**Introduction to Casting**

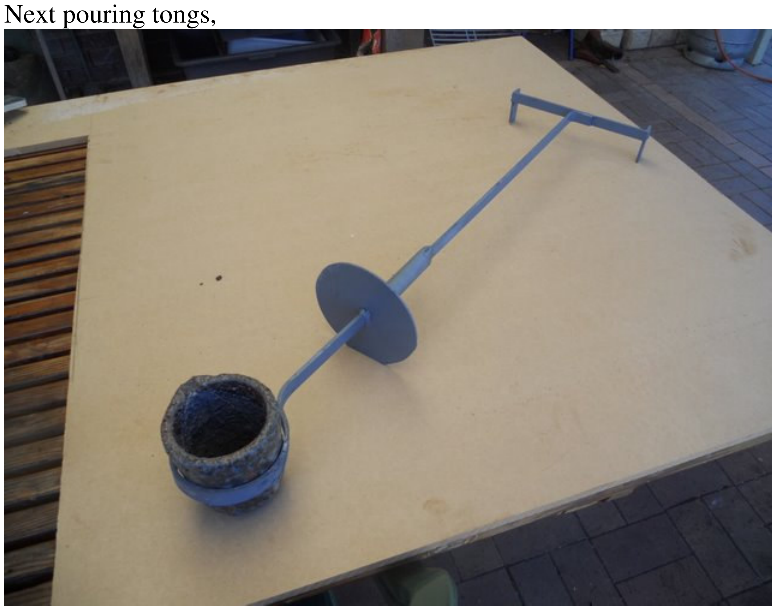
This is a summary of the tools needed for casting.    (all 5 threads combined into one pdf)

**Crucible Handling**

Starting with some basic tools that you will need for crucible handling

Lifting Tongs, are used to lift the crucible out of the furnace and place it in the pouring holder.

Next pouring tongs,



These tongs are for smaller crucibles, note the thing sits flat on the ground, and the legs on the far end stabilize it. The radiation shield has a flat on the bottom so the crucible can sit nice and stably.
When pouring, one hand is just behind the radiation shield, and the other operates the cross bar to control the pour.

Same as the smaller one, this time it's a bigger crucible and a bit more support, the little locking pin (made from titanium) is to allow you to turn the crucible upside down if needed.
Also the radiation shield is closer to the crucible, which is better for handling the heavier pours.

Charging tongs, these are used to add additional stuff to the crucible.


Skimmer, this is used to skim the slag from the surface before pouring, I have another that I'm going to use on cast iron, that has a small titanium plate for the skimming section, the last one (stainless steel) melted into a nice little blob when skimming cast iron.

I don't have dimensions on any of the above, if anyone is really interested I could make a few measurements, but since the critical dimensions are determined by the crucibles used, I'd suggest just make them to suit whatever crucibles you have.

One thing I would recommend, is that you try using the tools while wearing foundry gloves, before finalizing the designs. What feels comfortable with bare hands, can become unusable when wearing bulky gloves.

The procedure, is first to clear the area of trip and fall hazards, tie up the dog, lock the kids inside, set a safe boundary for any spectators, then do a few rehearsals of the entire process, while wearing all the safety gear, then and only then start up the furnace.

Next Installment, burners..

**Burners**

Here are three LPG burners, the first two are normally aspirated, the last one (most recent) is forced air.

The design is pretty simple, you have a LPG cylinder with an adjustable regulator, the one I use is a standard CIG (BOC) 0-400kpa, mostly I run in the range 0-150 kPa...

A gas jet, which can be as simple as a brass tube with a small hole pointing down the pipe, I've used gas tips so I can play with nozzle sizes, TWECO 14, I think from memory.

The next thing is a means of adjusting the mixture, this is just a series of slots that are covered with a sliding tube.

If you are running the burner in free air, then you need a flare on the end to reduce the gas velocity to less than the flame velocity, otherwise it will blow itself out, once the burner is inside the furnace, that problem goes away. A temporary flare of sheet metal is easy enough to make anyway.

Ok that's the basics.

This is the first one, normally aspirated, gas jet directed straight down the pipe, and sliding mixture adjustment.

The extra sliding section, was an experiment to see if the position of the gas jet relative to the air inlet section ending made any difference.. as a burner it worked fine, but struggled with larger bronze pours, so onto the second generation..

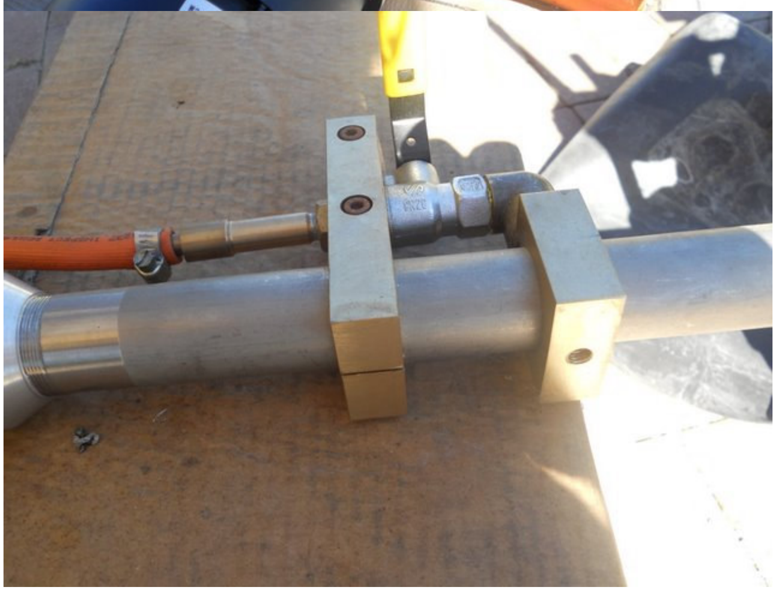
This one has a flared section for the air inlet, and the gas entry point is where we expect the air velocity to be the highest, just at the end of the flare (remember bernouilli)

This is the best normally aspirated burner yet, we can melt 1 kilo of bronze in 7 minutes. The secret is more air and more gas. Unfortunately we couldn't get to cast iron temperatures, for that we need... more air more gas... so the next one is forced air.

Initially we used a vacuum cleaner (make sure you connect to the correct outlet), and ran that off a variac, it worked fine, but was very noisy, and way too big for the job. We melted zirconia fibre blanket with that cranked up, so I got a spa air blower, the kind that you use to put bubbles in your hot tub... (my hot tub goes to 1400C ) Big plus was that it's completely silent. and small.

Going to forced air, meant that I had to bring the gas in from the side, not ideal, but, I thought a quick shut-off valve would be a handy addition, so it quickly got over-engineered.


AIR BLOWER
MOTOR MUST BE GROUNDED!




The other upgrade for this burner, was to get some titanium tubing, going to cast iron temperatures was a problem with the steel tubing on the previous burners. So it ended up over-engineered and you could make the same thing much simpler.  The blower speed is still controlled by a variac and the fuel/air ratio is a combination of gas pressure and blower speed.

This is a picture of one of the earlier normally aspirated burners, being tested, note the flare.

The burner tuning is done by observing the flame colour as you adjust the mixture.
A rich mixture has a green tinge to it.
A neutral mixture is a nice clean blue long cone.
A lean mixture is a blue with short cone and reddish tinge.

## Furnace

Before starting on the furnace construction, it might be worthwhile to re-visit some temperatures.

Pure elements melt at higher temperatures than they do when alloyed with other elements, so pure copper melts at a higher temperature than brass or bronze.. Pure Iron melts at a higher temperature than cast iron, and so on..

Here are a few Melting Points for common alloys.

| Element/Alloy | | Melting Point | | | Pouring Temp | |
|---|---|---|---|---|---|---|
| | | DegreesC | DegreesF | | DegreesC | DegreesF |
| Solder | | 200 | 392 | | | |
| Tin | | 232 | 450 | | 260 | 500 |
| Lead | | 327 | 621 | | 370 | 698 |
| Zinc | | 419 | 786 | | 455 | 851 |
| **Aluminium Alloy** | | **640** | **1184** | | **730** | **1346** |
| Aluminium | | 659 | 1218 | | 749 | 1380 |
| Magnesium | | 670 | 1238 | | | |
| Brass | | 920 | 1688 | | 1070 | 1958 |
| Silver | | 961 | 1762 | | | |
| **Bronze** | | **1000** | **1832** | | **1160** | **2120** |
| Gold | | 1063 | 1945 | | | |
| Copper | | 1083 | 1981 | | 1200 | 2192 |
| **Cast Iron** | | **1260** | **2300** | | **1350** | **2462** |
| Manganese | | 1260 | 2300 | | | |
| High Carbon Steel | | 1353 | 2467 | | | |
| Stainless | | 1363 | 2485 | | | |
| Medium Carbon Steel | | 1427 | 2601 | | | |
| Low Carbon Steel | | 1464 | 2667 | | | |
| Iron | | 1538 | 2800 | | 1605 | 2921 |
| Chromium | | 1615 | 2939 | | | |
| Titanium | | 1795 | 3263 | | | |
| Tungsten | | 3000 | 5432 | | | |
| | | | | | | |
| PyroCrete | 165 | 1649 | 3000 | | | |

Just melting the raw material isn't quite what we want to do, we need to go above the melting point to a temperature that pours and cast nicely, the above pouring temperatures are just a guide, and sometimes trial and error is needed to get the flow through the pattern to work.. this is the "black magic" part of pattern making.

The way you choose to construct the furnace is going to be determined by the maximum temperatures. Let's say we are going to do cast iron. That means we will be running at 1300-1400 degrees C and probably sometimes even a bit higher.

Ok, let's start.. forget any of those designs you've seen on the internet that use heavy castable refractory, this is a design that uses light weight zircon(ceramic) fibre blanket, the result is a lightweight highly efficient foundry that heats up quicker and to higher temperatures. For home foundry use it's more than durable enough to last for a few years.

Begin with the biggest crucible you are going to use.. and add 2-3 inches to the radius, that gives a rough internal diameter, now we have layers of zircon fibre blanket insulation, Let's use 1400C rated ISOWOOL CB25H or CB50H at least 3 layers (the standard rolls are 25x600x7200 or 50x600x3600)

That gives a rough guide to the overall diameter of the furnace, and the outer shell can be sheet metal. If you can find a suitable steel shell, a drum or whatever, in my case I used a scrap water pressure tank.

Next we need a base and a lid.

The lid can be a lift off style, or a lift and rotate style. There are lots' of options, but there are a few things to remember, the inside of the lid is going to be at casting temperatures when you lift it, so make sure that it opens away from gas lines and anything flammable.

Here's my (over-engineered as usual) lift and rotate mechanism.

It has an overcenter locking action, so that once you raise the lid, it stays there.
And you just rotate clockwise (away from the burner side).

The internal construction, I used was one I wouldn't recommend, I used a lining of Pyrocrete 165, which I don't think is needed if you use a good layer of ceramic blanket.


It's good stuff, rated to 1649 C, but I really don't think it's needed.

Here is the inside of the furnace with the ceramic fibre blanket removed.

Note the drain hole in the bottom, this is to cater for a broken crucible, rather than end up with a solid block of molten metal in the
bottom of the furnace, it can run out on the bottom.

In use the hole is covered by a plinth, cast from Pyrocrete 165, that the crucible sits on. It's a good idea to put a piece of cardboard under
the crucible to stop it from sticking to the plinth. I have had crucibles stick to the plinth and usually, you have to break the pyrocrete to get
the crucible loose.

The inside of the lid is lined with pyrocrete and ceramic fibre blanket, the ceramic fibre blanket is retained by titanium wire, I used to use stainless steel tig welding wire, but that eventually melted during a cast iron pour... this picture shows the melted stainless steel wires.

I didn't have a picture of the current setup with the titanium wires, so this is the best I could get

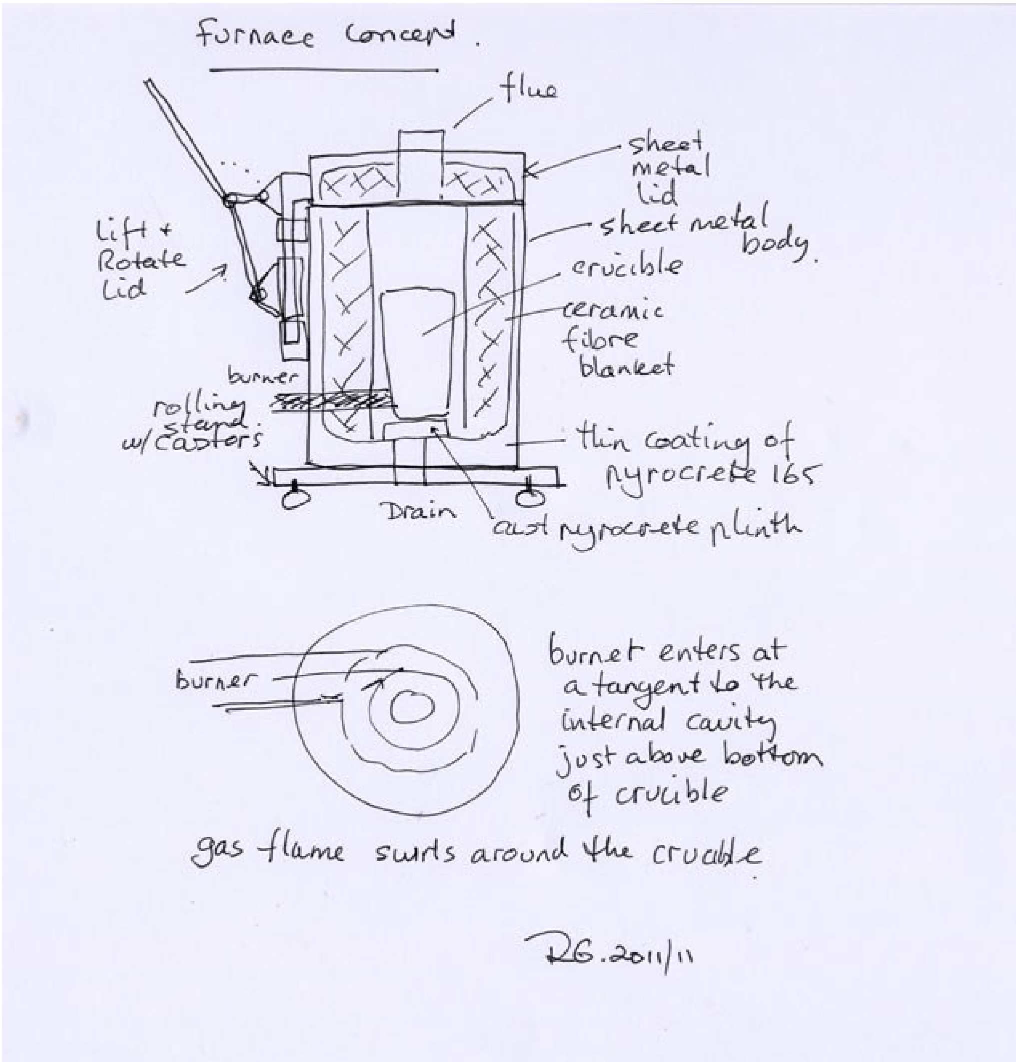
The ceramic fibre blanket sits up a little, so that it forms a seal of sorts when it is closed

The ceramic fibre blanket is dangerous stuff, you need to wear a face mask to stop breathing the fibres, and it need to be sealed to stop any loose fibres floating around, the
sealer I used was ITC-100, which is a brush-on IR reflective furnace lining compound, it's water based, and it's a bit like brushing on a layer of mud...

That's the current setup, I'll draw some sketches of what changes I would make if I was to build another. (that can be a new post)
Continuing on from previous post, which describes the current furnace construction, this is how I would

approach furnace construction, if I was to make another.

Apologies for the poor quality drawing, the concept is the important thing.




As previously, the zirconia blanket fibres are dangerous, and need to be sealed, with ITC-100 which is an IR reflective coating.

One thing, that's a possibility, is to replace the pyrocrete base and plinth, with lightweight insulating bricks that can be easily shaped, the LBK28 isolite bricks would be ideal I think.

Material Suppliers.

I've listed these before many times, but it doesn't hurt to re-list them here.

**Ceramic Fibre Blanket**

**IsoWool & Isolite Bricks**
Refractory & Ceramic - (03) 9560 4477
50 Geddes St, Mulgrave Vic 3170, Australia
**Ph:** +61 3 9560 4477

**Cerachem**
Thermal Ceramics
Factory 3-4 111-113 William Angliss Drive
Laverton North 3026
03 9360 0355

**Pyrocrete 165**
Foseco
19-21 Nicole Way
Dandenong 3175
03 9792 4033

**ITC-100** High Temperature reflective coating $80 per pint
ITC-200 High Temperature ceramic repair $80 per pint

Pinches Alloys
21 Malua Street
Reservoir 3073
03 9460 2466

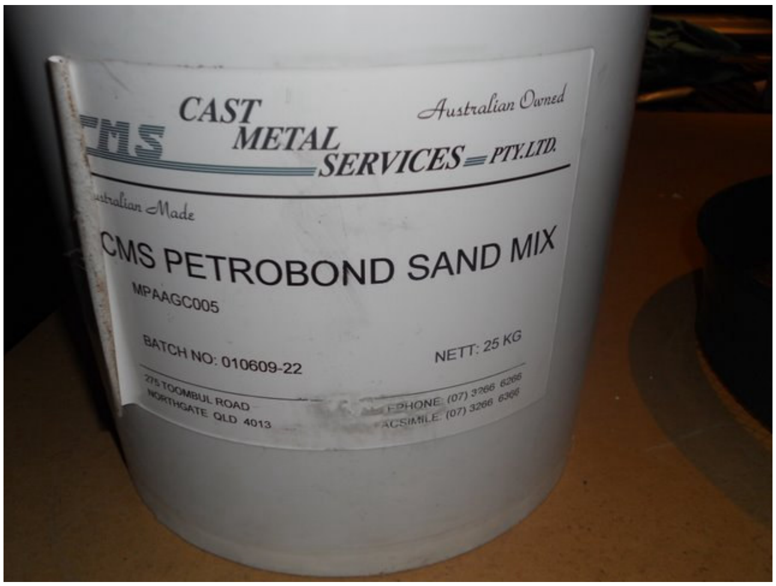
If you find other suppliers, feel free to list them here..

Next Installment, cope and drag

**Cope and Drag**

Just a quick overview of some of the tools used to prepare sand molds for casting, I'll leave patterns and cores for next time, these are just the tools used to do the preparation for the pour.

First, I recommend petrobond for home hobby casting, it's an oil bonded sand, rather than "green sand" which is a water bonded sand. It's re-usable many times, and a bucket will last just about forever for home use. I got it from CMS, but I've since found they have changed names, I think they are now called "Arnott & Guy Foundry Supplies" 20-22 Marni St, DANDENONG SOUTH, VIC, 3175.




The Queensland Address on the pail might still be the same..

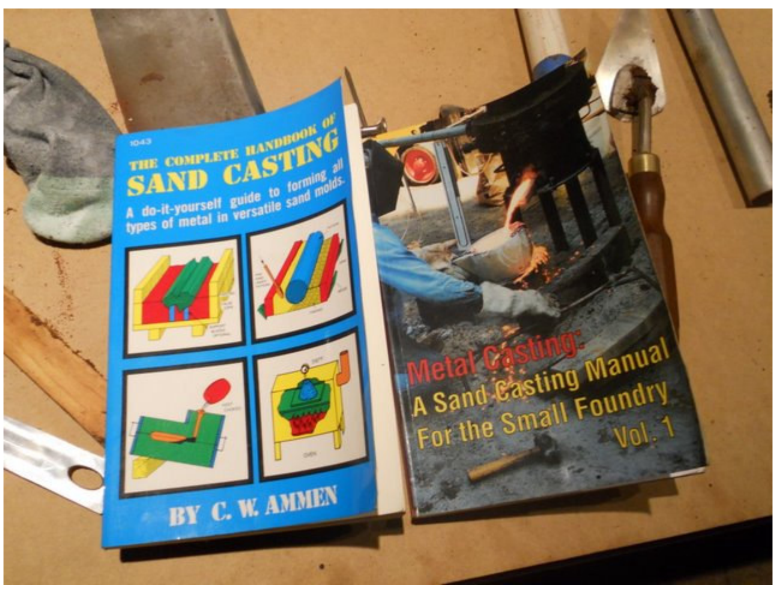
The consistency can change over time, and might require a touch extra oil, or sometimes I've added a squirt of iso-propanol, what you are looking for is when you grab a handfull, it packs cleanly and holds together nicely..

Here is a quick overview of some of the tools used...

Riddle (sieve) for removing clumps, scoops, rammers, scrapers, tubes for cutting sprues and risers, wire for making vent holes, trowell for cutting gates and parting lines, the sock is full of parting compound for dusting the pattern as well as the parting line in the cope and drag. The two screws are used to help remove split patterns from the sand. Also I'm told talcum powder works fine as a parting compound.

The cope and drag, the drag is the bottom, and the cope is the top, together they are sometimes called a flask.. some flasks have snap connections on the corners. It's important that the cope and drag register accurately, that's what the triangle shaped bits on the side are for.

Showing the two parts seperated..




The best book for sand casting techniques, is CW Ammen, he covers patterns and casting strategies in some detail, the other is the Stephen Chastain book, which covers just about everything, but is a bit light on the casting strategy stuff..

I'd recommend you get both.

The next installment (part 5) will be making a pattern and preparing the cope and drag for casting.. that will demonstrate the use of the tools above...

**Casting Something**

Finally got around to taking some pictures, I had to cast a new table locking ring for the Waldown drill press restoration, so this was a good opportunity to take some pictures.

The pattern is pretty simple, and the rough core was only added at the last minute, you would normally have designed the pattern with the core in mind..

The core in this case is just packed petrobond and a simple wooden pattern

The pattern was made by covering the original part with plastibond, and plywood covers top and bottom.

Ok, now flip the drag upside down and place on a flat board, put the pattern in place,

and dust it liberally with casting powder, (talcum powder works I'm told). The parting powder is in a special applicator.. (sock that is)...

Now riddle petrobond to cover the pattern, the riddle (sieve) is to keep out clumps and large bits

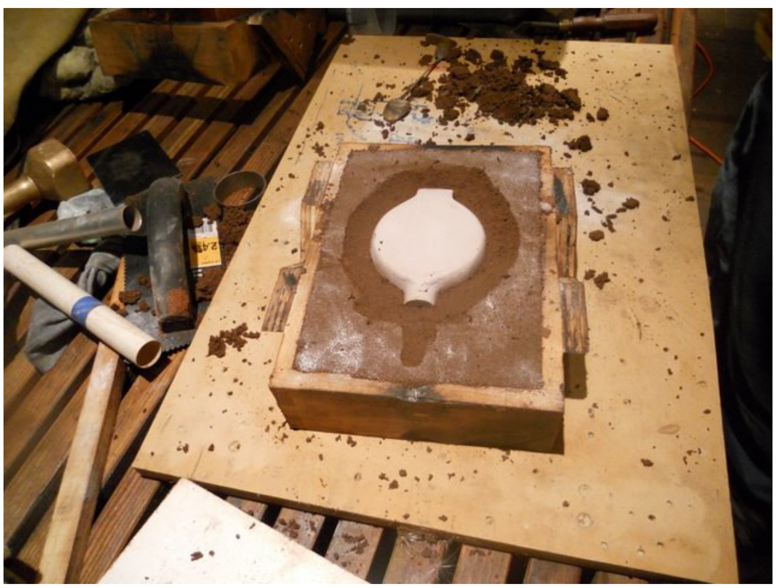
Once the pattern is completely covered, you can just shovel it in and pack down with a rammer as you go.

Pack it in nice and tight, and then screed off with a bit of light sheet metal angle.

Now flip the drag over (the right way up)

Ok, now define the parting line, a small spoon shaped spatula works a treat for this.

Cut down to about half way on the part, this is so that we can get the pattern out of the sand later, if you are doing a proper pattern, then a split pattern avoids this step.



Ok, now dust liberally with parting powder..

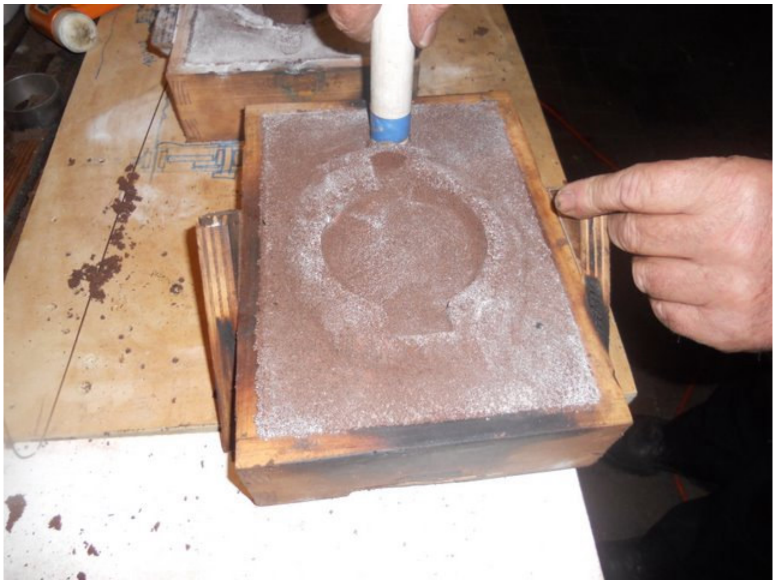
Now put the cope on top and riddle some sand in..then pack it down as before and screed off the top, carefully separate the cope and drag, and there you have a rough pattern.. Josh and I swapped over at this point, so he was a bit slack with the pictures.

Now for the tricky bit, getting the pattern out... tapping with a hammer and wiggling a bit with a screw helps...

Now to pin the core in place. (if this was a proper pattern there would be slots for the core to sit in...) The wire pins are to stop the core moving around when you do the pour.

Now to cut some sprues and risers..

The sprue is the feed point for the casting, sometimes you might need gates and provision for shrinkage... but that's a bit beyond this article.. A bit of pvc tubing with a bevelled edge cuts the sprue.



Now we cut the riser and some vents, the riser is at the far end of the pour, and we should see that fill up when the pour is completed.

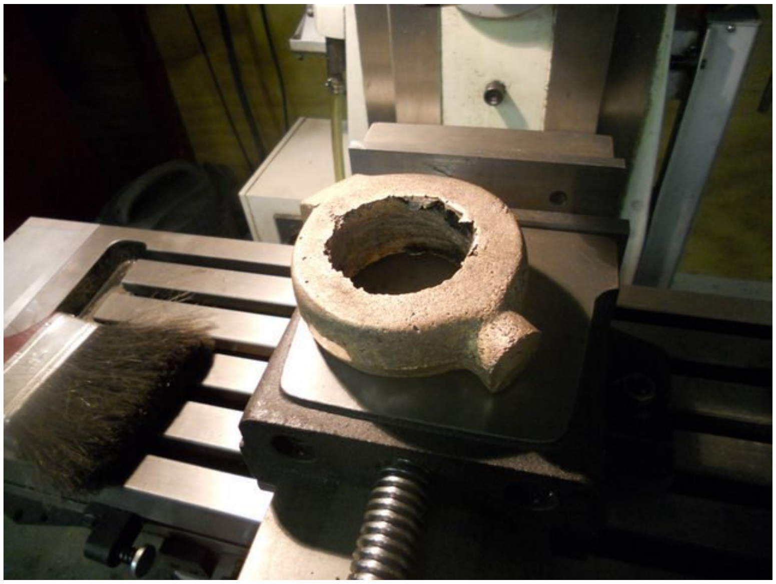
Ok, that's now ready for the pour, handle carefully so that you don't get loose sand dropping into the casting.

Load up with some weights and we are ready..

Melting the Silicon Bronze.

Here it is after breaking the part out, make sure you leave plenty of time for cooling...

You can see where the pour has crept under the core a little, but that flashing will go when it's machined. You can also see the where the bronze has flowed into the vents and riser.



Sprue's and risers cut off, and ready to start machining, the finish is better than it looks in this picture.. but it will be filled and painted anyway..

All things considered you can do more with metal in the liquid state than when it's solid...

It's really not all that complicated.. so get out there and give it a go!...

Regards
Ray