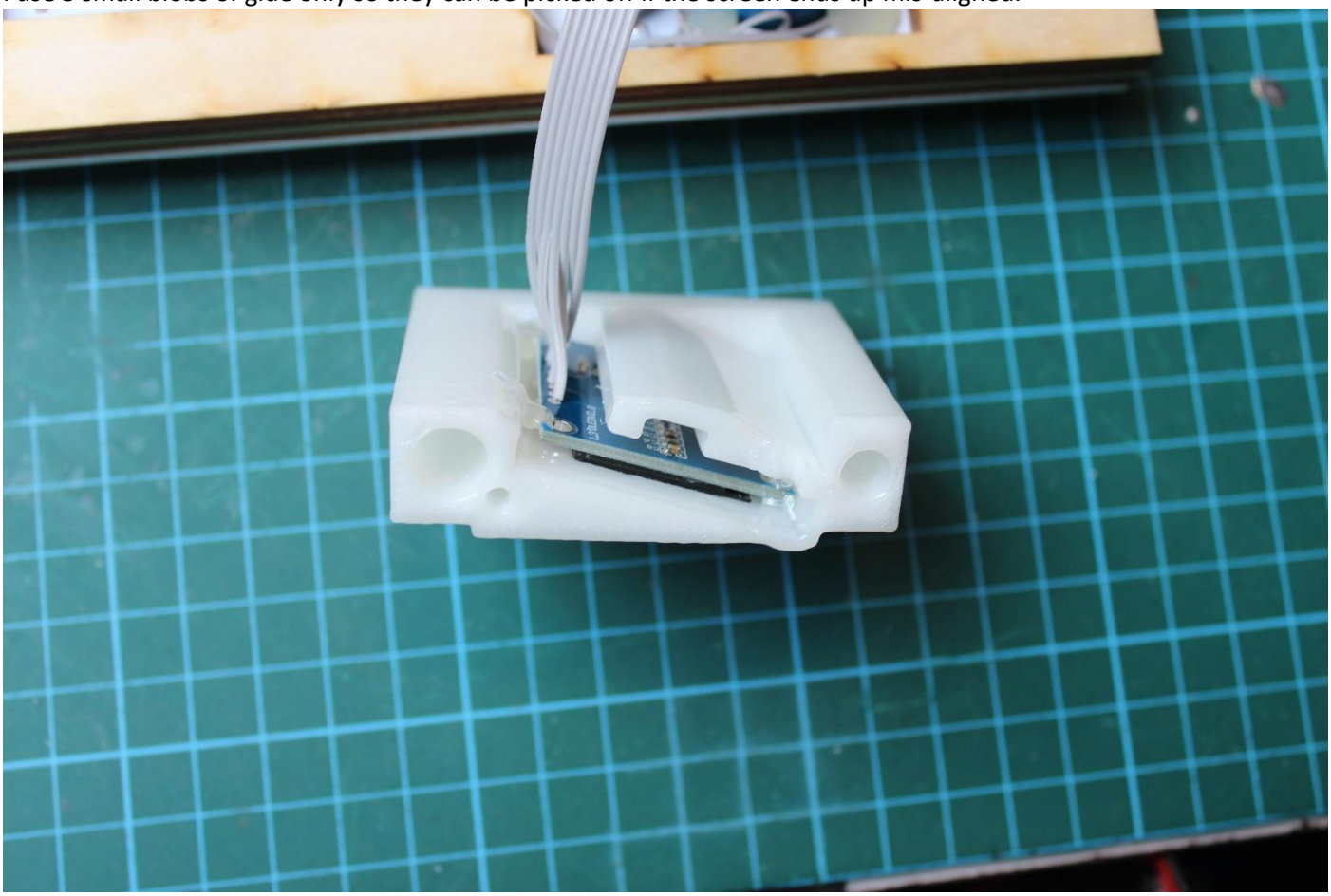
Use the glue with care. Big lumpy blobs of glue will stop the front panel sandwich fitting properly against this motor holder assembly, especially the region on the right hand side of this image.



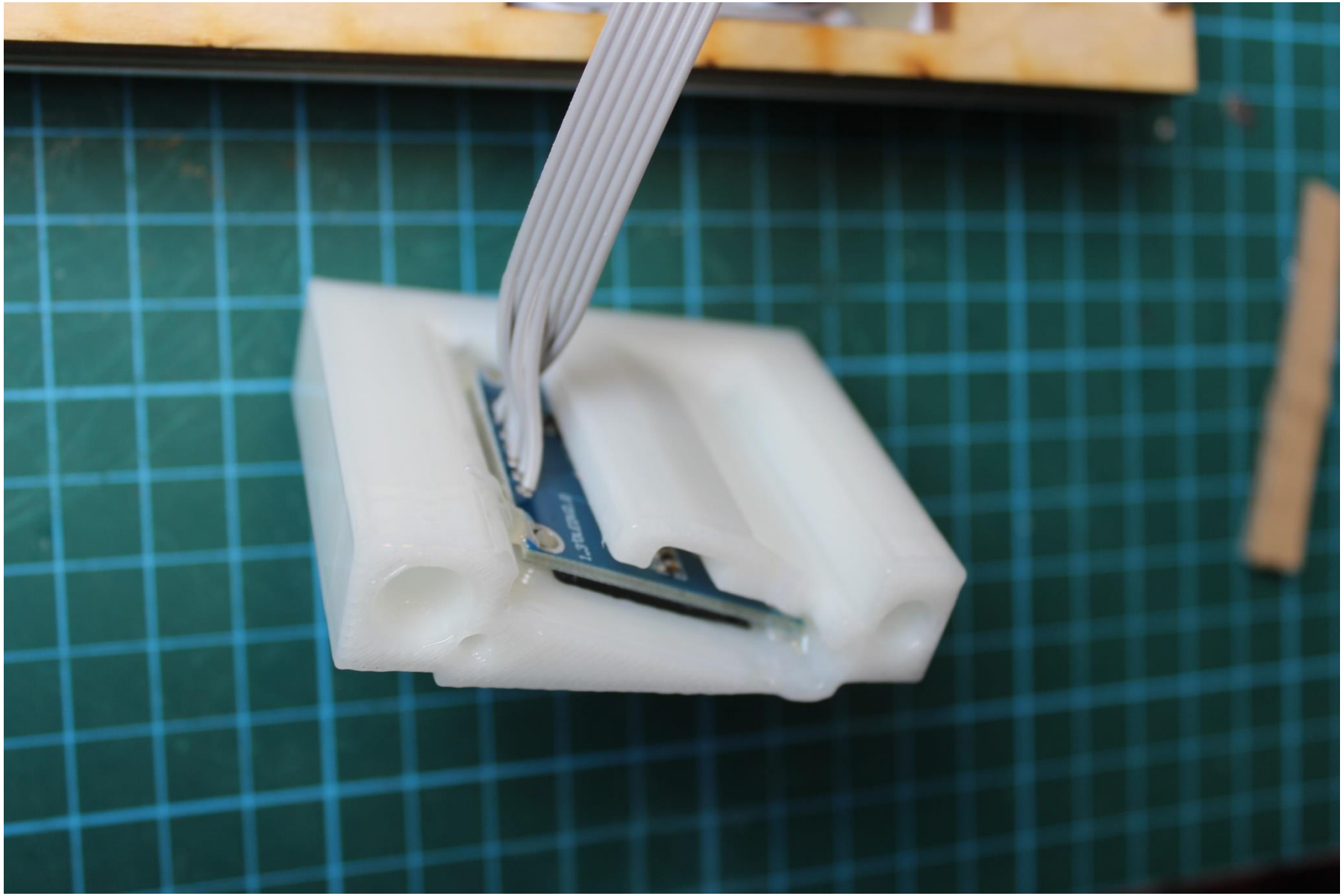
Glue screen into its holder. The thin strip of (compressible) corrugated card is inserted temporarily behind it to hold it in place prior to adding glue. Get it lined up with front rectangular viewing orifice first, before adding glue.

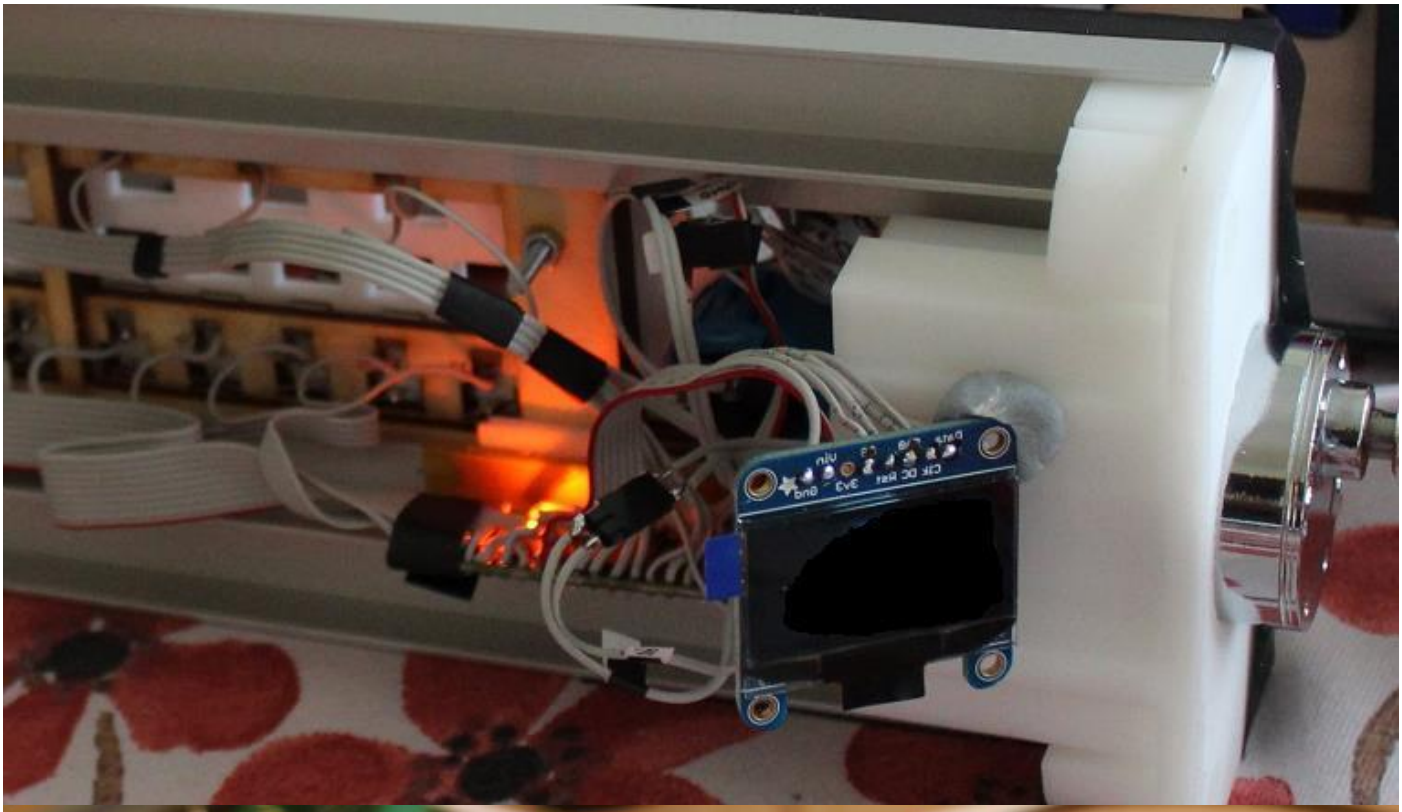


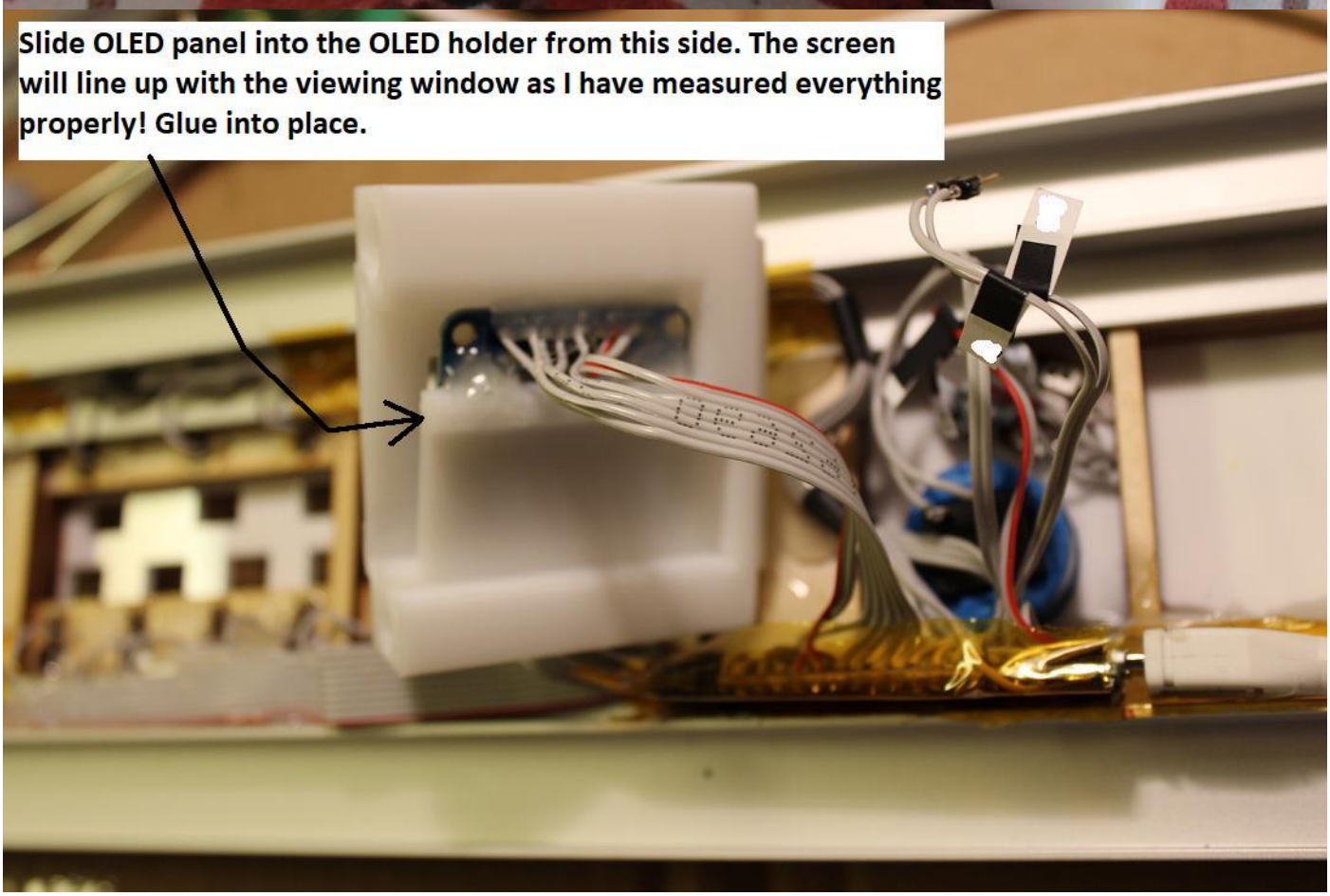
I use 3 small blobs of glue only so they can be picked off if the screen ends up mis-aligned.

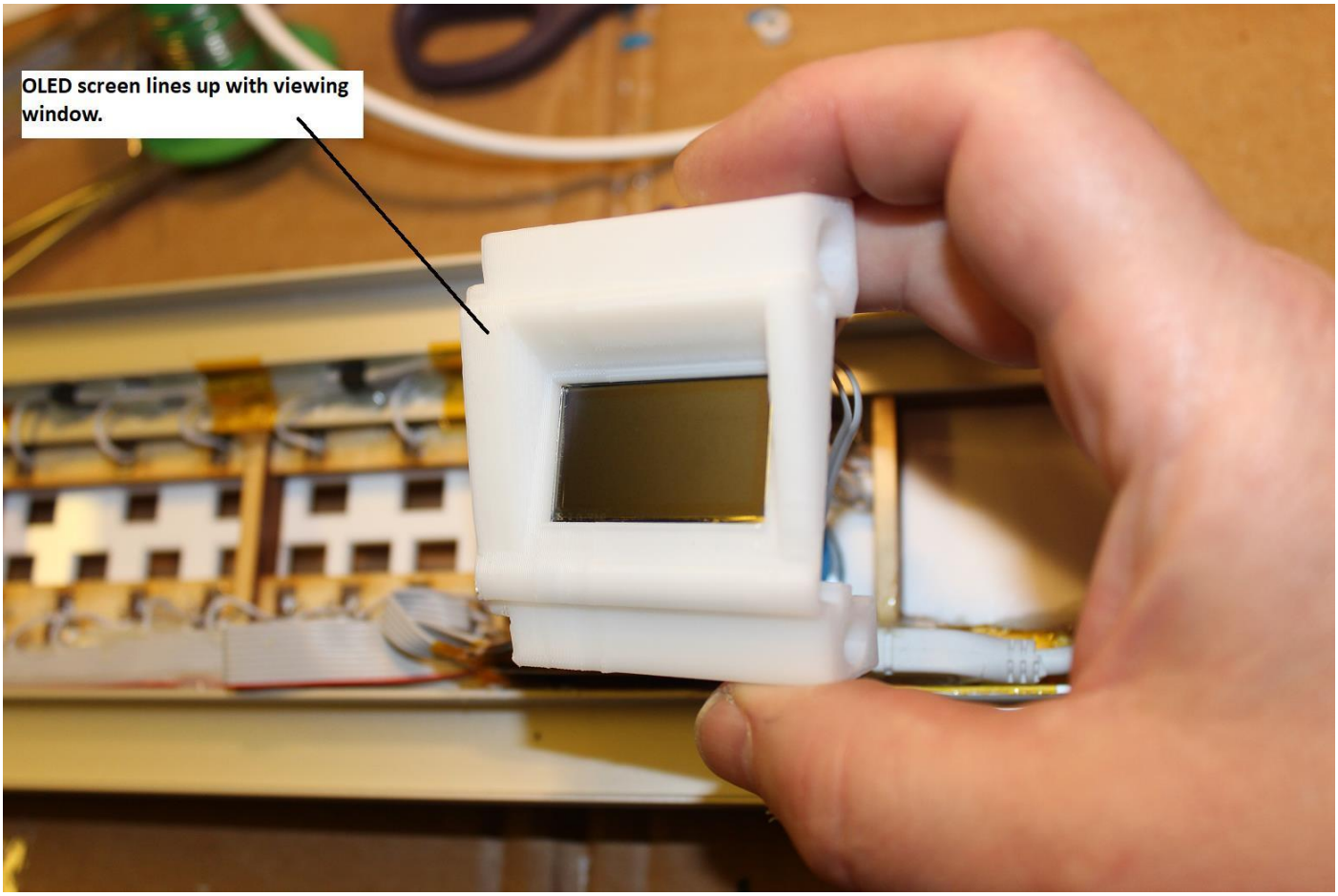


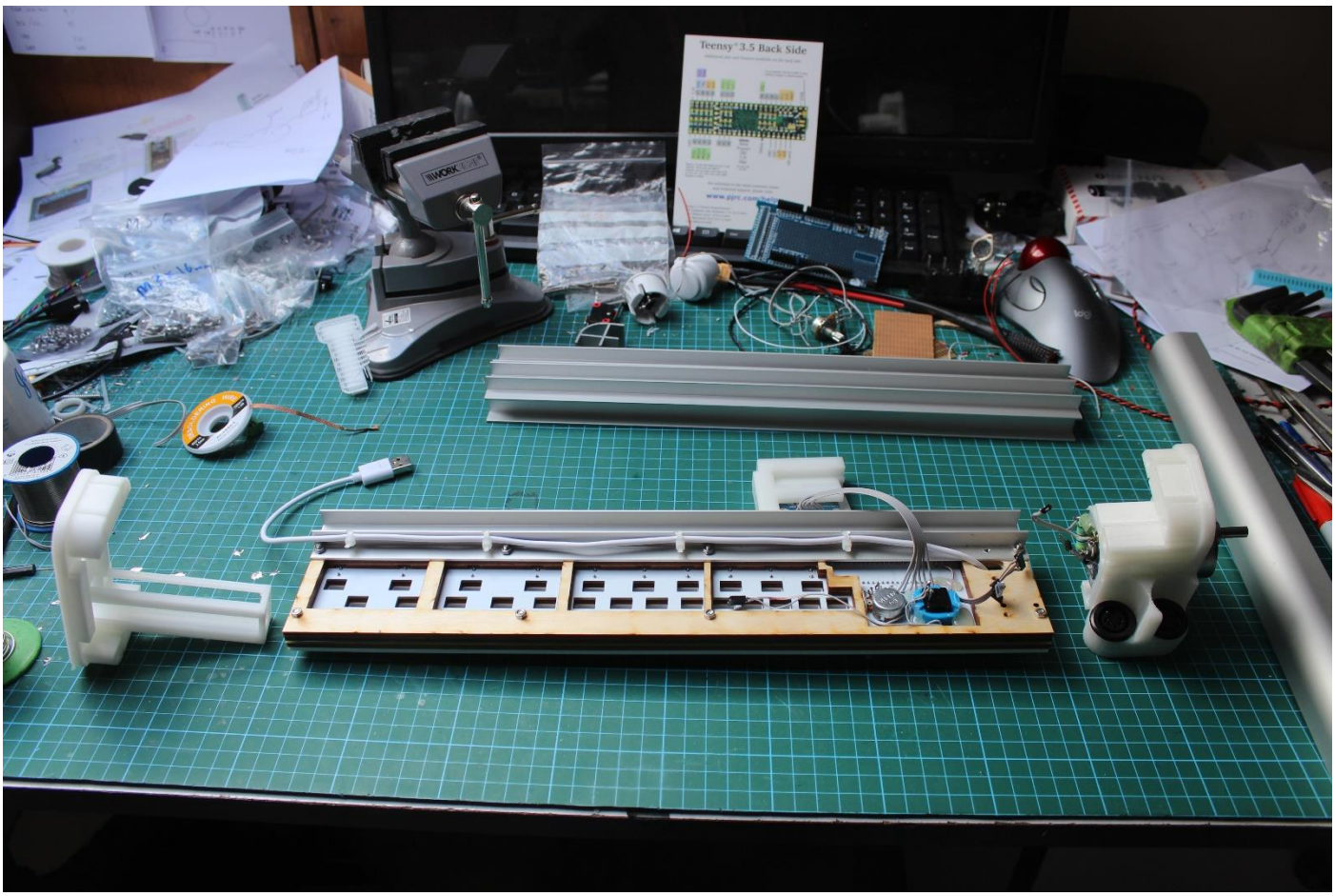
The remove the cardboard strip and with care all should be OK.



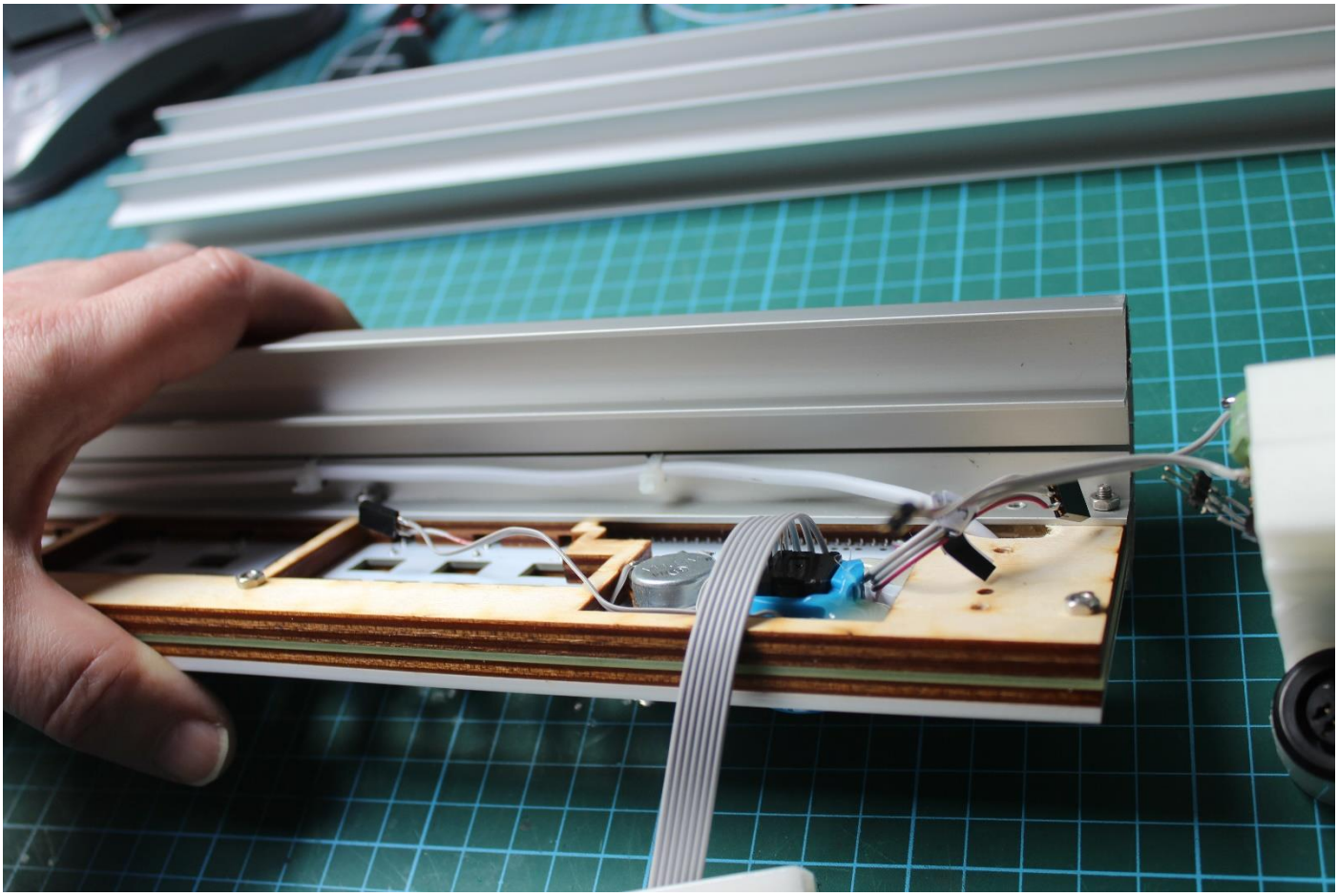



Slide OLED panel into the OLED holder from this side. The screen will line up with the viewing window as I have measured everything properly! Glue into place.

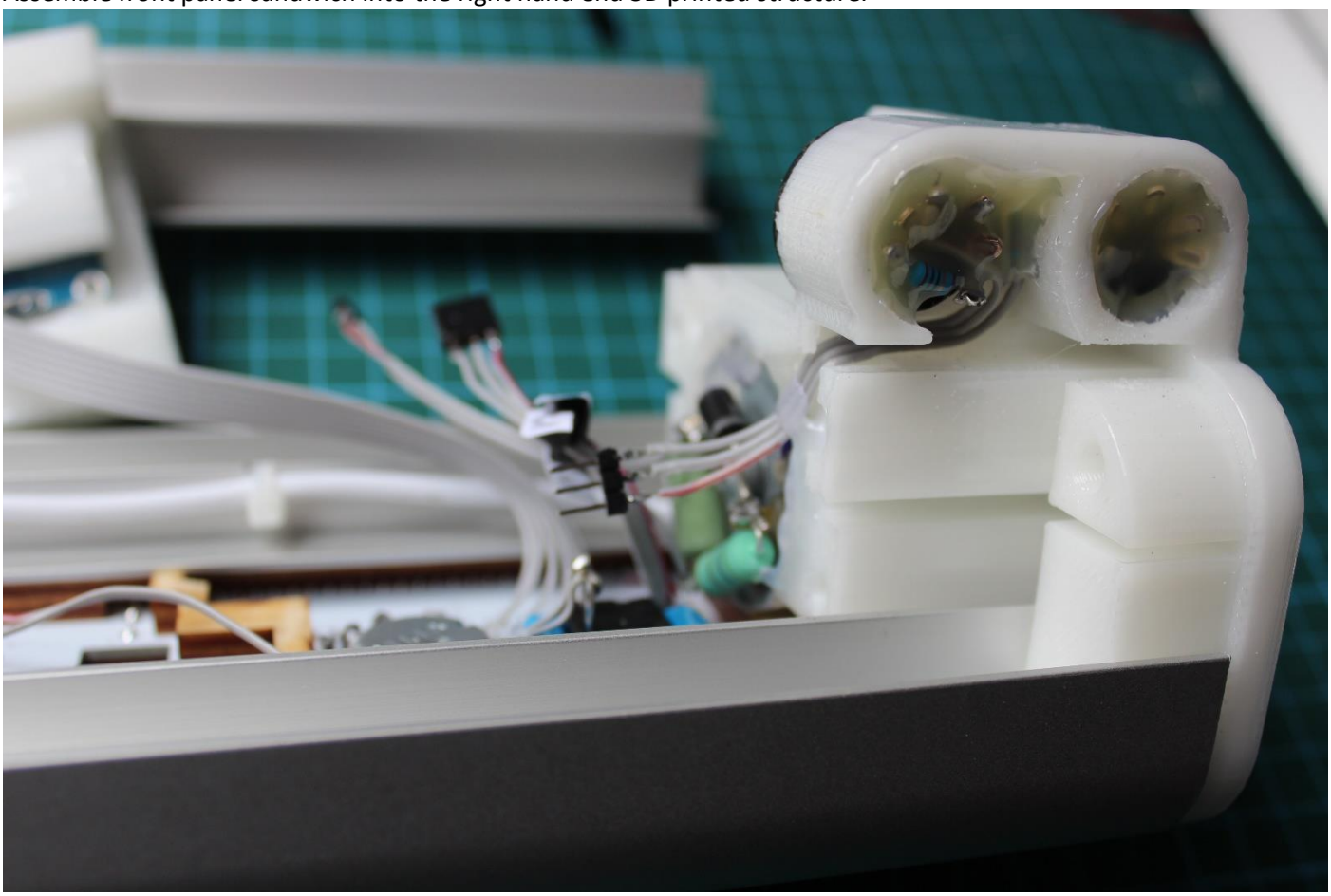




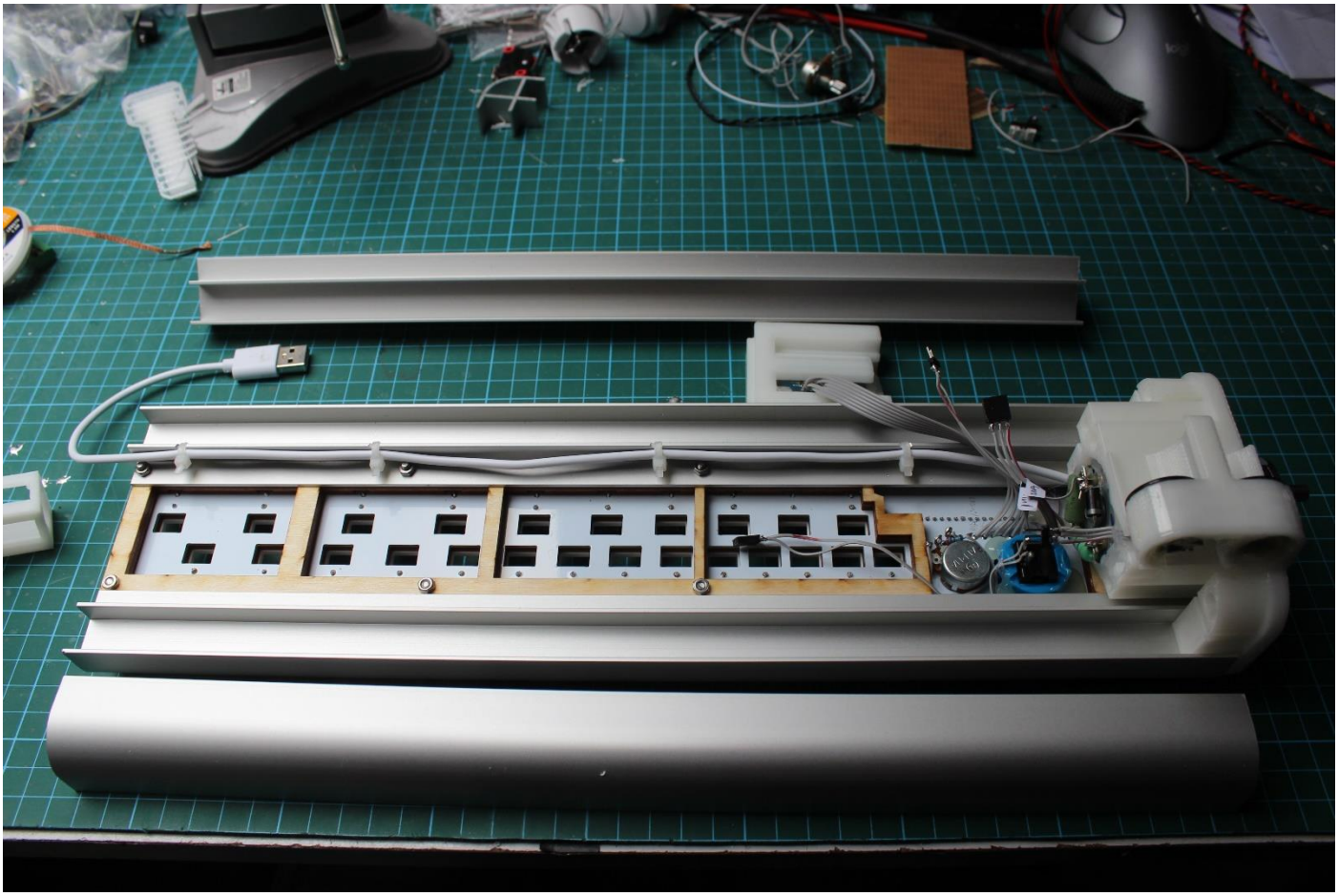
Here you can see the 2 main end 3D printed structures. These do many jobs but also hold the 4 lengths of alloy channel correctly located in place.



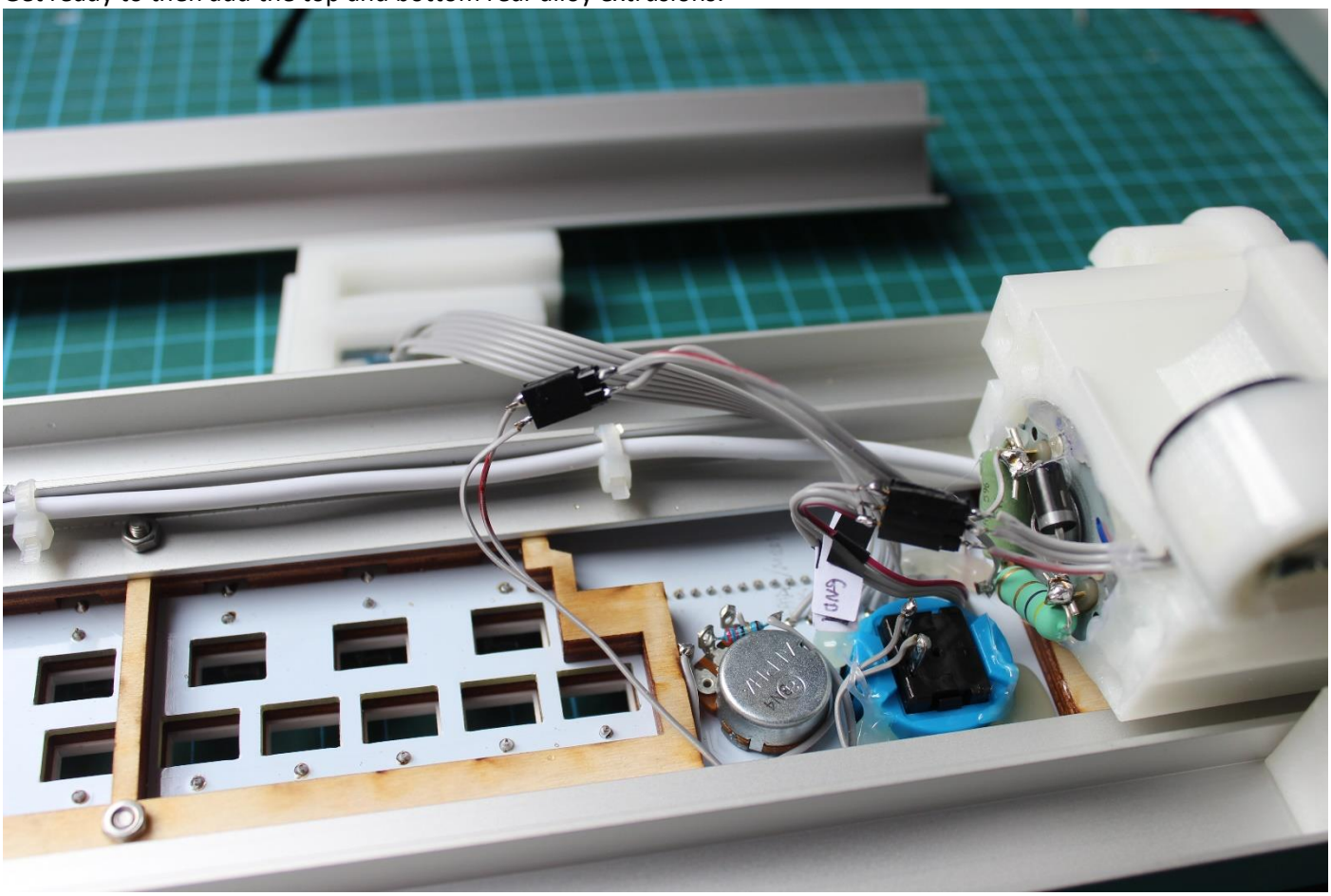
Assemble front panel sandwich into the right hand end 3D printed structure.



Add in the lower front alloy extrusion as shown.



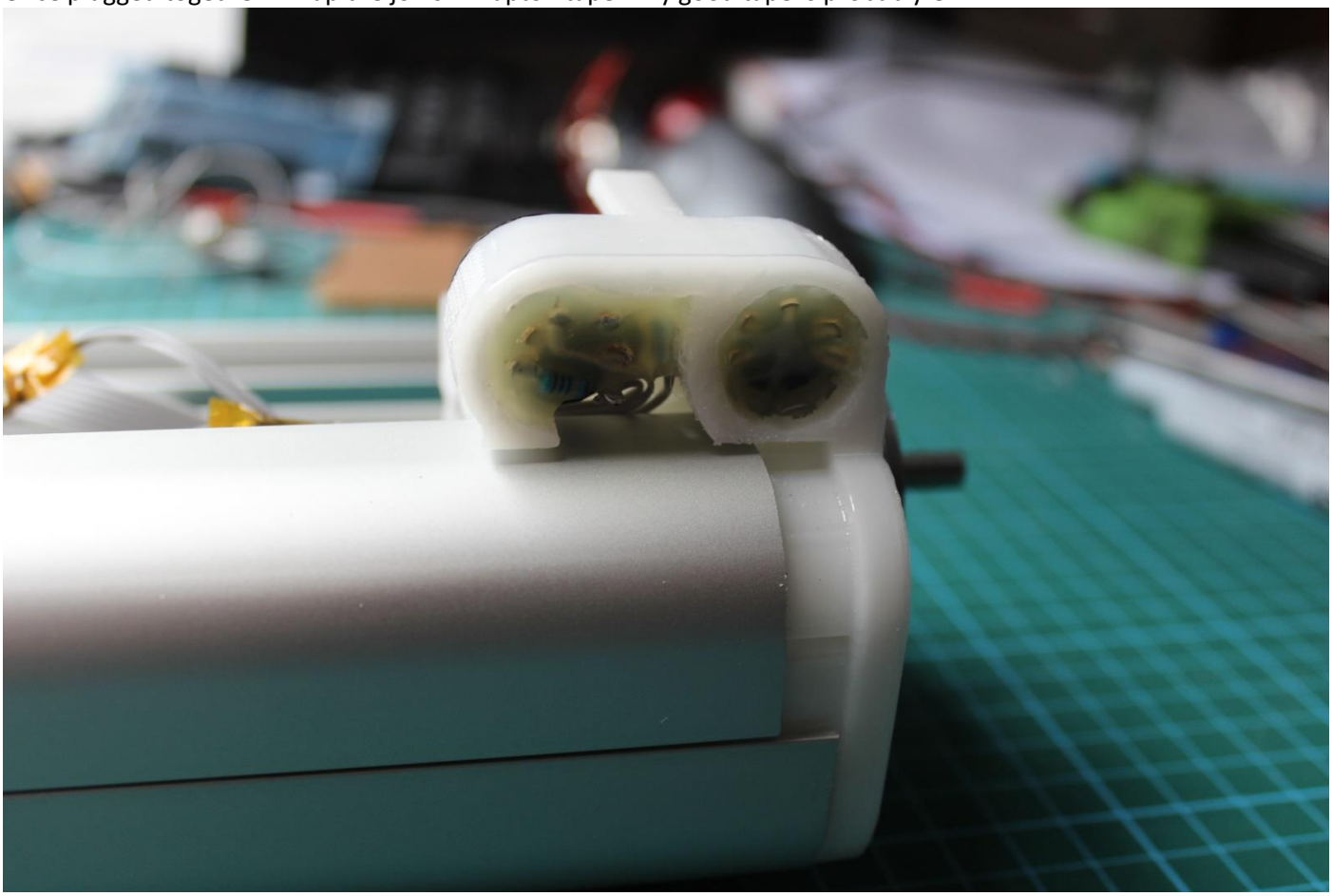
Get ready to then add the top and bottom rear alloy extrusions.



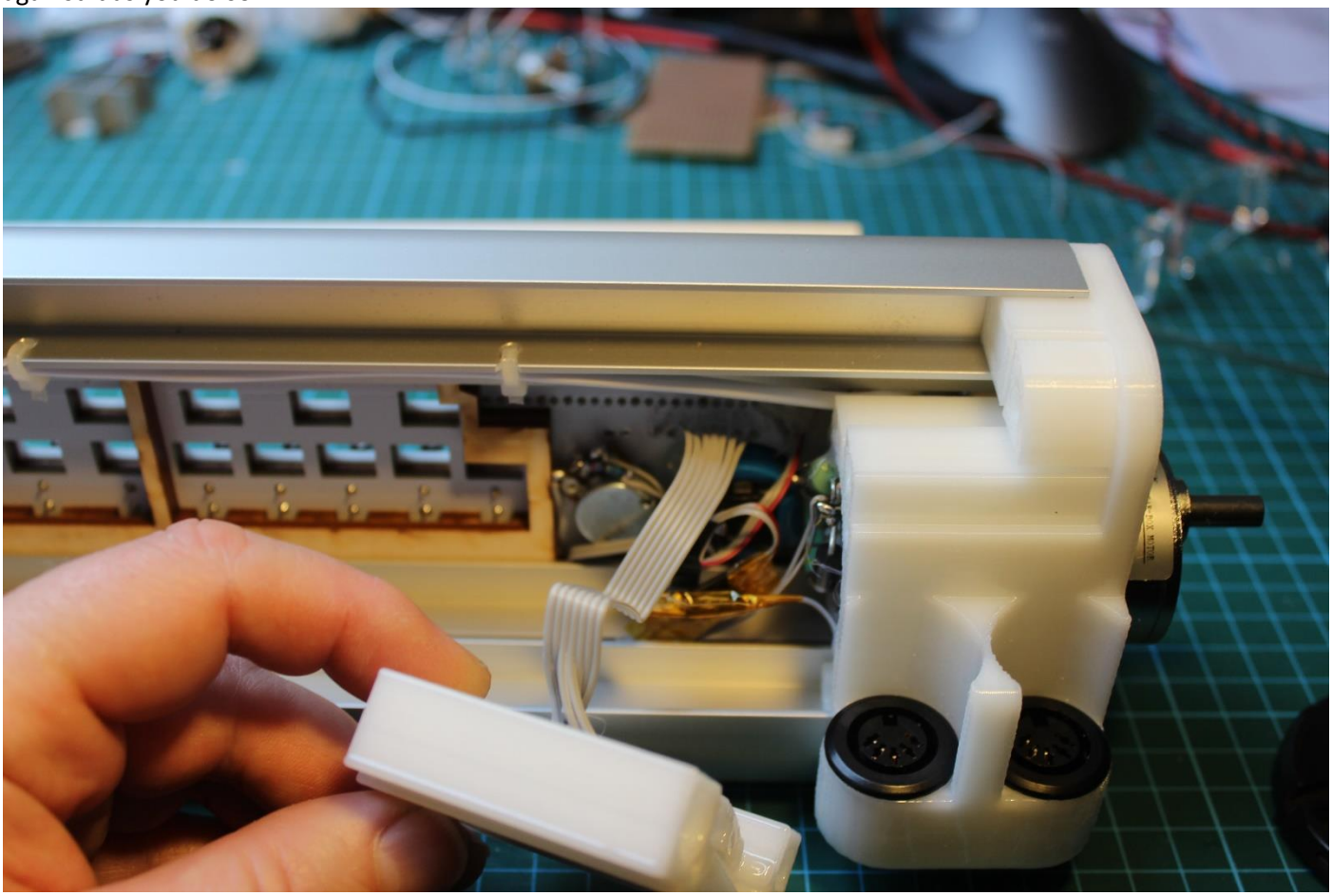
1) Join up the wires for the motor crank system. The ends you coloured in red on each of the pairs of wires should be joined to each other i.e. red to red.

2) Join the two 3 Pin plugs together carrying the 3 wires from the back of the Teensy board to the MIDI socket. i.e. Vin(i.e. 5V power), GND and Pin1(Tx) are then carried to their respective pins in the 5 pin MIDI socket as in the

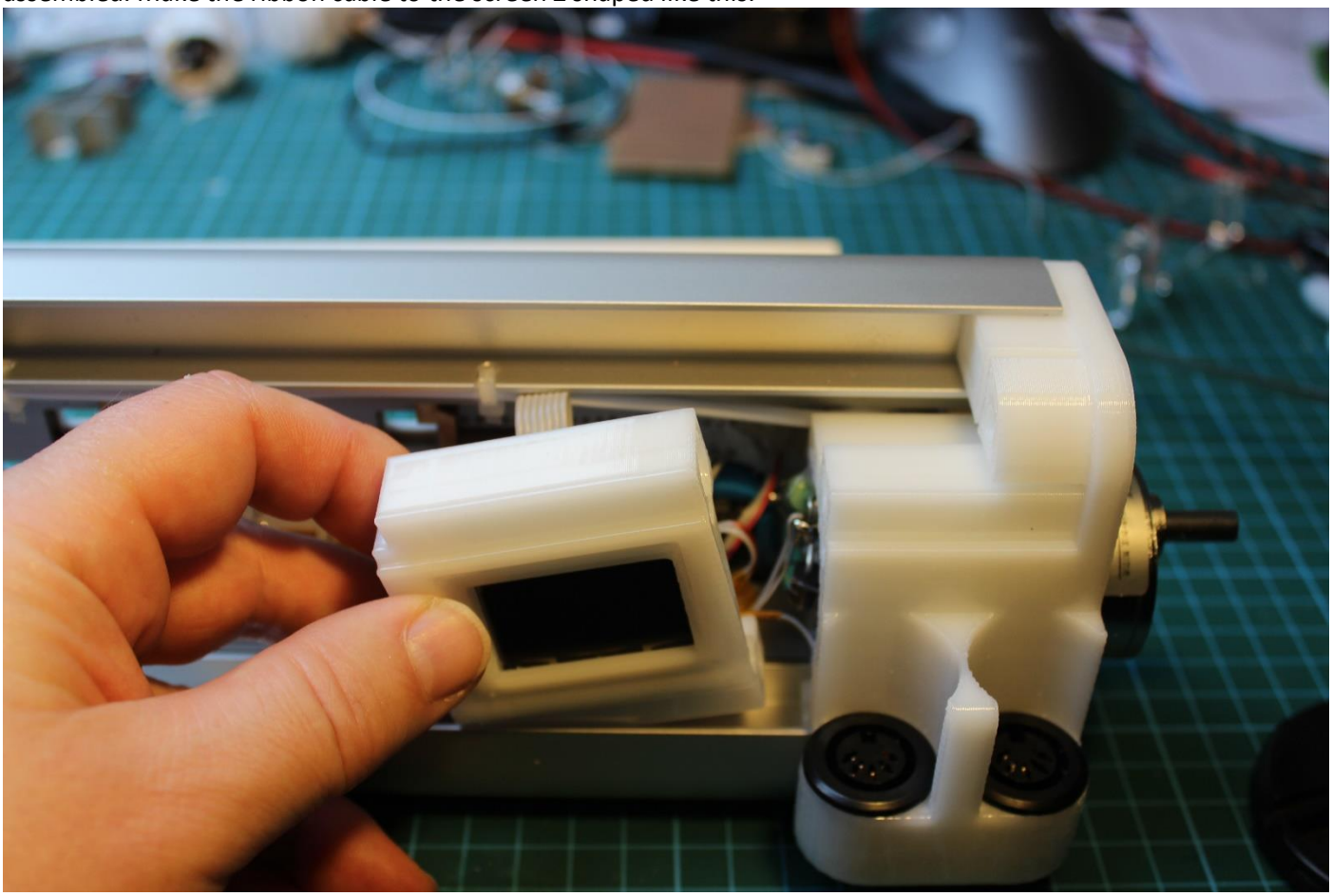
wiring diagram shown earlier. Check and double check you have not made a mistake with these 3 wires and the 2 resistors you must use with them that run to this MIDI socket.
Once plugged together I wrap the joins in Kapton tape. Any good tape is probably OK.



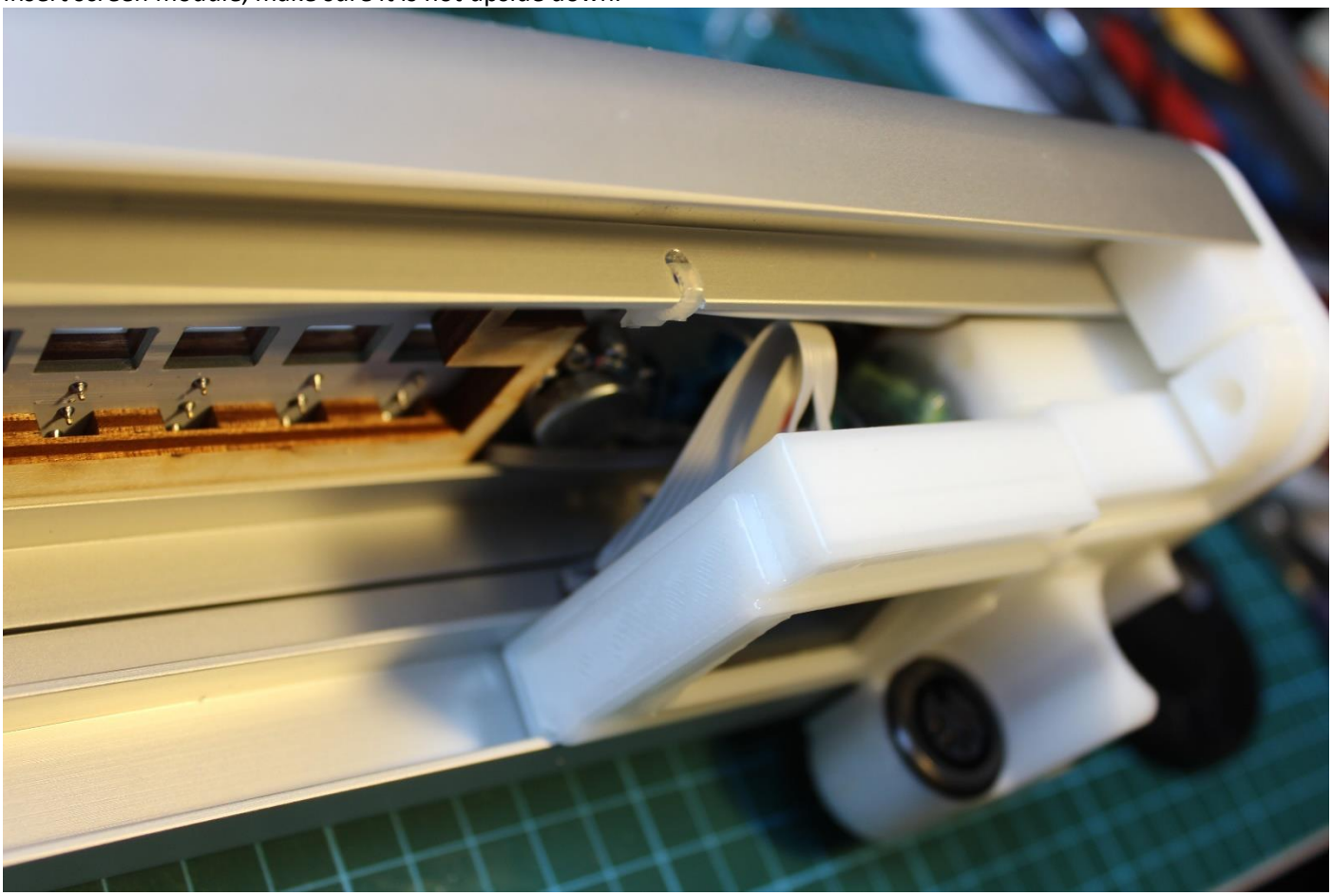
Insert the lower rear alloy extrusion and make sure the 3 wires from the DIN plug are not damaged or jammed hard against it as you do so.

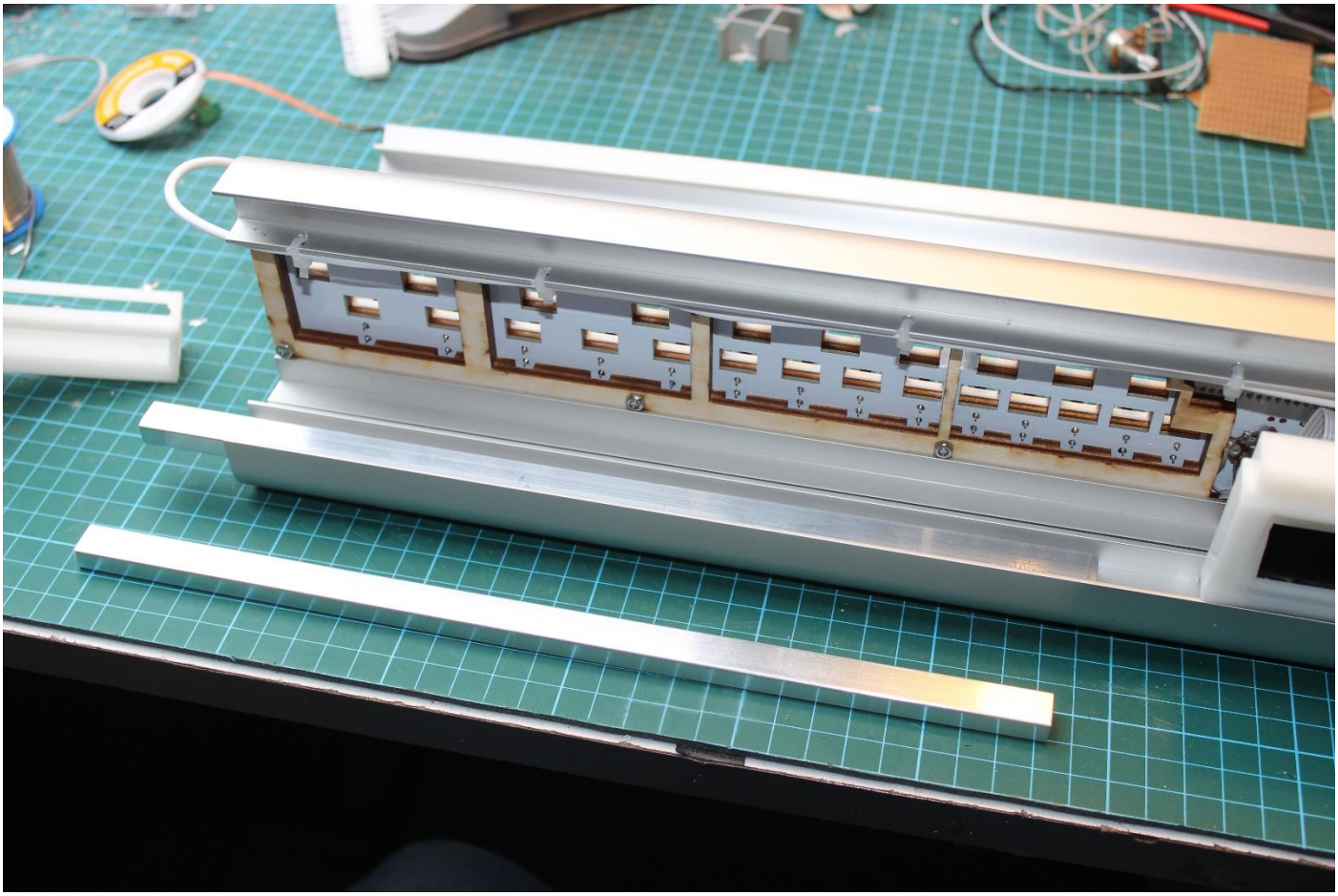


Tidy all the wires so they will not interfere with the stems of the keys of the higher notes when the DigiGurdy is fully assembled. Make the ribbon cable to the screen Z shaped like this.

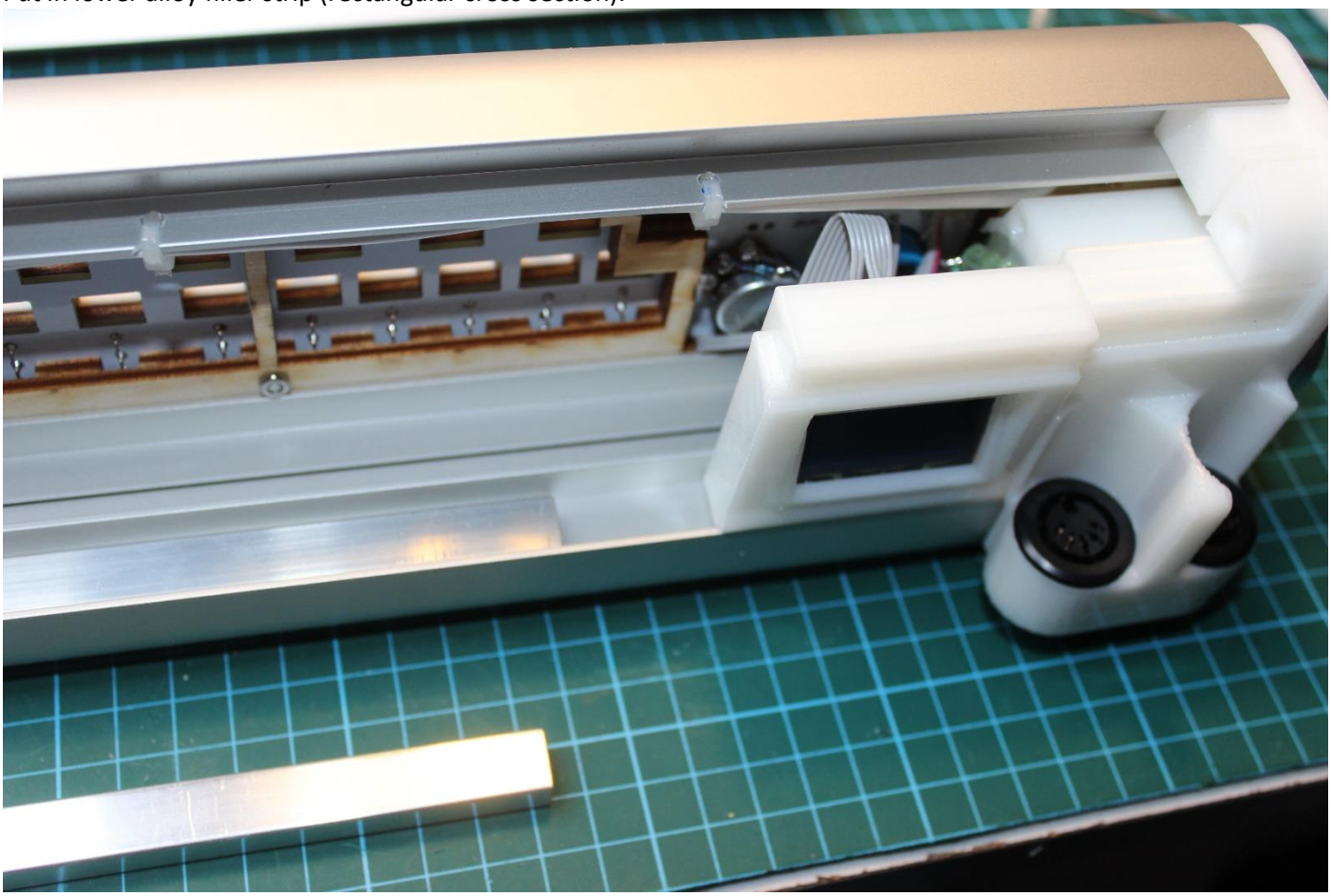


Insert screen module, make sure it is not upside down.

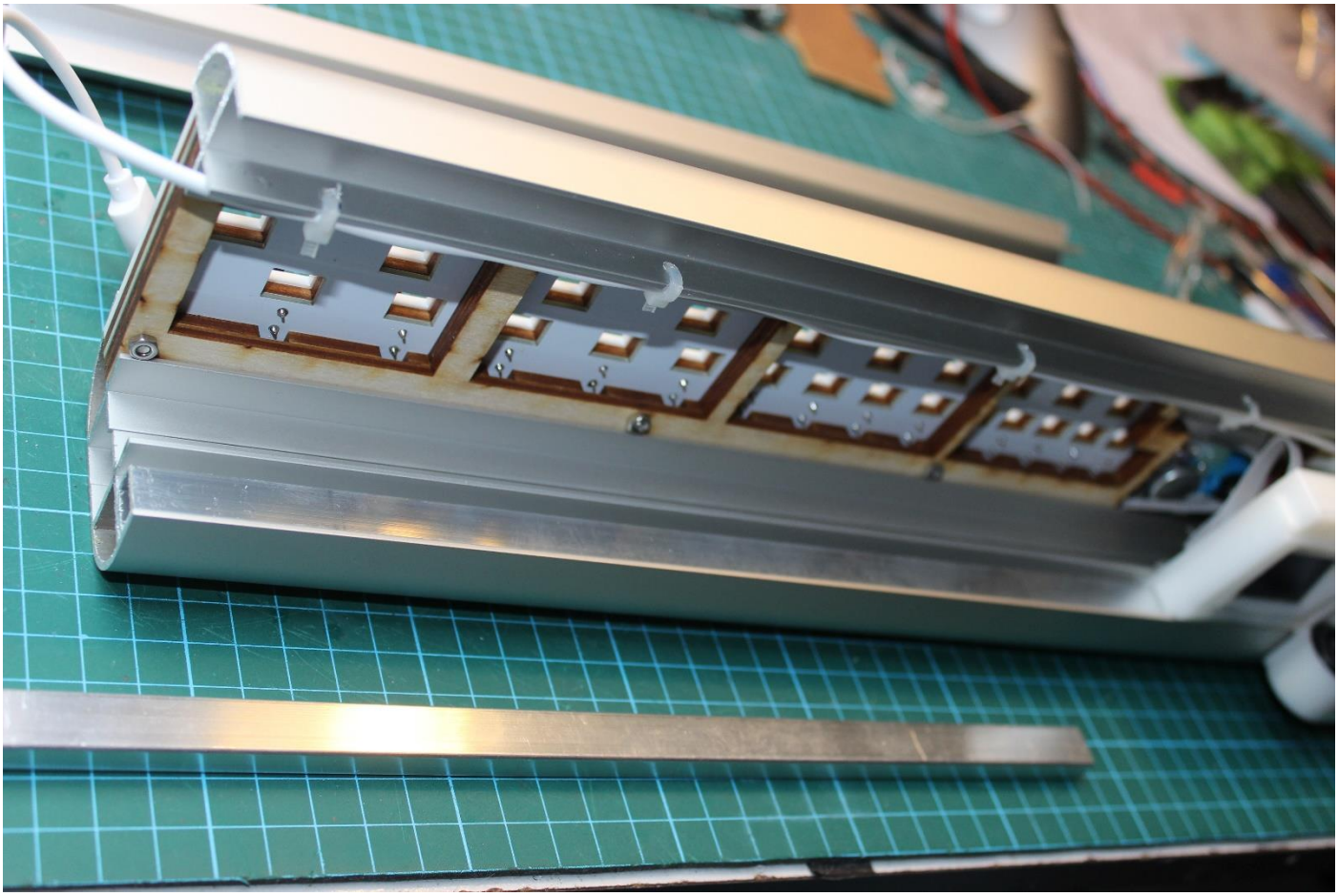




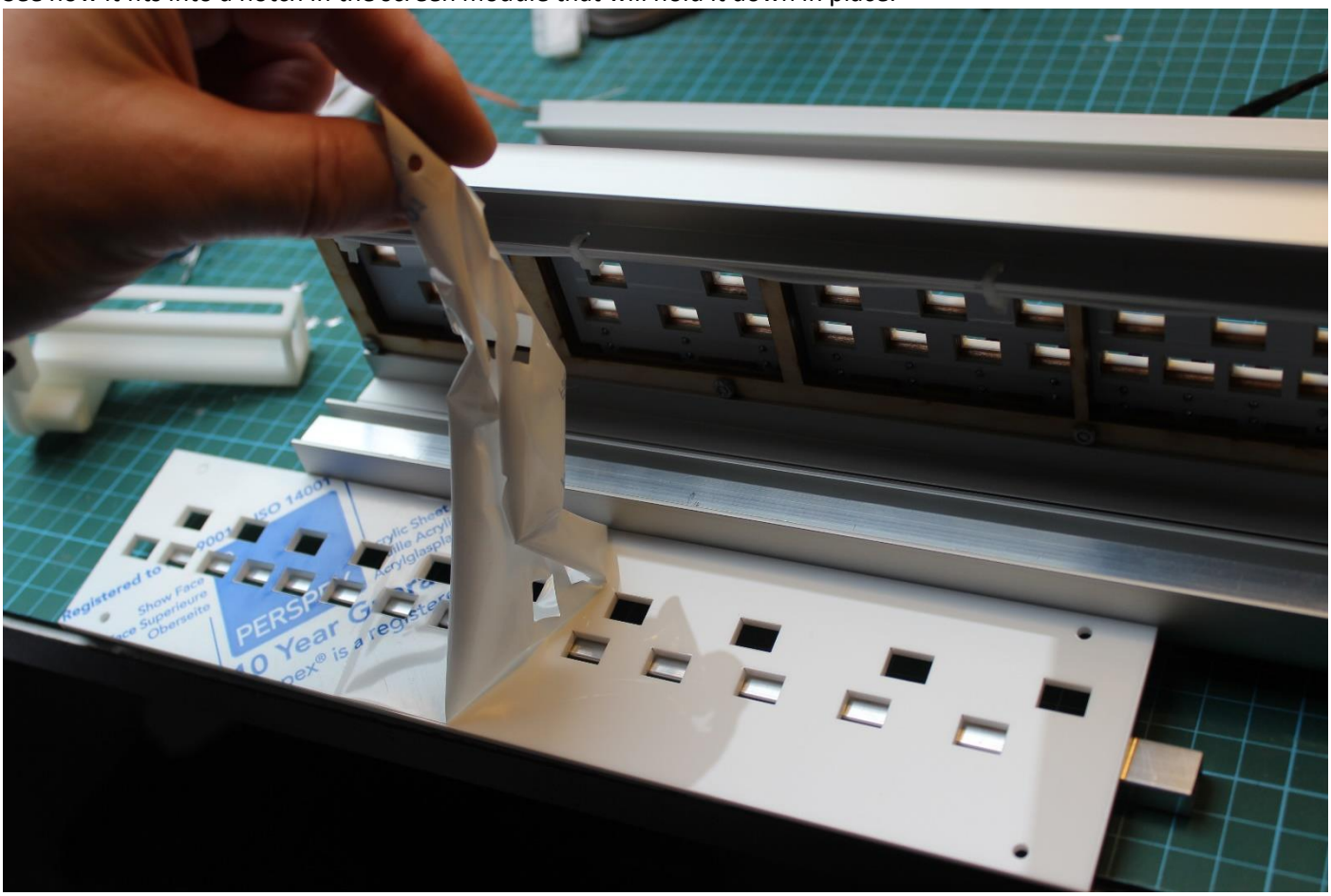
Put in lower alloy filler strip (rectangular cross section).



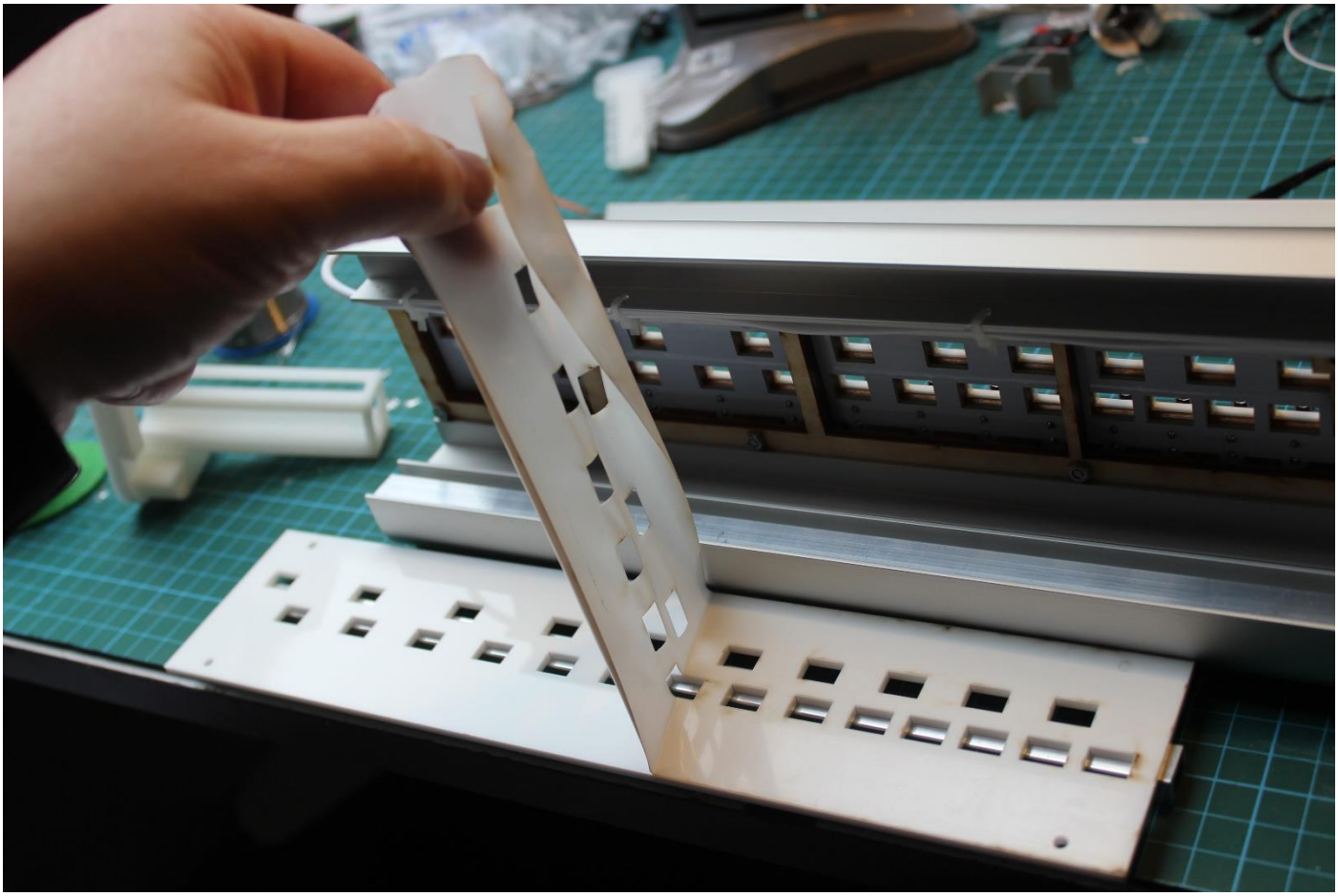
x



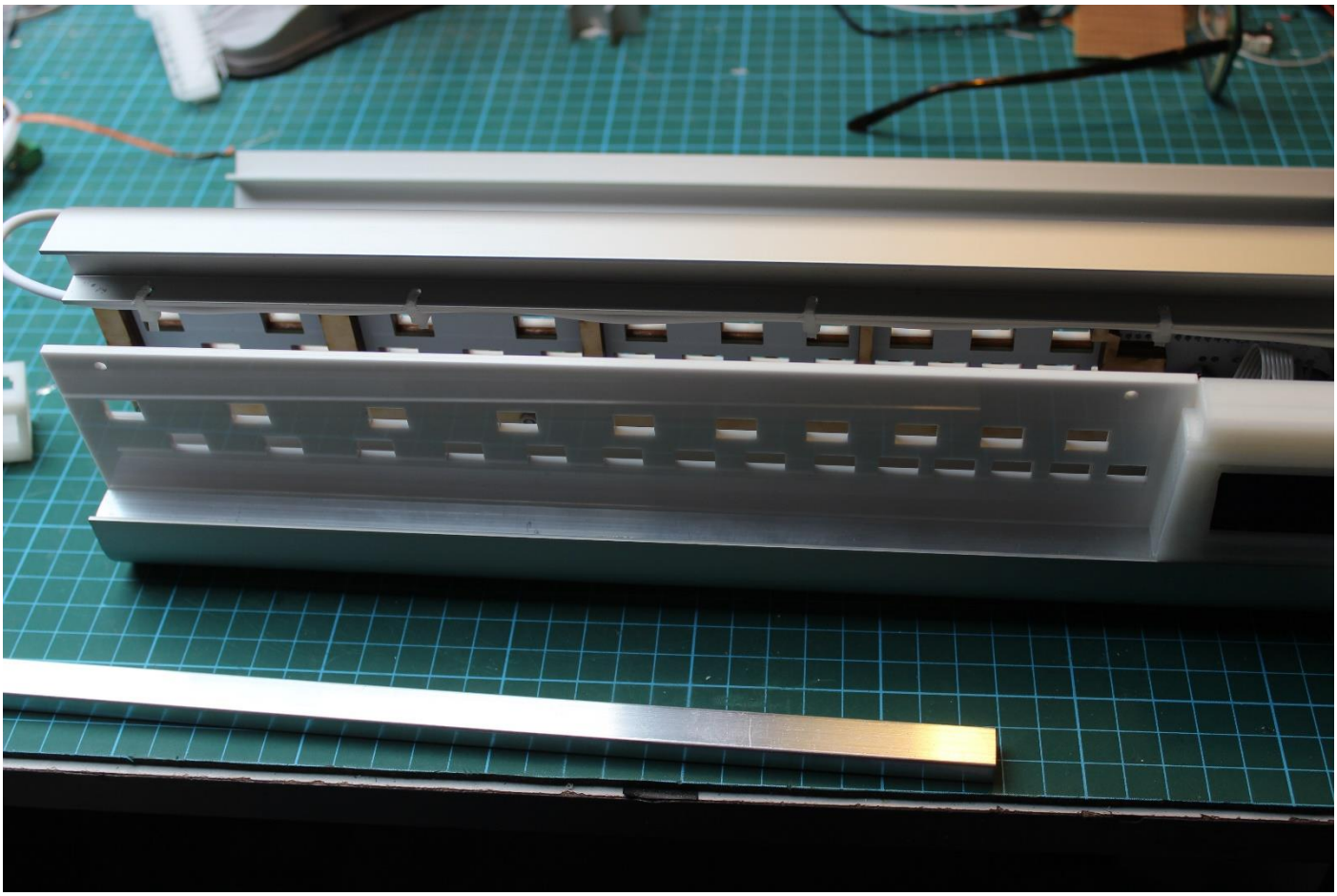
See how it fits into a notch in the screen module that will hold it down in place.



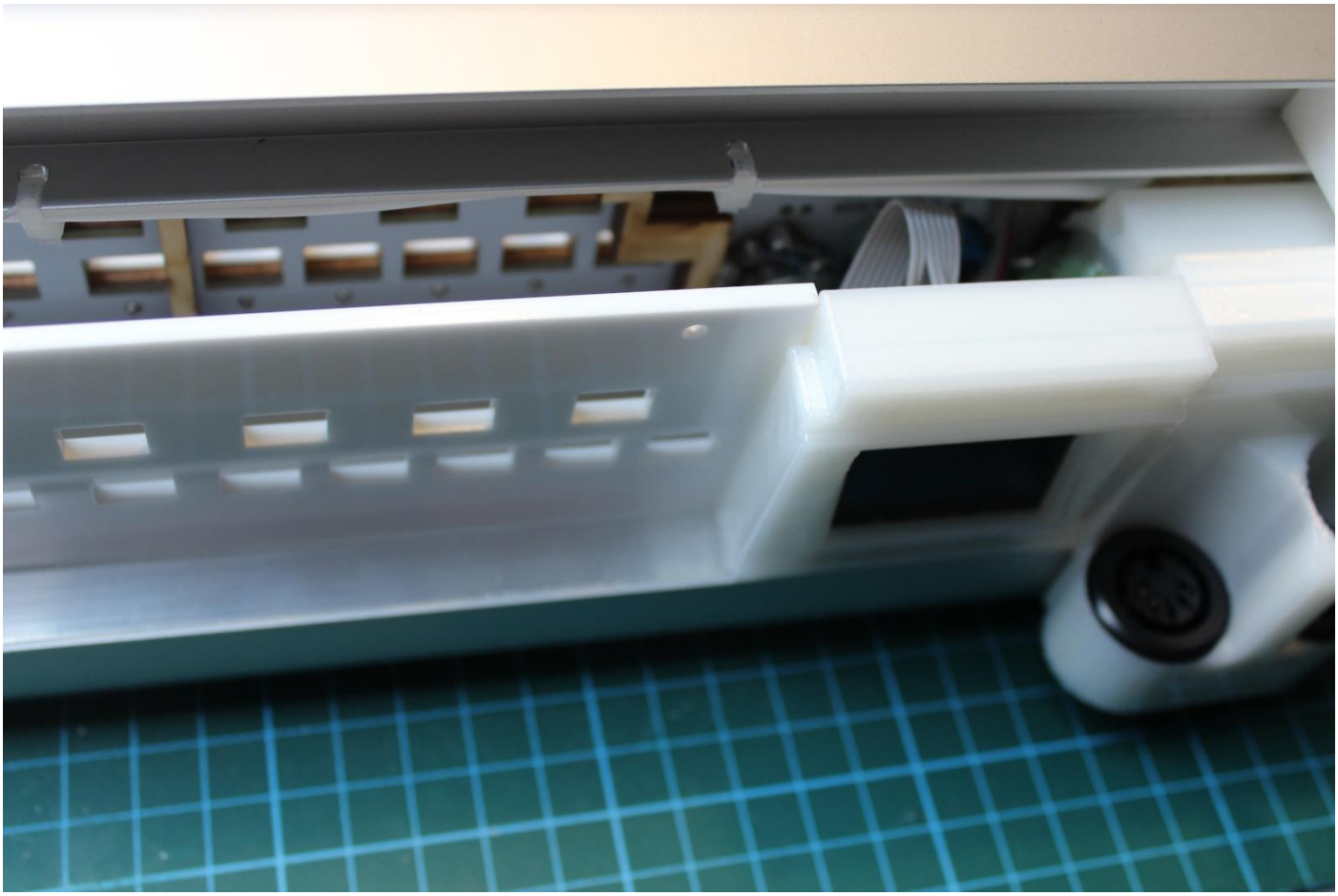
Peel protective film off BOTH sides of the white acrylic back panel.



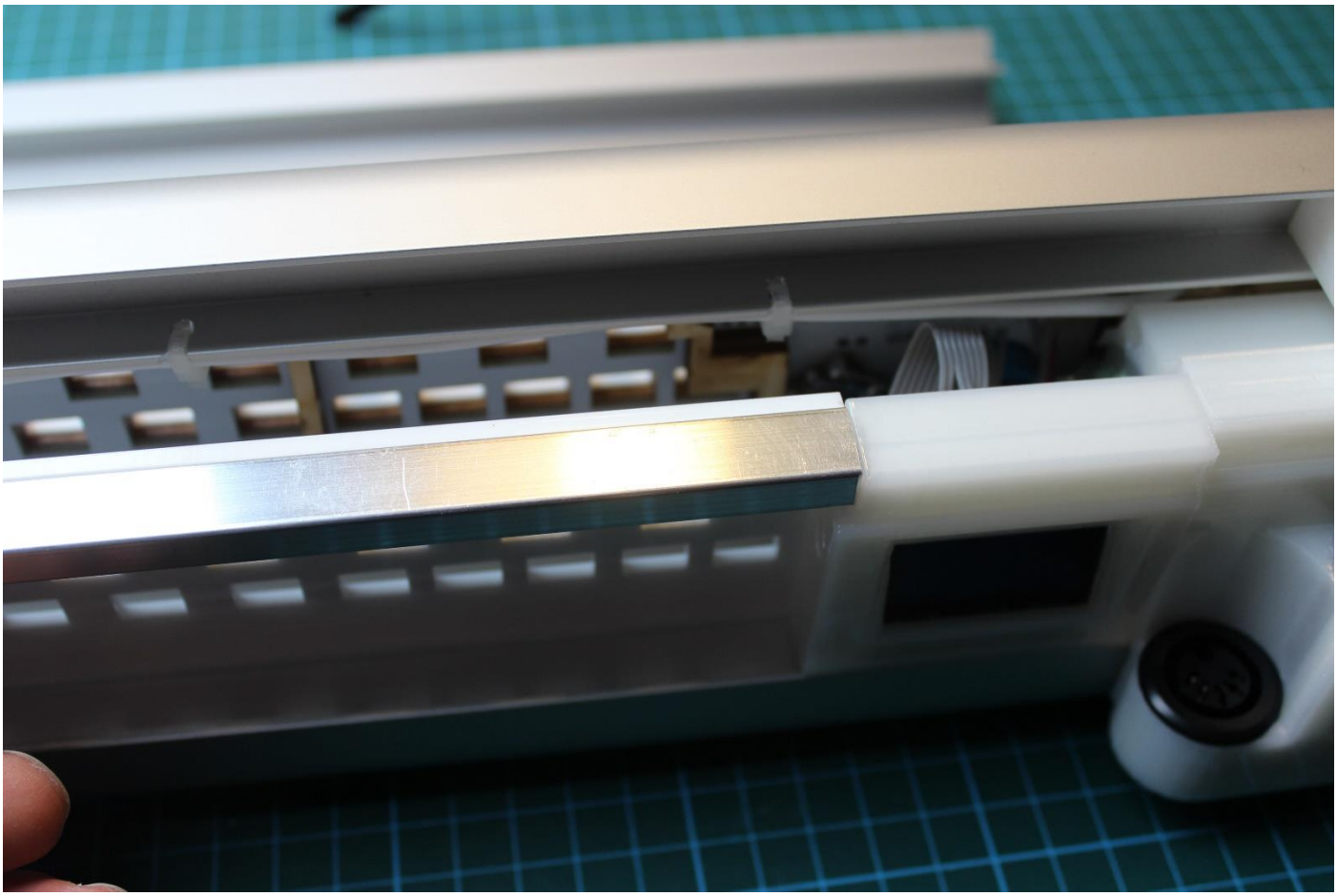
x



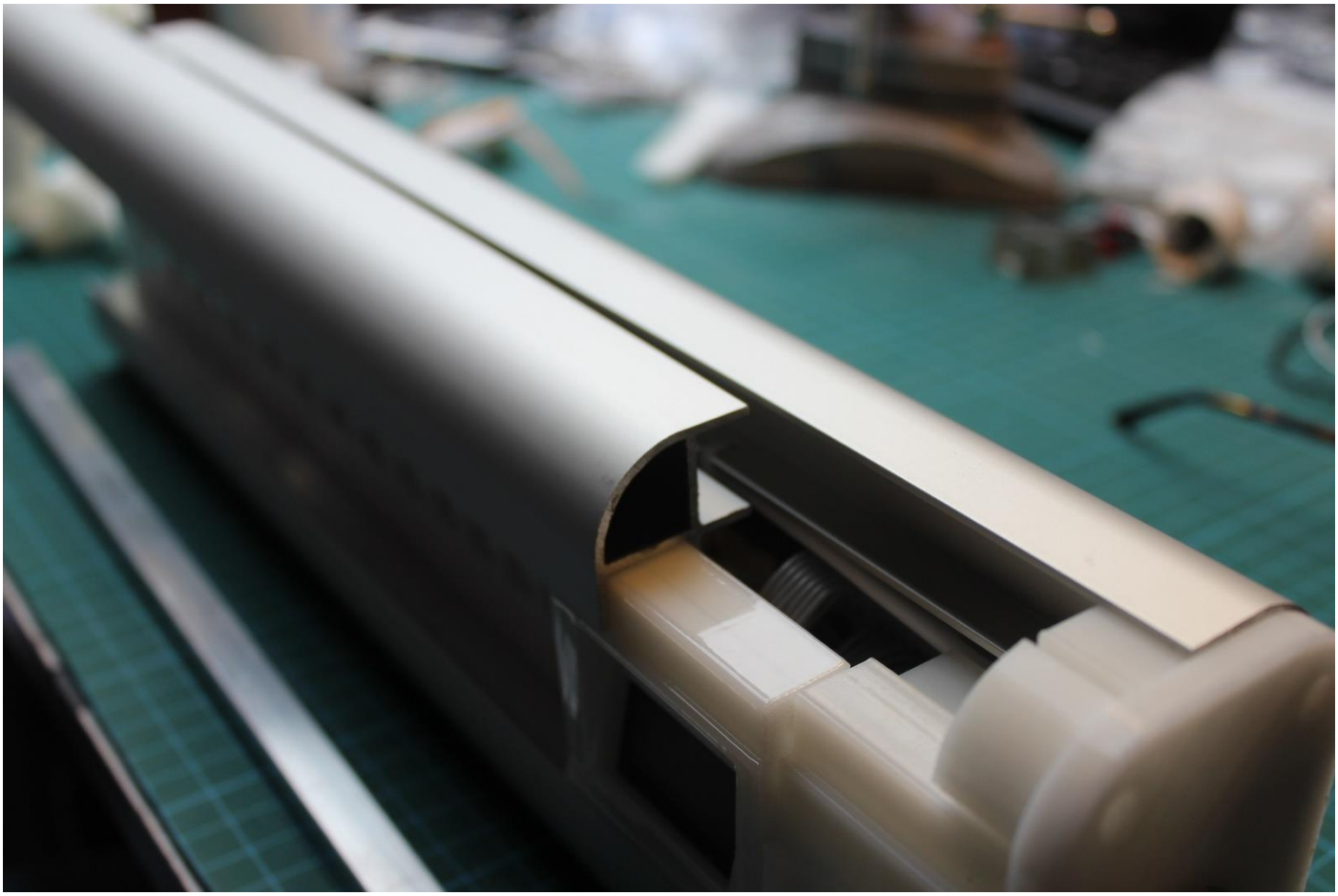
Insert it as shown, make sure it matches the holes in the front panel!



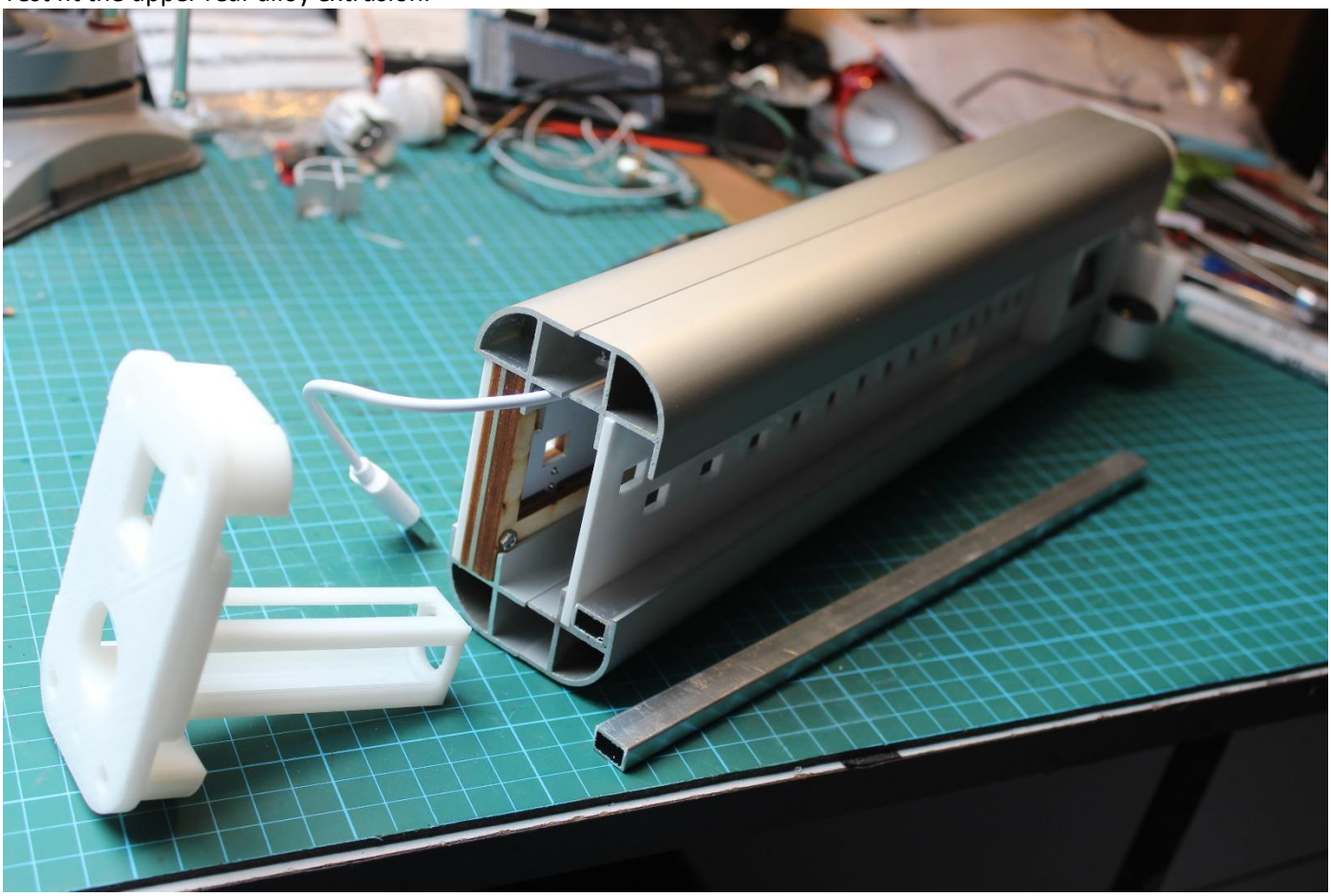
x



See how upper alloy filler piece will be held up in place by notch in the screen surround structure.



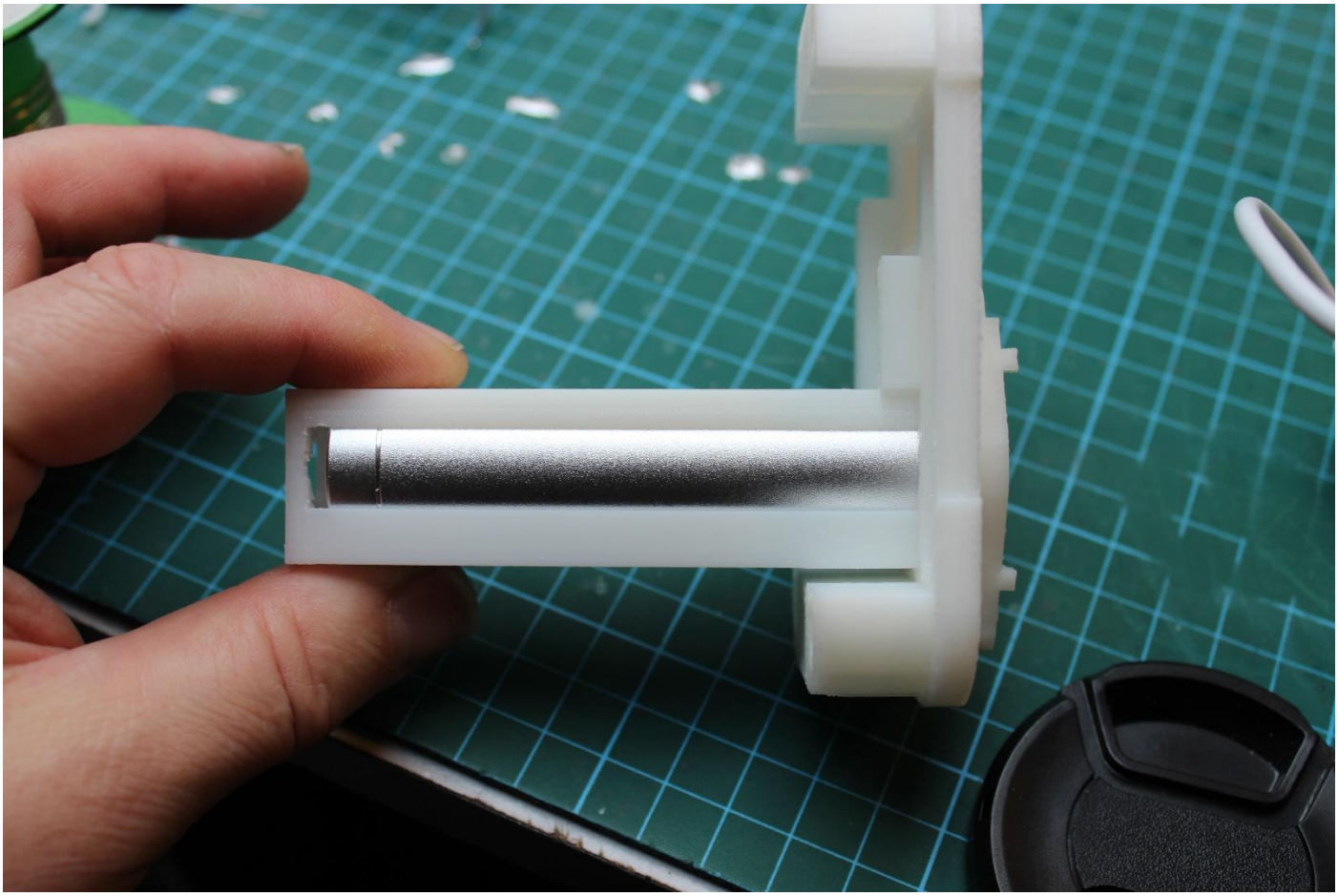
Test fit the upper rear alloy extrusion.



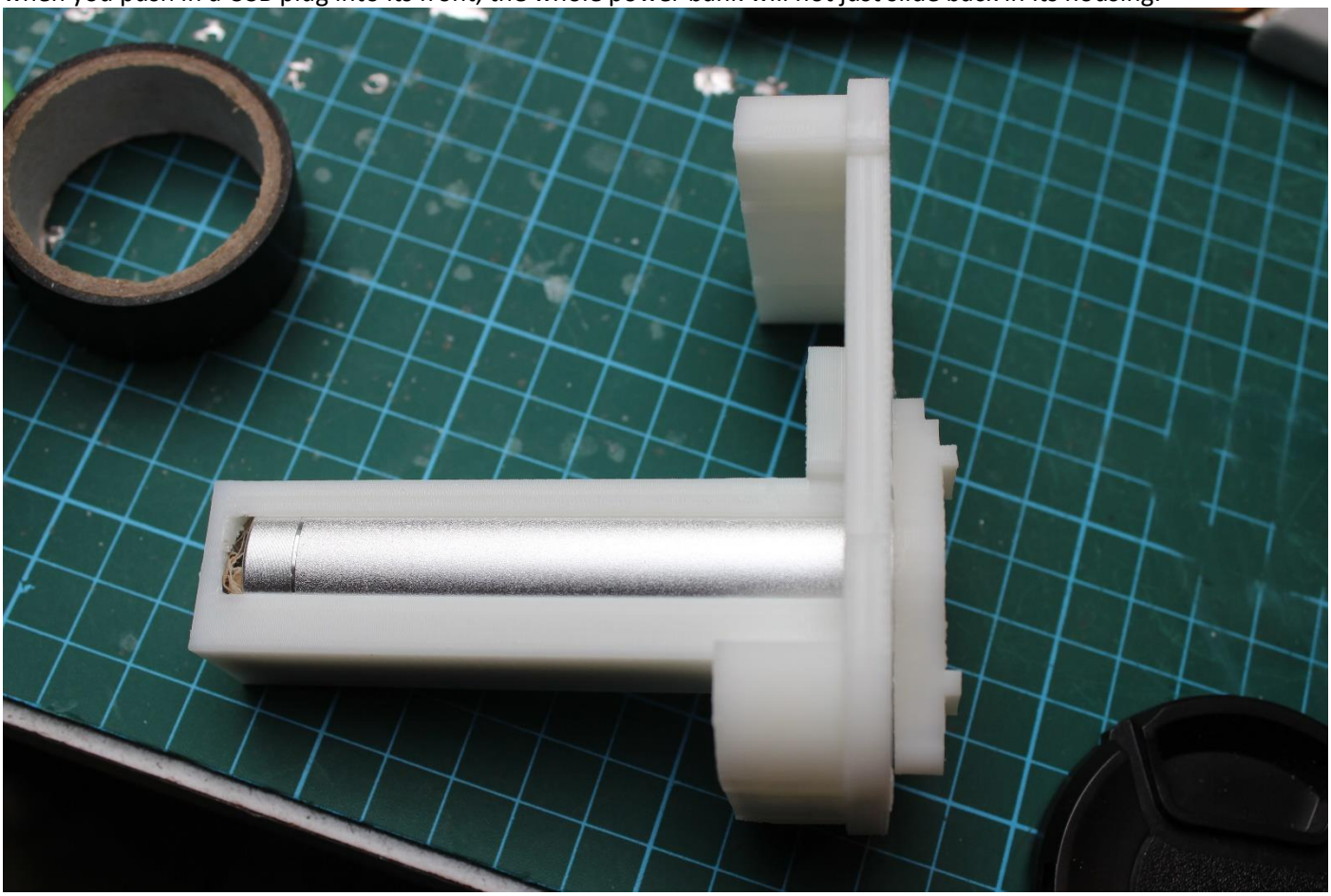
Now, we are going to insert the LEFT hand 3D printed structure that will hold everything together.

Test fit the rechargeable battery module (originally a phone power bank). File a little if it does not quite fit. This part of the print is fragile so take care.

Test fit the retaining cap. It should be a snug fit like this.



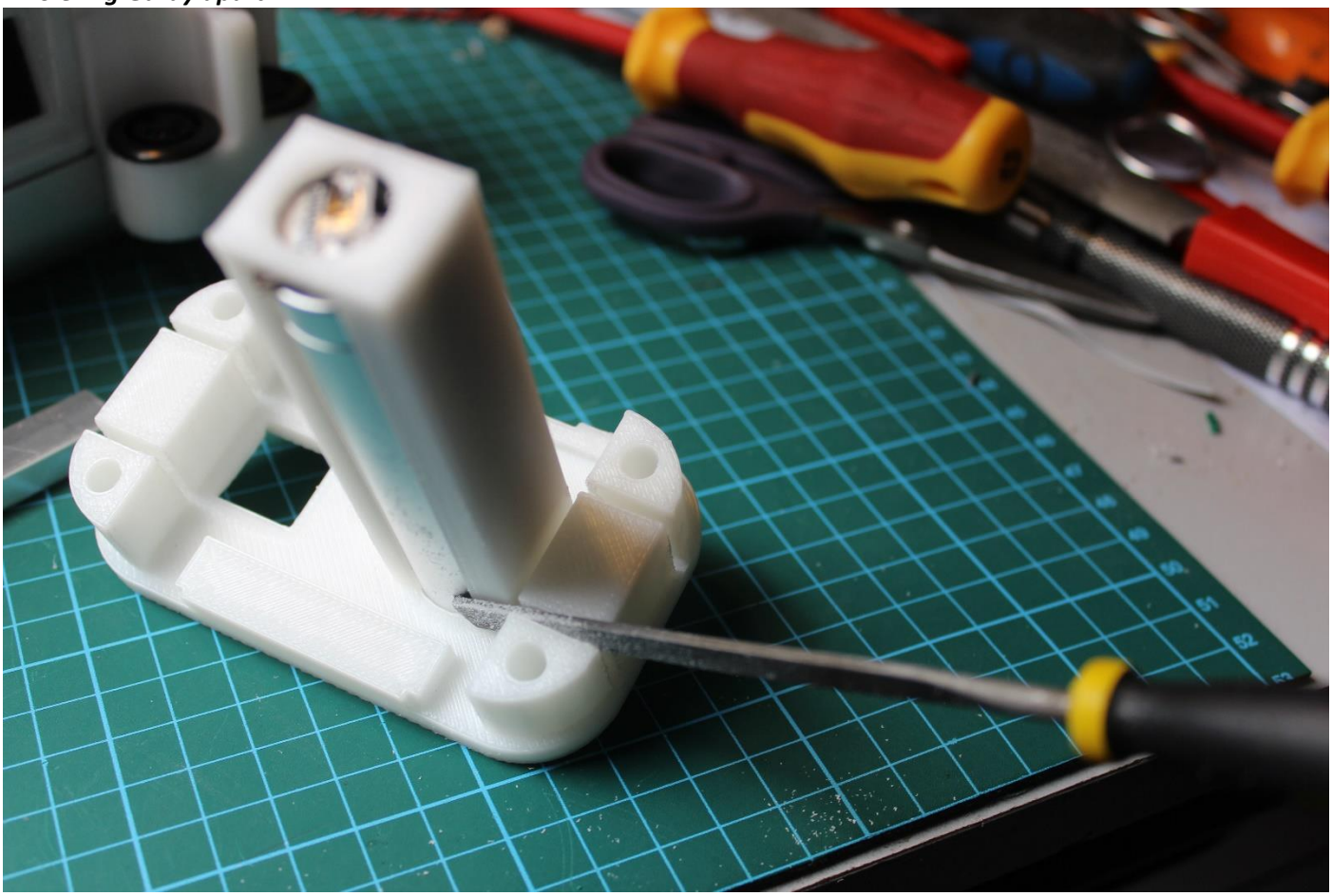
You may need a small piece of packing at the left hand end in this photo so the power bank is held snug in place, so, when you push in a USB plug into its front, the whole power bank will not just slide back in its housing.



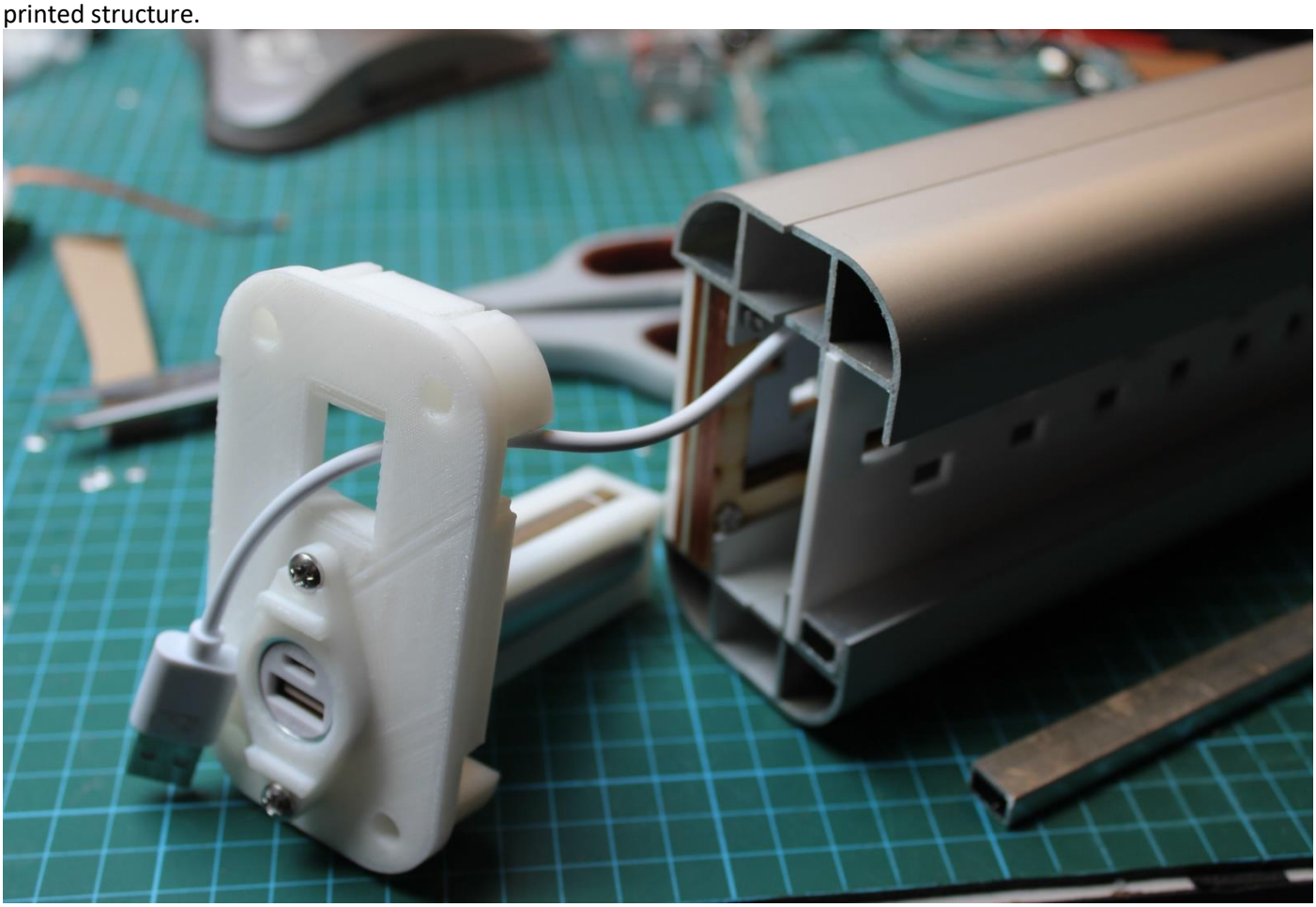
Small layer of carboard used to pack the back end of the phone power bank unit.

Screw on the cover plate that holds the power bank in. Self-tapping screws. Holes are present to take these screws in the main 3D print.

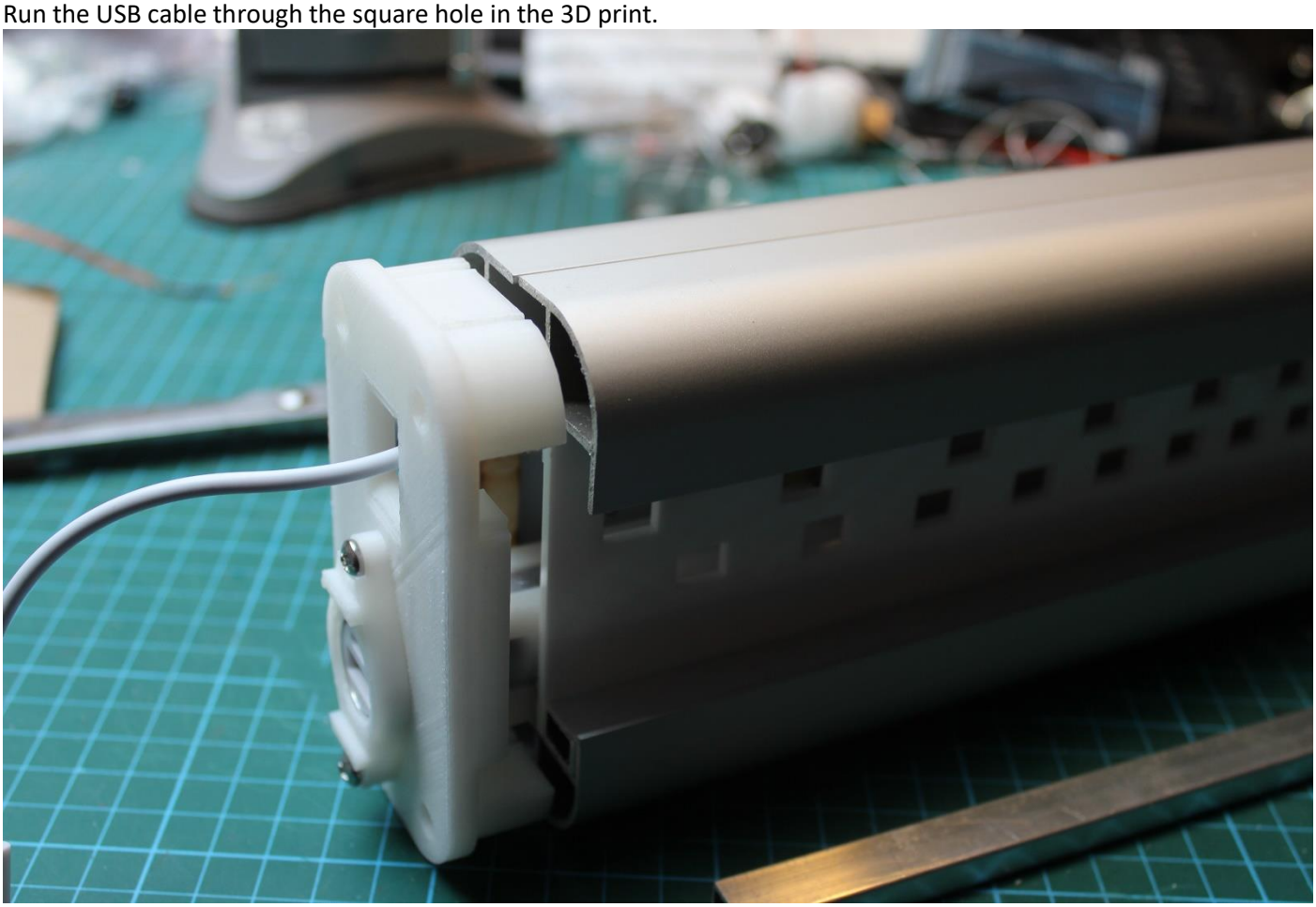
If you remove this cover, the aluminium power bank tube should project slightly, about 4 or 5mm, so you can grasp it and pull it out to fit the rechargeable battery should you wish to do so in the future without taking the whole DigiGurdy apart.



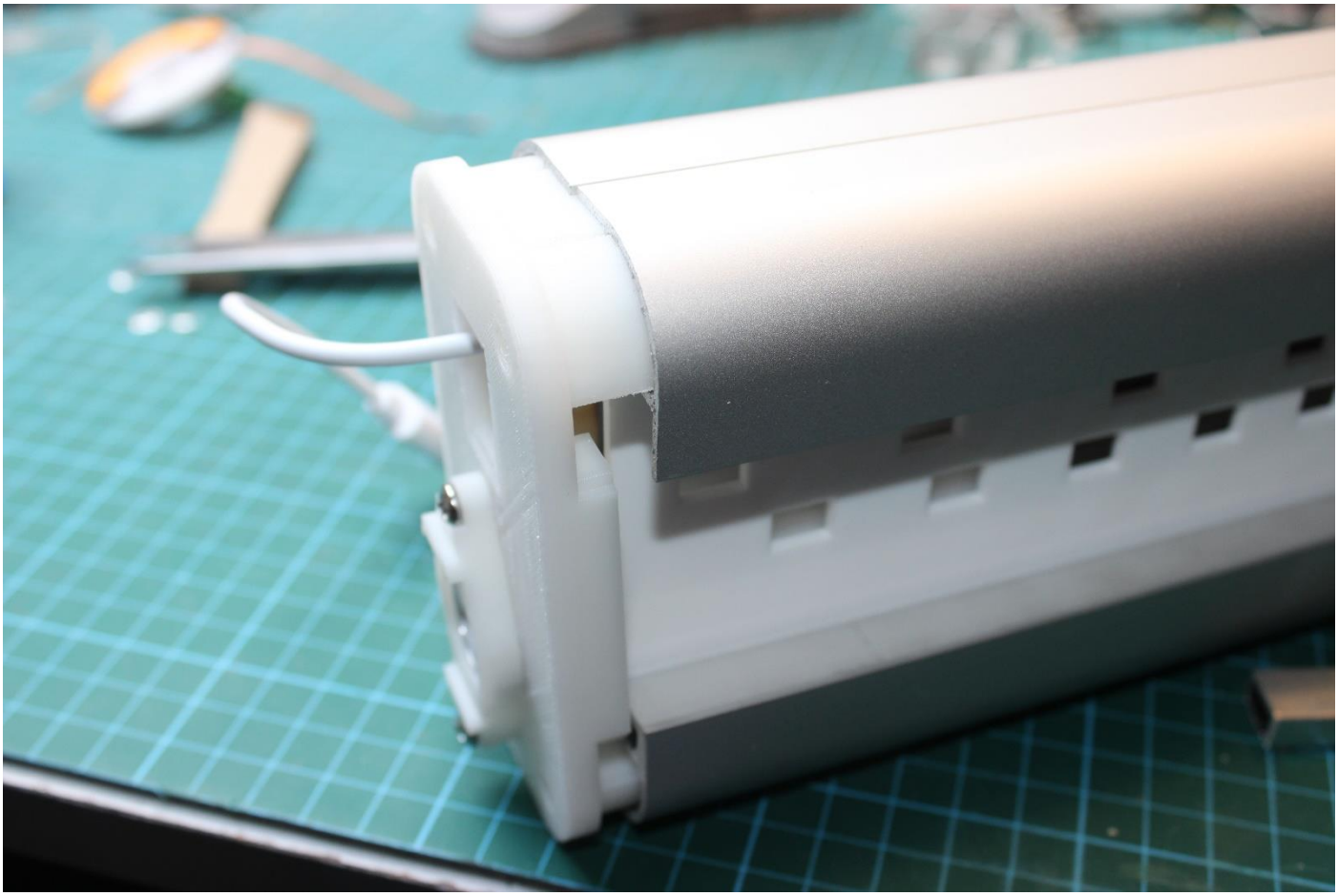
Use a small flat file to help assembly of the 4 main alloy extrusions where they insert into the left hand end 3D printed structure.



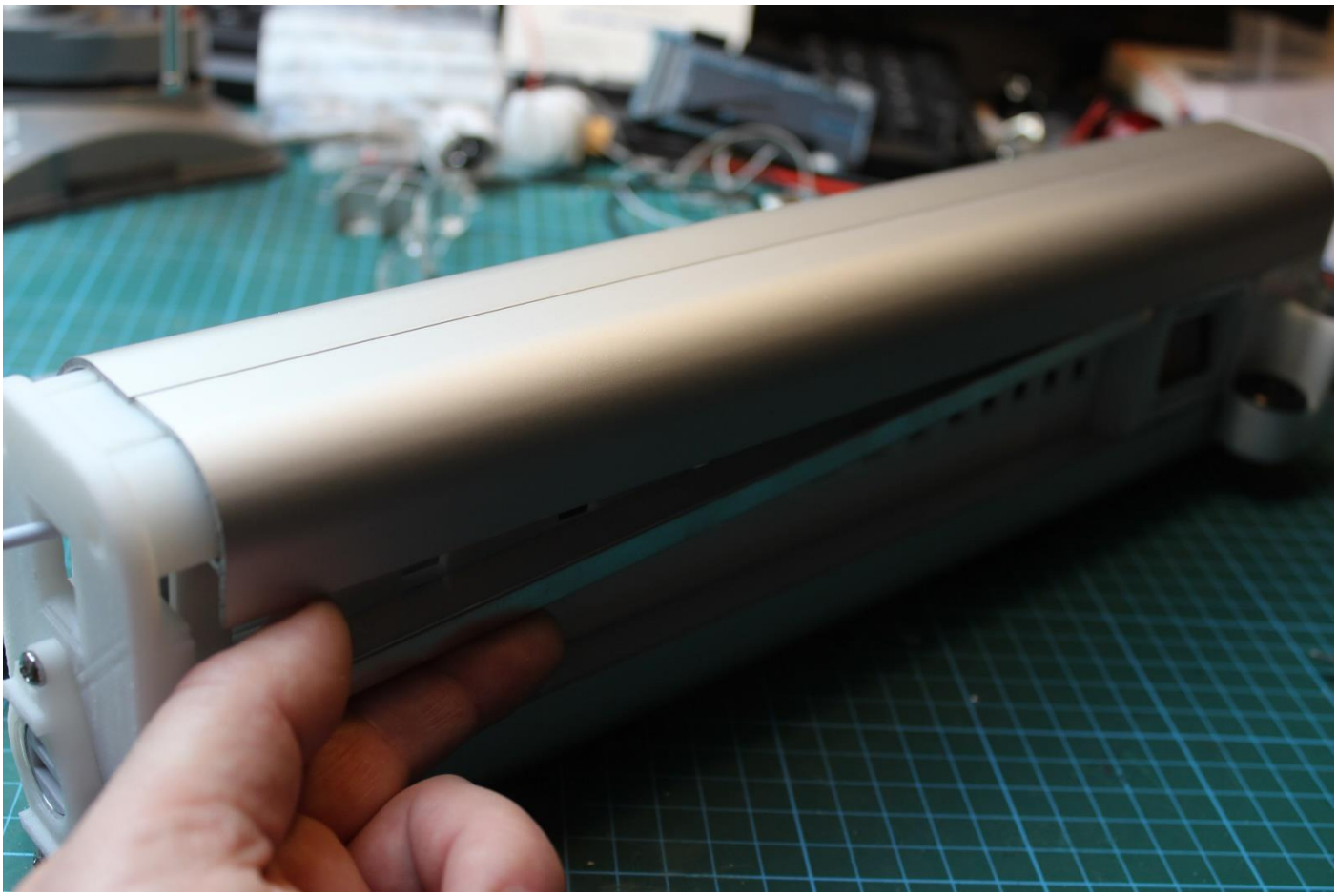
Run the USB cable through the square hole in the 3D print.



Start to gently work the left hand end structure into the 4 alloy extrusions. It need patience. Rock it back and forth. Do not use force to get it in. Don’t forget to locate the 2 alloy filler pieces at the same time with your third hand !



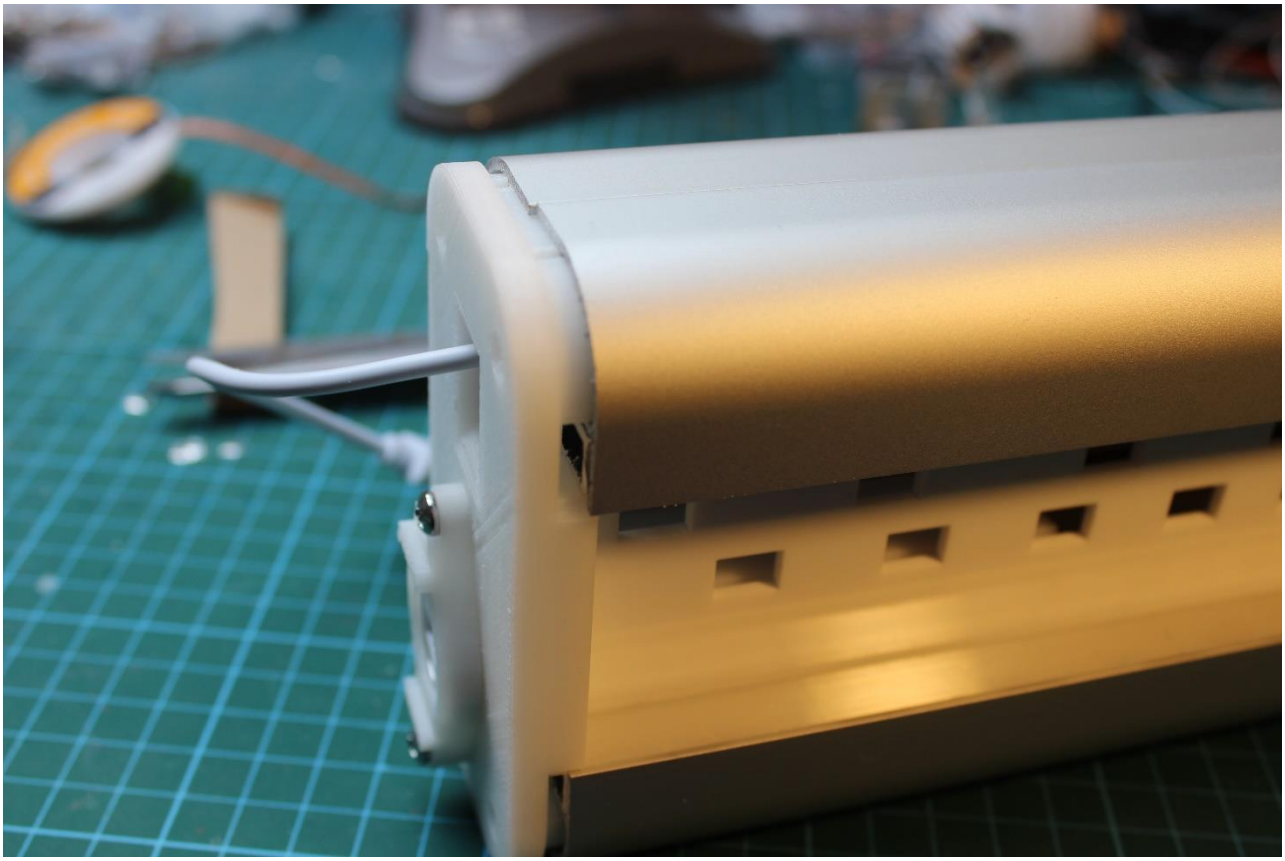
x



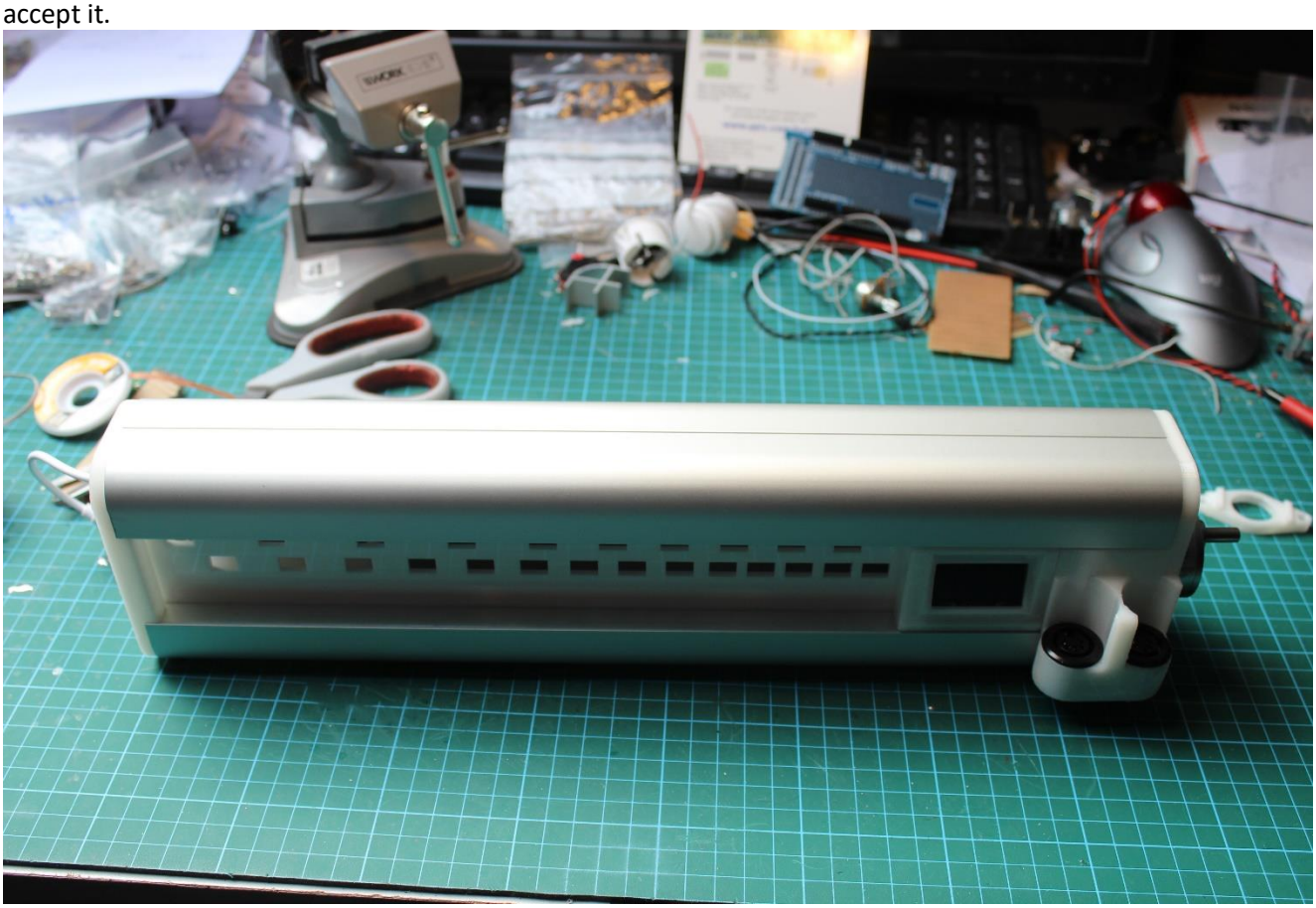
Make sure upper alloy filler piece is in place as you do this.

Like this.

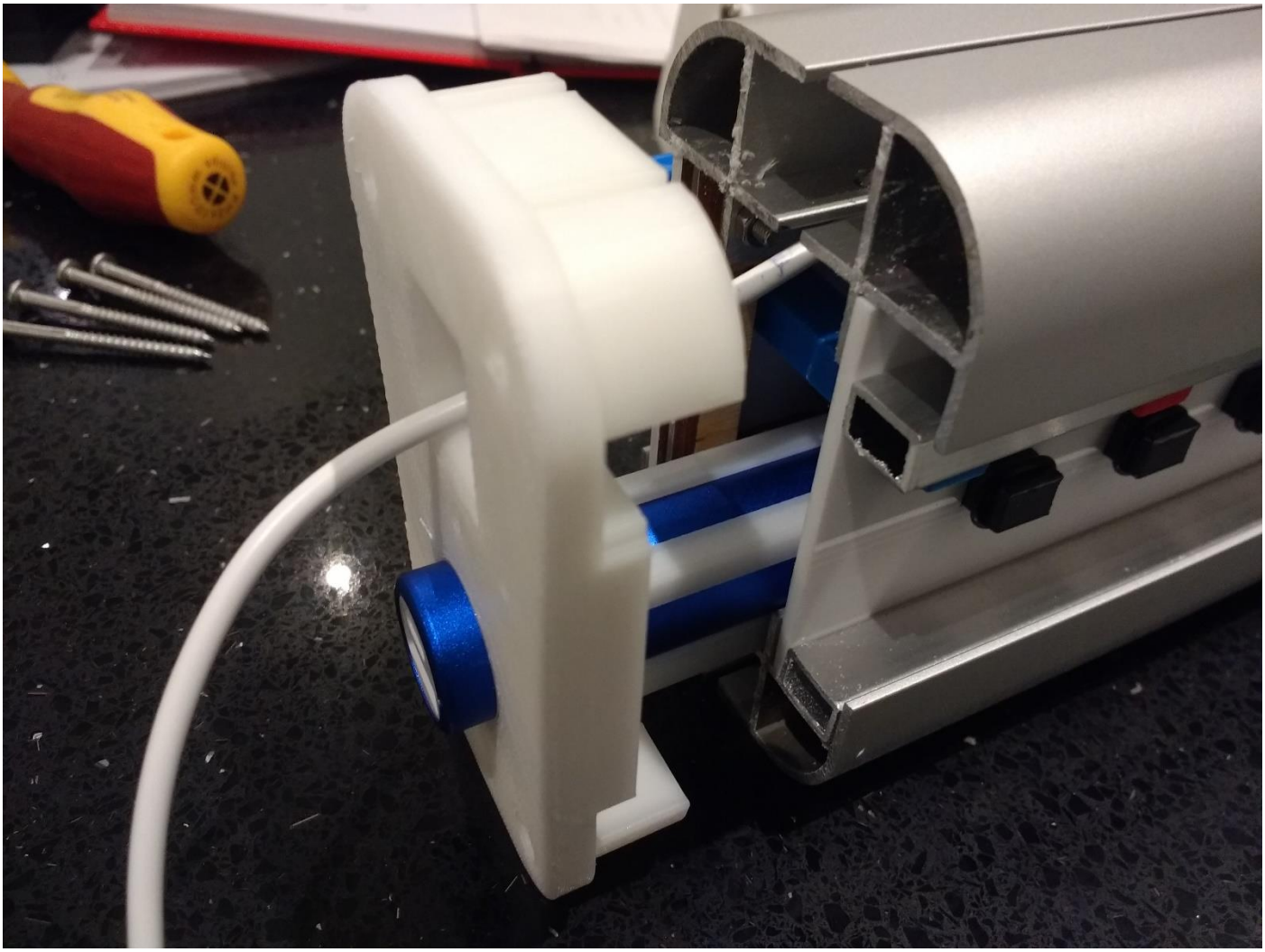
And as seen here.



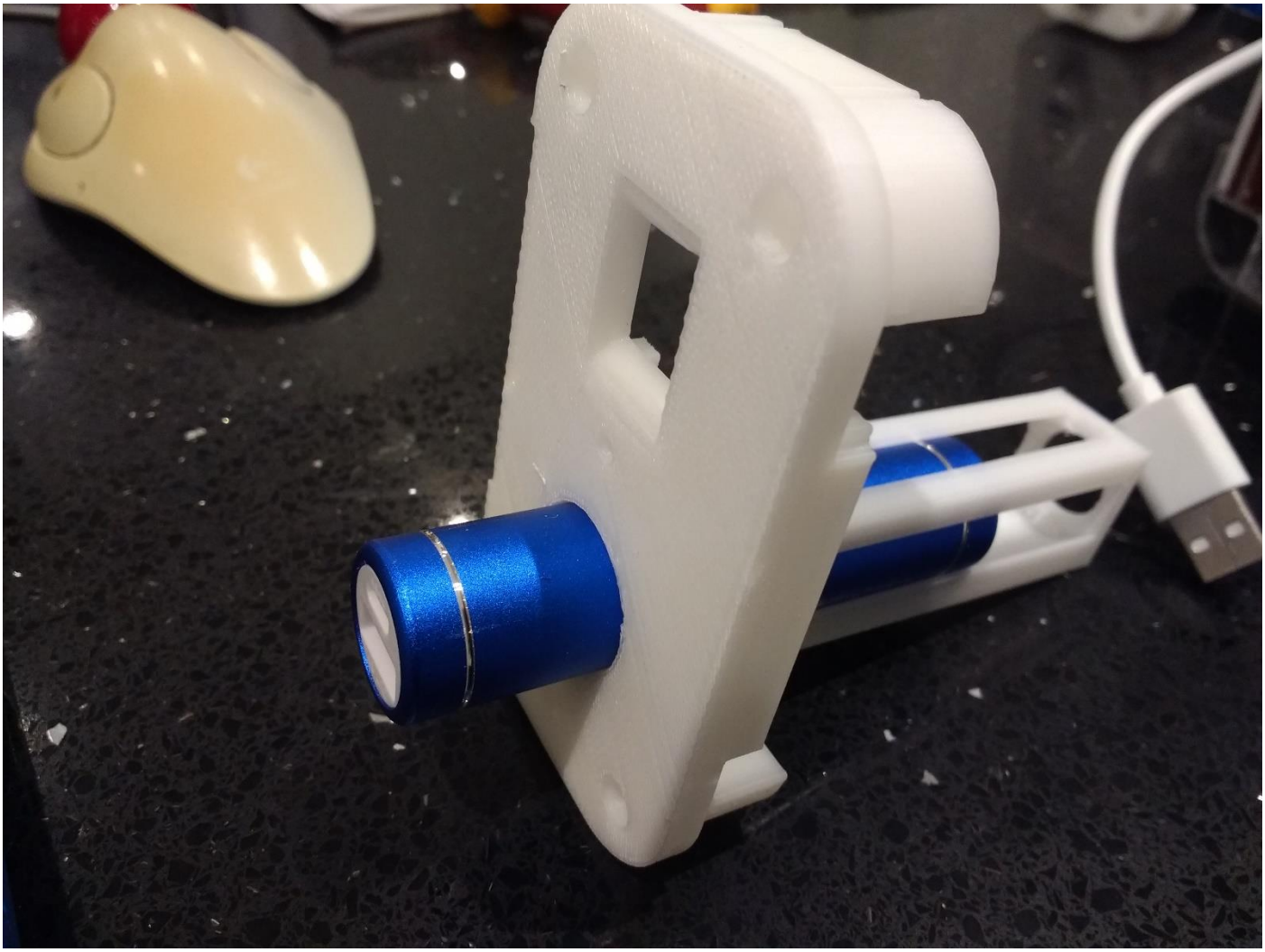
See how upper and lower alloy filler pieces are held in place at this end also by a notch in the 3D print designed to accept it.



Here it is all successfully put together. We need to add a cover plate at each end and 4 long main screws at each end but for now this is a good time to pause and do a full test of function. Load the software, press the microswitches directly as you need to, plug in a MIDI transmitter if you want to and just check everything works electronically while you can still take the machine apart relatively easily.

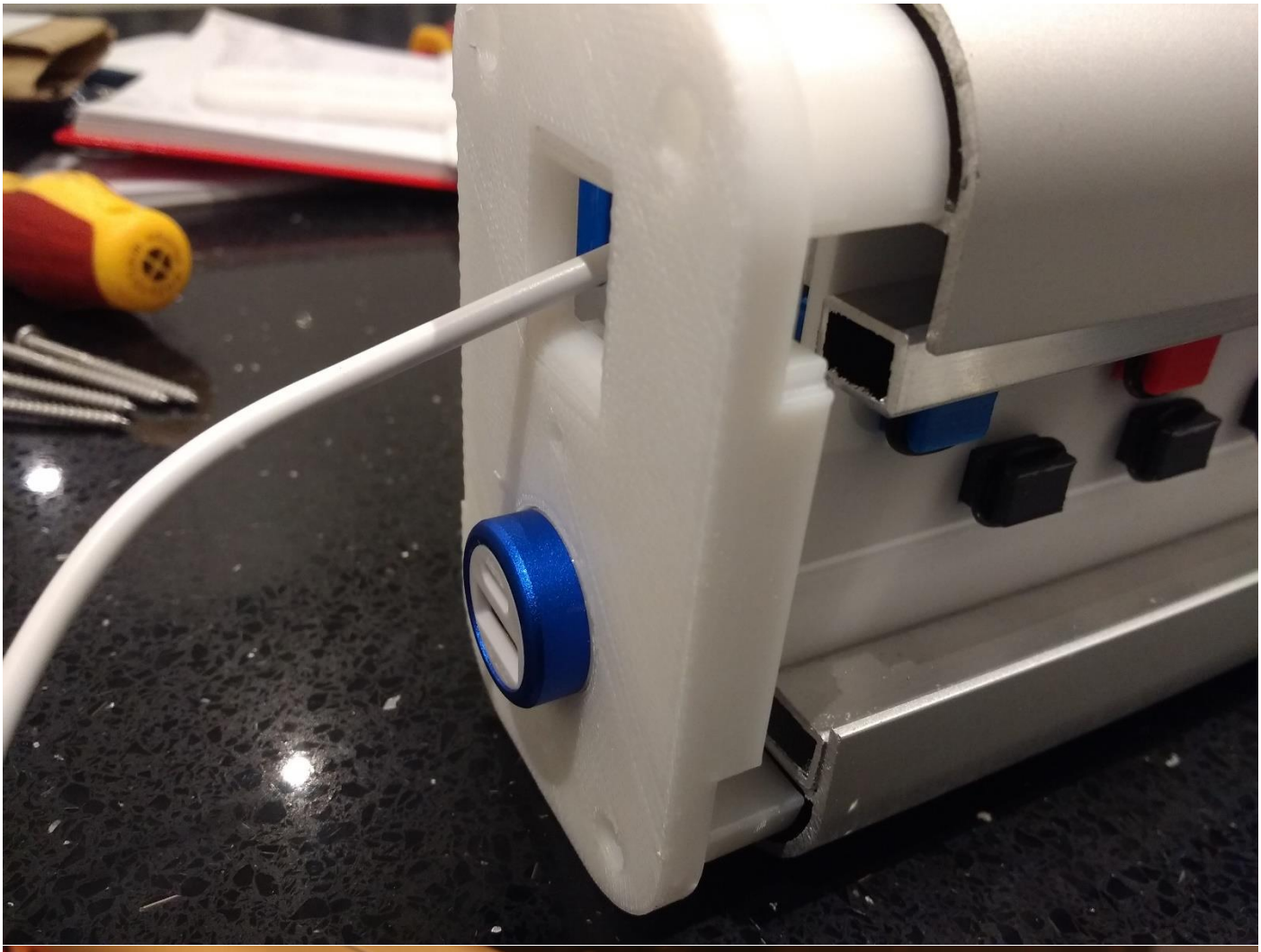


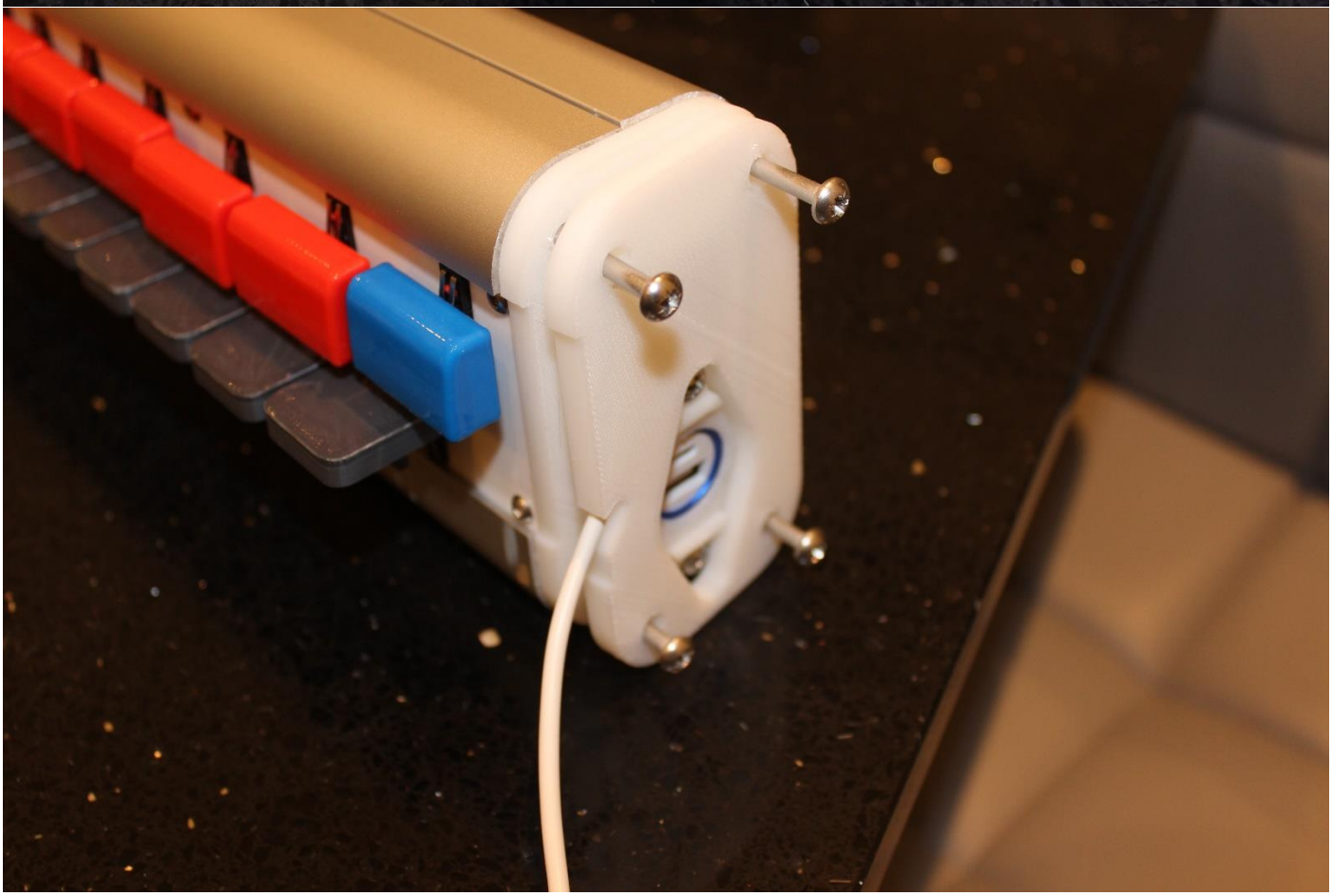
Another view of how left hand end goes together.



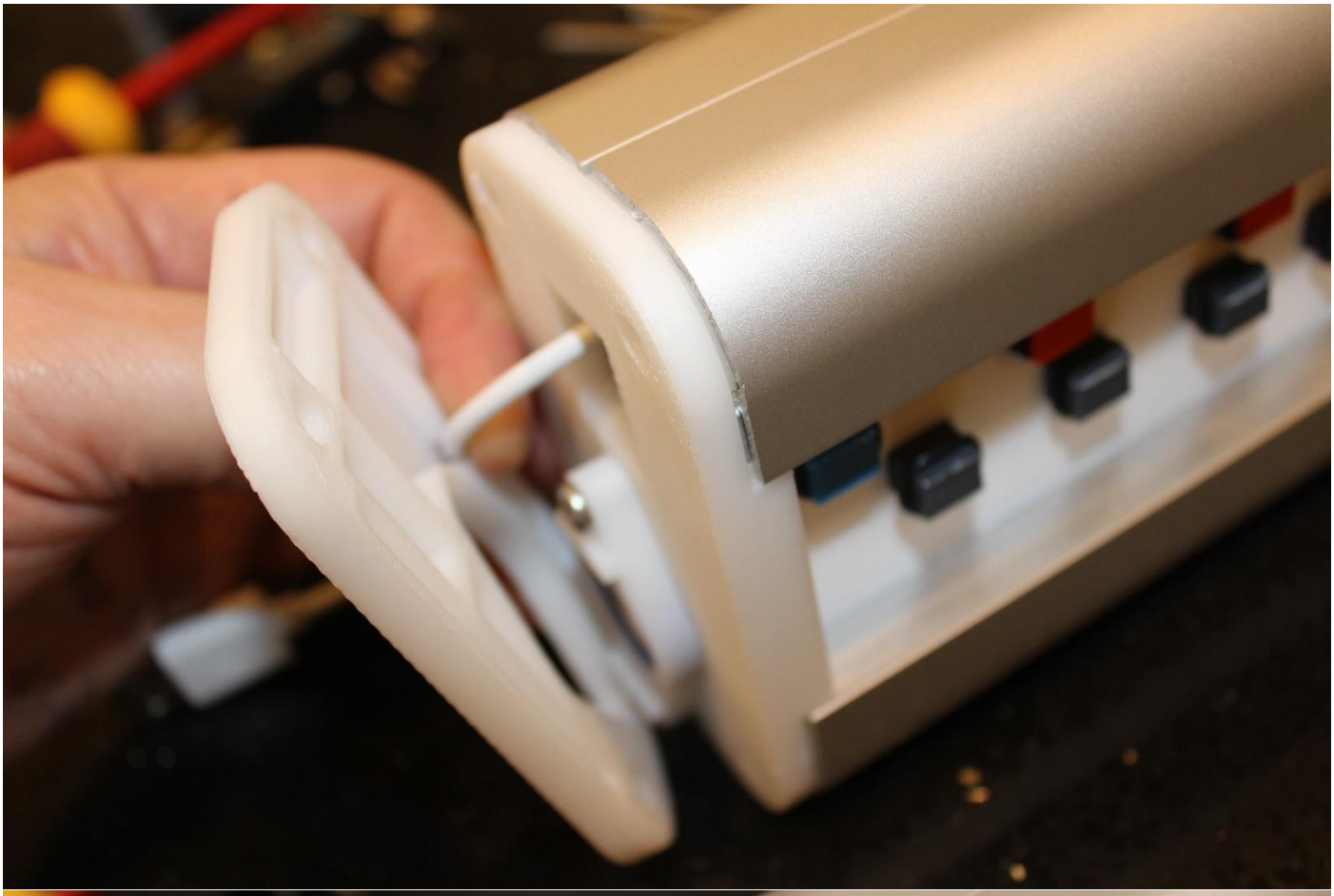
This is how you add a battery to the USB phone power bank tube if you want to use it later on to power the DigiGurdy when using it with a wireless MIDI Bluetooth module (that plugs into the 5 Pin sockets we have at the right hand end). You must use a 18650 battery. These are available anywhere in the world. You must use the sort that do NOT have a bump on the +ve end. The one you need is just flat on both ends. There is an inset ring around the +ve end but I have marked them in this photo to make things clear.

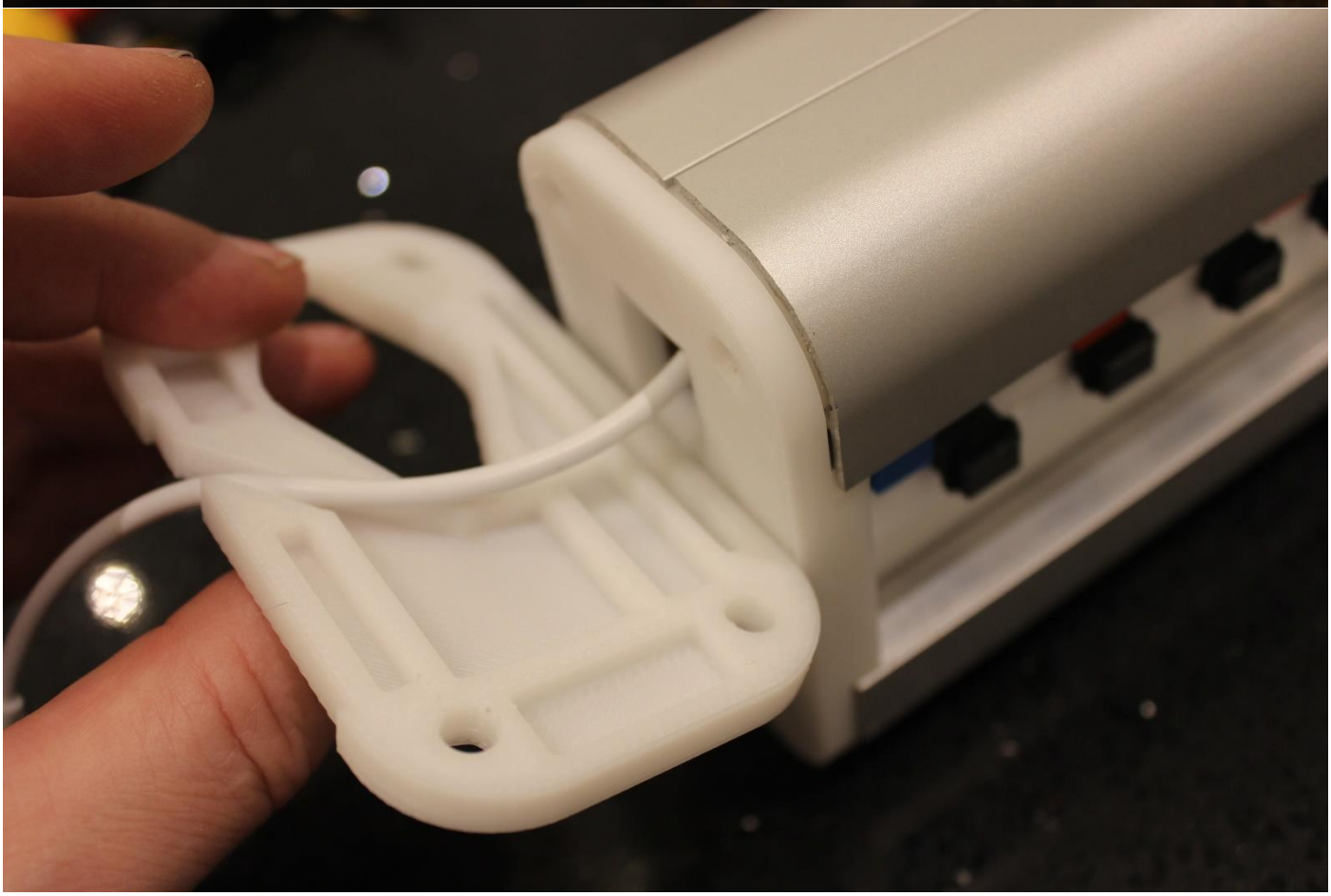
IMR 18650 3000mAh 3.7V

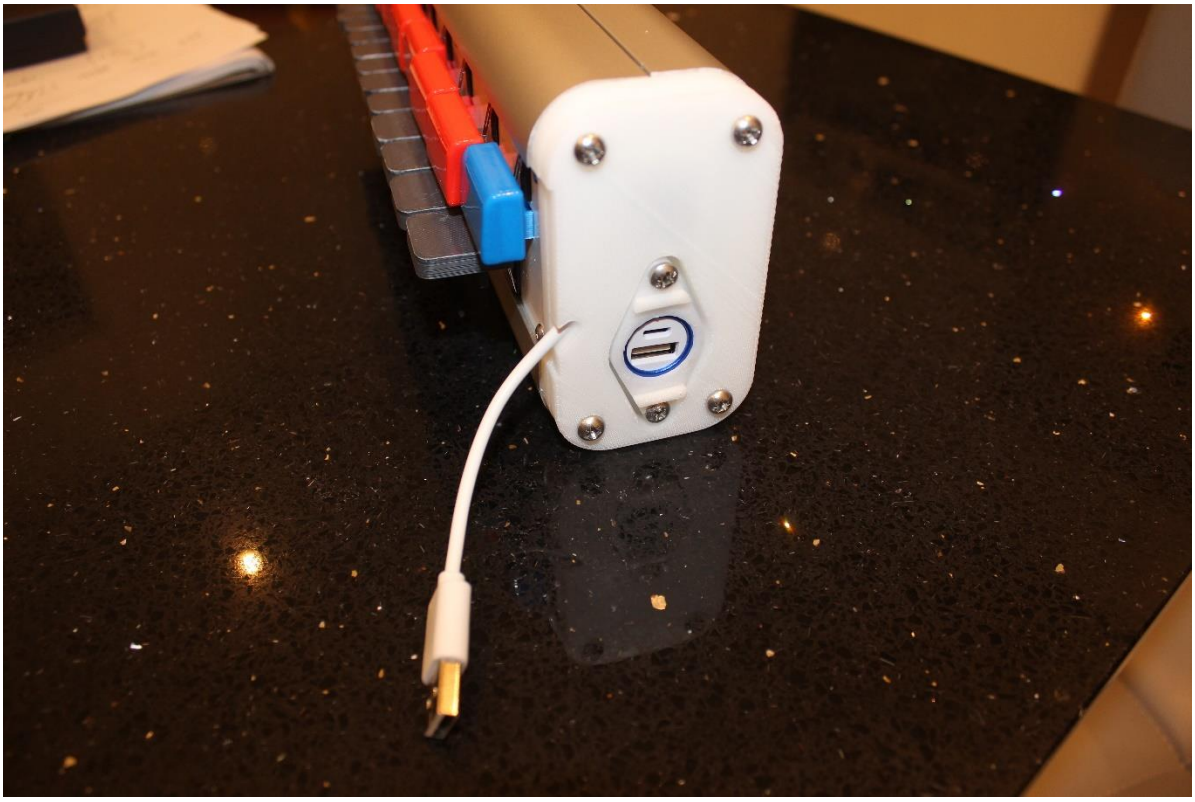




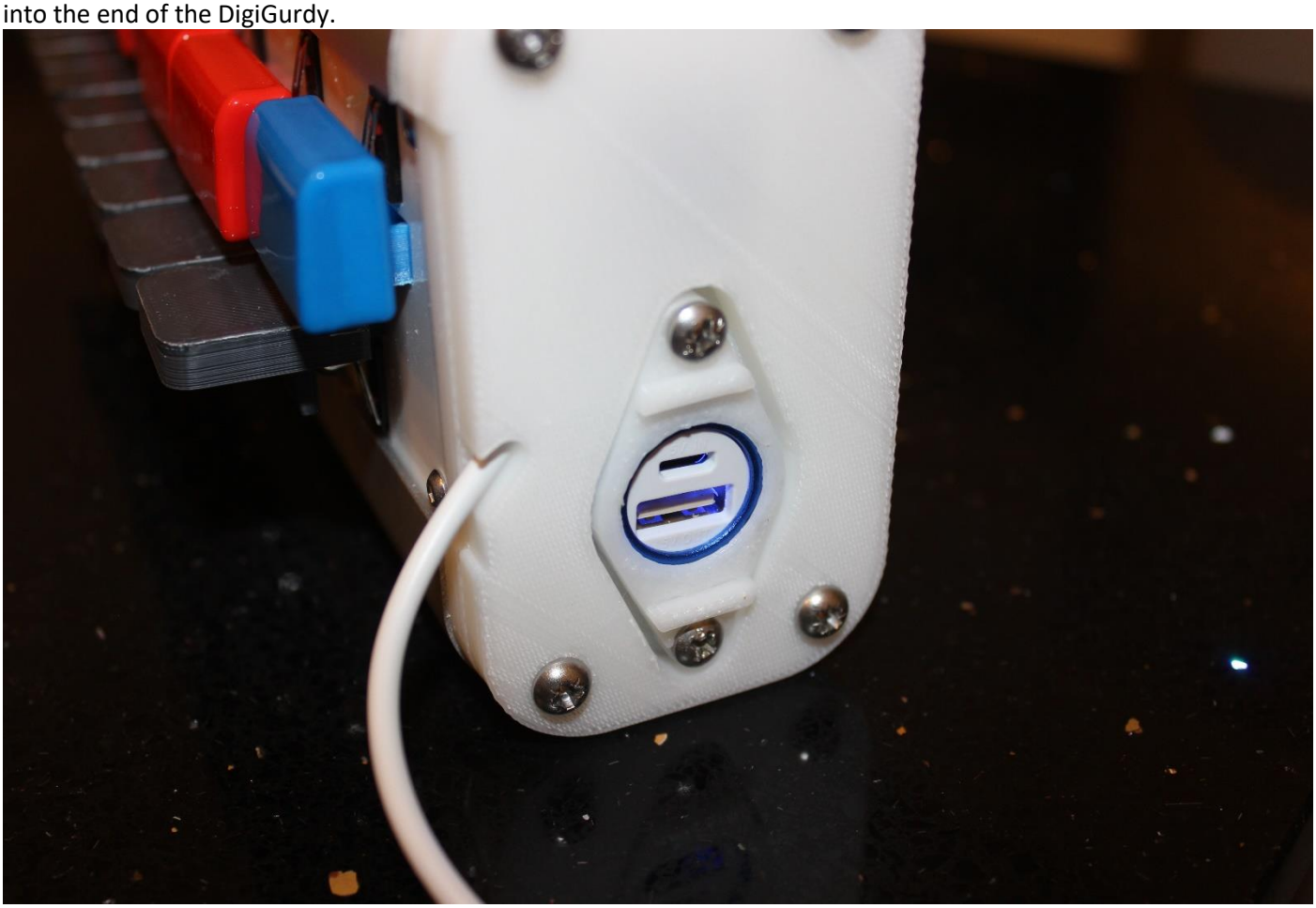
End cap goes on like this and there is a groove in the 3D print that guides the end of the USB cable forwards to make it neat.



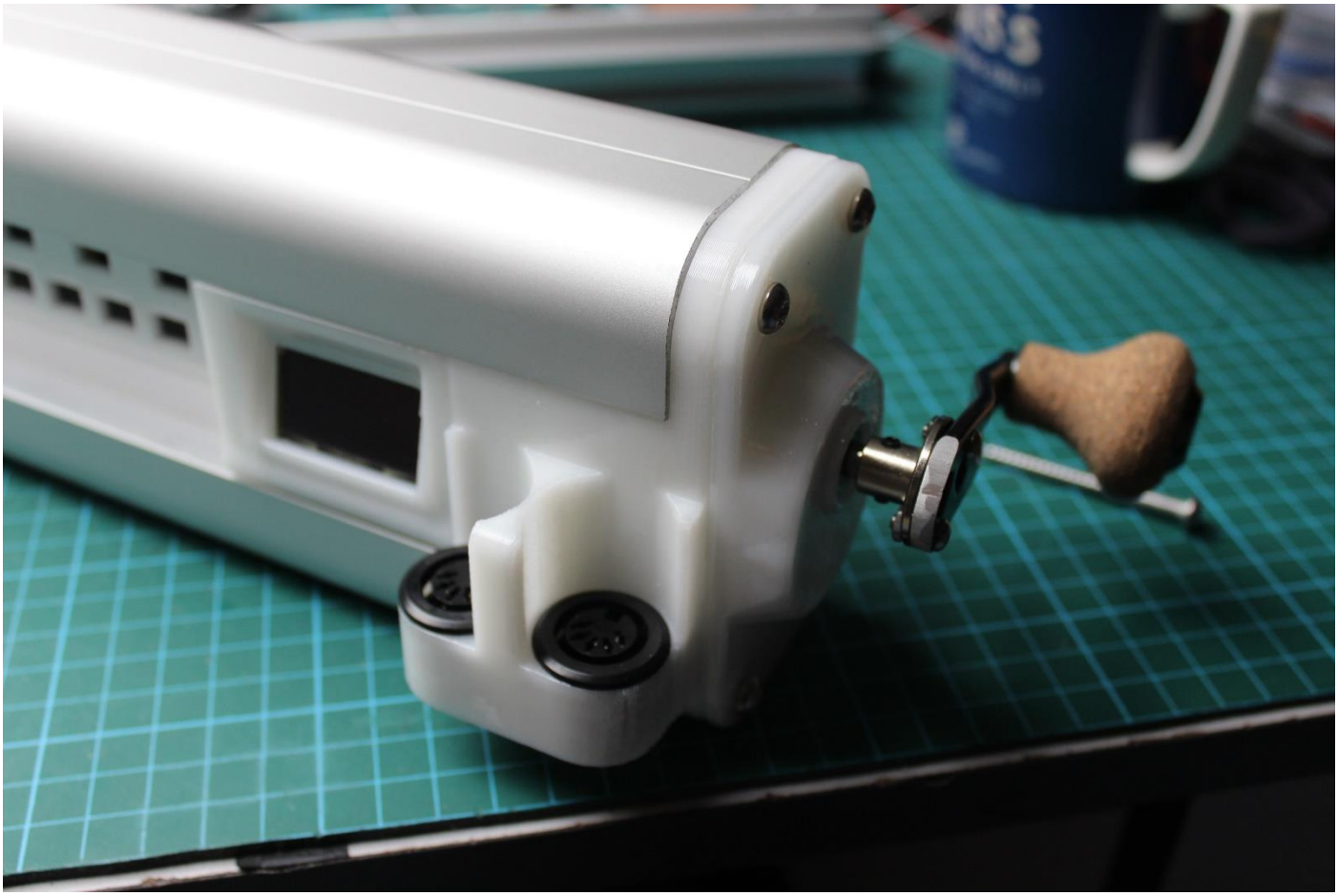




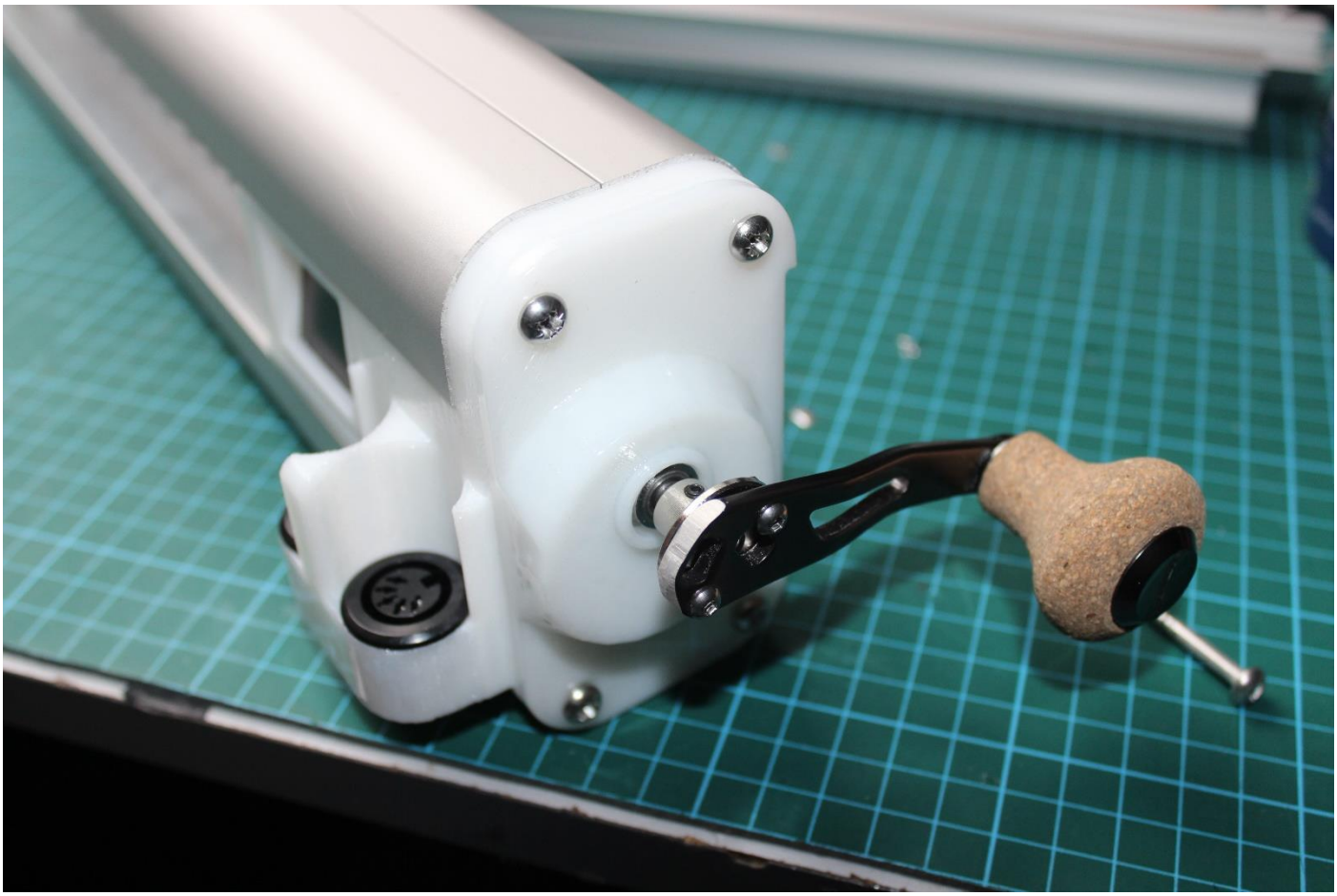
You either attach a USB extender cable (female one end and male the other) to the end of this white cable and directly attach the DigiGurdy to the connected Android phone or iPad/iPhone OR you loop it round and instead use the cable to power the DigiGurdy, i.e. the Teensy board, from the internal phone power bank that you have inserted into the end of the DigiGurdy.

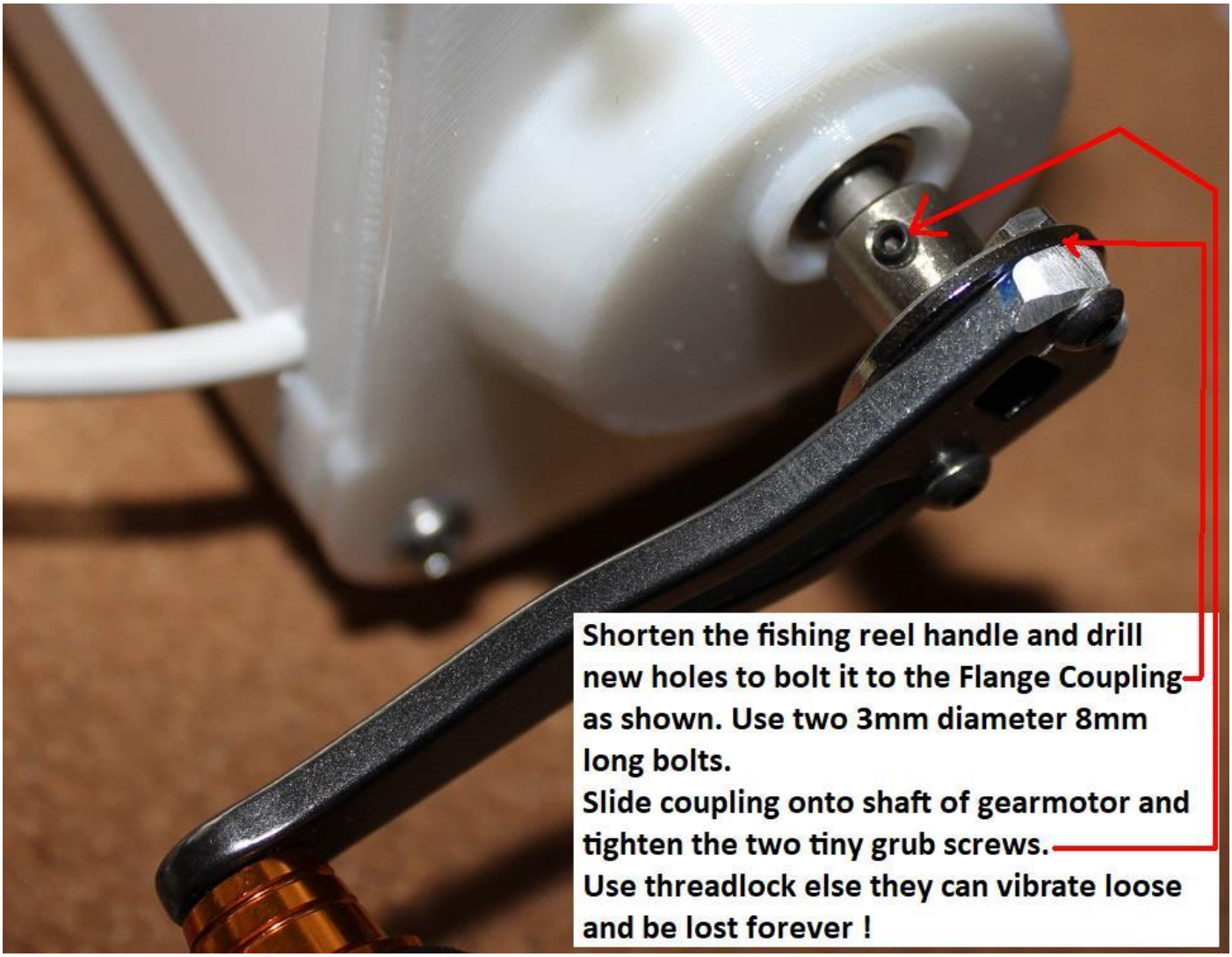


You charge up the phone power bank using a spare USB cable with a micro-USB male plug on the end. It is inserted into the smaller socket in the end of the mobile phone power bank module. These chargers are often supplied with many gadgets such as Android phones for example, or you use a cable and charge it up from for example a USB cable on your laptop.



Fit the motor cover and then fit the crank handle.

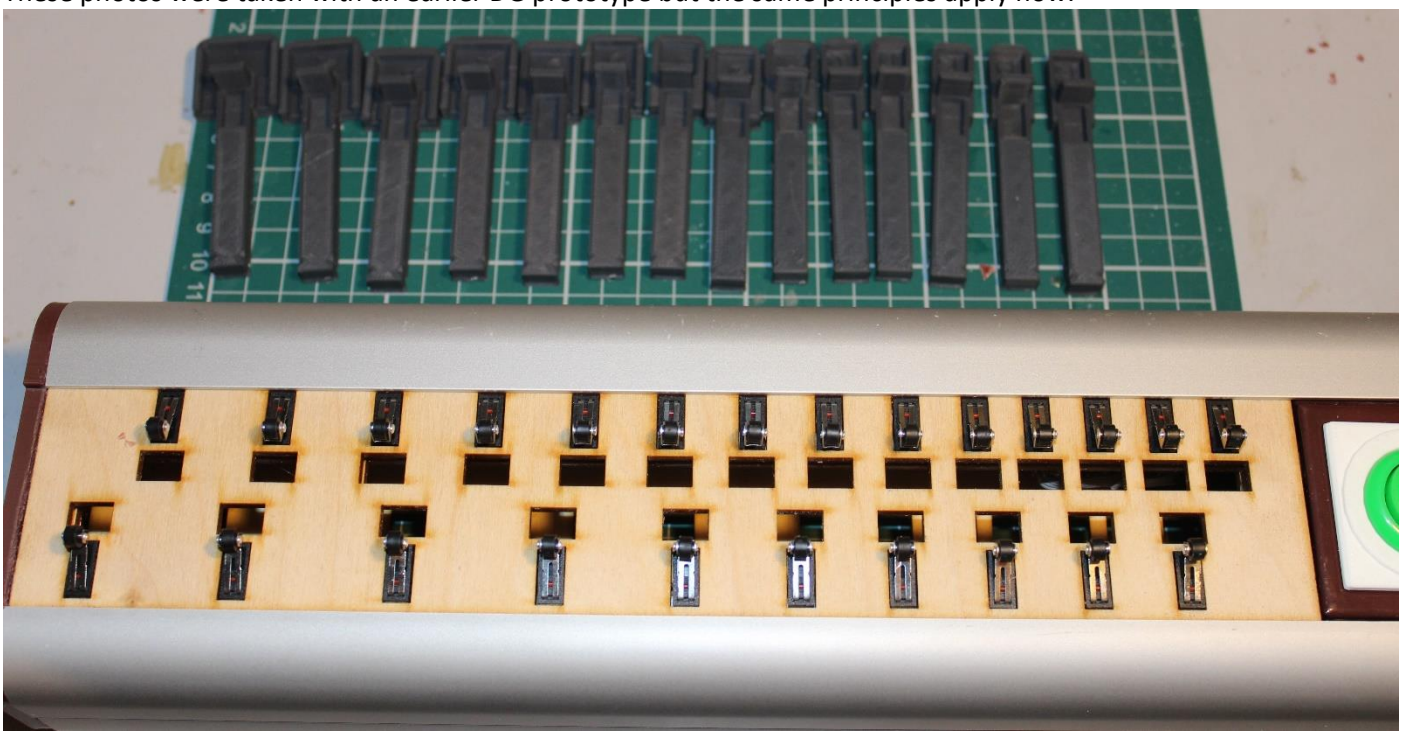


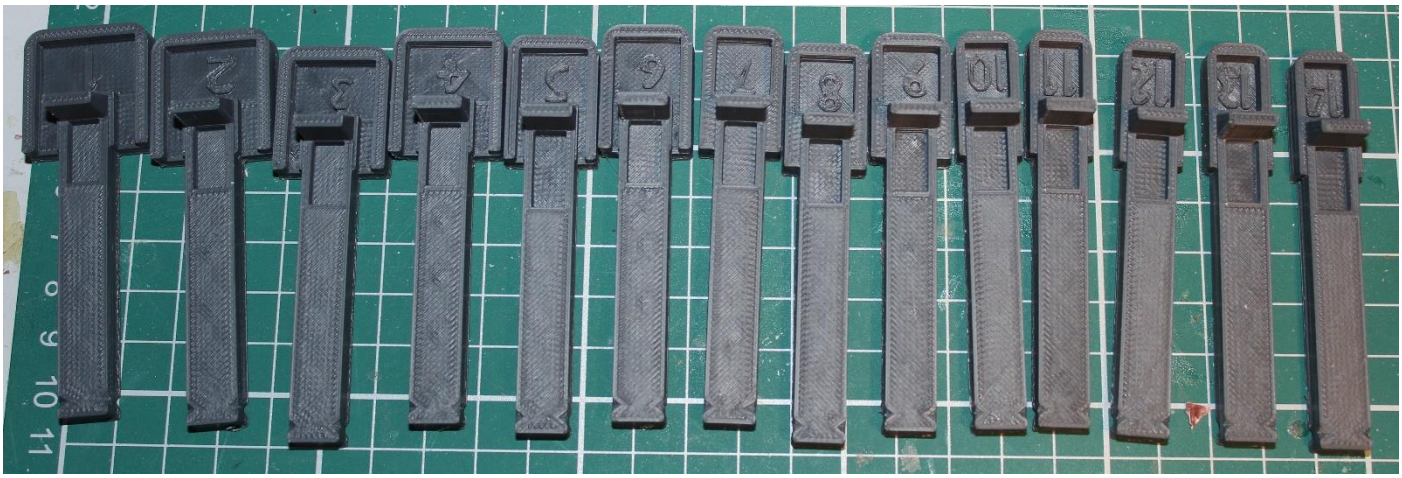


This photo is from an earlier version but it shows how the crank handle is fitted.

Assemble and fit the keys

These photos were taken with an earlier DG prototype but the same principles apply now.



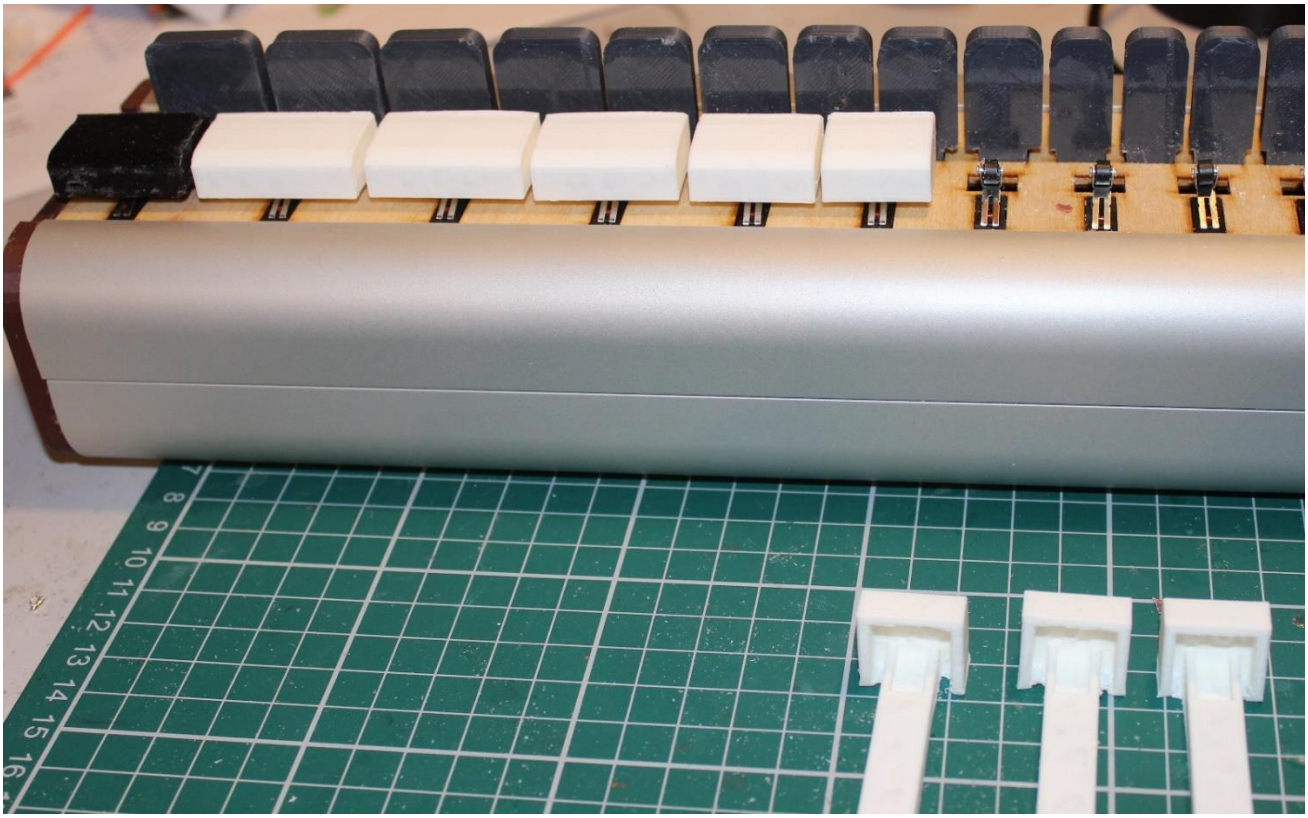


The lower keys are numbered on their undersides so you insert them in the correct sequence from 1 to 14, where 1 is the widest key of the series.

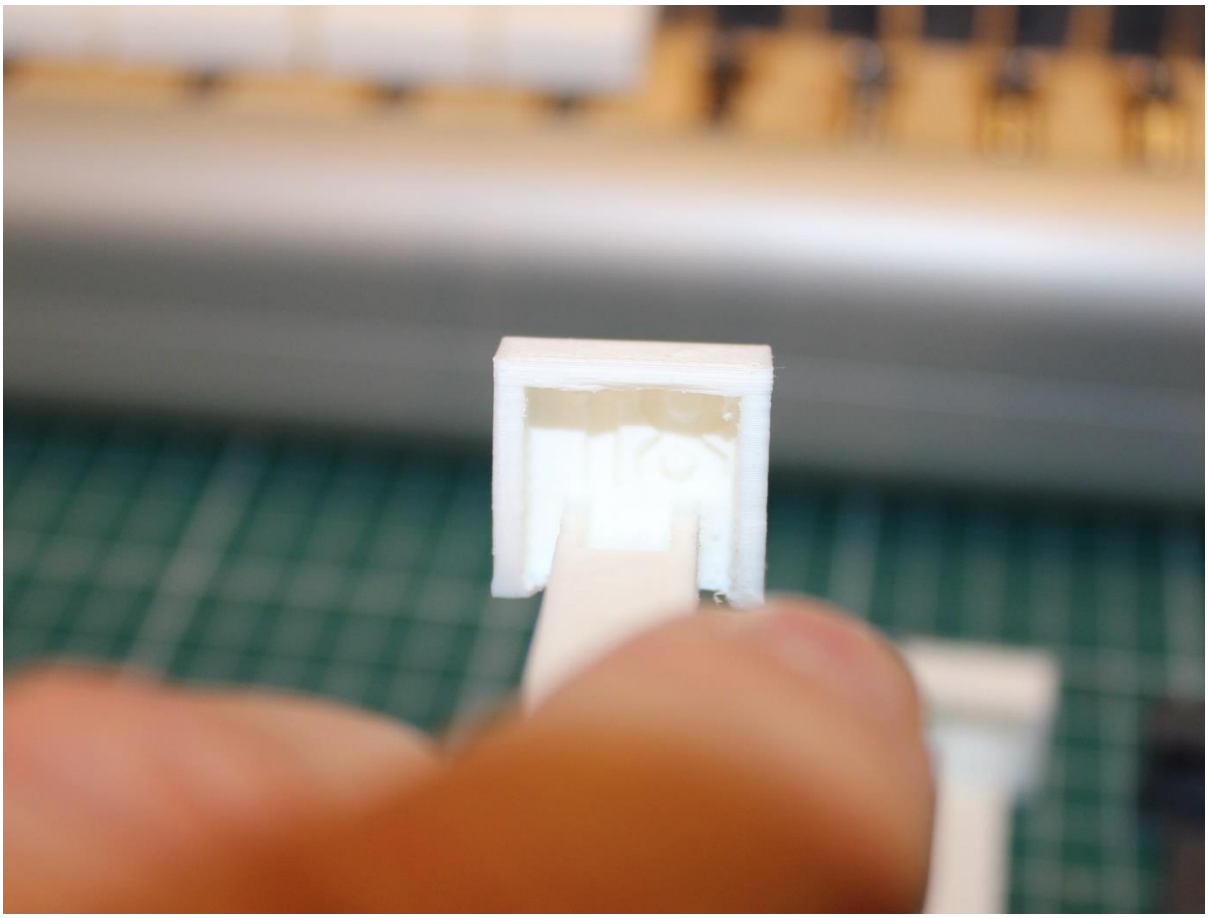
NOTE: The actual numbers are not of great significance. They just allow you to insert the keys in the correct order into the row of slots.

NOTE 2: The keys have been designed to fit the slots in the wooden panels with no filing of the plywood slots and minimal filing of the keys.
The keys must move freely within their slots with no restrictions at all.

NOTE 3: The keys are designed to hit the front white acrylic surface when pressed hard, ***just before*** the microswitch reaches it maximum possible compression point. This is intended to protect the microswitches from damage even if the keys are pressed too hard.

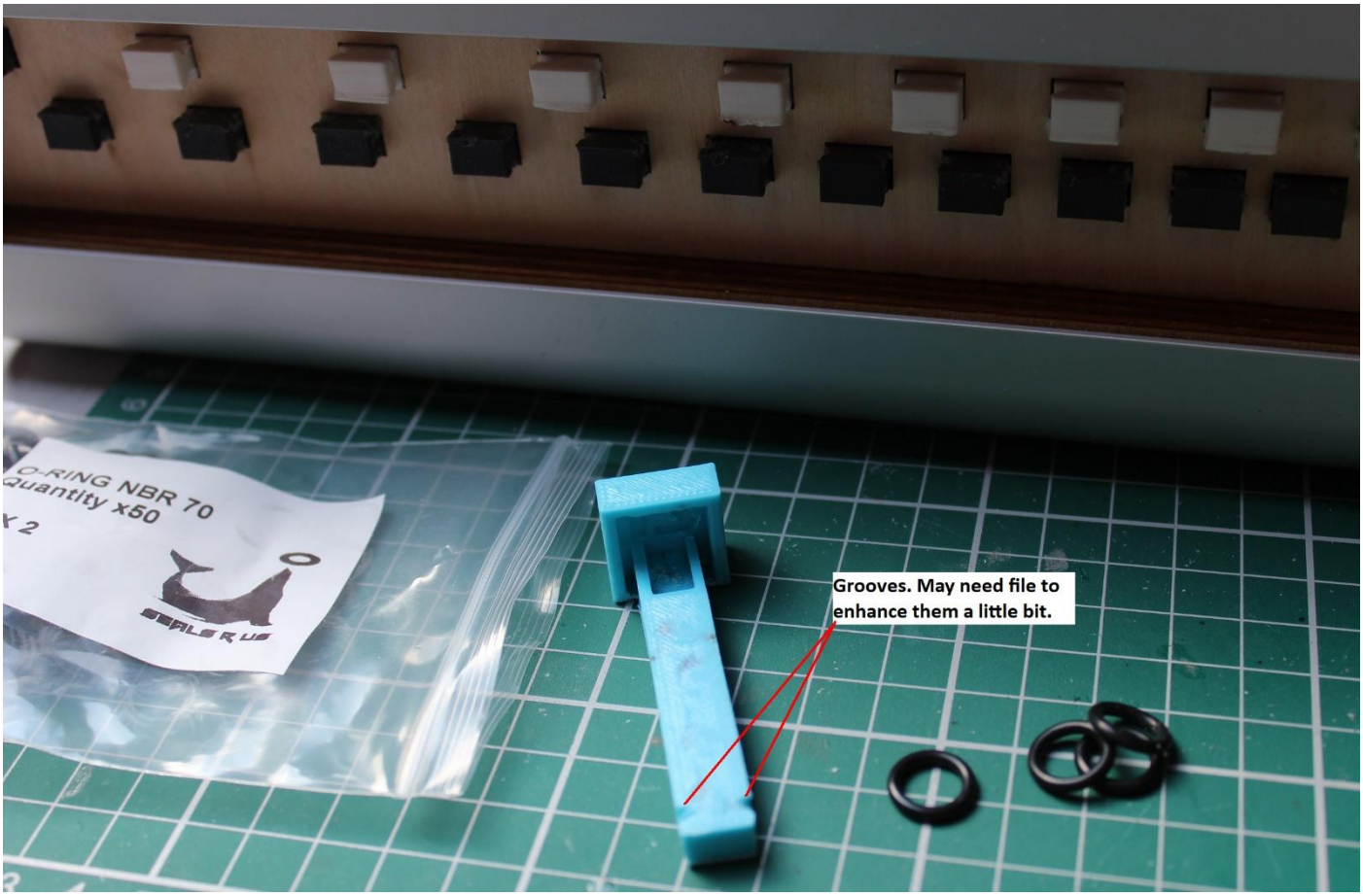


Lower keys have been inserted. Upper keys are in the process of being inserted. These are a different shape to the lower keys.

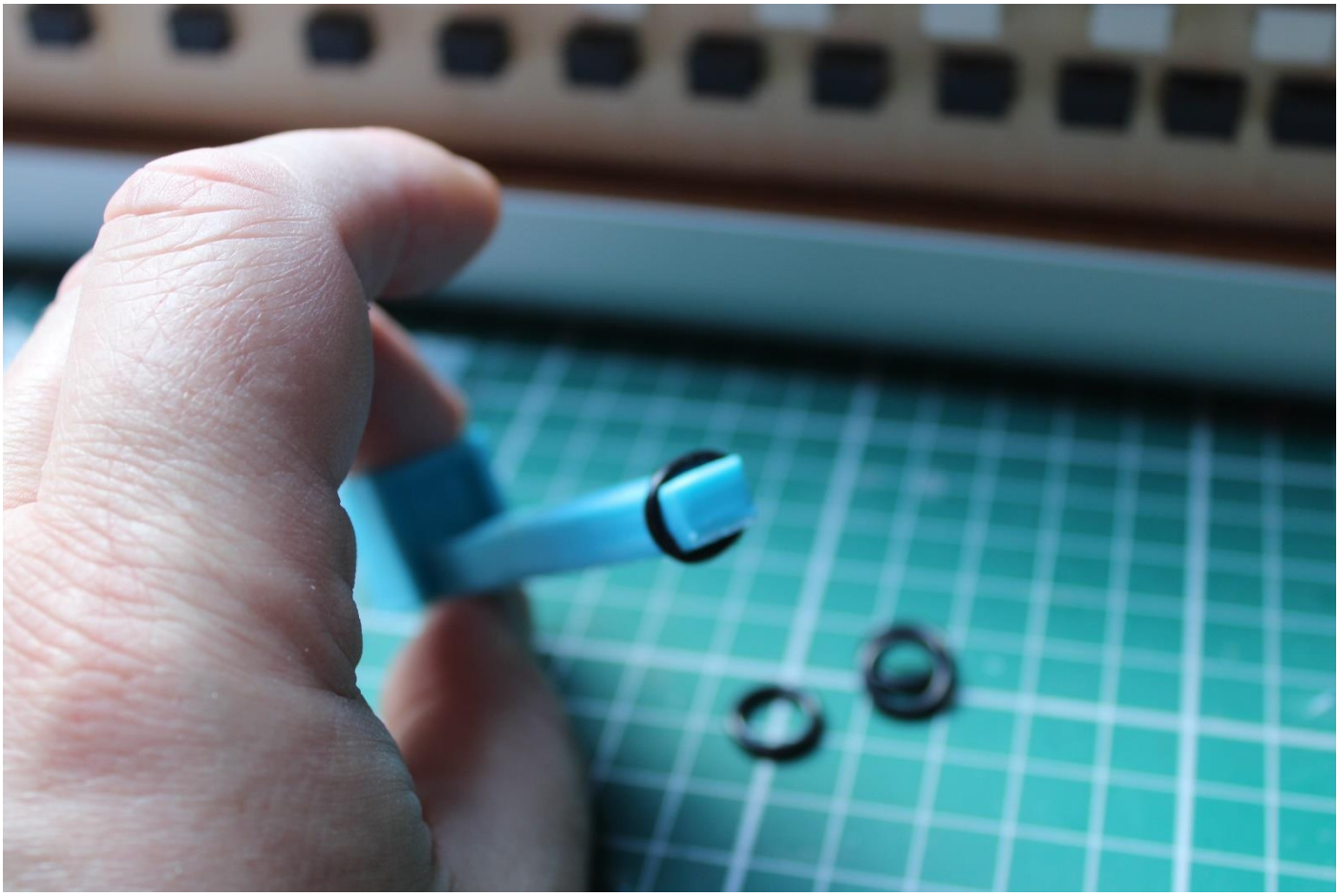


The upper keys also have numbers on their insides from 15 to 24, where 24 is the widest key of the series, again so you can insert them in the correct sequence. This is key 18. Make sure any support material is fully cleared from inside of each key so they activate the microswitches cleanly.

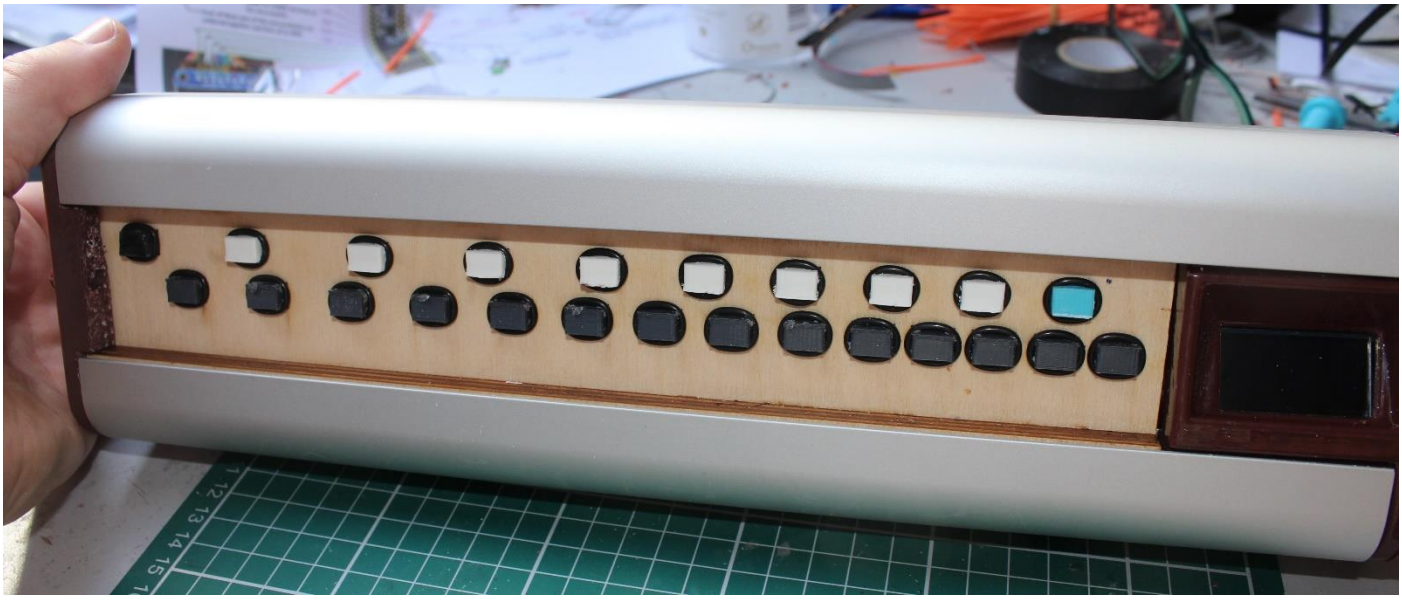
NOTE: *The actual numbers are* ***not*** *of great significance. They just allow you to insert the keys in the correct order into the row of slots.*



The keys are held in place so they do not fall out, by a simple mechanism: An O ring is fitted over the end of each key into a set of grooves made in the stem for the purpose. These grooves are present in the 3D printed keys but you may need to file them a little to make sure they are cleaned out ready to accept the O ring. This makes the keys easy to replace should you ever damage one.

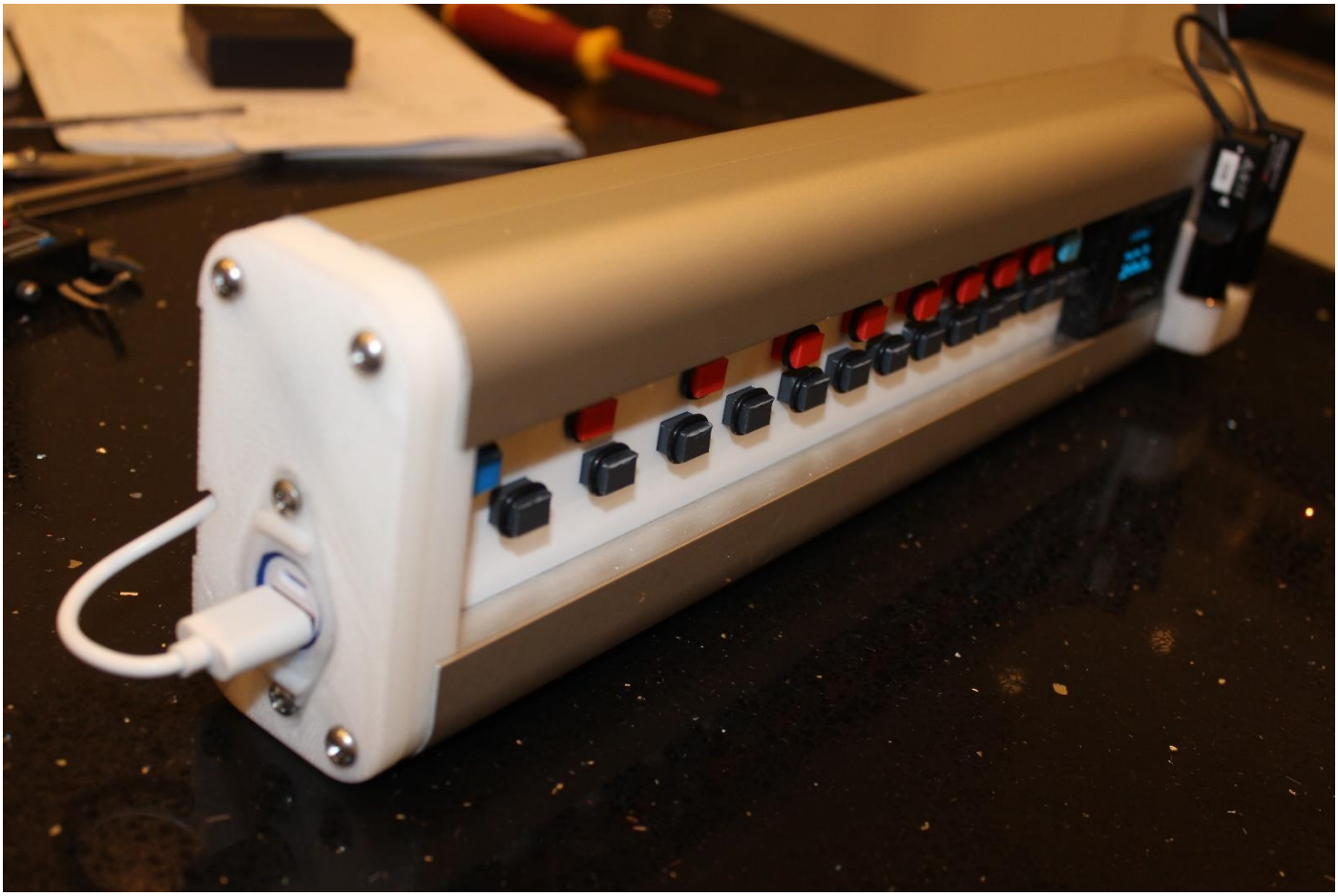


This shows how an O ring is fitted to a key.



Rear of the DigiGurdy showing O rings fitted to all the keys. (NOTE: Older version of the DigiGurdy shown here but the principles are all the same)

NOTE: In this photo the end keys of the top row of keys are different colours to the others as these are also used to navigate around menus that can appear on the OLED screen during setup. Top left is dark blue and top right (in this photo) is light blue. The on-screen menus will refer to these keys by the names Dark Blue and Light Blue (key).



Crank
on!