

# Arc Furnace User Manual

## Arc Furnace Safety

Before you can use the arc furnaces you must be trained by a qualified member of staff and ensured you have completed the risk assessment for the arc furnace. The risk assessment for all the equipment can be found at the following address:

[http://www2.warwick.ac.uk/fac/sci/hysics/research/condensedmatt/supermag/group\\_and\\_user\\_facilities/health\\_and\\_safety/](http://www2.warwick.ac.uk/fac/sci/hysics/research/condensedmatt/supermag/group_and_user_facilities/health_and_safety/)

Below outlines the main safety considerations when using the arc furnace.

- The arc furnace uses an arc of electricity to melt the sample. The arc produces a high level of UV light, which can cause damage to the eyes. **DO NOT LOOK AT THE ARC.** To prevent exposure to yourself there is a welding shield which has to be placed in front of the furnace. To prevent exposure to those around you there is a curtain around the surrounding area which needs to be closed before beginning.
- As with any furnace there will be a hot surface, which can cause serious burns. When melting use the heat resistant gloves, removed watch, jewellery and allow sufficient time to cool before removing your sample.
- To produce an arc a high voltage is needed. Do not touch any exposed wires and ensure the power is turned off before handling the arc furnace.
- The arc furnace uses a pump to create a vacuum in the sample chamber. This puts a lot of pressure on the quartz window. Before starting, just check the window to ensure there are no cracks that could cause the quartz window to break when the pump is turned on.

If at any time, you are unsure about using the arc furnace or the condition the arc furnace is in, do not use it and find a qualified staff member.

# Tri-arc Argon Arc Furnace

## Arc Furnace Components

Fig. 1(a) shows the arc furnace. The long silver rod (with the red end) is the vacuum attachment to the arc furnace. Fig. 1(b) shows the electrode, this strikes the arc. The tip is made of tungsten. Fig. 1(c) shows the reaction chamber, both the top and the bottom are water cooled.

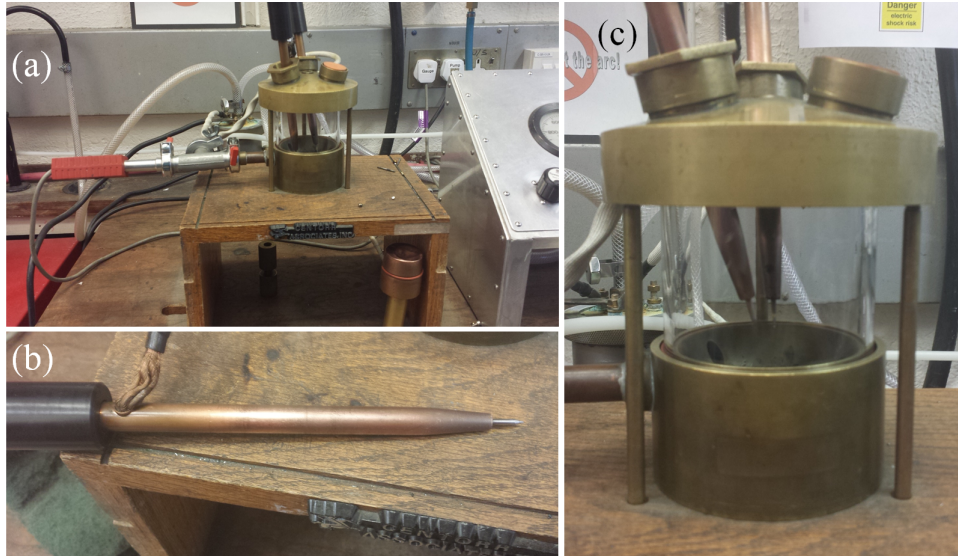


Figure 1: Different parts of the arc furnace. (a) The entire arc furnace, (b) The electrode and (c) The reaction chamber.

Fig. 2 shows the Copper crucibles used to strike the arc and melt the sample in. The two on the left are used for making rods, while the two on the right are used for making “lumps” of you compound.

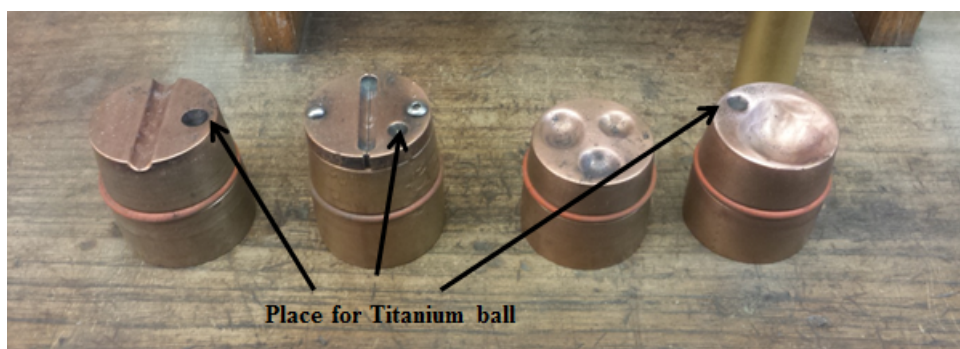


Figure 2: Different types of Copper crucible used in the arc furnace.

Fig. 3(a) shows the panel that controls the the vacuum pump and the argon flow into the chamber. Fig. 3(b) shows a zoomed in view of the pressure gauge. This is connected to both arc furnaces, so to ensure the correct vacuum is being measurement set it to “head 1”

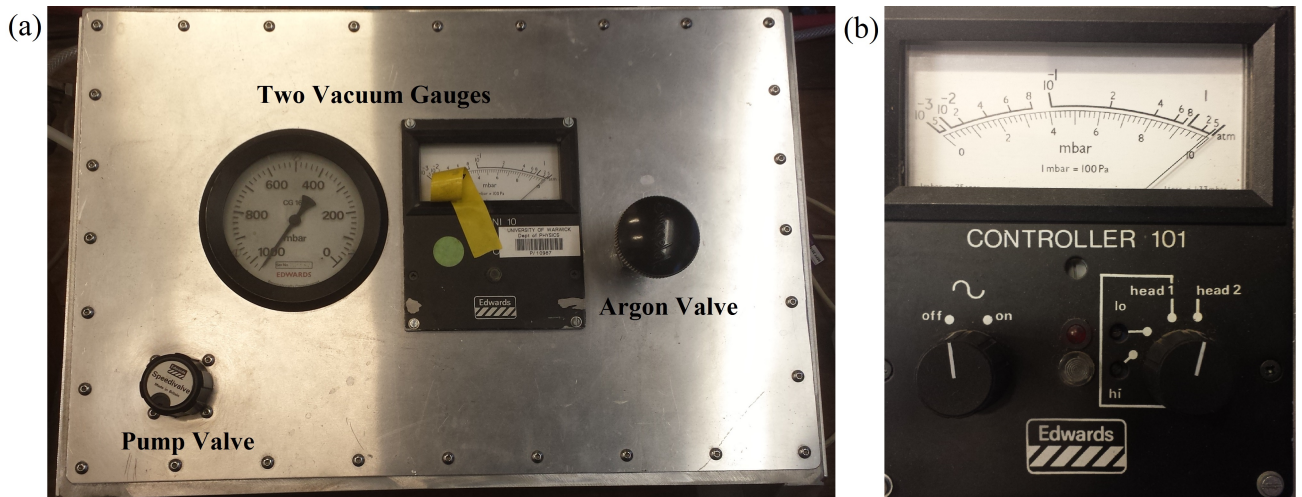


Figure 3: The control panel which controls the vacuum pump and argon flow.

## Using the Arc Furnace

**Step 1:** Clean the arc furnace (See Section below).

**Step 2:** The welding power supply is connected to both arc furnaces, so a switch is used to choose which arc furnace is supplied with power (fig. 4). To power the tri-arc arc furnace the lever has to be on the right (as indicated in the figure). To switch between the two loosen the screw, slide the lever to the correct side and tighten the appropriate screw.

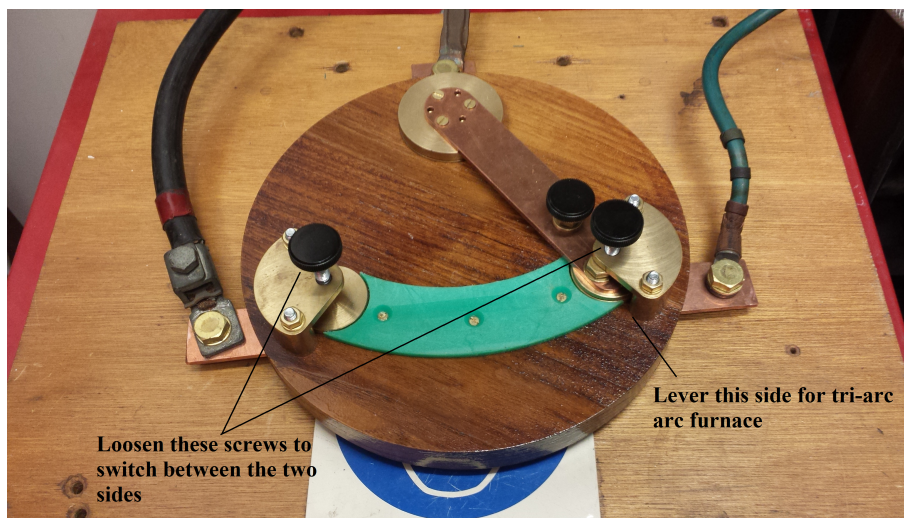


Figure 4: lever to determine which arc furnace is supplied with power (Left for single arc arc furnace and right for tri-arc arc furnace).

**Step 3:** Place the elements/ compounds you want to melt into the copper crucible (Fig. 2). The copper crucible on the far right is the one most frequently used. Place a clean titanium ball in the small pit.

**Step 4:** Turn the pump and gauge on at the wall.

**Step 5:** Attach the copper crucible to the brass support and place the copper crucible into the chamber and open the pump valve (Rotate dial anti-clockwise).

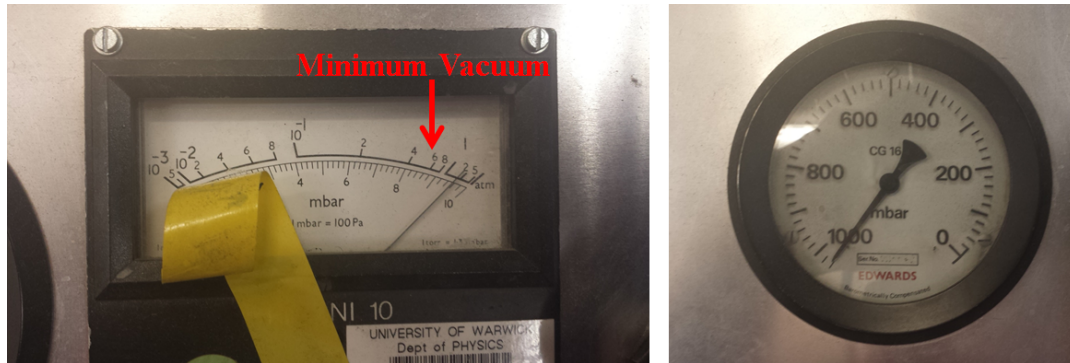


Figure 5: The two vacuum gauges.

**Step 6:** Check the butterfly nuts are still finger tight and place support under the copper crucible to ensure it does not fall out. You will now have to wait for a good vacuum. Fig. 5 shows the minimum value you should aim for (using top scale). Pump for about 3-5 minutes to make sure you have a reasonable vacuum as well.

**Step 7:** You need to flush the chamber with argon at least three times. To do this turn the Argon valve anti-clockwise, once the circular gauge reaches 1000 mbar, you will hear a slight pop. Close the Argon valve and then open the pump valve. Repeat this, except on the third time leave the Argon valve slightly on.

**Step 8:** Place the shield in front of the arc furnace (Fig 6(a)).

**Step 9:** Put the heat resistant gloves on (Fig 6(b)). You now have to turn the water on using the tap (Fig. 6(c)). Behind the arc furnace is a small plastic case with a red ball in it (Fig 6(d)). This is used to gauge the water flow. Ensure the red ball is going around before proceeding at a reasonable rate, 1 click per second is normally fine.

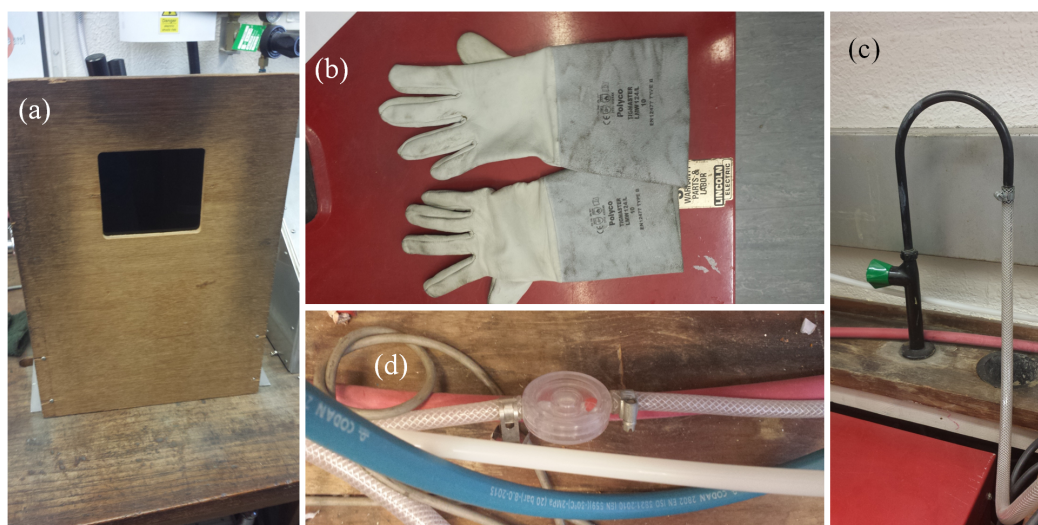


Figure 6: (a) UV shield placed in front of arc furnace. (b) Heat resistance gloves. (c) Tapes used to turn the water on and (d) gauge of the water flow.

**Step 10:** Everything is now ready to begin melting the sample. First of all turn the power on at the wall (Fig. 7(a)). Check the control output is set to 0 and then press the green button to turn on the welding power source when you are ready to begin (Fig. 7(b)).

**Step 11:** To strike an arc turn the output control to 7/8 (Fig. 7(b)). Push the electrode against the copper crucible and pull away slowly to ensure you do not lose the arc. Move the arc over the titanium ball and melt the titanium first. This is to ensure there is no oxygen in the chamber. Once the arc “jumps” onto the titanium ball, turn the output control down. This ensures the arc does not vaporise the titanium.

**Step 12:** Turn the power off by setting the control output to 1 and pressing the red button. Perform a visual check of the titanium ball, if it is clean and shiny, turn everything back on and melt the elements, if it is discoloured flush the chamber with argon again and attempt to melt the titanium again.



Figure 7: (a) Power source for the welding unit and (b) control panel for the welding unit.

**Step 13:** Melt the elements together in the same way the titanium ball was melted. Once finished, turn the power off. Close the argon valve and wait for the crucible to cool down. Once cool take everything out and clean the copper crucible. After melting a few times you will have to clean the entire arc furnace.

## Cleaning the Arc Furnace

You should clean the copper crucible after each melt, however cleaning the entire arc furnace can be done less frequently depending on what you are melting. For example melting borides will require more frequent cleaning compared to other compounds, but as a rule of thumb you normally clean the arc furnace after 6-10 melts.

**Step 1:** Ensure everything is turned off.

**Step 2:** Take apart the arc furnace. Start by unscrewing the butterfly nuts, these are located underneath the chamber.

**Step 3:** Take the top off, hold the quartz window and lift off (Fig. 8). Be very careful not to knock the quartz window. Place the window to the side in a safe place.

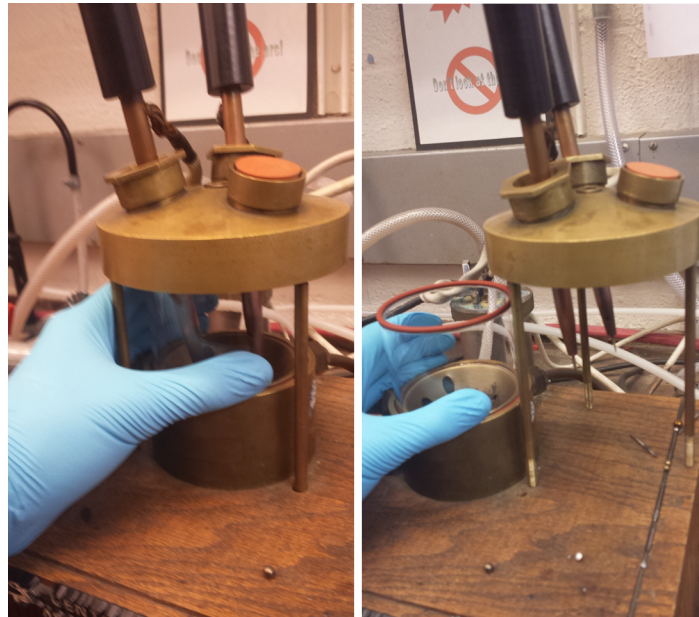


Figure 8: Removing the top from the arc furnace.

**Step 4:** Clean everything (except the window) by scrubbing it with scotch blight (Fig. 9(a)). Spray a bit of solvent (Ethanol/Methanol) into a tissue (Fig. 9(b)) and use it to clean the surface (Fig. 9(c)).

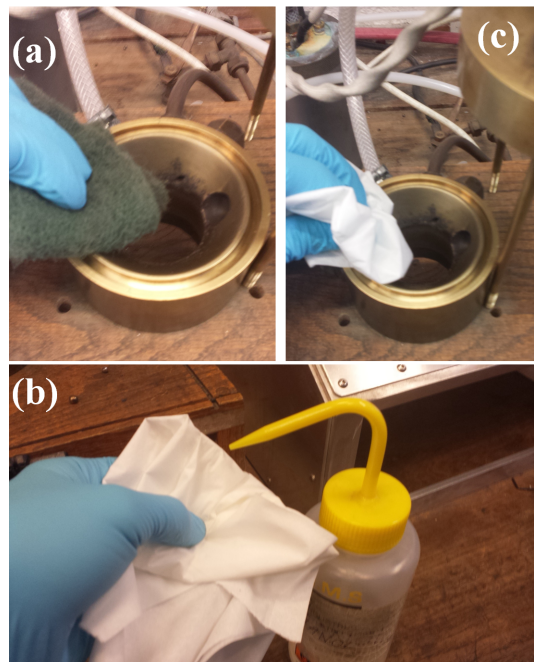


Figure 9: Cleaning the arc Furnace.

**Step 5:** Clean the quartz window by spraying the tissue with solvent and wiping it.

**Step 6:** Put everything back together, take care again when putting the top back on to the quartz window.

# Mono-arc Argon Arc Furnace

## Arc Furnace Components

The mono-arc arc furnace and the labelled components is shown in Fig. 10. It works in essentially the same way to the tri-arc arc furnace, but with some slight differences, which will be explained later.

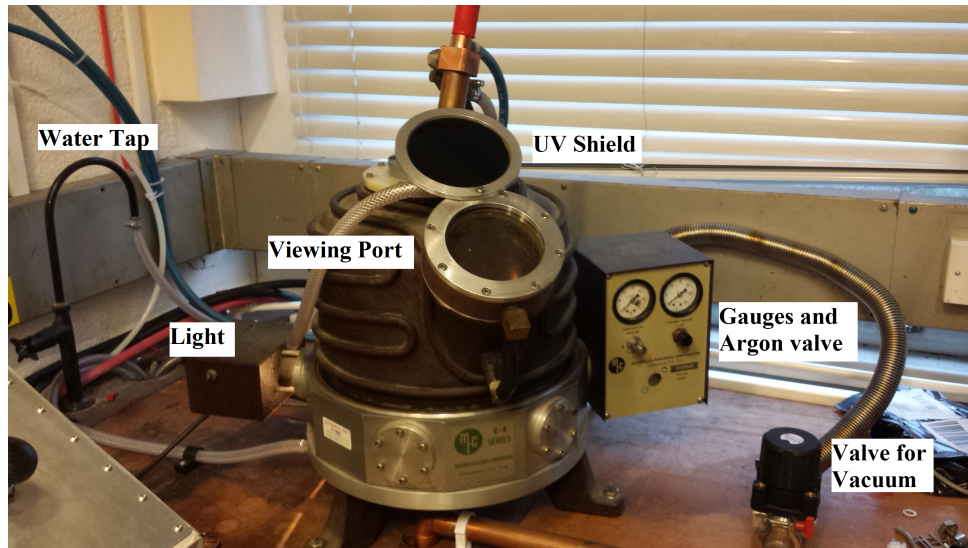


Figure 10: The mono-arc argon arc furnace with its various components labelled.

Fig. 11 shows the interior of the arc furnace. It consists of a copper hearth, with slots for the elements/ compounds that need to be melted. Unlike the tri-arc arc furnace, you do not strike the arc against the copper to produce the arc, this will damage the hearth. Instead there is a bit of tungsten attached the hearth which is used for striking the arc.



Figure 11: Interior of the arc furnace

## Using the Arc Furnace

**Step 1:** Clean the arc furnace (see below).

**Step 2:** The welding power supply is connected to both arc furnaces, so a lever is used to choose which arc furnace is supplied with power (Fig. 12). To power the mono-arc arc furnace the lever has to be on the left (as indicated in the figure).

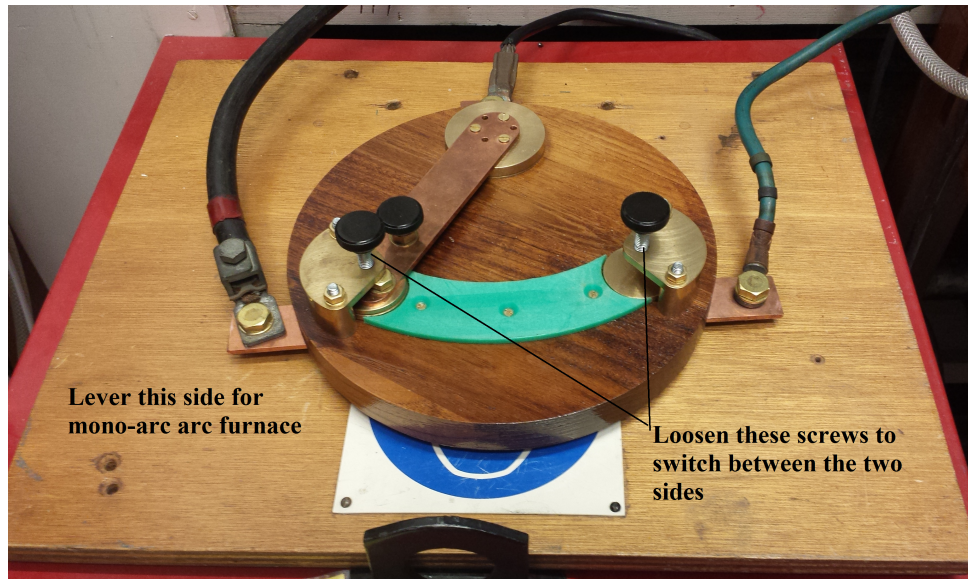


Figure 12: Position of the lever when the mono-arc argon arc furnace needs to be used.

**Step 3:** Place the elements/ compounds you want to melt into the dips in the copper hearth. Place a clean titanium ball in the pit closest to the tungsten used for striking the arc.

**Step 4:** Turn the pump and gauge on at the wall.

**Step 5:** Close the arc furnace and open the vacuum valve slowly by rotating it anti-clockwise (Fig. 13(a)). The chamber is very large so leaving arc furnace pumping for 10-15 minutes may be worth while. You can also check the pressure on the other control panel by changing the dial to "head 2".

**Step 6:** Once the chamber is pumped out, it needs to be flushed out with argon. This is done by pressing the black button labelled "Fill". You do not want to fill the chamber completely, fill it until the chamber vacuum is at 15 on the scale (Fig. 13(b)).

**Step 7:** Pump the chamber out again by opening the vacuum valve slowly and waiting until the chamber vacuum is at 30, close the valve and fill with argon until the scale reads 15. Do this once more.



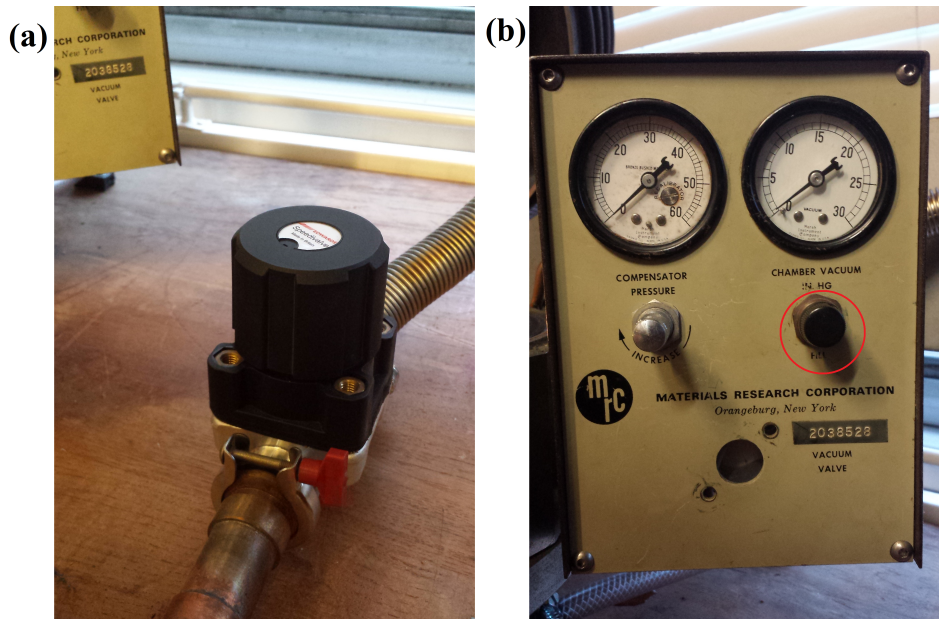


Figure 13: (a) Shows the valve used for pumping the chamber of the arc furnace out. (b) Shows the control used to fill the arc furnace chamber with argon.

**Step 8:** Turn on the light and use the view port to adjust the position of the electrode. It should be placed so that you can strike it against the tungsten.

**Step 9:** Place the UV shield over the viewing port (Fig. 14(a)).

**Step 10:** Turn the water on at the tap (Fig. 14(b)).

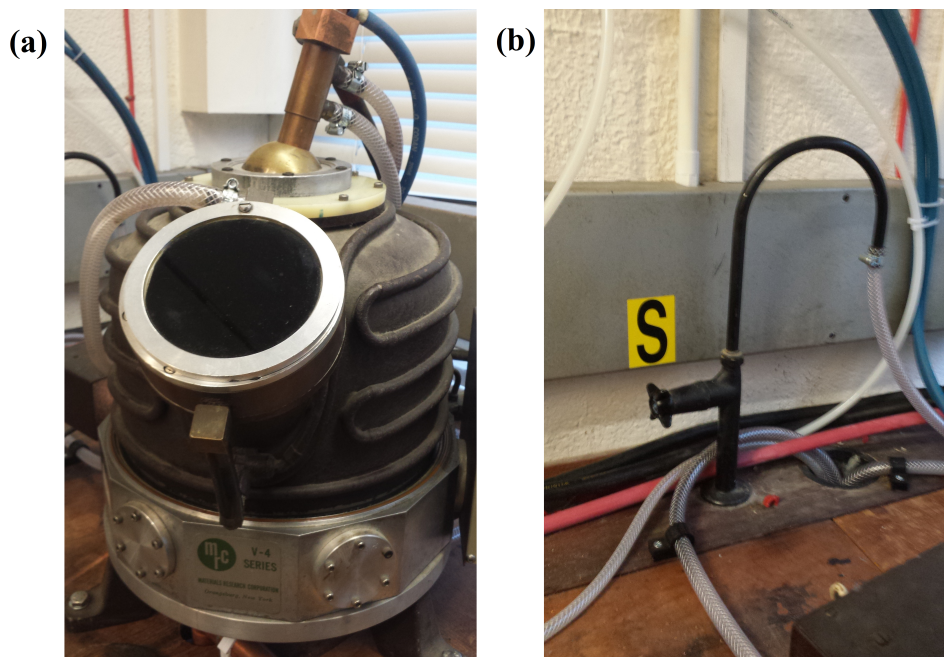


Figure 14: (a) UV shield in place, (b) water tap used for cooling the mono-arc arc furnace.

**Step 11:** Everything is ready to begin melting the sample. First of all turn the power on at the wall (Fig. 7(a)). Check the control output is set to 1 and then press the green button on the

welding power source when you are ready to begin (Fig. 7(b)).

**Step 12:** To strike an arc turn the output control to 7/8. Push the electrode against the tungsten piece and pull away slowly to ensure you do not lose the arc. Move the arc over the titanium ball and melt the titanium first. This ensures there is no oxygen in the chamber.

**Step 13:** Turn the power off by setting the control output to 1 and pressing the red button. Perform a visual check of the titanium ball through the view port. If it is clean and shiny, turn everything back on and melt the elements, if it is discoloured try and flush the chamber with argon again and attempt to melt the titanium again.

**Step 14:** Melt the elements together in the same way the titanium ball was melted. Once finished, turn the power off. Wait for the arc furnace to cool down. Once everything is cool fill the chamber with argon so that it reads 0 on the scale and then take your sample out.

## **Cleaning the Arc Furnace**

**Step 1:** Ensure everything is turned off.

**Step 2:** Open the arc furnace.

**Step 3:** Clean copper hearth by scrubbing it with scotch blight. Spray a bit of solvent (Ethanol/ Methanol) into a tissue and use it to clean the surface of the hearth.