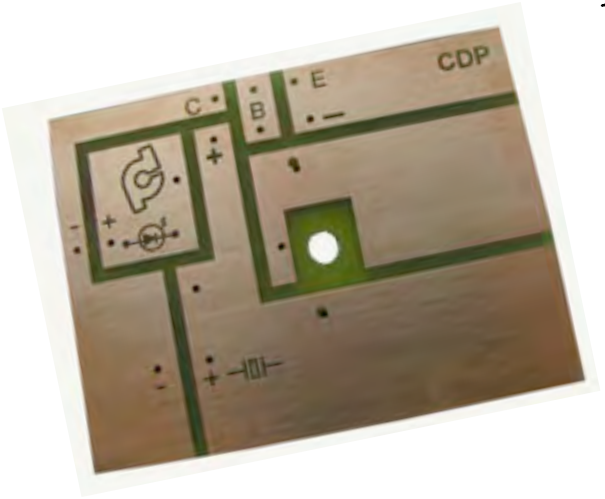
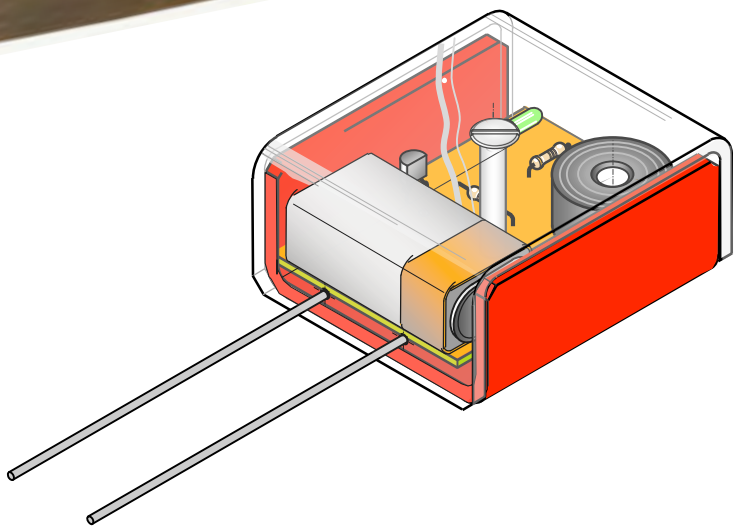
centre de développement pédagogique
pour la formation générale en science et technologie

Working document

TECHNICAL FILE FOR THE "HUMIDITY DETECTOR"

This technical file is intended for technical or teaching personnel





APRIL 2012

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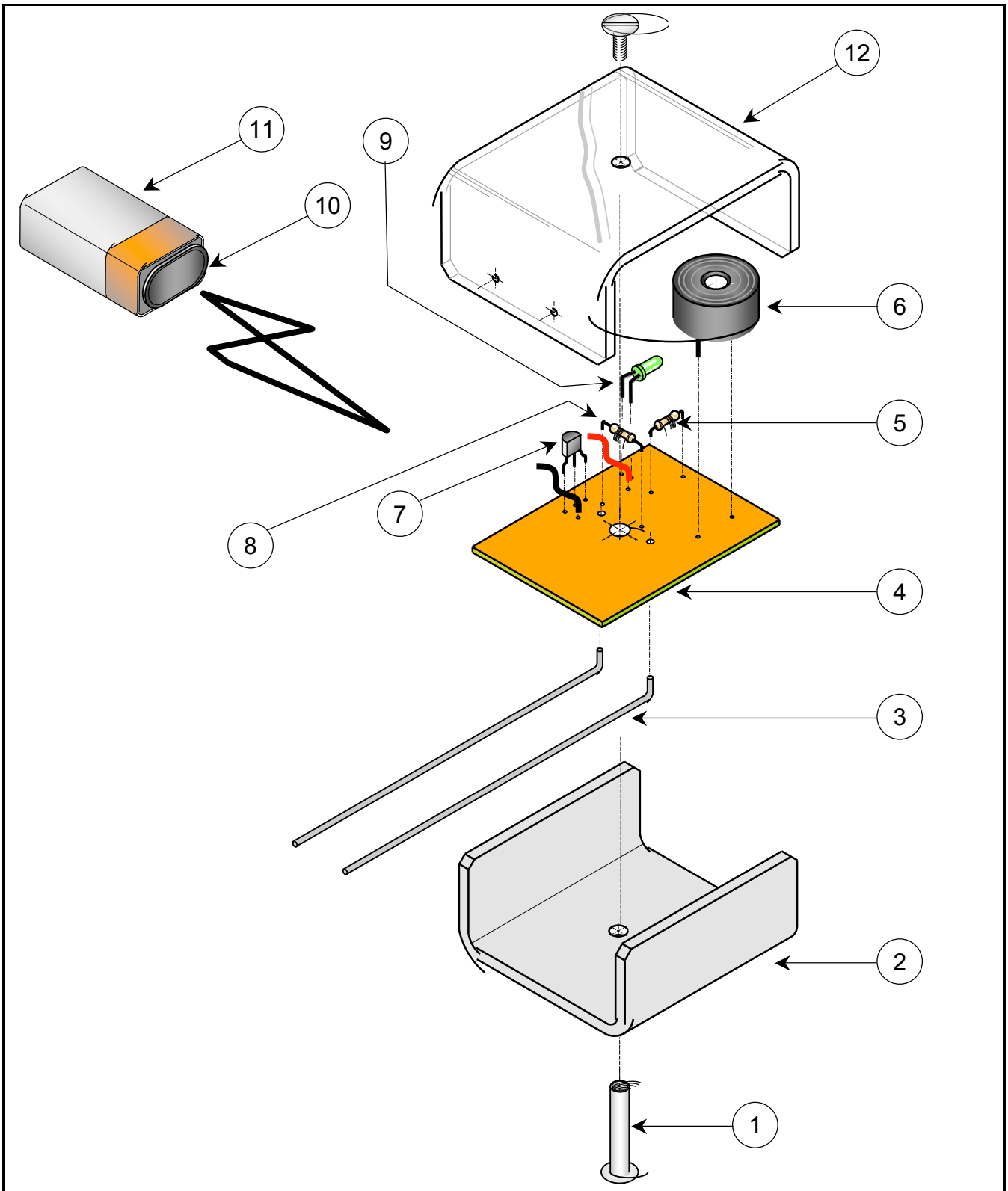

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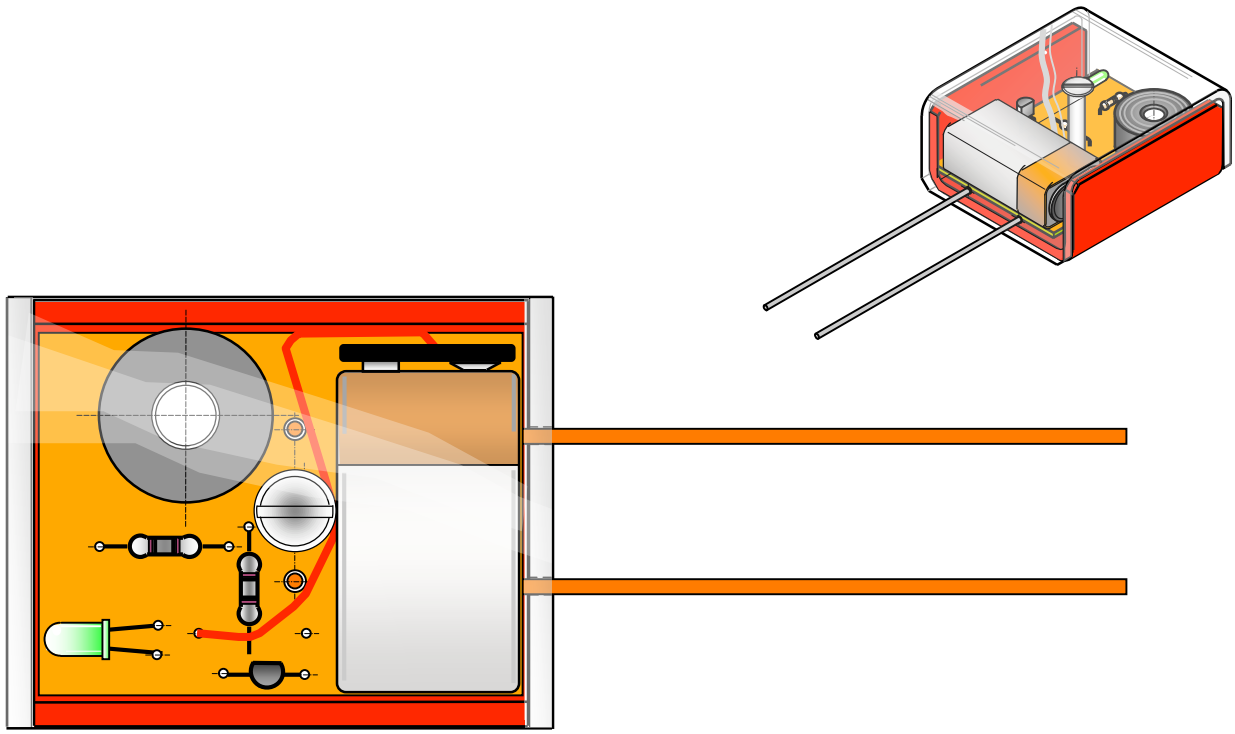
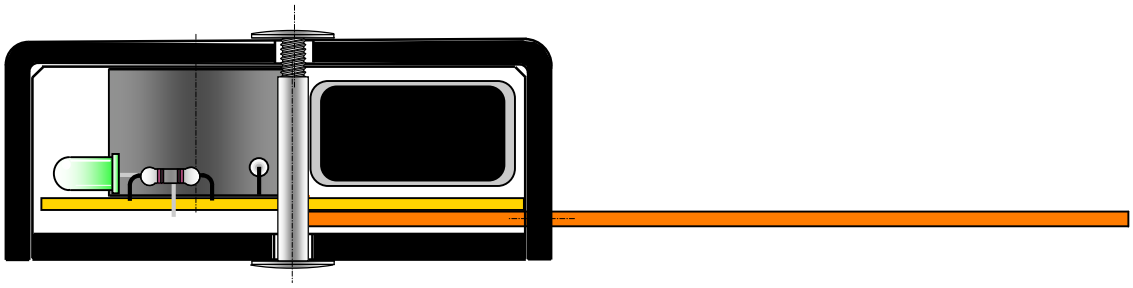
ACTIVITY: **HUMIDITY DETECTOR**		
TITLE: **EXPLODED DRAWING FOR THE HUMIDITY DETECTOR**		
DATE: **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N^{O}1**

NOMENCLATURE			
REF.	**DESIGNATION**	**No.**	**OBSERVATIONS**
23			
22			
21			
20			
19			
18			
17			
16			
15			
14			
13			
12	Housing cover	1	Transparent acrylic moulded plate 120 mm x 57 mm x 3 mm (before folding)
11	Battery	1	9 volt battery
10	Connector	1	9 volt battery connector
9	LED	1	Red light emitting diode
8	Fixed resistor	1	100 ohm resistor
7	Transistor	1	NPN - 2N4401 transistor
6	Buzzer	1	Piezoelectric buzzer - 9 volt
5	Fixed resistor	1	470 ohm resistor
4	Circuit plate	1	Pre-cut photo sensitive plate 64 mm x 48 mm x 1/16 in.
3	Electrode	2	#14 gauge copper wire, 140 mm before folding
2	Housing base	1	Polystyrene moulded plate 98 mm x 65 mm x 3 mm (before folding)
1	Screw	1	26 mm (1 in.) - Chicago screw

centre de développement pédagogique pour la formation générale en science et technologie	TITLE: **HUMIDITY DETECTOR**	
	DATE: **JUNE 2011**	Reference: **Drawing N^{o} 1**

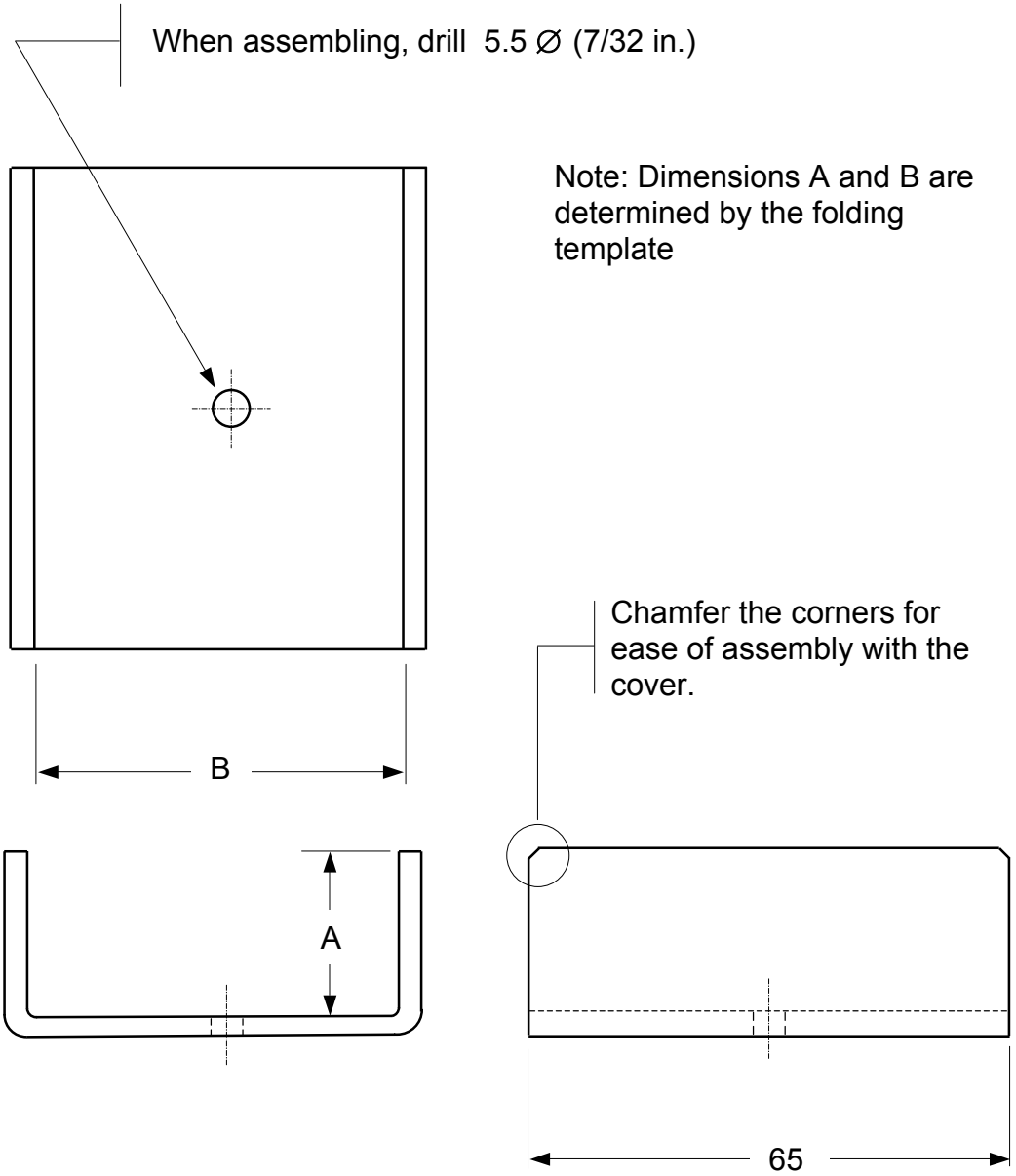


Top view



Cut view

centre de développement pédagogique *pour la formation générale en science et technologie*	ACTIVITY: **HUMIDITY DETECTOR**		
	TITLE: **DIFFERENT VIEWS**		
	DATE: **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N° 2**



2- Detail drawing for the housing base

REF	No.	DESIGNATION	MATERIALS	OBSERVATIONS
2	1	Housing base	Polystyrene	98 mm x 65 mm x 3 mm

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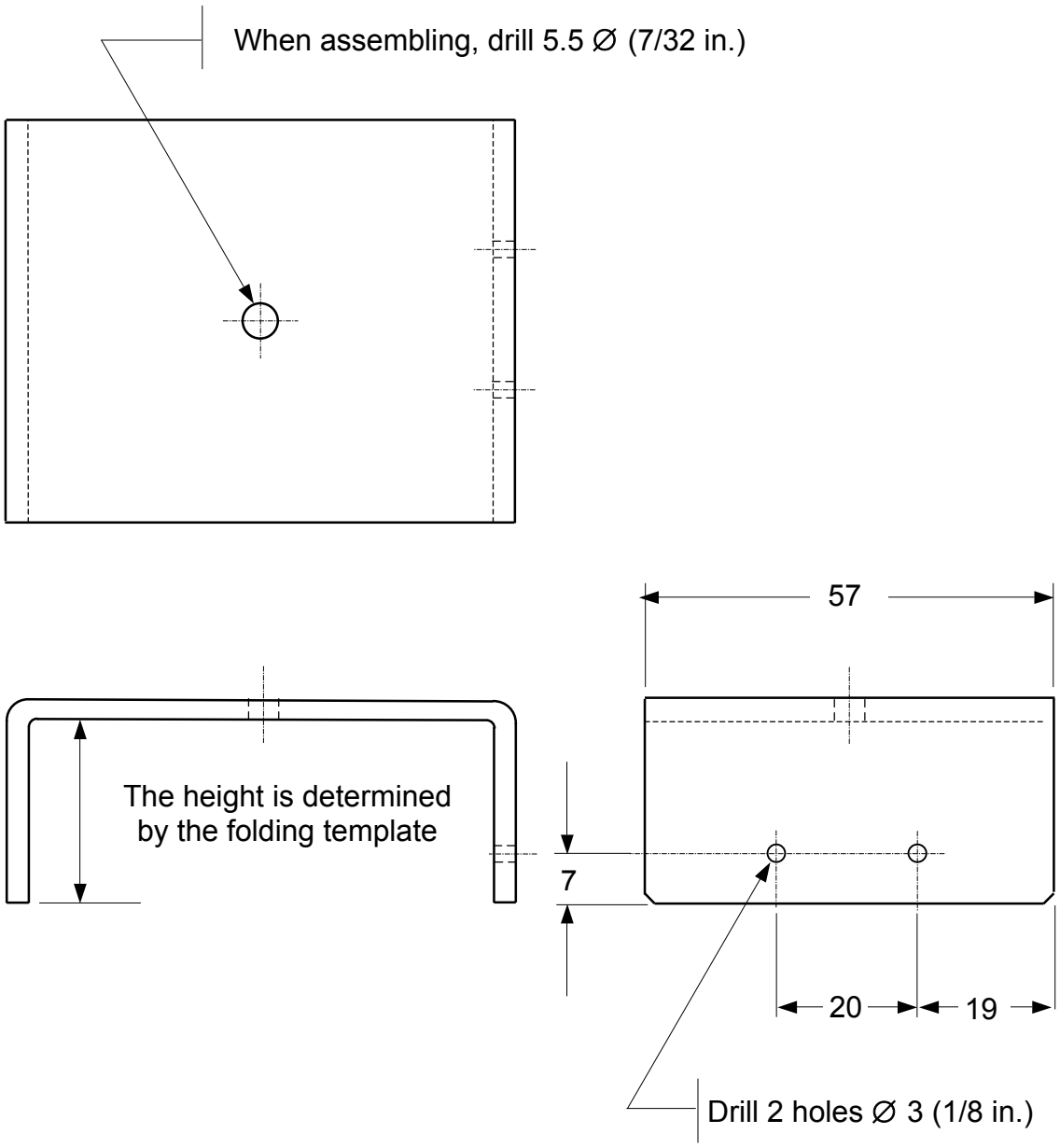
ACTIVITY: **HUMIDITY DETECTOR**		
TITLE: **DETAIL DRAWING FOR THE HOUSING BASE**		
DATE: **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N^{O} 3**



12 - Detail drawing for the housing cover

REF	No.	DESIGNATION	MATERIALS	OBSERVATIONS
12	1	Housing cover	Transparent acrylic	120 mm x 57 mm x 3 mm

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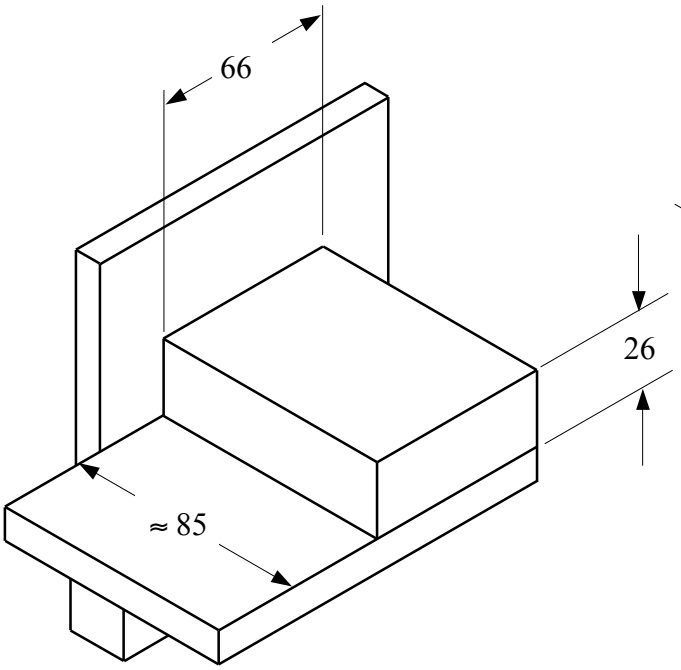
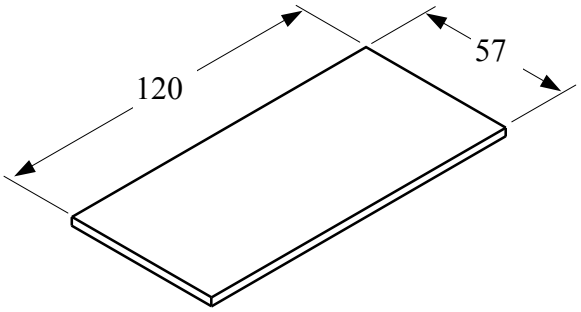
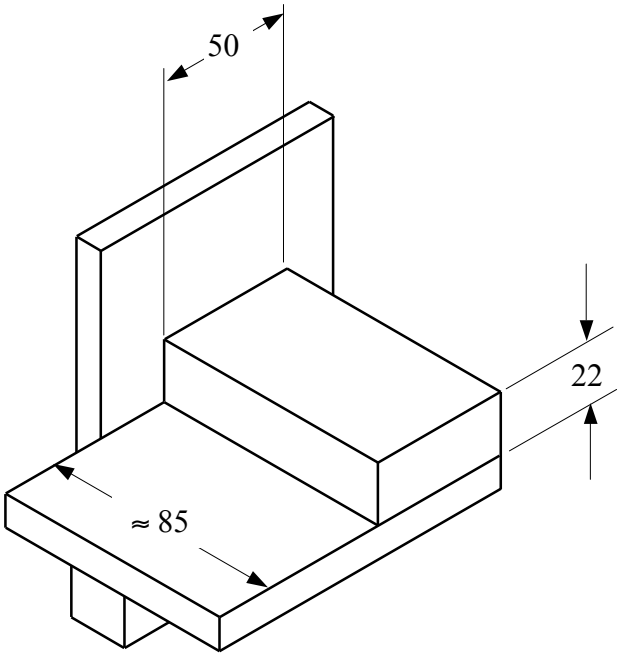
ACTIVITY: **HUMIDITY DETECTOR**		
TITLE: **DETAIL DRAWING FOR THE HOUSING COVER**		
DATE : **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N^{O} 4**

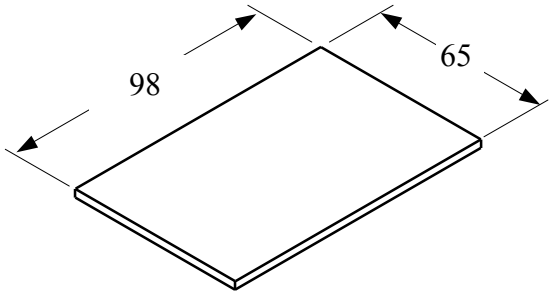




3 mm transparent acrylic before folding

Detail drawing for the housing cover template





3 mm polystyrene before folding

Detail drawing for the housing base template

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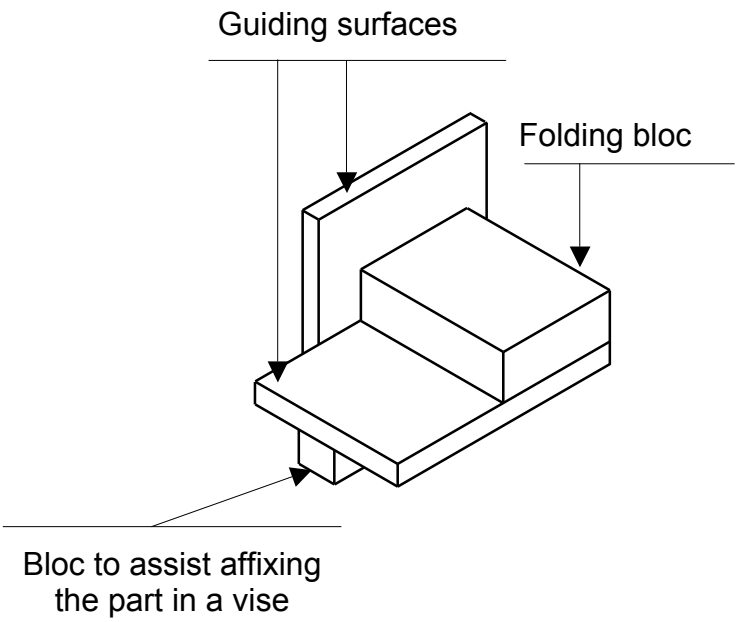
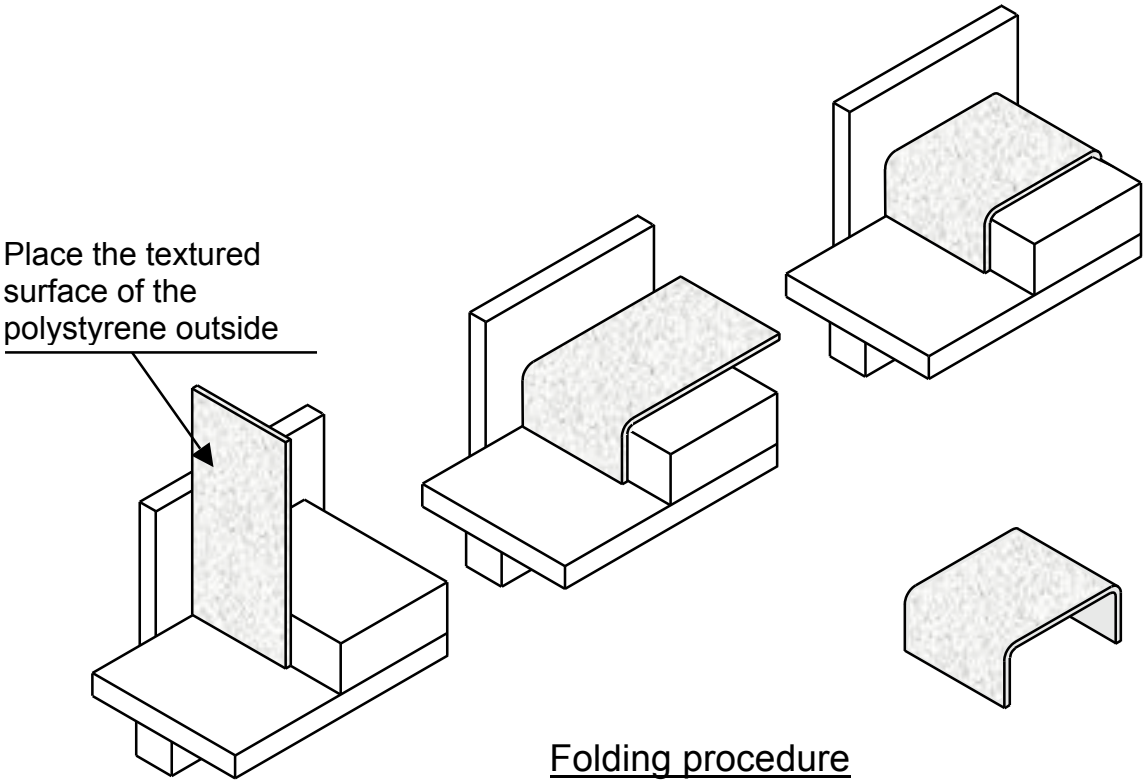
ACTIVITY: **HUMIDITY DETECTOR**		
TITLE: **DETAIL DRAWINGS FOR THE HOUSING TEMPLATES**		
DATE: **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N^{O} 5**



Detail drawing of the template



Folding procedure

centre de développement pédagogique *pour la formation générale en science et technologie*	ACTIVITY: **HUMIDITY DETECTOR**		
	TITLE: **"FOLDING PROCEDURE WITH TEMPLATES" DRAWING**		
	DATE: **JUNE 2011**	SCALE: **NOT TO SCALE**	DRAWING: **N^{O} 6**

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FABRICATION RANGE

ELEMENT: **PRINTED CIRCUIT PLATE**

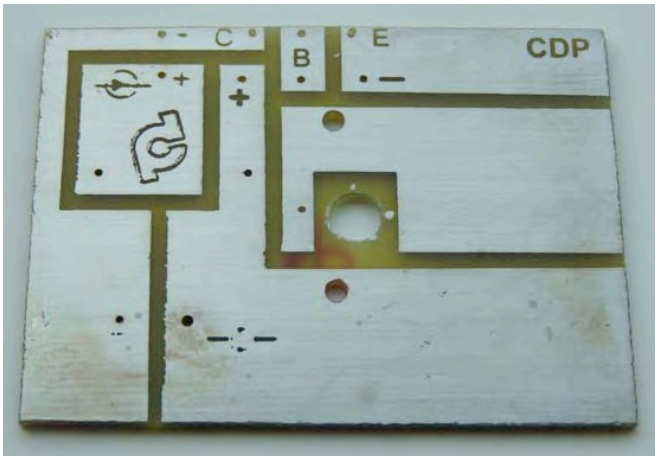
SET: **HUMIDITY DETECTOR**

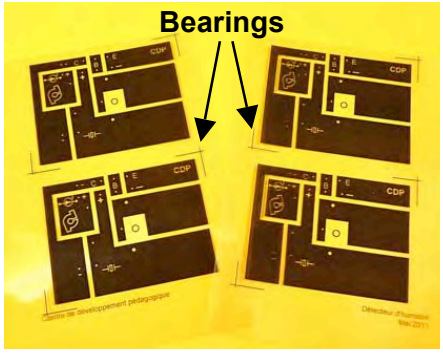
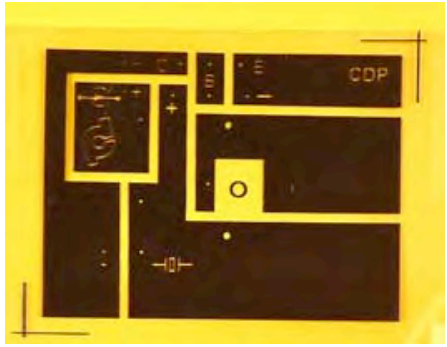
RANGE: **1**

SHEET : **1 of 6**

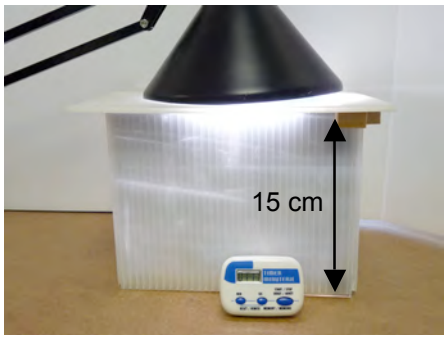
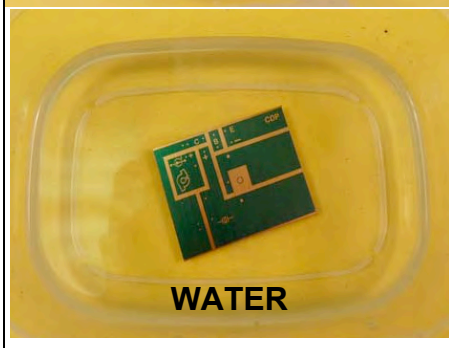
NUMBER: **1**

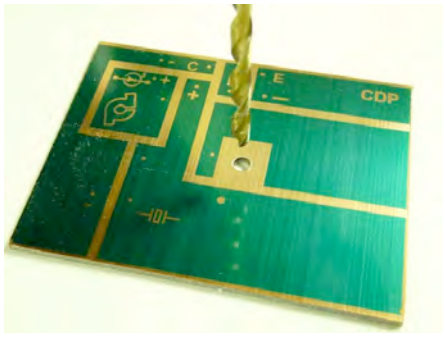
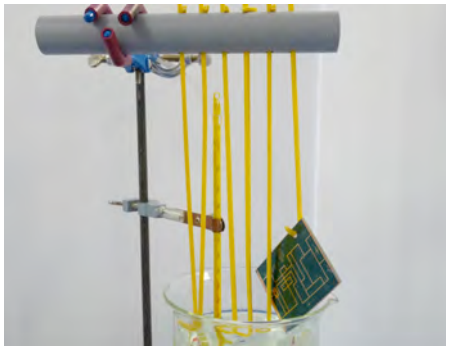
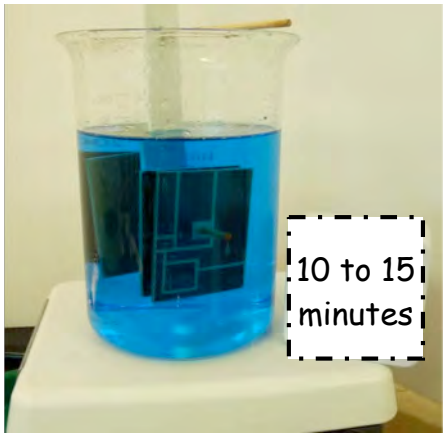
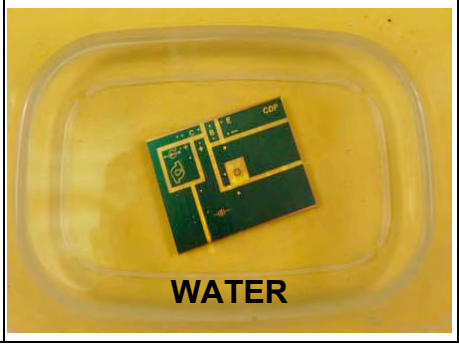
MATERIALS: **Various**



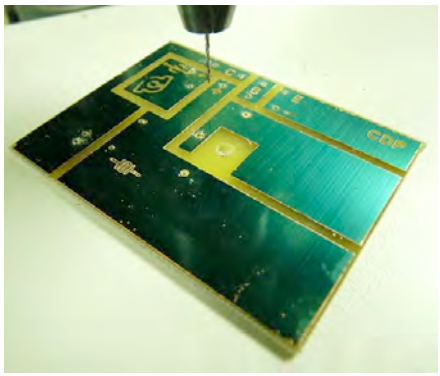
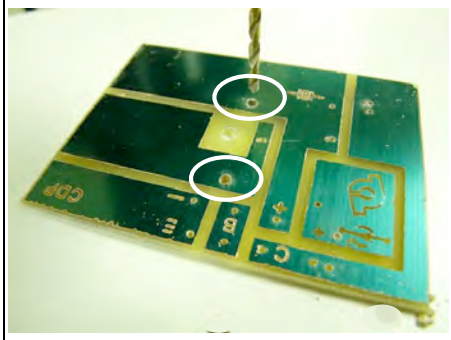
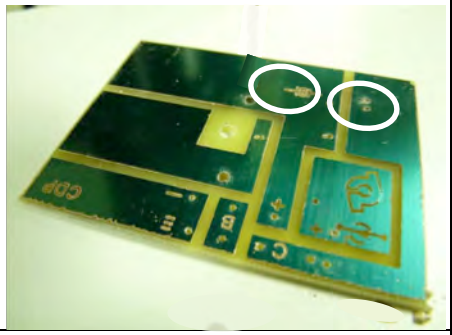
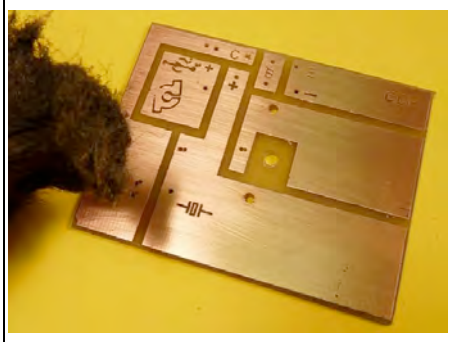
N°	PHASE, SUB-PHASE OR OPERATION	PHOTO OR DRAWING	MACHINE-TOOL, TOOLS
10	**PRINTING THE MASK**		
11	Print the mask for the circuit (image).		– Printer
12	Using this copy, print a transparency (acetate).		– Transparency (acetate) – Photocopier
13	Cut two masks of the circuit and superimpose them. The corner bearings will allow you to line up the two pieces correctly. The CDP logo and letters can also be used as bearings. Glue the two masks together using adhesive tape.		– Scissors – Adhesive tape
	Important: Superimposition allows the mask to be sufficiently opaque.		

FABRICATION RANGE FOR THE PRINTED CIRCUIT PLATE			SHEET: **2 of 6**
N°	**PHASE, SUB-PHASE OR OPERATION**	**PHOTO OR DRAWING**	**MACHINE-TOOL, TOOLS**
20	**RESIN EXPOSURE**		
21	Place the mask in a picture frame. Affix it using adhesive tape. **Note**: The CDP logo must be right side up once the frame is turned over.		– Frame – Adhesive tape
22	Identify your photosensitive resin plate on the (beige) insulated side by writting your initials.		– Photosensitive resin plate – Permanent marker
23	Remove the protective film from the photosensitive resin plate. **Careful:** It is very easy to scratch the plate's photosensitive resin.		– Photosensitive resin plate
24	Place the plate on the acetate. The green coloured photosensitive resin must be face down (i.e. on the transparency).		– Frame – Affixed mask
25	Close the frame and turn it right side up. **Important**: The CDP logo must be right side up once the frame is closed and turned over.		

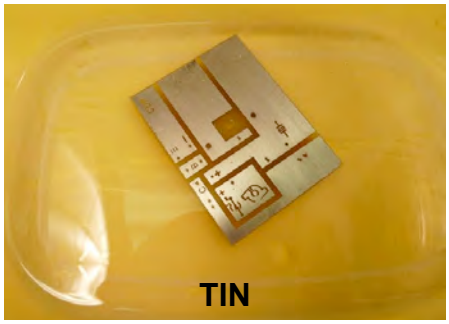
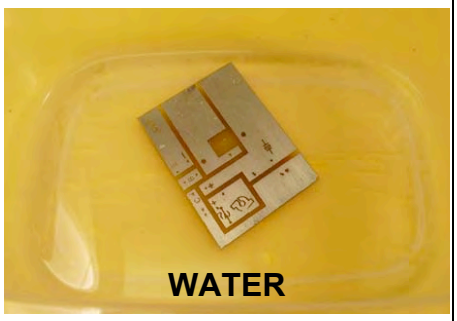
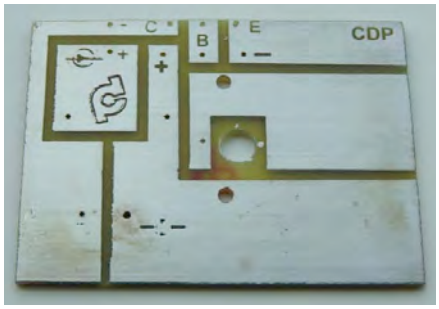
FABRICATION RANGE FOR THE PRINTED CIRCUIT PLATE			SHEET: **3 of 6**
N°	**PHASE, SUB-PHASE OR OPERATION**	**PHOTO OR DRAWING**	**MACHINE-TOOL, TOOLS**
26 27	Expose* the plate **8 to 10 minutes** under a lamp with an ultra violet bulb. Withdraw the exposed plate from the frame. * Expose: Subject to light.		– Desk lamp – UV or ordinary compact fluorescent bulb – Timer
	The use of a reflector allows you to move the light further away and produces a more uniform, precise exposure. The reflector is made from a Coroplast box adapted to the size of the frame and whose interior is lined with a reflective substance (aluminium foil or Mylar).		– Reflector – Desk lamp – UV or ordinary compact fluorescent bulb – Timer
30	**DEVELOPING THE PLATE**		
31	Place the plate in the "Developer" solution. **(Resin side up)** Shake the plate until it is completely developed (i.e. until the pattern appears completely copper covered). This takes about **10 seconds**.		– Safety glasses – Bath containing developer solution – Plastic tweezers
32	Rinse in the "developer" water bath. Carefully sponge without scratching the resin. **Careful!** At this stage, the resin is fragile and the plates need to be handled with care. Any scratches may cause a defect in the circuit.		– Safety glasses – Water bath – Plastic tweezers – Absorbent paper

FABRICATION RANGE FOR THE PRINTED CIRCUIT PLATE			SHEET: **4 of 6**
N°	**PHASE, SUB-PHASE OR OPERATION**	**PHOTO OR DRAWING**	**MACHINE-TOOL, TOOLS**
40	**DRILLING**		– Safety glasses – 7/32 in Ø bit. – Press drill – Drill vice – Martyr
41	Slowly drill the central hole to a diameter of 5.5 mm (7/32 in.). This hole will be used to hang the plate during the next step. **See note at the bottom of the page.**		
50	**ENGRAVING THE PLATE ***		– Laboratory hood – Safety glasses – 1000 mL beaker – Hot plate with magnetic agitator – Magnetic bar – Thermometer with clamp – Universal support – Timer – Support for the plate
51	Suspend the plate in a sodium persulfate solution. Let it react until the copper that was exposed to the UVs is completely dissolved. The solution must be at 40°C and must be stirred. **Note:** When the copper borders are dissolved, the plate must be removed. This may take **10 to 15 minutes.** *** IMPORTANT: It is recommended to carry out this operation under the hood or to ensure the room is well ventilated**.		
52	Rinse in a water bath and wipe.		– Safety glasses – Water bath – Plastic tweezers – Absorbent paper

Note: The drill vise and martyr do not appear in the photos in order to make the operation more clear.

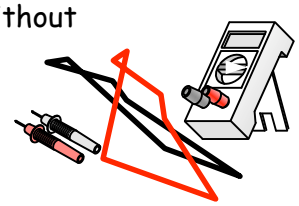
FABRICATION RANGE FOR THE PRINTED CIRCUIT PLATE			SHEET: **5 of 6**
N°	**PHASE, SUB-PHASE OR OPERATION**	**PHOTO OR DRAWING**	**MACHINE-TOOL, TOOLS**
60	**DRILLING THE PLATE**		
61	Slowly drill all the holes with a .8 mm (1/32 in.) diameter. **See note at the bottom of the page.**		– Safety glasses – 1/32 in. Ø bit. – Press drill – Drill vise – Martyr
62	Widen the connector holes to a diameter of 2.5 mm (3/32 in.). **Note:** The holes corresponding to the electrodes are on each side of the central hole.		– Safety glasses – 3/32 in. Ø bit. – Press drill – Drill vise – Martyr
63	Widen the holes for the buzzer to a diameter of 1.2 mm (3/64 in.). **Note:** The hole to be widened is circled on the photo at right. It will be used as a reference in the next step. **See note at the bottom of the page.**		– Safety glasses – 3/64 in. Ø bit. – Press drill – Drill vise – Martyr
70	**BARING THE COPPER**		
71	Using steel wool, remove the remaining photosensitive resin. Rinse with water and **wipe well.** **Important**: Handle the plate with a pair of tweezers or by the sides, since the oil from your fingers may prevent the tin from adhering at the next step.		– Safety glasses – Steel wool – Water bath – Plastic tweezers – Absorbent paper

Note: The drill vise and martyr do not appear in the photos in order to make the operation more clear.

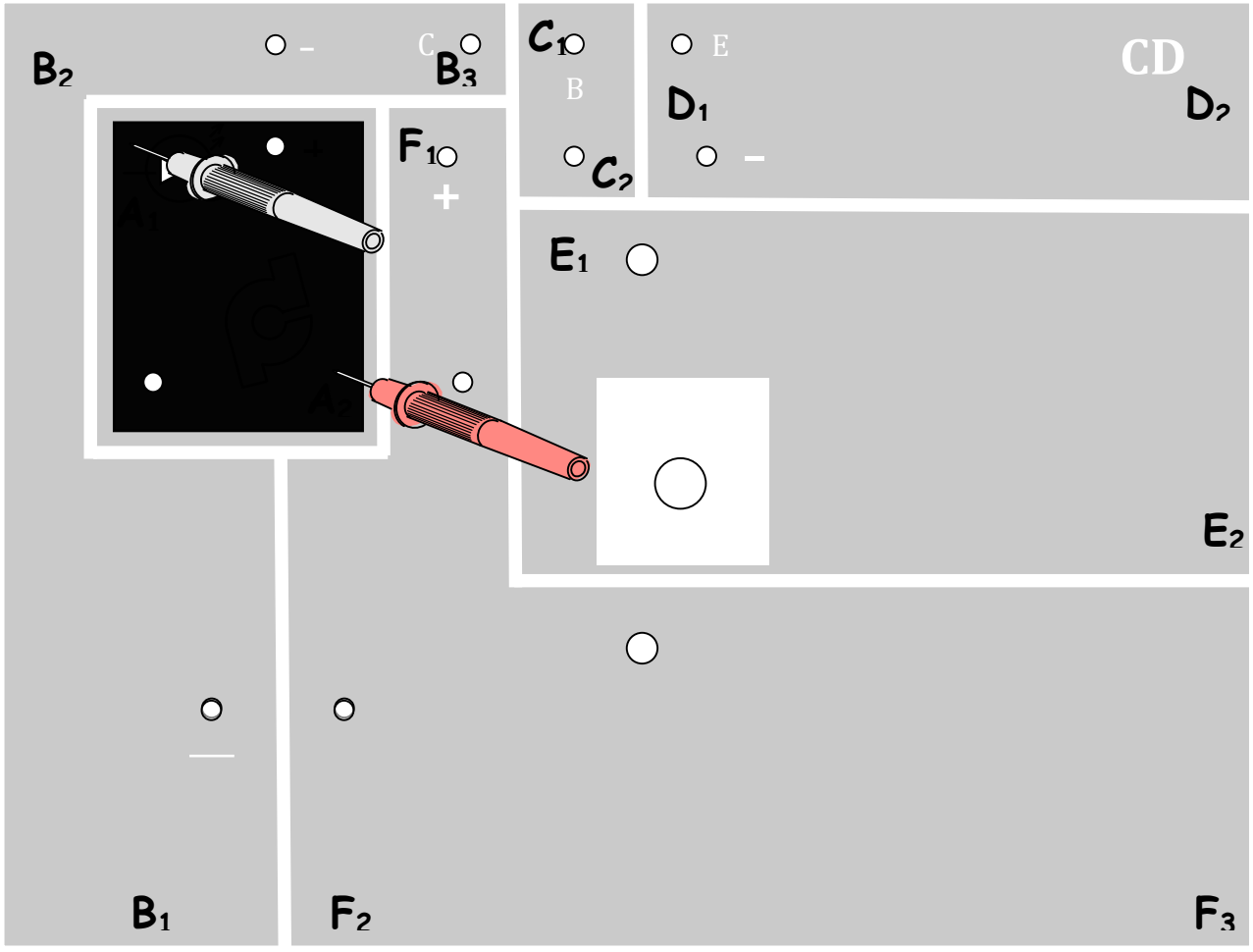
FABRICATION RANGE FOR THE PRINTED CIRCUIT PLATE			SHEET: **6 of 6**
N°	**PHASE, SUB-PHASE OR OPERATION**	**PHOTO OR DRAWING**	**MACHINE-TOOL, TOOLS**
80	**TINNING THE PLATE ***		
81	Soak the plate **about one minute** in a liquid tin solution. **Note:** This operation makes soldering the components easier and prevents the copper from oxidising.		– Laboratory hood – Safety glasses – Liquid tin bath – Plastic tweezers – Timer
82	Rinse in a water bath and sponge off without rubbing. * **IMPORTANT: It is recommended to carry out this operation under the hood or to ensure proper ventilation in the room.**		– Safety glasses – Water bath – Plastic tweezers – Absorbent paper
83	Now it is time to verify the state of electrical conductivity of this plate (see following section). Once this verification has been carried out, the plate will be ready to have its components installed. (See "Component installation procedure").		– "Electrical conductivity control" document – "Component installation procedure" document

Controlling the state of conductivity of the printed circuit plate for the humidity detector

Here is the printed circuit for the humidity detector. The grey areas are conductive and tinned. The white lines are insulating borders stripped of conductor (without copper).



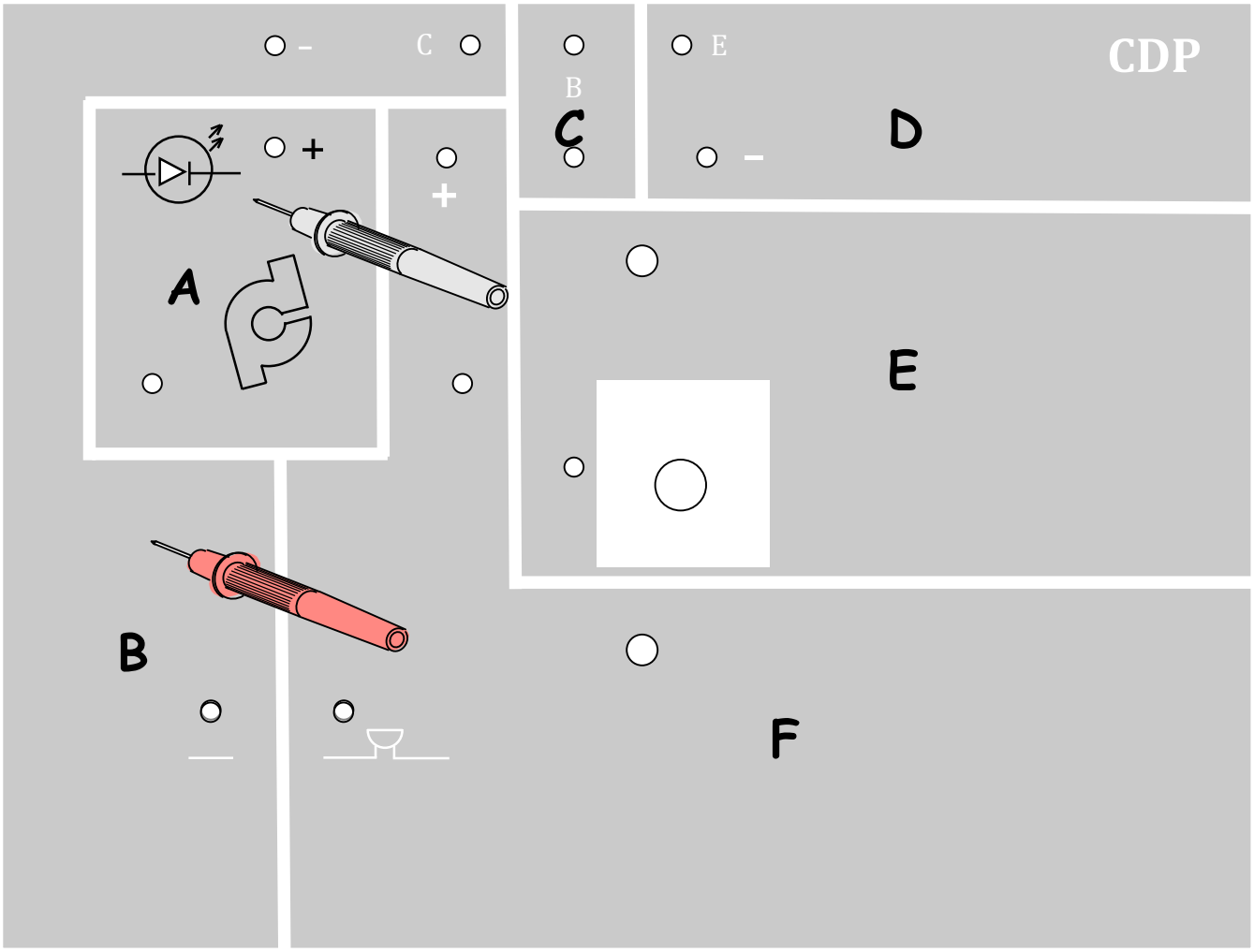
First, we must verify the electrical conductivity of each area. A fabrication defect may arise if the photosensitive resin is scratched before the engraving stage. Let's take textured area "A" below as an example: we need to test the conductivity between two distant points using a multi-meter in conduction mode. If the conductivity is good, we tick the control points in the table below. When the area has a more complex shape, additional measurements are necessary. If there were a defect, a dab of solder may re-establish conduction.



Verification table for good conductivity in each area							
Control points	✔	Control points	✔	Control points	✔	Control points	✔
A_1 to A_2		B_1 to B_2		B_1 to B_3		C_1 to C_2	
D_1 to D_2		E_1 to E_2		F_1 to F_2		F_2 to F_3	

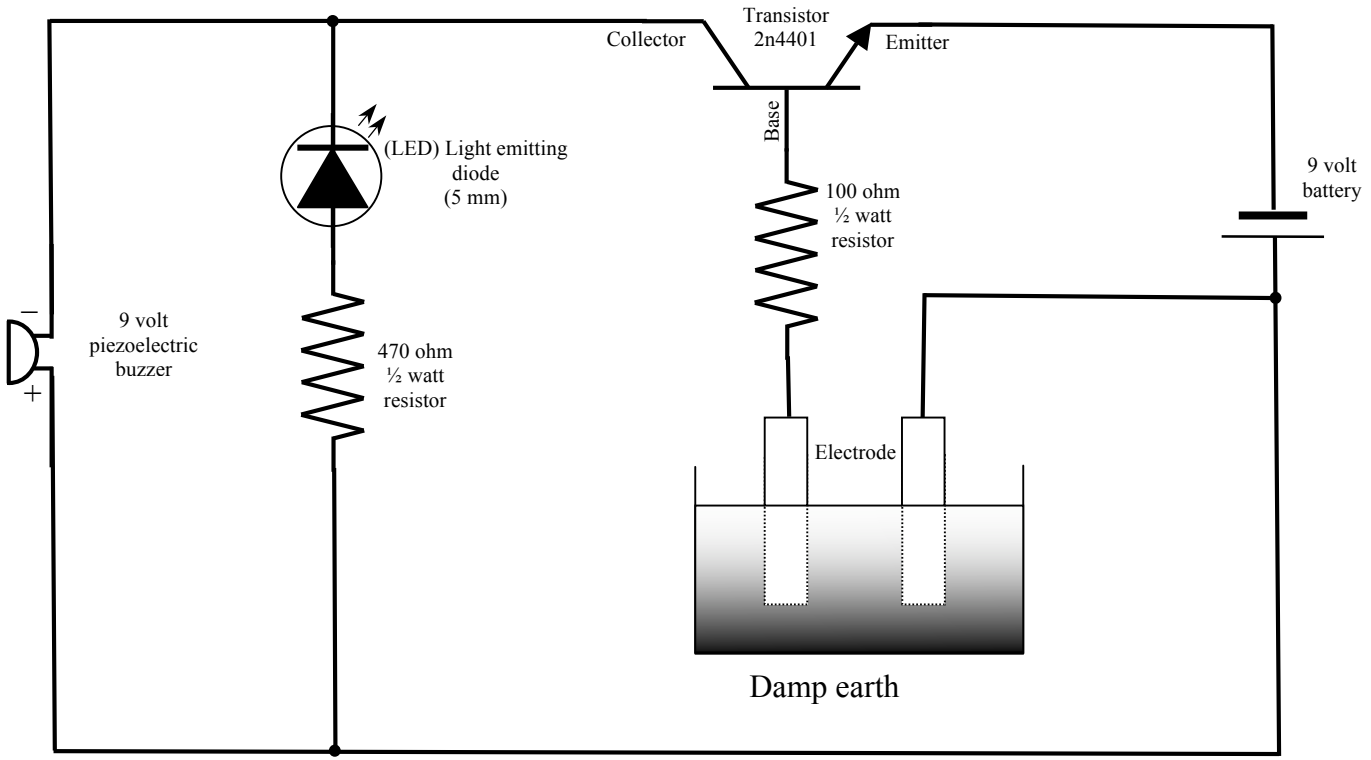
VALIDATING THE INSULATING BORDERS BETWEEN CONDUCTIVE AREAS IN THE HUMIDITY DETECTOR CIRCUIT PLATE

Secondly, we need to **test if the borders insulate correctly**. A fabrication defect may arise when we superimpose the masks or when we print them. This time, we need to check that electrical current does not travel between adjacent areas (see example below between areas **A** and **B**). If the insulation is adequate, we will tick the control points in the table below. If there were a defect, it would be possible to separate the two areas by scratching the borders using the point of a plastics knife.



Verification table for border insulation							
Control points	✔	Control points	✔	Control points	✔	Control points	✔
A and B		A and F		B and C		B and F	
C and F		C and D		C and E		C and F	
D and E		E and F					

Electrical circuit for the humidity detector



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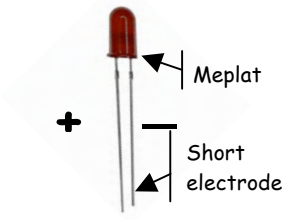
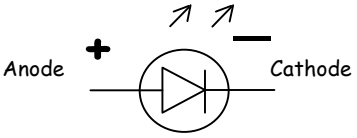
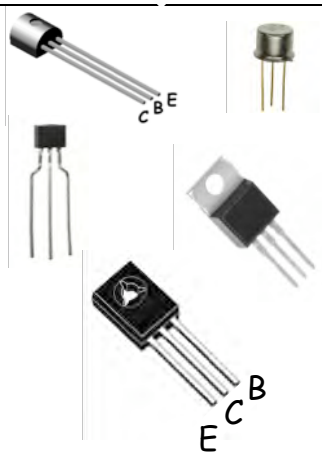
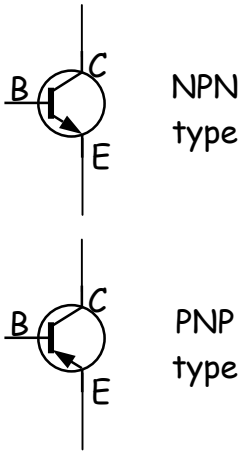
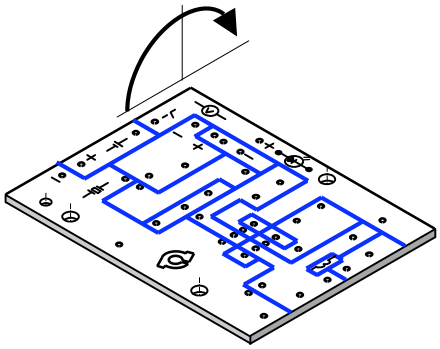
Electronic components used in the humidity detector

Here is a summary description of the components used in making the humidity detector. The "Gaussbuster" LES allows you to gain a deeper understanding of these components and to broach other electronic devices for the 4th year training program (AST stream).

Name and description	Photo	Symbol
Fixed resistor A resistor has a fixed resistance (R) which is measured in ohms (Ω). A code made up of coloured strips indicates its value.		
Light emitting diode An LED can emit several colours and is polarised. The cathode (-) is usually indicated by the shorter electrode and by its meplat (flat side).		
Bipolar transistor There are many types of transistors. We will concentrate only on the bipolar transistor. This transistor is made up of 3 electrodes: the emitter (E), the base (B), and the collector (C). The position of each one varies depending upon which model is used. The number of the transistor is written on its side. There are 2 major types of bipolar transistors: PNP and NPN types.		
Piezoelectric buzzer (vibrator) The buzzer is made up of a crystal (quartz) which is distorted when alternating electrical current runs through it. The crystal is between the two metal electrodes which vibrate to generate sound. The buzzer is polarised. The anode (+) is usually indicated on top of the buzzer. If the buzzer has connecters, you must depend on the colour of the wires.	 	

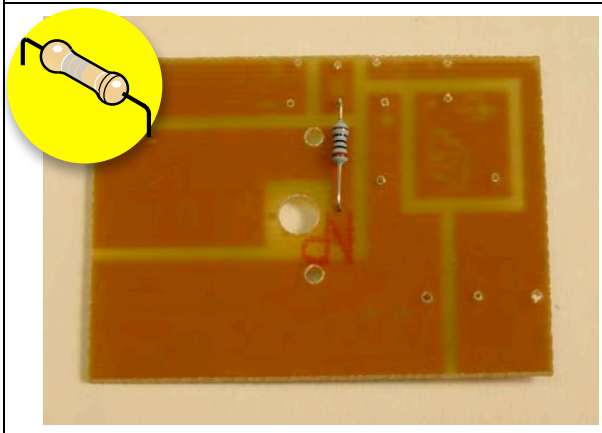
Before installing the components, it is preferable to drill the housing (see p.28)

COMPONENTS INSTALLATION PROCEDURE FOR THE HUMIDITY DETECTOR



If it has not already been done, check the state of conductivity of the circuit before installing the first component.

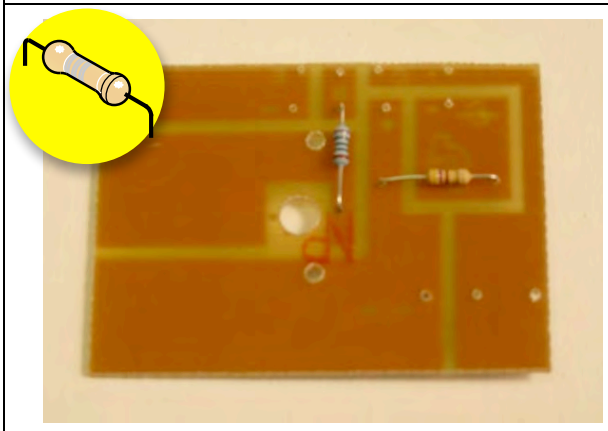
Pivot the circuit plate, tinned side towards the table (the CDP logo is facing the table).



On the insulated surface of the plate, find the location for the 100 ohm resistor (see photo at left).

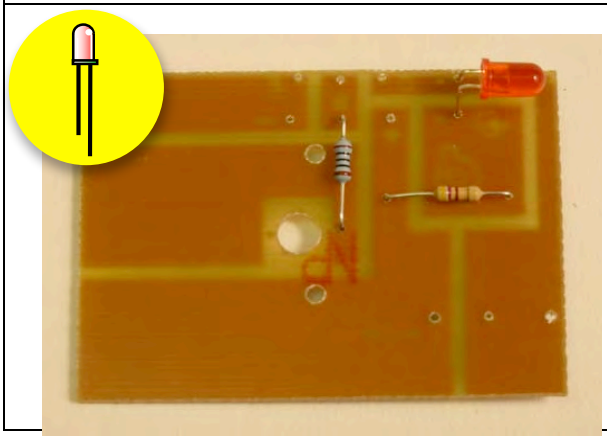
Solder the resistor.

R=100 Ω (brown, black, brown)



Position the 470 ohm resistor and solder it.

R=470 Ω (yellow, purple, brown)



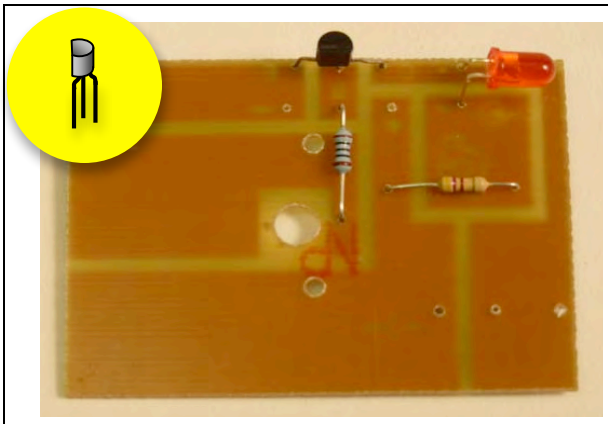
Fold the LED electrodes and position it on the plate. Solder it.

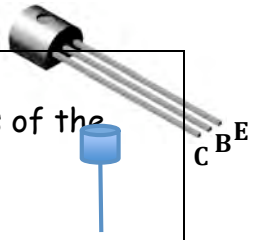
Watch the polarity.

The cathode (-) is usually shown by the shorter electrode and the meplat.

COMPONENTS INSTALLATION PROCEDURE FOR THE HUMIDITY DETECTOR

(continued)

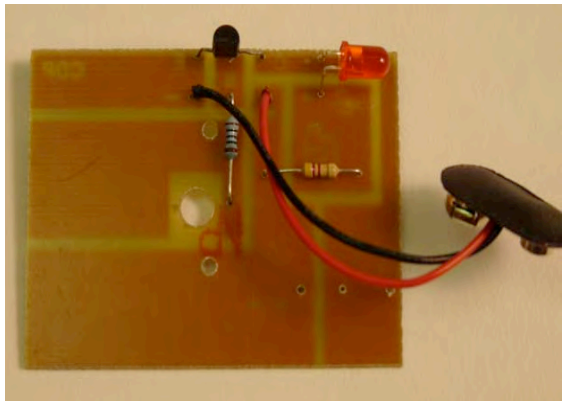




Fold the "outside" electrodes of the transistor horizontally.

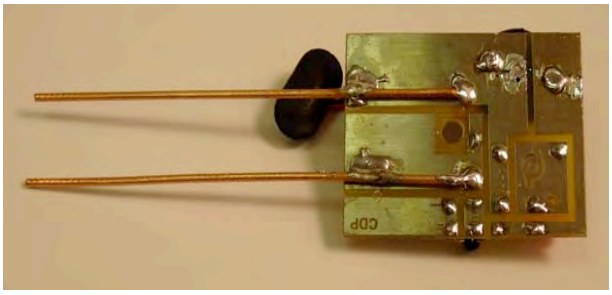
Solder the transistor.

Watch the polarity of the elements (collector, base and emitter).



Respecting the polarity, solder the 9V battery connector in the planned locations.

Before soldering the electrodes, you must be sure that they are straight. The preparation method for these is described on page 30.



Position the electrodes onto the tinned side. They must be parallel.

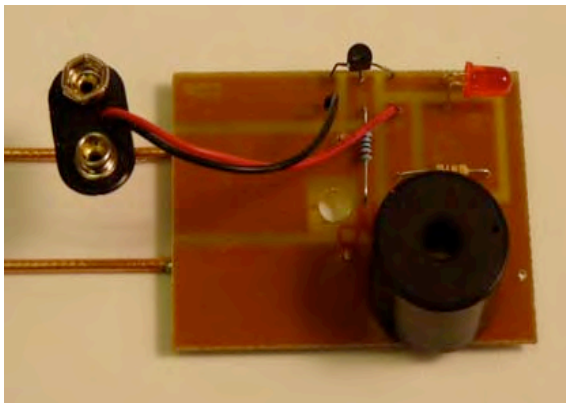
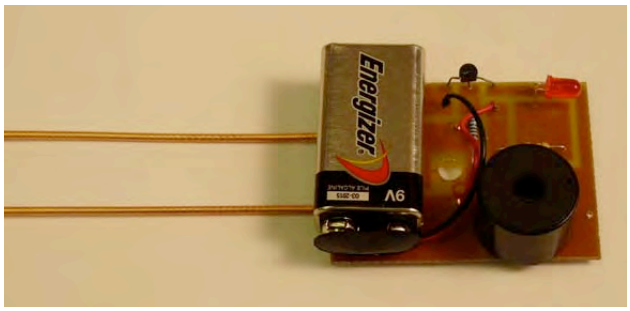
Solder the electrodes at the anchor points and at the extremities of the plate.

The solder must be carried out using a 200 watt iron and 0.062" diameter soldering wire.

Be sure that the solders hold the electrodes firmly in place.

COMPONENTS INSTALLATION PROCEDURE FOR THE HUMIDITY DETECTOR

(continued)

	Position and solder the piezoelectric buzzer in place. **Watch the polarity (it is indicated on the buzzer).**
	Connect the 9 volt battery.
After having connected the 9 volt battery, the circuit should be functional. To test it, you need simply place your fingers on the electrodes. The buzzer should sound and the LED light up. If this is not the case, consult the "Controlling the state of operation of the humidity detector" section.	

The procedure for drilling the holes for the electrodes can be found on page 29.

Controlling the state of operation of the humidity detector

Here is a process to guide you should your humidity detector fail to work. This process should help you to identify the anomalies. It is important that you follow the process in the order indicated, since the most common problems are at the beginning of the list.

Previous verifications

☑ **Verify the following points then tick the box once you have done so.**

☐ 1. If you did not check the state of conductivity of your plate before installing the components, you are not in an ideal position. A visual exam may still allow you to detect certain anomalies.

☐ 2. Check the state of the battery using a multi meter in tension mode. (≈ 9 V).

☐ 3. Visually check the state of all your solders (those on the plate and those on the external components connected with wires). If in doubt, solder again.

☐ 4. Check to see whether all the components that should be soldered onto the plate are indeed present by consulting the drawing of the humidity detector circuit.

☐ 5. Check the values of the capacitors by consulting the components installation procedure.

☐ 6. Check the direction of the transistor connection by consulting the drawing of the humidity detector circuit.

☐ 7. Check the polarity of the 9V battery connector.

☐ 8. Check the polarity of the LED.

☐ 9. Check the polarity of the piezoelectric buzzer.

PROCEDURE FOR MAKING THE PLASTIC HOUSING OF THE HUMIDITY DETECTOR

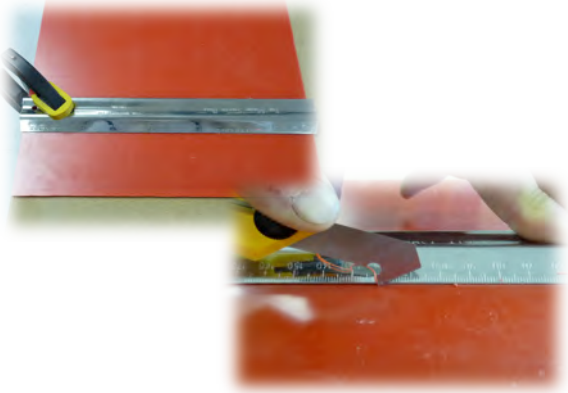
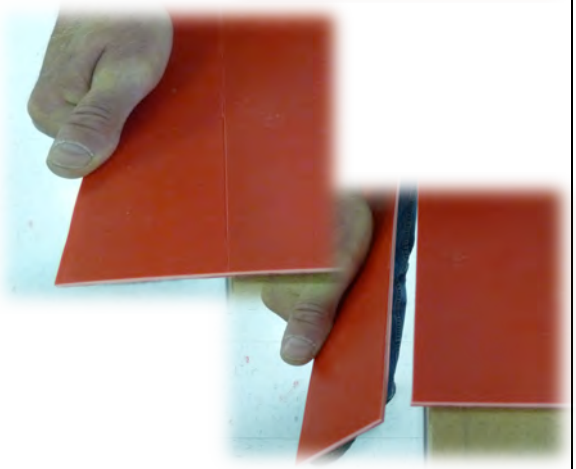
1	Ruler	5	Bar clamp
2	Safety ruler	6	Retractable blade knife
3	Combined square	7	Non-permanent marker
4	Plastics knife	8	Pencil

PREPARING THE PARTS (marking and cutting)

On the smooth side of the polystyrene, measure and mark the following dimensions:
98 mm X 65 mm.

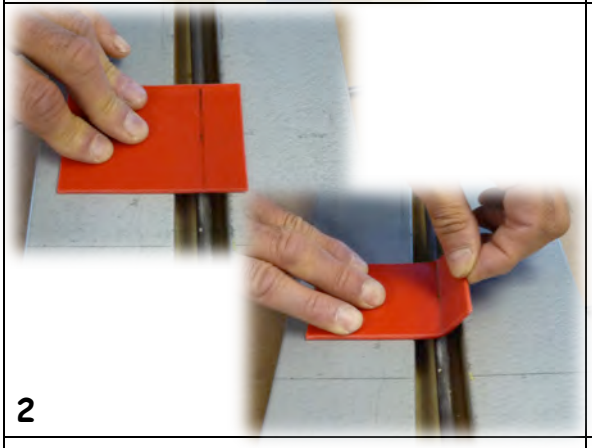
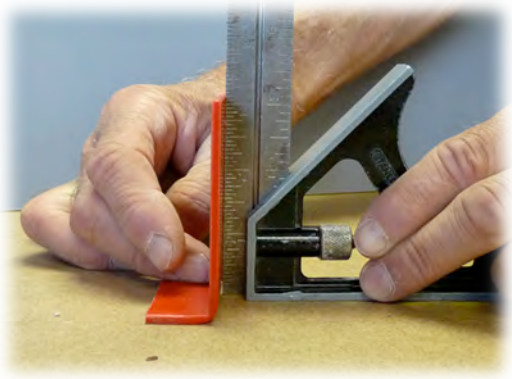
(See drawing N° 3 in the humidity detector technical file.)

PREPARING THE PARTS (marking and cutting) - continued

	Affix the safety ruler and the plastic part to be grooved to the worktable. Allow for the part to hang over the table so as not to damage the table with the plastics knife. Running the knife along the ruler, make a groove, then go over it several times to make the groove deeper.
	Place the plastic part on the worktable with the groove over the edge of the table. Hold the part. Apply firm pressure on the part overhanging the table to separate the two parts. If the resistance is too great, make the groove deeper. This will avoid the plastic breaking unevenly.
	Repeat the preceding operations to finish cutting the base of the housing.
	Using a metal ruler or a scraper, scrape the outer edges of the polystyrene part.

Repeat the same operations for the acrylic part (cover). Mark and measure the following dimensions: 120 mm X 57mm. (See drawing N° 4).
You will have to make more grooves, since the acrylic is denser.

PREPARING THE PARTS (folding the parts)

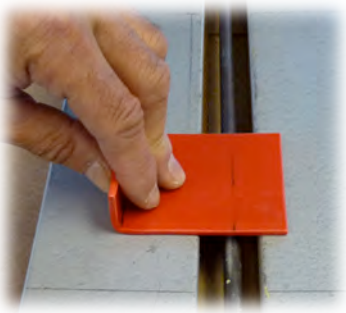
1 	Using the folding template, mark the first fold (the smooth side of the polystyrene must be inside the fold). The polystyrene part must be leaned all the way to the bottom of the template.
2 	Position the line marking the fold at the center of the linear heating element. Once the part is hot enough, fold it several times to weaken the material. This will make folding easier.
3 	Quickly place the polystyrene onto the template. Make the fold using small scraps of wood to apply pressure and hold them in place a few seconds. It is critical that the polystyrene is well aligned and leaned all the way to the bottom of the folding template.
4 	Validate that the fold is exactly 90° using the combined square.

PREPARING THE PARTS (folding the parts) - continued

5

Reposition the part on the template in such a way as to respect the first fold.

Mark the second fold and repeat operations #2, #3 and #4 for the housing's second fold.

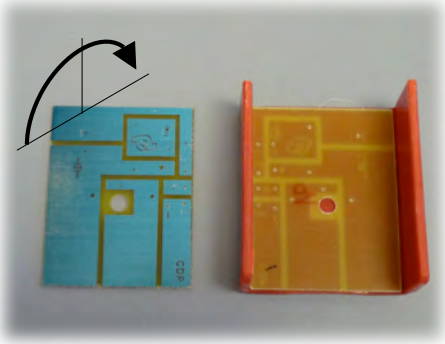
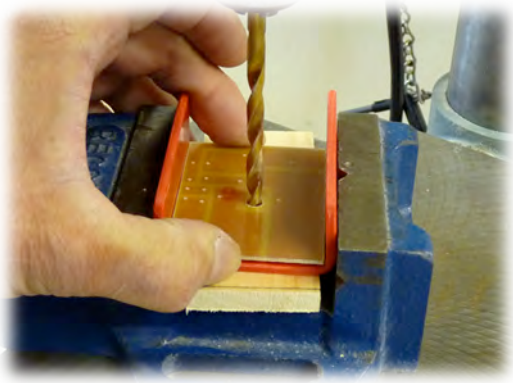
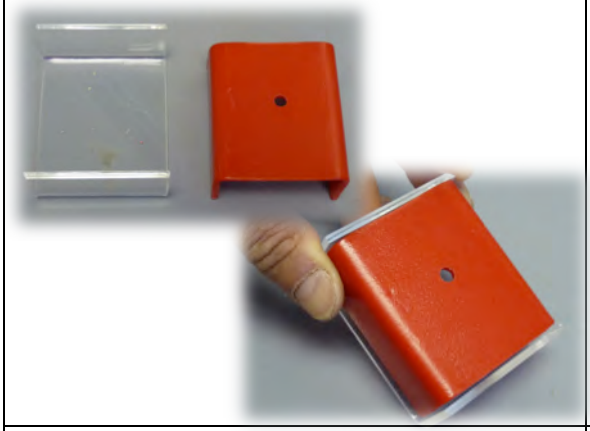
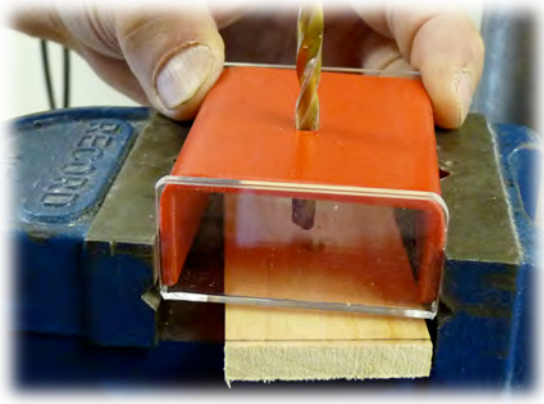


Sand the corners of the housing to round them out.

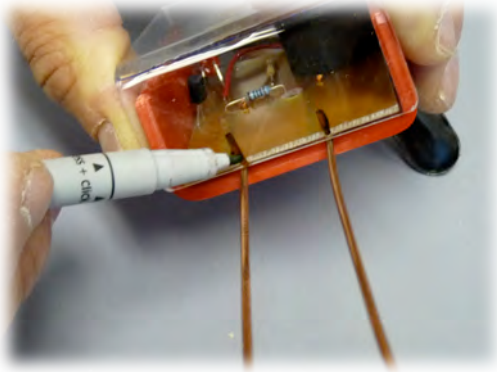
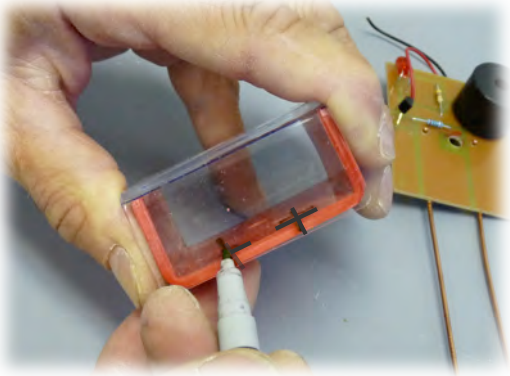
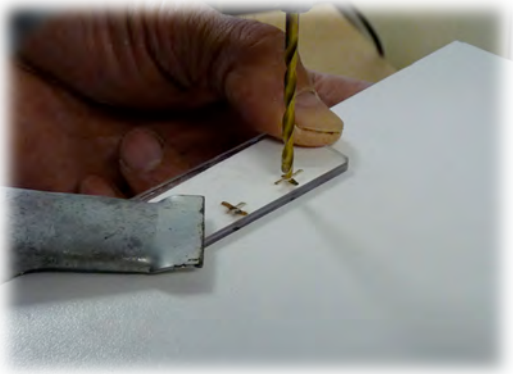
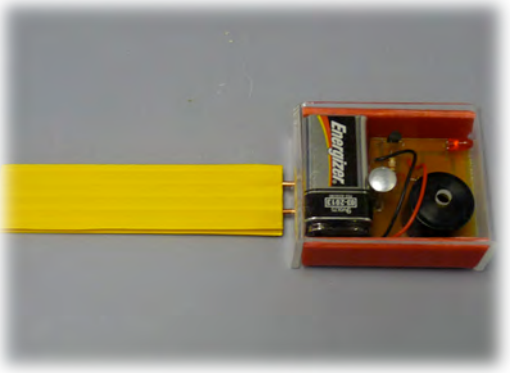
Repeat the same operations for the acrylic part (cover).

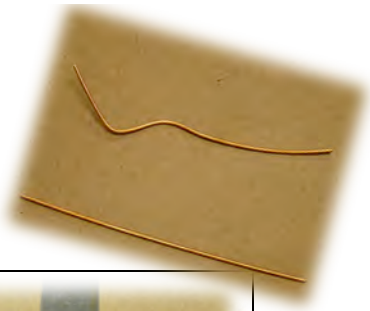
- **Use the acrylic folding template.**
- **Withdraw the protective film before marking and especially before heating on the linear heating element.**
- **Heat the acrylic longer, since it is denser than polystyrene.**

PREPARING THE PARTS (drilling the parts)

	Pivot the circuit plate so that the insulating layer is on top. Place it in the base of the housing.
	Affix the housing in a drill vise. Drill the housing using a 7/32 in. bit. The hole in the plate is used as a drilling template.
	Place the cover over the base. The drill hole in the housing base will serve as a bearing for drilling the cover.
	Affix the set in a drill vise. Drill using a 7/32 in. bit. **Careful! Drill the acrylic slowly, since it is brittle and splits easily.**

PREPARING THE PARTS (drilling the parts) - continued

	Place the printed circuit plate in the housing base (insulated side up). Put the cover on. It is critical to **align the drill holes of the three elements.** Mark the position of the electrodes using a non-permanent marker.
	Remove the plate and replace the cover on the housing. Mark the thickness of the base. The join of the two lines marks the location to drill for the electrodes.
	Using a clamp, affix the cover to a martyr. Drill the two holes using a 1/8 in. bit.
	Assemble the three parts (base, plate with components and cover). Affix using the Chicago screw. Cut a 4 cell section out of Coroplast. This section will protect the electrodes when the detector is being transported.

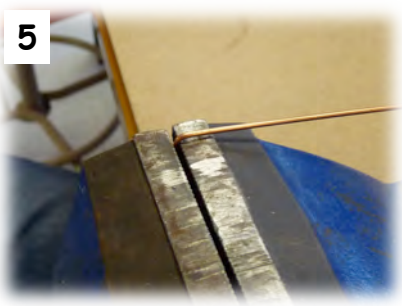


PREPARING THE PARTS (electrodes)

1- Insert the electrode into the vise. Tighten the vise onto it.

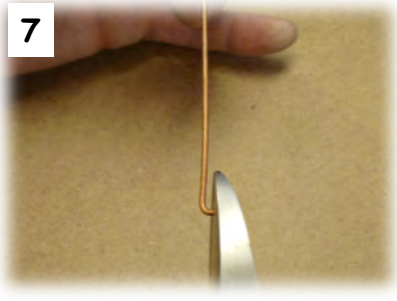
2- Loosen, turn the electrode and re-tighten the vise.

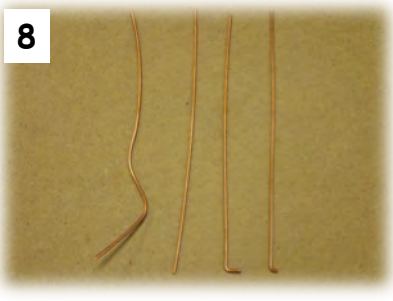
3- Loosen, move the electrode and start again until the electrode is perfectly straight.



4- Place 5 mm of the electrode into the vise.

5- Fold it to get a 90° folding angle.





6- Use a hammer to get a perfect fold.

7- Cut the elbow of the electrode so that it measures about 3 mm.

8- What the electrode will look like, (step by step).