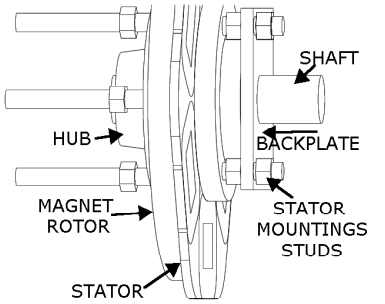
to the back of the hub flange, but this is not easy unless the flange has been machined at the back. In some cases the hub itself can be reversed on its shaft, but this has implications for seals and dust covers. The 1200 machine really needs the magnet rotor to be mounted behind the hub flange so take care to look for a machined back face on the flange for this turbine.

Alternator frame

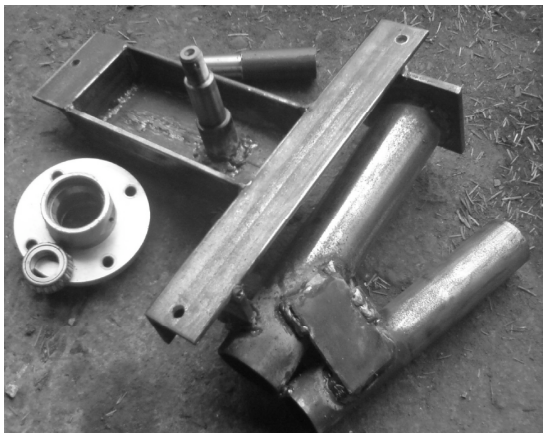
The alternator frame supports the stub shaft that carries the hub. It also supports the stator. The frame in turn is supported by the yaw bearing. The centre of the alternator needs to be offset sideways from the centre of the yaw bearing so as to make the turbine yaw away from the wind (under the control of the furling tail described later).

The frame of the smallest turbine is simply a small backplate, because the stator mounts are at the centre.



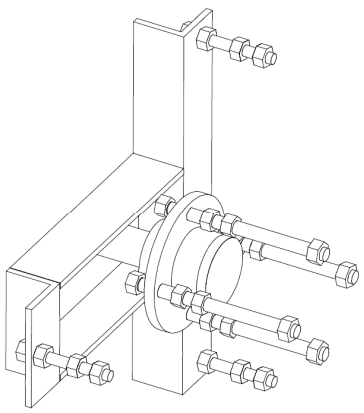
ALTERNATOR FOR SMALLEST TURBINE

Frames for all the other turbines are made from angle-section steel, in a T or an H shape, depending on the number of stator mounting points.



The stator mounts are the short studs with nuts in the drawing. The rotors and blades will mount on the longer studs in the hub.

Two pieces of steel angle make a channel section with a flat surface in the middle. If the shaft has a flange, then this can be bolted onto this flat surface.

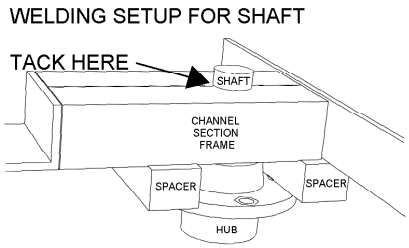


You also need to try to get the magnet rotor close to the frame so as to keep the stator mounts short, and this can affect how far forward you mount the shaft Sometimes the shaft must pass through the flat surface, and the flange is bolted on from behind.

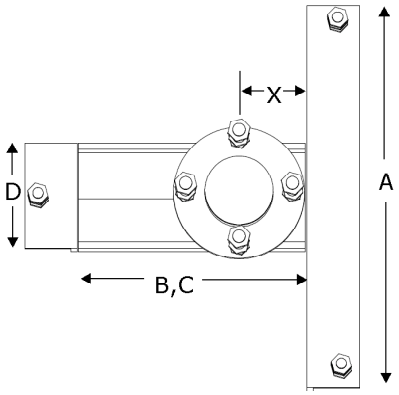
If the shaft has a spindle rather than a flange then you can make a big hole into the same flat surface using a hole saw and weld in the spindle. Or if you have no saw, you can grind out two semicircular hollows in the two pieces of angle (B and C below) prior to welding them together.

Make sure that the stub shaft is central in the alternator frame and mounted exactly square to it. Use spacers to keep the spindle square to the frame while tack welding. The spacers should be chosen to allow clearance for any magnet rotor and nuts behind the hub flange.

Start with three small tacks, bearing in mind that steel contracts as it cools. If it is not tacked on square, then grind off the tacks and try again.



The 1800 – 3000 turbines use a T shaped frame for 3 stator mounts. Their stators have 9 coils, and hence 3 mounting points.



FRAME DIMENSIONS - 50 X 50 X 6 ANGLE			
Turbine diameter	1800	2400	3000
Length of upright A	319	353	411
Channel pieces B,C	187	216	267
End bracket D	100	100	100-130
Position of shaft X	55	65	82

Cut 4 pieces A, B, C and D. Weld B and C together in a channel. A and D go on the ends. Take care to make the T symmetrical. The stator mounting faces must be in the same plane. Lay the frame face down on the bench while welding.

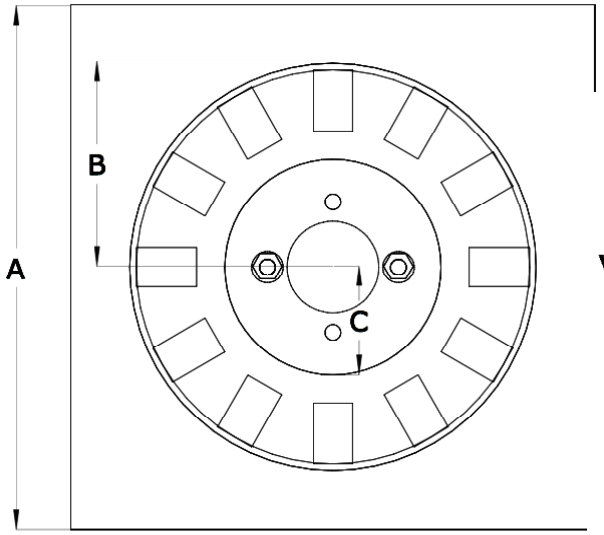
In the case of the 3000 diameter turbine the hub might be larger, so you may have to spread B and C apart instead.

X is the distance of the shaft centre from the upright piece.

STEEL DISK SIZES mm			
Turbine diameter	**1200**	**1800**	**2400**
DIAMETER	230	250	300
THICKNESS	6	6	8
Turbine diameter	**3000**	**3600**	**4200**
DIAMETER	350	400	450
THICKNESS	10	10	10

The hole in the surround is about 5 mm larger radius than the magnet rotor, so that the casting covers and protects the edges of the magnets. Make an island of 9 mm plywood bolted to the steel plate that prevents resin from flooding over the mounting holes at the centre of the steel disk. All the parts are kept in concentric position by two bolts that penetrate the base, the steel disk and the island. The nuts go on top of the island. The lid has larger holes to fit over the nuts.

Here are the sizes for the moulds. The nominal overall size of the pieces is A. The radius of the hole in the surround that forms the outside of the rotor is B. The island has radius C.

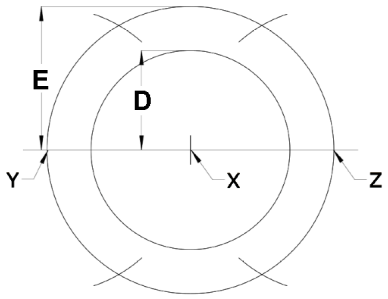


Turbine diameter	**1200**	**1800**	**2400**
Approx. mould side A	350	400	400
Rotor radius B	120	130	155
Island radius C	65	66	83
Turbine diameter	**3000**	**3600**	**4200**
Approx. mould side A	500	500	600
Rotor radius B	180	205	230
Island radius C	99	129	147

The magnet positioning jig

Before casting the magnet rotor you should glue the magnets to the steel disk. Use a jig (template) to place the magnets accurately on the disk. The jig is made of thin plywood with two holes that are used to bolt it to the steel disk concentrically.

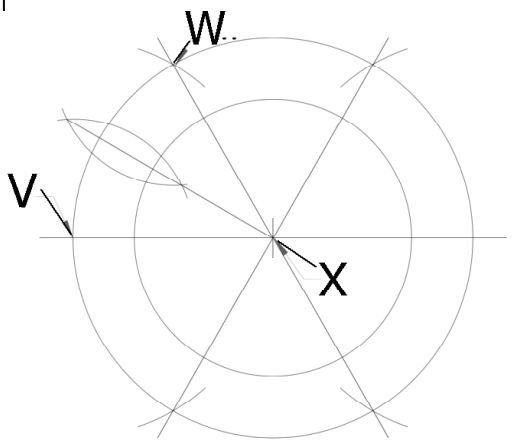
Start by finding a centre point X that is more than E mm away from the edges of a piece of thin plywood.



Draw a l line through X. Draw two circles centred on X with radius D and radius E.

Turbine diameter	**1200**	**1800**	**2400**
Smaller radius D	83	93	104
larger radius E	115	125	150
Turbine diameter	**3000**	**3600**	**4200**
Smaller radius D	129	154	194
larger radius E	175	200	225

If there are 12 magnets then you will need to divide the circle into six parts as follows. Using the same radius B, but centring on Y and Z, draw arcs on the outer circle marking the 60 degree points. Draw lines through the centre X at 60 degrees.

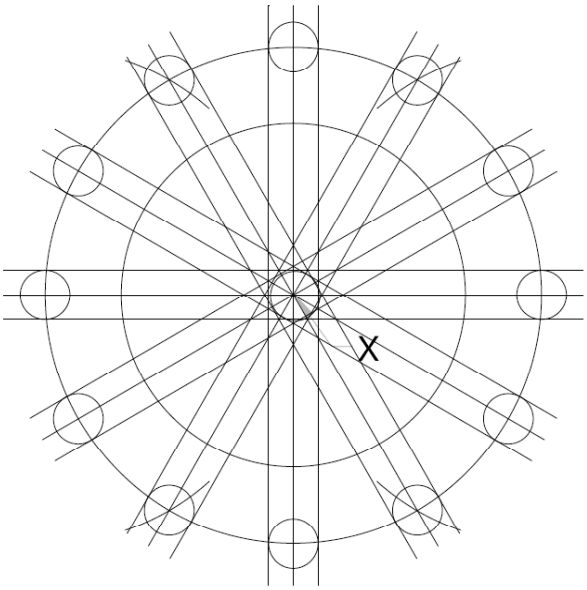


Start to divide the 60 degree angles in half as follows. Choose an arbitrary setting of the compasses to create overlapping arcs centred on V and W as shown. Draw lines through the intersections of these latest arcs and the circle's centre X to cut the angle in two.

Continue right around the circle carefully marking out 12 evenly spaced centres for the 12 magnets.

If you are working with 8 or 16 magnets then you can skip the 60 degree stage of the process, and just use this angle-halving technique to keep on dividing angles in two until you have the correct number of divisions. Start with Y and Z and find 90 degrees then go to 45 (for 8 magnets) and further halving them again for 16 magnets.

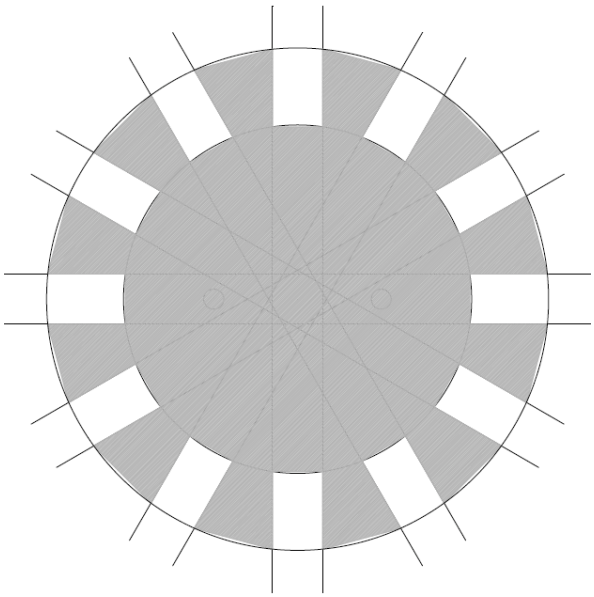
Now you should have divided the outer circles neatly up so as to mark the evenly spaced centres for the magnets.

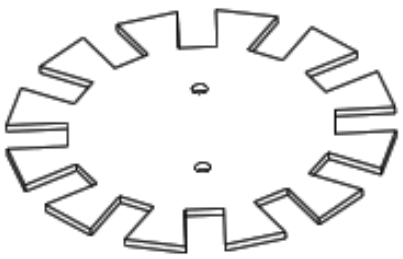


When you have marked all the points, then draw a small circle with diameter same as a magnet width on each point, and at the centre.

Turbine diameter	**1200**	**1800**	**2400**
Circle radius	23	23	15
Turbine diameter	**3000**	**3600**	**4200**
Circle radius	15	15	15

Draw many parallel lines that just touch these circles as shown and you have the outlines of the magnet jig. Cut out the shaded portion with a jigsaw to create the jig.





Resin casting

You can cast the stator and magnet rotors in ordinary polyester resin (as used for making fibreglass boats or for resin castings). NPG polyester resin is slightly better because it withstands higher temperatures. It is also possible to use epoxy resin. This is much more expensive but better for the magnets because it adheres better and is also waterproof. Corrosion of the magnets is more likely when the casting is polyester. Epoxy is not so good for the coils because it does not conduct heat so well. Vinyl Ester resin is very popular for resin casting both coils and magnets because it is easier to cast and withstands higher temperatures than polyester. It is also waterproof.

Ester resins contain an accelerator premixed with them and you add a catalyst to make them set. The catalyst (highly toxic peroxide) reacts with the cobalt accelerator producing heat that sets the resin. When you make castings you need a lot less catalyst than for laying up fibreglass boats. Castings tend to heat up and set prematurely because the heat is trapped inside. If you use too much catalyst or the room is warm, this can mean that the resin sets before you get the lid on the mould and squeeze it to the right thickness. If the casting heats up then it will also get very stressed as it cools, and it may warp or crack.

Adding a powder such as talcum powder, or alumina trihydrate (ATH) powder to the resin mix will reduce the tendency of the casting to heat up. These powders conduct heat well, and this also helps the stator's coils to keep cool when working with currents. Filler powder is very cheap and pretty essential for making good resin castings. Other powders may also be suitable. You can also add powders to epoxy to reduce cost and improve heat dissipation.

Casting the stator

Start by preparing everything You will need:

- A mould with a lid that clamps down,
- An assembly of coils connected together,
- Two pieces of fibreglass cloth cut out to the shape of the stator,
- Some wax or grease to make sure the mould doesn't get stuck to the resin. (Don't get this on anything that you do want resin to stick to),
- Resin and disposable buckets to mix it in
- Scales to weigh out the resin.
- Catalyst, and a syringe or similar to measure it out.
- Talcum powder or aluminium trihydrate.
- Silicone or other caulk in a tube,

Take it apart and grease everything you do not wish to have resin stick to. Grease the mould all over and both sides of the island. Keep the glass cloth and magnet rotor free of grease and greasy fingers. Grease the lid, including the inside edges of the holes in it. Smooth off the grease inside the mould to get a neat finish around the edges. Drop the rotor into place carefully and bolt the island down gently. If you over-tighten the nuts you will warp the island. Hold the spanner in both hands or it will damage the magnets. Grease the nuts and the bolt threads liberally so you can undo them later.

Mix a runny resin mix and pour it carefully into the gap around the edge of the rotor disk, trying to chase out any bubbles that might spoil the appearance. Put a line of silicone around the surround to catch surplus resin. Mix a thicker mix to fill the spaces between magnets. Hammer the mould to remove bubbles. Finish with a runny mix on top of the glass cloth so as to saturate it. Place the lid on top carefully so as not to drag the cloth out of place. Hold it down by placing many steel objects evenly on top of the magnet faces.

You can set the mould(s) level under a heat lamp for a while to speed up the polyester setting process. It is good to get the lids off before they have fully hardened though, because there will be some resin over the top of the island that has to be trimmed off neatly. Take great care working near the magnets with a knife.

When you have taken the rotor out of the mould, clean away surplus resin, especially from the areas around the mounting holes. Store the rotor safely out of the way of fingers and magnetic debris.

You may wish to paint the magnet rotors with a special paint such as a bitumen epoxy coating. Corrosion of the steel disk can cause the magnets to come off. If the magnets' coating gets damaged then the magnets themselves corrode. An impermeable seal over the whole thing is a good investment.

Alternator assembly and testing

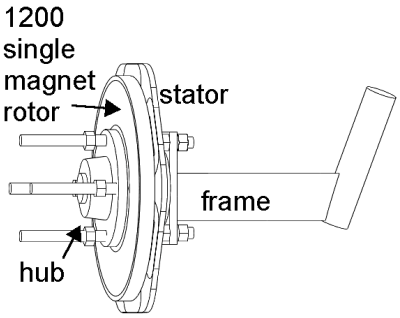
The alternator is held together by long studs made of threaded rods ('all-thread'). These are the same threaded rods that the blade hub is mounted on. I like to use stainless steel rods. The rods need to fit the holes in the hub

Recommended sizes for stainless steel studs (mm)						
machine	1200	1800	2400	3000	3600	4200
Stud dia.	10	10	10-12	12	12-14	14

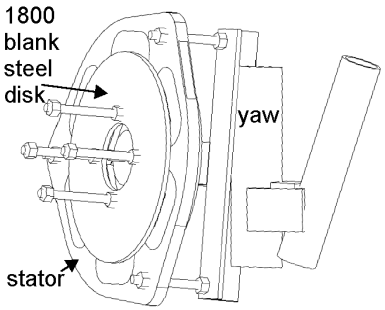
If necessary, enlarge the holes in the hub flange by boring them out, or you can make them smaller by inserting bushes, or even 'helicoils' that create a thread. If enlarging the hub holes it helps to place the steel rotor disk on the hub, and drill through the precisely cut pattern of holes in the disk. This helps to avoid eccentricity. Do all such drilling jobs before casting the magnets onto the disk.

Rotor mounting options

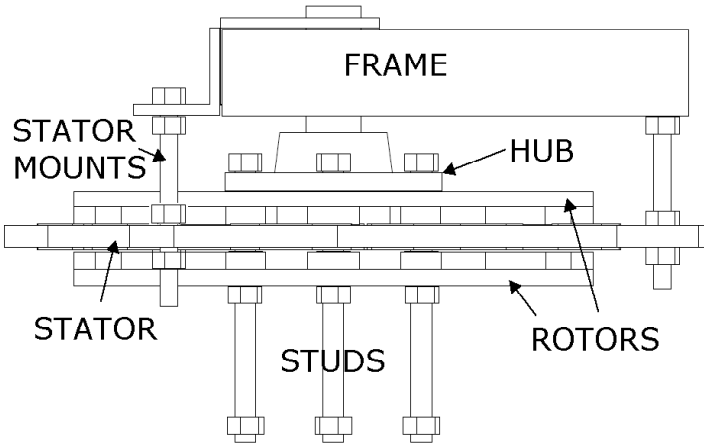
The single rotor for the 1200 turbine is mounted on the back of the hub, facing the stator.



The other turbines have two rotors although the 1800 has only got magnets on the back rotor.



There are various options for mounting the two magnet rotors of larger turbines on the wheel hub. You can mount them in front or behind the wheel flange. In the top view shown below, the magnet rotors are both mounted on the front of the hub.



(In some of these sketches the magnets are visible, whereas in reality they would be embedded in resin.)

In some cases the hub flange is machined flat on the back, and so you can mount one disk behind and the other in front. This makes for a more compact alternator with shorter stator mounts.